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- It is an international electronic journal.
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#### Authors are required to prepare manuscripts in accordance with the international guidelines\* below

|                                                                             |                                                                                                                                                                                               |
|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Randomized Controlled Trial**                                               | <b>CONSORT</b> (Consolidated Standards of Reporting Trials)                                                                                                                                   |
| Non-Randomized Trial**                                                      | <b>TREND</b> (Transparent Reporting of Evaluations with Non-randomised Designs) ( <a href="https://www.cdc.gov/trendstatement/index.html">https://www.cdc.gov/trendstatement/index.html</a> ) |
| Trial Protocol                                                              | <b>SPIRIT</b> (Standard Protocol Items Recommendations for Interventional Trials)                                                                                                             |
| Observational Epidemiologic Studies (cohort, case-control, cross-sectional) | <b>STROBE</b> (the STrengthening the Reporting of OBservational studies in Epidemiology)                                                                                                      |
| Systematic Reviews and Meta-Analyses                                        | <b>PRISMA</b> (the Preferred Reporting Items for Systematic Reviews and Meta-Analyses)                                                                                                        |
| Systematic Reviews and Meta-Analyses Protocol                               | <b>PRISMA-P</b> (the Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Protocol)                                                                                           |
| Experimental Animal Studies                                                 | <b>ARRIVE</b> (the Animal Research: Reporting of In Vivo Experiments)                                                                                                                         |
| Diagnostic Accuracy Studies                                                 | <b>STARD</b> (the Standards for Reporting Diagnostic Accuracy)                                                                                                                                |
| Qualitative Research                                                        | <b>SRQR</b> (the Standards for Reporting Qualitative Research)                                                                                                                                |
|                                                                             | <b>COREQ</b> (COnsolidated criteria for Reporting Qualitative research: interviews and focus groups)                                                                                          |
| Methodological Studies (Translating and Adapting Tests)                     | <b>ITC</b> (International Test Commission) Guidelines for Translating and Adapting Tests ( <a href="https://www.intestcom.org/">https://www.intestcom.org/</a> )                              |
| Methodological Studies (Developing Tests)                                   | <b>COSMIN</b> (COnsensus based Standarts for the selection of Health Measurement Instruments- Study Design for Patient-reported outcome measurement instruments)                              |
| Case Report                                                                 | <b>CARE</b> (Case Reporting)                                                                                                                                                                  |

\*Enhancing the QUALity and Transparency Of Health Research (equator network) (<https://www.equator-network.org/>)

\*\*The Lokman Hekim Health Sciences encourages the registration of all clinical trials (randomized and non-randomized) via ClinicalTrials.gov ([www.clinicaltrials.gov](http://www.clinicaltrials.gov)) or one of the registries of the WHO's International Clinical Trials Registry Platform (ICTRP: <http://www.who.int/ictcp/network/primary/en/index.html>). The name of the trial registry and the registration number together should be provided at the end of the abstract.

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| Type of manuscript   | Word limit | Abstract word limit   | Reference limit                      | Table or figure limit        |
|----------------------|------------|-----------------------|--------------------------------------|------------------------------|
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| Original article     | 3000–3500  | 250 (Structured)      | 30                                   | 6                            |
| Brief report         | 1500       | 150                   | 15                                   | 1 table and 3 figures        |
| Narrative review     | 4000       | 250                   | 40                                   | 6                            |
| Systematic review    | 4000       | 250 (Structured)      | Depends on review frame (60 maximum) | 6                            |
| Case report          | 1200       | 150 (Structured)      | 10                                   | 1 table, 2 figures or images |
| Letter to the editor | 500        | No abstract, keywords | 5                                    | No tables, figures, images   |
| History of medicine  | 1500       | 250                   | depends on review frame (40 maximum) | 6                            |

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Armstrong N, Ryder S, Forbes C, Ross J, Quek RGw. A systematic review of the international prevalence of BRCA mutation in breast cancer. *Cecconi M, Evans L, Levy M, Rhodes A. Sepsis and septic shock. Lancet* 2018;392(10141):7587.

Aslan MH, Vural M. Gram Negative Bacteria Isolated from Blood Cultures and Their Antibiotic Susceptibility. *Trends Surg Sci* 2025;4(1):11-17. [In Turkish]

**Epub ahead-of-print article:** Huyut MA. Kidney Injury Molecule-1 Is Associated with Contrast-Induced Nephropathy in Elderly Patients with Non-STEMI. *Arq Bras Cardiol.* 2021 Mar 29;S0066-782X2021005005201. Portuguese, English. doi: 10.36660/abc.20200172. Epub ahead of print. PMID: 33787767.

**Manuscript published in electronic format:** T.C. Ministry of Health, General Directorate of Public Health. COVID-19 (SARS-CoV2 Infection) Guide (Science Board Study) March 25, 2020. [www.hsgm.saglik.gov.tr](http://www.hsgm.saglik.gov.tr)

**Book section:** Suh KN, Keystone JS. Malaria and babesiosis. *Gorbach SL, Barlett JG, Blacklow NR, editors. Infectious Diseases. Philadelphia: Lippincott Williams; 2004.p.2290-308.*

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# The Relationship Between Surgical Nurses' Attitudes Toward Teamwork and Missed Nursing Care: A Descriptive Study

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## Abstract

**Introduction:** Surgical units require highly skilled and well-equipped multidisciplinary teamwork to provide patient-centered care. Effective teamwork among surgical nurses is critically important for ensuring patient safety and preventing missed nursing care. The aim of this study is to examine the relationship between surgical nurses' understanding of teamwork and missed nursing care.

**Methods:** This study was conducted between March 30 and July 25, 2025, with 120 nurses working in the surgical units of two district and one provincial state hospitals located in southern Türkiye. The study employed the "Nurse Information Form," the "Nursing Teamwork Survey (NTS)-Turkish," and the "MISSCARE Survey – Turkish Version" scales.

**Results:** The study determined that surgical nurses exhibited a high level of teamwork (NTS mean score:  $3.78 \pm 0.67$ ). However, higher nursing teamwork scores were positively associated with higher MISSCARE Part A scores ( $r=0.319$ ,  $p<0.001$ ). While teamwork and missed nursing care differed across clinical units, the reasons for missed nursing care differed according to professional experience and absenteeism during the previous three months ( $p<0.05$ ).

**Discussion and Conclusion:** Although surgical nurses demonstrated high levels of teamwork, higher teamwork scores were positively associated with higher levels of missed nursing care. These findings suggest that missed nursing care may not be explained by teamwork alone and that, given the complex and dynamic nature of surgical care, teamwork should be considered together with clinical and organizational conditions when addressing missed nursing care.

**Keywords:** Surgical nursing; Nursing teamwork; Missed nursing care; Teamwork attitudes

Surgical clinics are highly specialized units that require dynamic, stressful, and multidisciplinary teamwork, where patient-centered nursing care is provided with advanced technological equipment and surgical nurses possess specialized knowledge, skills, and competencies.<sup>[1]</sup>

Surgical nurses, who play a key role in all these processes and in patient-centered care, must take an active part in teamwork to ensure safe surgical care. In patient-centered care, teamwork and multidisciplinary collaboration are of great importance for patient safety and quality care.<sup>[2]</sup>

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Surgical intervention causes many changes in patients, such as fear of death, anxiety, difficulty recovering from anesthesia, changes in body image, and separation from loved ones. To ensure patient recovery by providing nursing care to patients in surgical units that helps them cope with these challenges, nurses must communicate with the patient, family, and physician. Effective teamwork is necessary, allowing patients to easily reach their nurses.<sup>[3,4]</sup> The success of teamwork in the surgical process positively affects the quality of patient care and postoperative outcomes. Effective communication and coordination within the team enhance patient safety and help prevent complications.<sup>[5,6]</sup>

The concept of "Missed Nursing Care (MNC)" was first introduced in the literature by Kalisch and Williams<sup>[7]</sup> as "the omission or delay of all or part of the required care". Studies show that the global incidence of missed nursing care ranges between 10% and 50%.<sup>[8]</sup> According to findings from the literature, missed nursing care occurs regularly in clinical settings.<sup>[9,10]</sup>

Frequently neglected or unperformed nursing tasks include providing psychological and emotional support, maintaining complete nursing records, patient repositioning, nutrition, hygiene, oral care, physical assessments, patient education, and discharge planning.<sup>[9,11,12]</sup> Additionally, the five most overlooked nursing tasks identified by perioperative nurses are: team communication before patient transfer to the operating room (43%), suspension of activities during time-out checks (39.9%), implementation of isolation precautions (36.1%), use of standard communication protocols (33.7%), and reporting of abnormal lab results (33.4%).<sup>[13]</sup>

Missed nursing care is an error of omission—failing to do the right thing—which can lead to adverse outcomes for patients and negatively affect the quality of care. It can increase the risk of patient falls and pressure injuries, delay wound healing, and result in severe pain.<sup>[14]</sup> It also extends the length of hospital stays following surgical interventions, leads to insufficient holistic and quality care, and increases the need for emergency interventions and intensive care unit admissions.<sup>[10]</sup> Surgery can cause pain and wounds in patients. Surgical nurses provide nursing care for the patient, including pain management and wound care. Inadequate wound care by surgical nurses can lead to surgical infection, morbidity, and mortality. Inadequate pain management can lead to respiratory and cardiovascular complications, delayed mobilization, poor sleep quality, the development of chronic pain, and delayed discharge.<sup>[11]</sup> Missed nursing care has negative impacts not only on the quality of healthcare services but also on the patient's perception

of being undervalued, decreased patient satisfaction, and a breakdown in trust and communication between the patient, nursing staff, healthcare team, and institution.<sup>[15]</sup> Although studies have been conducted on missed care and teamwork among nurses,<sup>[3,5]</sup> this relationship has received limited attention specifically in the context of surgical nursing. The time-sensitive and highly interdependent nature of care delivery in surgical units highlights the importance of nurses' teamwork attitudes in determining their capacity to provide necessary care. Despite evidence that poor coordination and communication increase the likelihood of missed care nursing, this relationship has not been thoroughly investigated in the context of surgical nursing. Therefore, by assessing the impact of teamwork attitudes on missed nursing care, particularly among surgical nurses, this study seeks to make a unique contribution.

## Aim

This study was conducted to examine and clarify in more detail the relationship between surgical nurses' understanding of teamwork and missed nursing care.

## Materials and Methods

### Study Place and Design

This study was conducted between March 30, 2025, and 25 July, 2025, with nurses working in surgical units at two district state hospitals and one provincial state hospital located in the south of Türkiye.

### Research Questions

The research questions of this study were:

- What is the level of surgical nurses' understanding of teamwork?
- What is the level of missed nursing care needs among surgical nurses?
- What is the relationship between surgical nurses' understanding of teamwork and their missed nursing care needs?

Considering the risk of data loss and missing data, a larger sample was preferred, and data were collected from 120 nurses. Inclusion criteria for the study were: (a) voluntary participation, (b) being employed as a surgical nurse, and (c) having worked actively in a surgical clinic for at least six months. Exclusion criteria included: (a) withdrawal from the study at any stage, (b) being on extended leave, such as unpaid leave, maternity leave, or medical leave, during the data collection period.

## Research Type

This study is descriptive, correlational and cross-sectional in design.

## Population

The study population consisted of a total of 143 nurses working in surgical departments (urology, otorhinolaryngology, ophthalmology, orthopedics, neurosurgery, general surgery), surgical intensive care units, and emergency departments. The sample size was calculated using the known population sampling formula, based on a 95% confidence level ( $Z=1.96$ ), a 5% margin of error, and a probability value of  $p=0.5$ . According to the calculation, the minimum required sample size was determined to be 105 nurses. The study, however, included 120 nurses.

## Data Collection Tools

The data for this study were collected using the "Nurse Information Form," the "Nursing Teamwork Survey (NTS)-Turkish," and the "MISSCARE Survey – Turkish Version."

## Nurse Information Form

This form was developed by the researchers based on the literature to determine the demographic and professional characteristics of the participating nurses.<sup>[4,16]</sup> It consists of 13 questions: 3 related to demographic information (e.g., most recently graduated school, age, gender) and 10 related to professional attributes (e.g., role in the clinic, total years of professional experience, shift hours, number of days or shifts missed in the last three months due to illness, injury, or other reasons, intent to leave the current nursing position, and tasks required during the shift but not considered within the scope of nursing roles).

## Nursing Teamwork Survey (NTS)-Turkish

This scale was developed by Kalisch et al.<sup>[17]</sup> to assess nursing-specific teamwork. The Turkish adaptation and validation were conducted by Taskiran Eskici and Baykal.<sup>[18]</sup> The scale comprises 33 items and five subscales: trust (items 1–7), team orientation (items 8–16), backup (items 17–22), shared mental model (items 23–29), and team leadership (items 30–33). The nine items under team orientation are reverse scored. The scale uses a 5-point Likert-type (1=Rarely, 2=Sometimes, 3=Occasionally, 4=Frequently, 5=Always). Total average scores range from a minimum of 1 to a maximum of 5, with higher scores indicating better teamwork among team members. The overall Cronbach's alpha for the original scale is 0.94, with subscale values ranging from 0.74 to 0.85. In this study,

the Cronbach's alpha for the scale was found to be 0.907, and for the subscales: trust (0.920), team orientation (0.818), backup (0.904), shared mental model (0.931), and leadership (0.889).

## MISSCARE Survey – Turkish Version

Originally developed by Kalisch and Williams<sup>[7]</sup> and adapted into Turkish by Kalisch et al.<sup>[19]</sup> this scale evaluates missed nursing care needs. The survey includes 21 items rated on a 4-point Likert scale (1=rarely missed, 2=occasionally missed, 3=frequently missed, 4=always missed), with higher scores indicating greater levels of missed nursing care. Moreover, there was an option of not applicable (0 points), where nursing care activities are not required. The Cronbach's alpha was 0.936, and the test-retest reliability was 0.95 ( $p<0.001$ ). In this study, the Cronbach's alpha was 0.980.

The survey also includes a 16-item section measuring nurses' perceptions of the reasons for missed care, categorized into three subscales: labor resources, communication/teamwork, and material resources. This part is rated using a 4-point Likert scale, where increasing scores indicate greater perceived importance of each reason. The Cronbach's alpha for this section was 0.80, and the test-retest reliability was 0.667 ( $p<0.001$ ). In the present study, the Cronbach's alpha was 0.929, with subscale reliabilities of 0.810 for labor resources, 0.926 for communication/teamwork, and 0.883 for material resources.

## Study Procedure

The researchers visited the clinical settings and provided eligible nurses with detailed information regarding the study's purpose, scope, and procedures. Written informed consent was then obtained to secure their voluntary participation.

During the data collection phase, three instruments were utilized: the Nurse Information Form, the NTS, and the MISSCARE Survey – Turkish Version. The Nurse Information Form was used to gather data on participants' demographic and professional backgrounds. The NTS assessed nurses' levels of teamwork, collaboration, and communication, while the MISSCARE Survey evaluated missed nursing care needs and the perceived reasons behind them.

Nurses were given sufficient time to complete the questionnaires independently and comfortably, either within their working environment or in a designated suitable area. Throughout the data collection process, the researcher provided clarifications only when necessary, ensuring that responses were given autonomously.

**Table 1.** Descriptive characteristics of the nurses participating in the study (n=120)

| Variable                                                             | Category                                                  | n                             | %    |
|----------------------------------------------------------------------|-----------------------------------------------------------|-------------------------------|------|
| Age (year) min-max, average $\pm$ SD                                 |                                                           | 23.55<br>35.15 $\pm$ 8.30     |      |
| Education                                                            | Associate degree                                          | 11                            | 9.2  |
|                                                                      | Bachelor's/Master's/Doctorate (PhD) in non-nursing fields | 10                            | 8.3  |
|                                                                      | Bachelor's/Master's/Doctorate (PhD) in Nursing            | 99                            | 82.5 |
| Gender                                                               | Female                                                    | 88                            | 73.3 |
|                                                                      | Male                                                      | 32                            | 26.7 |
| Clinical role                                                        | Staff nurse                                               | 109                           | 90.8 |
|                                                                      | Nurse manager                                             | 11                            | 9.2  |
| Weekly working hours                                                 | <40 h                                                     | 14                            | 11.7 |
|                                                                      | 40 h or more                                              | 106                           | 88.3 |
| Work schedule                                                        | Day shift                                                 | 43                            | 35.8 |
|                                                                      | Evening shift                                             | 6                             | 5.0  |
|                                                                      | Night shift                                               | 4                             | 3.3  |
|                                                                      | Rotating shifts                                           | 23                            | 19.2 |
|                                                                      | 24 h shift                                                | 44                            | 36.7 |
| Unit of employment                                                   | Surgical ward                                             | 46                            | 38.3 |
|                                                                      | Surgical intensive care unit                              | 32                            | 26.7 |
|                                                                      | Emergency department                                      | 42                            | 35.0 |
| Total professional experience (months)<br>min-max, average $\pm$ SD  |                                                           | 12-444<br>148.03 $\pm$ 109.59 |      |
| Experience in the current unit (months)<br>min-max, average $\pm$ SD |                                                           | 12-348<br>51.49 $\pm$ 60.79   |      |
| Shift duration                                                       | <8 h                                                      | 4                             | 3.3  |
|                                                                      | 8 h                                                       | 34                            | 28.3 |
|                                                                      | 10-12 h                                                   | 5                             | 4.2  |
|                                                                      | >12 h                                                     | 77                            | 64.2 |
| Absence duration in the last 3 months                                | 1 day/shift                                               | 54                            | 45.0 |
|                                                                      | 2-3 days/shift                                            | 14                            | 11.7 |
|                                                                      | 3-6 days/ shift                                           | 9                             | 7.5  |
|                                                                      | >6 days/ shift                                            | 9                             | 7.5  |
|                                                                      | No leave taken                                            | 34                            | 28.3 |
| Intention to leave the nursing position                              | Within 6 months                                           | 8                             | 6.7  |
|                                                                      | Within 1 year                                             | 8                             | 6.7  |
|                                                                      | I am not considering leaving                              | 104                           | 86.7 |
| Mandatory non-nursing duties                                         | Yes                                                       | 50                            | 41.7 |
|                                                                      | No                                                        | 70                            | 58.3 |
| Non-nursing mandatory duties                                         | Physician duties                                          | 24                            | 48.0 |
|                                                                      | Clerical/secretarial duties                               | 11                            | 22.0 |
|                                                                      | Auxiliary/support staff duties                            | 3                             | 6.0  |
|                                                                      | Physician and clerical duties                             | 4                             | 8.0  |
|                                                                      | Physician, clerical, and support staff duties             | 8                             | 16.0 |
|                                                                      | Total                                                     | 50                            | 100  |

SD: Standard deviation.

**Table 2.** Mean total scores of the NTS and the questionnaire on missed nursing care needs and reasons for missed nursing care services among participants (n=120)

| Scales                                                   | Minimum–Maximum <sup>a</sup> | Mean±SD   |
|----------------------------------------------------------|------------------------------|-----------|
| Nursing teamwork survey (NTS)                            | 1.97–4.94                    | 3.78±0.67 |
| Trust                                                    | 1–5                          | 3.69±0.91 |
| Team orientation                                         | 1–5                          | 3.76±0.75 |
| Backup                                                   | 1–5                          | 3.67±0.94 |
| Shared mental models                                     | 1–5                          | 3.89±0.86 |
| Team leadership                                          | 1–5                          | 3.93±0.91 |
| Missed nursing care needs questionnaire-A                | 1.05–4                       | 3.59±0.58 |
| Reasons for missed nursing care services questionnaire-B | 1–4                          | 1.74±0.66 |
| Labor resources                                          | 1–4                          | 1.36±0.59 |
| Communication/teamwork                                   | 1–4                          | 1.93±0.80 |
| Material resources                                       | 1–4                          | 1.67±0.87 |

a: The values were obtained in this study. SD: Standard deviation.

Completion of the surveys took approximately 20 to 30 minutes. Once completed, all questionnaires were reviewed for missing or incorrect responses. In cases where incomplete data were identified, the respective participant was contacted to complete the missing information. All collected data were coded and entered a database in accordance with confidentiality principles, with each participant assigned a unique identification number.

### Ethical Considerations

The study was approved by Akdeniz University Medical Scientific Research Ethics Committee (Date: March 06, 2025 and No: TBAEK-273). Permission was obtained from the Antalya Provincial Health Directorate (Date: March 28, 2025 and No: E-98360293-604.01-272662667). Informed consent was obtained from all participants. Each research phase was conducted according to the ethical principles of the Declaration of Helsinki of the World Medical Association.

### Data Analysis

The research data were analyzed using the Statistical Package for the Social Sciences (IBM SPSS Statistics 25, New York, NY, USA). The distribution of numerical variables was examined using the Kolmogorov-Smirnov test, and it was determined that the data did not follow a normal distribution. Therefore, non-parametric test methods were preferred for data comparison. Descriptive statistics included frequency, percentage, arithmetic mean, median, and interquartile range (IQR) values.

The Mann-Whitney U test was used for comparisons between two groups, while the Kruskal-Wallis test

was employed for comparisons involving more than two groups. Spearman correlation analysis was used to determine the relationships between variables. A significance level of  $p < 0.05$  was accepted for all statistical analyses.

### Results

A total of 120 nurses participated in the study. The majority were female (73.3%) and staff nurses (90.8%), with a mean age of  $35.15 \pm 8.30$  years. Most worked 40 hours or more per week (88.3%), primarily in surgical wards (38.3%), surgical ICUs (26.7%), or emergency departments (35.0%). The mean professional experience was  $148.03 \pm 109.59$  months (Table 1).

The mean total score on the NTS was  $3.78 \pm 0.67$ , indicating level of teamwork. Subscale scores were as follows: Trust= $3.69 \pm 0.91$ , Team Orientation= $3.76 \pm 0.75$ , Backup= $3.67 \pm 0.94$ , Shared Mental Model= $3.89 \pm 0.86$ , and Team Leadership= $3.93 \pm 0.91$ . For the MISSCARE Survey, mean scores were  $3.59 \pm 0.58$  for Part A and  $1.74 \pm 0.66$  for Part B. Subscale mean scores in Part B were: Labor Resources= $1.36 \pm 0.59$ , Communication/Teamwork= $1.93 \pm 0.80$ , and Material Resources= $1.67 \pm 0.87$  (Table 2).

No statistically significant differences were found in NTS and MISSCARE (Part A and B) scores by educational background, gender, age, clinical role, weekly working hours, shift duration, experience in the current unit, work schedule, intention to leave the nursing position, or mandatory non-nursing duties ( $p > 0.05$ ). However, significant differences were found in NTS ( $\chi^2=11.29$ ,  $p=0.004$ ) and MISSCARE

**Table 3.** Comparison of NTS, MISSCARE Part A, and MISSCARE Part B scores according to participants' characteristics (n=120)

| Variable                                  | Category                                                     | NTS<br>M (IQR) | Missed Nursing Care<br>Needs Survey – A<br>M (IQR) | Reasons for Missed<br>Nursing Care<br>Services Survey – B<br>M (IQR) |
|-------------------------------------------|--------------------------------------------------------------|----------------|----------------------------------------------------|----------------------------------------------------------------------|
| Education                                 | Associate degree                                             | 3.97 (0.91)    | 3.81 (0.53)                                        | 1.56 (1.94)                                                          |
|                                           | Bachelor's/Master's/Doctorate<br>(PhD) in non-nursing fields | 4.09 (1.53)    | 3.76 (0.53)                                        | 2.16 (1.69)                                                          |
|                                           | Bachelor's/Master's/Doctorate<br>(PhD) in Nursing            | 3.82 (1.00)    | 3.84 (0.48)                                        | 1.56 (0.88)                                                          |
|                                           | $\chi^2/df$                                                  | 1.09/2         | 0.28/2                                             | 1.84/2                                                               |
|                                           | p                                                            | 0.578          | 0.869                                              | 0.399                                                                |
| Gender                                    | Female                                                       | 3.88 (1.02)    | 3.84 (0.46)                                        | 1.56 (0.88)                                                          |
|                                           | Male                                                         | 3.88 (1.18)    | 3.63 (0.47)                                        | 1.75 (1.23)                                                          |
|                                           | Z/U                                                          | -0.07/1396.50  | -1.52/1157.50                                      | -1.37/1178.00                                                        |
|                                           | p                                                            | 0.946          | 0.129                                              | 0.172                                                                |
| Age (year)                                | 34 and under                                                 | 3.82 (1.02)    | 3.80 (0.53)                                        | 1.66 (1.03)                                                          |
|                                           | 35 or older                                                  | 3.94 (1.09)    | 3.84 (0.46)                                        | 1.53 (0.86)                                                          |
|                                           | Z/U                                                          | -1.25/1531.50  | -1.04/1575.00                                      | -1.24/1534.50                                                        |
|                                           | p                                                            | 0.210          | 0.296                                              | 0.215                                                                |
| Clinical role                             | Staff nurse                                                  | 3.85 (1.00)    | 3.82 (0.53)                                        | 1.56 (0.94)                                                          |
|                                           | Nurse manager                                                | 4.03 (1.58)    | 3.84 (0.46)                                        | 1.56 (0.75)                                                          |
|                                           | Z/U                                                          | -0.64/529.50   | -0.58/536.50                                       | -0.45/550.50                                                         |
|                                           | p                                                            | 0.524          | 0.558                                              | 0.655                                                                |
| Weekly working hours                      | Less than 40 hours                                           | 3.92 (0.37)    | 3.85 (0.43)                                        | 1.69 (0.83)                                                          |
|                                           | 40 hours or more                                             | 3.85 (1.14)    | 3.82 (0.53)                                        | 1.56 (0.89)                                                          |
|                                           | Z/U                                                          | -0.89/633.50   | -0.81/645.00                                       | -0.63/665.00                                                         |
|                                           | p                                                            | 0.375          | 0.418                                              | 0.528                                                                |
| Work schedule                             | Day shift                                                    | 3.94 (1.21)    | 3.88 (0.46)                                        | 1.50 (0.81)                                                          |
|                                           | Evening shift                                                | 3.08 (1.49)    | 3.47 (0.84)                                        | 1.78 (1.33)                                                          |
|                                           | Night shift                                                  | 3.70 (1.45)    | 4.00 (0.68)                                        | 1.31 (1.50)                                                          |
|                                           | Rotating shifts                                              | 3.58 (0.67)    | 3.80 (0.46)                                        | 1.94 (0.69)                                                          |
|                                           | 24-hour shift                                                | 3.91 (0.98)    | 3.82 (0.49)                                        | 1.50 (1.14)                                                          |
|                                           | $\chi^2/df$                                                  | 8.05/4         | 7.19/4                                             | 1.74/4                                                               |
|                                           | p                                                            | 0.090          | 0.126                                              | 0.784                                                                |
|                                           |                                                              |                |                                                    |                                                                      |
| Unit of employment                        | Surgical ward                                                | 4.11 (0.77)    | 3.95 (0.24)                                        | 1.66 (0.98)                                                          |
|                                           | Surgical intensive care unit                                 | 3.70 (0.86)    | 3.55 (0.63)                                        | 1.53 (0.88)                                                          |
|                                           | Emergency departmentc                                        | 3.74 (1.08)    | 3.54 (0.62)                                        | 1.56 (0.83)                                                          |
|                                           | $\chi^2/df$                                                  | 11.29/2        | 11.49/2                                            | 0.61/2                                                               |
|                                           | p                                                            | 0.004*         | 0.003*                                             | 0.736                                                                |
| Total professional experience<br>(months) | 147 and below                                                | 3.83 (0.95)    | 3.82 (0.53)                                        | 1.75 (0.92)                                                          |
|                                           | 148 and above                                                | 3.92 (1.17)    | 3.83 (0.46)                                        | 1.38 (0.89)                                                          |
|                                           | Z/U                                                          | -1.42/1484.00  | -1.04/1558.00                                      | -2.51/1280.00                                                        |
|                                           | p                                                            | 0.157          | 0.296                                              | 0.012*                                                               |

**Table 3 (cont.).** Comparison of NTS, MISSCARE Part A, and MISSCARE Part B scores according to participants' characteristics (n=120)

| Variable                                   | Category                     | NTS<br>M (IQR) | Missed Nursing Care<br>Needs Survey – A<br>M (IQR) | Reasons for Missed<br>Nursing Care<br>Services Survey – B<br>M (IQR) |
|--------------------------------------------|------------------------------|----------------|----------------------------------------------------|----------------------------------------------------------------------|
| Experience in the current unit<br>(months) | 50 and below                 | 3.79 (1.00)    | 3.84 (0.49)                                        | 1.56 (0.97)                                                          |
|                                            | 51 and above                 | 3.94 (0.94)    | 3.80 (0.48)                                        | 1.56 (0.75)                                                          |
|                                            | Z/U                          | -1.29/1350.00  | -0.80/1439.00                                      | -0.14/1555.50                                                        |
|                                            | p                            | 0.198          | 0.421                                              | 0.893                                                                |
| Shift duration                             | <8 hours                     | 4.06 (0.29)    | 3.88 (0.88)                                        | 1.63 (0.83)                                                          |
|                                            | 8 hours                      | 3.82 (1.58)    | 3.91 (0.61)                                        | 1.66 (0.80)                                                          |
|                                            | 10-12 hours                  | 4.12 (1.77)    | 3.54 (0.28)                                        | 1.56 (1.25)                                                          |
|                                            | >12 hours                    | 3.85 (0.97)    | 3.82 (0.49)                                        | 1.56 (0.97)                                                          |
|                                            | $\chi^2/df$                  | 1.76/3         | 1.05/3                                             | 0.22/3                                                               |
|                                            | p                            | 0.623          | 0.788                                              | 0.974                                                                |
| Absence duration in the last 3<br>months   | 1 day/shift                  | 3.76 (1.00)    | 3.78 (0.53)                                        | 1.50 (0.89)                                                          |
|                                            | 2-3 days/shift               | 3.68 (1.58)    | 3.67 (0.77)                                        | 1.78 (0.88)                                                          |
|                                            | 3-6 days/ shift              | 3.85 (1.08)    | 3.85 (0.50)                                        | 1.75 (1.38)                                                          |
|                                            | 6+ days/ shift               | 3.82 (0.73)    | 3.56 (1.14)                                        | 2.19 (0.81)                                                          |
|                                            | No leave taken               | 3.91 (0.84)    | 3.86 (0.46)                                        | 1.38 (1.06)                                                          |
|                                            | $\chi^2/df$                  | 0.74/4         | 3.16/4                                             | 9.72/4                                                               |
| Intention to leave the nursing<br>position | p                            | 0.947          | 0.531                                              | 0.045*                                                               |
|                                            | Within 6 months              | 3.45 (0.99)    | 3.86 (0.46)                                        | 1.47 (0.56)                                                          |
|                                            | Within 1 year                | 3.47 (1.07)    | 3.78 (0.96)                                        | 2.09 (1.36)                                                          |
|                                            | I am not considering leaving | 3.89 (1.02)    | 3.83 (0.49)                                        | 1.56 (0.88)                                                          |
|                                            | $\chi^2/df$                  | 2.34/2         | 1.09/2                                             | 4.59/2                                                               |
|                                            | p                            | 0.310          | 0.581                                              | 0.101                                                                |
| Mandatory non-nursing duties               | Yes                          | 3.84 (0.92)    | 3.94 (0.47)                                        | 1.53(0.95)                                                           |
|                                            | No                           | 3.89 (1.11)    | 3.76 (0.53)                                        | 1.59 (0.86)                                                          |
|                                            | Z/U                          | -0.51/1653.50  | -1.63/1450.00                                      | -0.56/1644.00                                                        |
|                                            | p                            | 0.607          | 0.103                                              | 0.572                                                                |

Z: Mann-Whitney U test;  $\chi^2$ : Kruskal-Wallis H test; M: Median; IQR: Interquartile range; \*: p<0.05.

Part A scores ( $\chi^2=11.49$ ,  $p=0.003$ ) based on clinical unit. Significant differences were also found in MISSCARE Part B scores based on total professional experience ( $z=-2.51$ ,  $p=0.012$ ) and absence duration during the previous three months ( $\chi^2=9.72$ ,  $p=0.045$ ) (Table 3).

A positive and statistically significant correlation was found between total NTS scores and MISSCARE Part A scores ( $r=0.319$ ,  $p<0.001$ ), whereas no significant correlation was found between NTS scores and MISSCARE Part B scores ( $r=0.069$ ,  $p=0.456$ ). Among the NTS subscales, Trust ( $r=0.296$ ,  $p=0.001$ ), Team Orientation

( $r=0.233$ ,  $p=0.011$ ), Backup ( $r=0.234$ ,  $p=0.010$ ), Shared Mental Model ( $r=0.183$ ,  $p=0.045$ ), and Team Leadership ( $r=0.267$ ,  $p=0.003$ ) were positively and significantly correlated with MISSCARE Part A scores. No statistically significant correlations were found between the NTS total or subscales and MISSCARE Part B or its subscale scores ( $p>0.05$ ) (Table 4).

## Discussion

Team cognition reflects the extent to which team members understand each other's roles and responsibilities, act in

**Table 4.** The relationship between the total scores of the NTS and the missed nursing care needs questionnaire-a and the reasons for missed nursing care services questionnaire-B among participants (n=120)

| Scales/Sub scales    | Missed nursing care needs questionnaire-A<br>r/p | Reasons for missed nursing care services questionnaire-B<br>r/p | Sub scale              | Sub scale                         | Sub scale                    |
|----------------------|--------------------------------------------------|-----------------------------------------------------------------|------------------------|-----------------------------------|------------------------------|
|                      |                                                  |                                                                 | Labor resources<br>r/p | Communication/<br>teamwork<br>r/p | Material<br>resources<br>r/p |
| NTS                  | 0.319/<0.001**                                   | 0.069/ 0.456                                                    | 0.039/0.671            | 0.064/0.485                       | 0.036/0.699                  |
| Trust                | 0.296/0.001**                                    | 0.102/0.267                                                     | 0.059/0.521            | 0.066/0.472                       | 0.099/0.282                  |
| Team orientation     | 0.233/0.011*                                     | 0.071/0.439                                                     | 0.022/0.813            | 0.060/0.513                       | 0.082/0.375                  |
| Backup               | 0.234/0.010*                                     | 0.083/0.367                                                     | -0.001/0.992           | 0.088/0.340                       | 0.048/0.602                  |
| Shared mental models | 0.183/ 0.045*                                    | 0.011/0.909                                                     | -0.046/0.619           | 0.033/0.721                       | -0.058/0.530                 |
| Team leadership      | 0.267/0.003*                                     | 0.084/0.365                                                     | 0.031/0.735            | 0.092/0.315                       | 0.068/0.460                  |

\*: p<0.05; \*\*: p<0.01. r=Spearman's rank correlation coefficient. NTS: Nursing teamwork survey.

alignment with shared goals, and coordinate effectively. Surgical units, by their nature, are multidisciplinary environments where all healthcare professionals must work in close collaboration due to time pressure and low tolerance for errors. Previous studies have shown that clear role definitions and shared mental models enhance team communication and collaboration.<sup>[20]</sup> In line with these findings, the present study also revealed high levels of teamwork among surgical nurses, consistent previous studies conducted by Taskiran Eskici and Baykal.<sup>[18]</sup> This high level of teamwork appears to be inherent to the nature of surgical care, which demands mutual trust, collaboration, and rapid decision-making.

In the current study, nurses scored highest on the team leadership subscale and lowest on the backup subscale, differing from previous studies in which shared mental model was the highest-scoring dimension.<sup>[18,21]</sup> This difference may reflect variations in sample characteristics and clinical settings. The relatively high team leadership scores observed among surgical nurses may be related to the nature of surgical care, which requires rapid decision-making, effective coordination, and clear leadership within the team.

The mean MISSCARE part A score in our study was higher than those reported by Yurttaş et al.<sup>[5]</sup> and Chegini et al.<sup>[15]</sup> This difference may be related to variations in clinical settings, workload, staffing conditions, and sample characteristics. The relatively high level of missed nursing care observed in the present study may also reflect the complex and time-sensitive nature of care delivery in surgical units.

The positive correlation between total NTS scores and MISSCARE Part A scores indicates that higher teamwork

levels were accompanied by higher levels of missed nursing care in this study. Positive correlations with MISSCARE Part A were also observed across all NTS subscales. However, this finding contrasts with several studies reporting that higher team orientation is associated with lower levels of missed care.<sup>[3,5]</sup> The finding that higher teamwork scores were associated with increased levels of missed nursing care in this study requires careful interpretation. One plausible explanation is the phenomenon of compensatory teamwork, in which nurses exhibit heightened mutual support under conditions of excessive workload, staffing shortages, and resource limitations. Previous research has shown that when structural conditions are suboptimal, nurses rely more heavily on one another to maintain basic care continuity, leading to increased perceptions of teamwork even as care omissions rise.<sup>[7,15]</sup> In line with this, rather than deficiencies in interpersonal collaboration, missed care has been repeatedly associated with insufficient staffing, role overload, and conflicting demands.<sup>[9,11]</sup> Therefore, rather than being a sign of the best possible care delivery, high teamwork scores in our study may represent an adaptive response to workload pressure. Previous studies have shown that staffing adequacy and the nursing practice environment are important factors associated with missed nursing care and patient outcomes.<sup>[12,13]</sup> Taken together, these findings suggest that systematic and organizational factors, rather than team process alone, are the primary determinants of missed nursing care; thus, teamwork by itself is insufficient to overcome structural constraints.

Furthermore, 41.7% of the surgical nurses reported performing tasks outside their nursing role, including

duties normally assigned to physicians, clerks, and support staff. Among these nurses, the reported duties included tasks normally assigned to physicians, clerical staff, and support personnel. The literature identifies insufficient staffing, poor communication, lack of professional role clarity, and inadequate material resources as important factors contributing to missed nursing care.<sup>[9,22]</sup> Although performing non-nursing duties was not significantly associated with NTS or MISSCARE scores in the present study, a considerable proportion of nurses reported undertaking such duties. This finding highlights the importance of considering workload distribution and role clarity in clinical practice.

The results also showed that both NTS and MISSCARE Part A scores differed significantly across clinical units. Consistent with our findings, a previous study also reported significant variation in nursing teamwork according to unit type.<sup>[23]</sup> Likewise, Dursun Ergezen et al.<sup>[24]</sup> reported significant unit-based differences in several missed nursing care activities. This difference may be related to variations in workload intensity and unit-specific stress. The structural characteristics of the clinical environment may influence teamwork and missed nursing care. Accordingly, unit-based strategies addressing communication, teamwork, workload, and stress may be considered in pressure settings such as ICUs and emergency departments.

In terms of professional experience, less experienced surgical nurses reported higher scores for the reasons behind missed care, suggesting that they perceive more factors contributing to missed nursing care. Although some previous studies have reported no significant differences in missed care by experience level<sup>[25,26]</sup> or higher levels among more experienced nurses,<sup>[27,28]</sup> However, it aligns with findings by Mainz et al.,<sup>[29]</sup> who reported that nurses with less than five years of experience were more likely to leave basic care needs missed.

Although numerous studies have examined the relationship between professional experience and the frequency of missed care,<sup>[25,26]</sup> few have explored how experience influences perceptions of why care is missed. These findings suggest that professional experience may influence nurses' perceptions of the reasons for missed care, even though the overall level of missed nursing care did not differ significantly according to professional experience. Overall, the findings highlight that teamwork alone cannot ensure comprehensive care; structural and organizational support is equally essential to prevent omissions and strengthen patient safety.

Finally, one of the noteworthy findings of this study was that scores related to the reasons for missed nursing care differed according to the duration of absence during the previous three months. The highest median MISSCARE part B score was observed among nurses who reported more than six days/shifts of absence. Similarly, a previous study reported an association between nurses' absenteeism and missed nursing care.<sup>[30]</sup> However, in the present study, the observed difference emerged not in the frequency of missed care itself, but in nurses' perceptions of the reasons contributing to missed nursing care. This finding suggests that the duration of absence may be associated with how nurses perceive the conditions that contribute to interruptions or omissions in care.

### Strength and Limitations

A major strength of this study is its specific focus on the relationship between teamwork and missed nursing care among surgical nurses. However, the study has several limitations. First, it included only nurses working in the surgical units of three public hospitals, which may limit the generalizability of the findings. Second, the study relied entirely on self-reported data from nurses for all primary variables, rather than using direct observational techniques. As with all survey-based research, this introduces the potential for response bias and social desirability bias. Third, since the study was conducted in three hospitals located within a specific geographical region, the findings may not reflect working conditions or cultural differences in other regions.

### Conclusion

This study demonstrated that surgical nurses had high levels of nursing teamwork and missed nursing care. Nursing teamwork and missed nursing care differed across clinical units, while the reasons for missed nursing care varied according to professional experience and duration of absence during the previous three months. In addition, a positive association was found between nursing teamwork and missed nursing care. Therefore, when addressing missed nursing care, nursing teamwork should be considered together with clinical and organizational conditions.

The current findings suggest that strengthening teamwork alone may not be sufficient to reduce missed nursing care in surgical settings. Nurse managers should also consider workload distribution, adequate staffing, and clarity of professional roles.

**Ethics Committee Approval:** The Akdeniz University Medical Scientific Research Ethics Committee granted approval for this study (date: 06.03.2025, number: TBAEK-273).

**Informed Consent:** Informed consent was obtained from all participants.

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# Exploring Occupational Therapists' Perspectives on Client-centered Approaches

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## Abstract

**Introduction:** Client-centered approaches are considered best practice in occupational therapy. Therapists adopt this focus due to education and the nature of the profession. This study aimed to investigate occupational therapists' perspectives on client-centered approaches, their perceived effectiveness, and the factors facilitating their implementation, while also examining the difficulties encountered.

**Methods:** A cross-sectional survey was conducted with 104 occupational therapists, mainly specializing in pediatric rehabilitation. Data were collected through Google Forms, following a comprehensive literature review.

**Results:** Occupational therapists reported that they prioritized client preferences and used practice-based experiential knowledge to facilitate this approach. However, it was determined that barriers such as limited client awareness and institutional standards hindered its full implementation.

**Discussion and Conclusion:** The findings offer practical tools for facilitating client-centered approaches and suggest addressing challenges and barriers to enhance the perceived effectiveness of occupational therapy in Türkiye. These measures can promote a more client-centered approach in practice.

**Keywords:** Client-centered practice; Education; Intervention; Occupational therapy; Regulations

Identifying the common methods and tools used by healthcare professionals in the assessment and intervention processes, as well as the periodic review of these practices by professionals, is important. Information obtained from surveys contributes to an understanding of the degree to which professional services align with best practices within the profession.<sup>[1]</sup> A fundamental element of best practice is client-centered services. This element is consistent with the American Occupational Therapy

Association (AOTA)'s centennial vision for the profession and the Occupational Therapy Practice Framework.<sup>[2,3]</sup> Client-centered practice researches are missions of occupational therapy.<sup>[4]</sup> Occupational therapists have always considered client-centered approaches to be of significant importance.<sup>[5]</sup> The client-centered approach is a fundamental characteristic of best practice, and is a service philosophy that embraces respect for individuals/communities and partnership with them. Occupational therapists inherently adopt a client-

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centered approach when they collaborate with clients to develop or select activities that align with their interests, health-related goals, and participation in daily life, especially those activities that hold personal significance or interest.<sup>[6]</sup> Occupational therapists who adopt this approach involve clients in the assessment and intervention planning process, taking time to understand their values, needs, priorities, daily occupations, and preferences. This information is then used to guide clinical decisions throughout the service delivery process.<sup>[7]</sup> However, the extent to which occupational therapists are measuring the effectiveness of client-centered practice remains to be fully explored. In addition, there is a need for further research into how occupational therapists assess the effectiveness of interventions, including client-centered approaches. The identification, description, and testing of client-centered interventions is where the knowledge gap lies. Addressing this knowledge gap is imperative to ensure the effective implementation and outcomes of these interventions.<sup>[8]</sup>

In Türkiye, the principle of client-centeredness in health professions has been formally recognized in the occupational therapist's job description, as outlined in the Regulation on Job and Task Descriptions of Health Professionals and Other Professionals Working in Health Services, published in the Official Gazette on May 22, 2014 (No. 29007).<sup>[9]</sup> As stated in the articles of the National Core Education Programme for Occupational Therapy in Türkiye, the aim is to train professional occupational therapists who, after undergraduate training, can work in a client-centered manner throughout the country.<sup>[10]</sup> This study aims to explore the perspectives of occupational therapists on client-centered approaches. In this context, the study will identify the tools and actions employed to facilitate the implementation of client-centered approaches. Furthermore, the study will identify the barriers and challenges in the implementation of these approaches and contribute to the national development of occupational therapy in Türkiye, which is a relatively recent profession in the country compared to the global context.

## Materials and Methods

### Design

The present study adopted a descriptive cross-sectional survey design, utilizing survey methodology.<sup>[11]</sup> The questionnaire was designed to include a Likert scale, multiple-choice questions, and one open-ended question. The distribution of the survey instrument to participants was facilitated by the Turkish AOTA via a web-based survey tool. A total of 253

members of the Turkish AOTA were contacted via email, and 104 occupational therapists completed the survey, yielding a response rate of 41.1%. Ethical approval for the study was received from the Scientific Research Ethics Committee of University Lokman Hekim on March 28, 2024 (Approval No: 2024095). The study was conducted in accordance with the Declaration of Helsinki. Before commencing the survey, informed consent was obtained from the occupational therapists via a link embedded within an email. The reporting of this descriptive cross-sectional survey was primarily guided by the Strengthening the Reporting of Observational studies in Epidemiology guidelines.<sup>[12]</sup>

### Participants

Since there is no national registry indicating the exact number of occupational therapists in Türkiye, a convenience sampling method was employed to reach the study population. The inclusion criteria stipulated that therapists must have accumulated a minimum of 6 months of professional experience and must have provided their consent to participate in the study. Furthermore, they must have been available to participate within the designated 4-week data collection period. The data collection period commenced on April 2, 2024, and concluded after a period of 4 weeks, at which point the survey was closed to any additional occupational therapists who could have potentially been included as study participants.

### Measures

#### *The Client-centered Approaches Survey*

The survey was designed based on a pool of research questions from previous studies.<sup>[5,13,14]</sup> From an initial pool of 41 questions, a final set of 28 questions as survey items was developed through consensus among the researchers. The electronic survey tool Google Forms ([https://docs.google.com/forms/d/1C-0oVoH3QRF4sI4\\_rxOeDQaNOHVmSYLaRTShGvFRqmM/edit](https://docs.google.com/forms/d/1C-0oVoH3QRF4sI4_rxOeDQaNOHVmSYLaRTShGvFRqmM/edit)) was utilized to create a draft survey, with the objective being to assess occupational therapists' client-centered approaches and their effectiveness. The survey concentrated on the intensity and effectiveness of these approaches, as well as the barriers and facilitators to their use. Three occupational therapists working in hospital and clinic settings were selected to pilot the electronic survey. Based on their feedback, the sub-options of the multiple-choice questions were revised and finalized to ensure accurate translation and clear comprehensibility. The final version of the survey incorporated questions on sociodemographic

characteristics (4 questions), working conditions (7 questions), aspects related to client-centered approaches and their effectiveness (16 questions), and the addition of further aspects (1 question). The survey incorporated Likert-type scale questions as well as multiple-choice questions and one open-ended question. The survey instrument is available in Appendix 1.

## Data Analysis

The data were analyzed using Google Forms, Microsoft Excel (2016; Microsoft Corp., Redmond, WA), and IBM Statistical Package for the Social Sciences Statistics (Version 24; IBM Corp., Armonk, NY). The survey data were collected through Google Forms, where all closed-ended items were set as mandatory; therefore, there were no missing data. Likert-type items were treated as ordinal variables. Consequently, descriptive statistics for these items were summarized using frequencies (n), percentages, medians, and minimum–maximum values. The development of tables and graphs illustrating the results was conducted using Microsoft Excel.

## Results

### Sociodemographic Characteristics

A total of 104 occupational therapists participated in the study by completing the survey. The majority of participants (88.5%) were aged between 22 and 29 years, and nearly half (46.2%) had between 6 months and 2 years of experience as occupational therapists. The majority of occupational therapists (47.1%) were working in the Central Anatolia Region. The majority of participants (63.5%) worked in the field of pediatric rehabilitation, followed by those working in hand rehabilitation (15.3%) (Table 1).

### Working Conditions

Participants were asked to indicate the conditions of their work environment. Most of the participants (79.3%) reported independently planning their interventions, indicating a high level of autonomy (Median=5; Min–Max=1–5). Considering their views on the necessity of following fixed routines in the clinic, 30.8% of participants (n=32) agreed with this situation; but 26.9% remained neutral; overall, the responses showed a central tendency (Median=3; Min–Max=1–5). Among the respondents, 35.6% expressed that they provided services to a regular and specific number of clients throughout the day (Median=3; Min–Max=1–5), whereas 23.1% disagreed with this idea. In addition, 39.4% of participants indicated that the daily number of clients and schedules was known a few days before; in comparison,

**Table 1.** Descriptive statistics

| Variable                    | n  | %    |
|-----------------------------|----|------|
| Age                         |    |      |
| 20–29 years                 | 92 | 88.5 |
| 30–39 years                 | 12 | 11.5 |
| Experience                  |    |      |
| 6 months–2 years            | 48 | 46.2 |
| 3–5 years                   | 41 | 39.4 |
| 6–10 years                  | 13 | 12.5 |
| 10 years and more           | 2  | 1.9  |
| Work area                   |    |      |
| Hand rehabilitation         | 16 | 15.3 |
| Geriatric rehabilitation    | 2  | 1.9  |
| Neurological rehabilitation | 11 | 10.6 |
| Mental health               | 9  | 8.7  |
| Pediatric rehabilitation    | 66 | 63.5 |

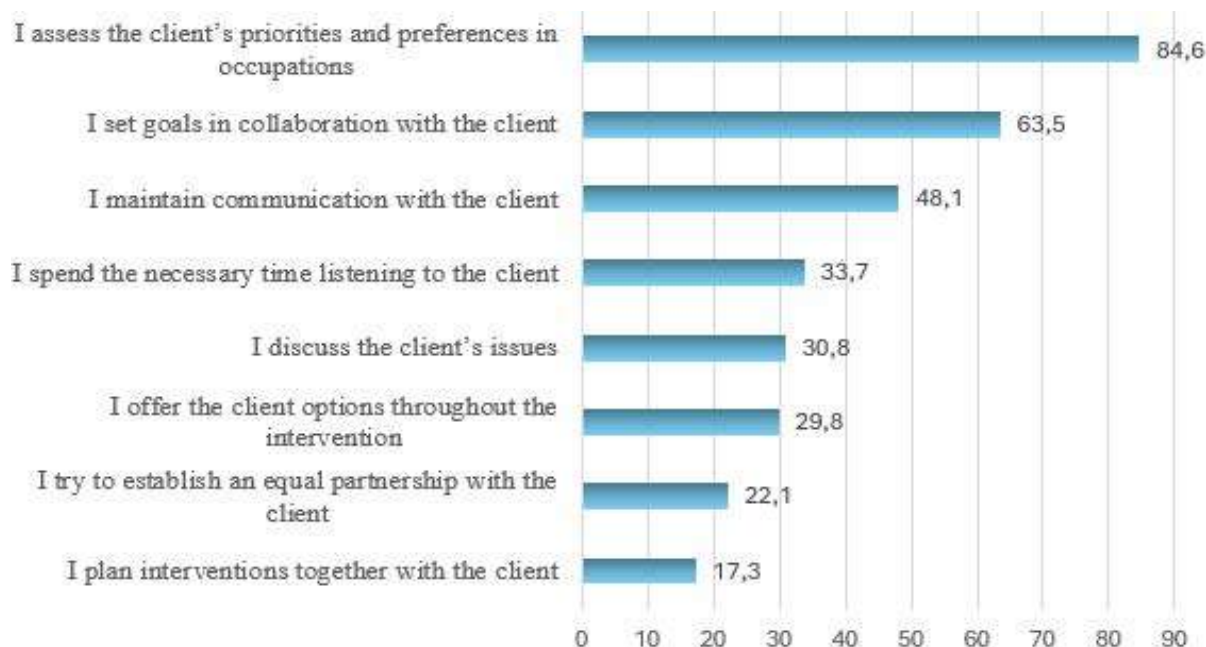
23.1% stated that the scheduling was done only on the same day. Whether occupational therapists have enough time for each client was evaluated, 48.1% reported that they had enough time; but 24% strongly disagreed with this view (Median=3; Min–Max=1–5). Moreover, regarding whether each client had a fixed or specific session duration, 32.7% of participants strongly agreed, while 46.2% supported this view (Median=5; Min–Max=1–5).

### Client-centered Approaches

Participants answered questions about the use and importance of the client-centered approach. Almost half of the participants said they always use client-centered practices (49%), and the overall frequency of use was high (Median=4; Min–Max=2–5). In addition, most of the participants (70.2%) stated that the client-centered approach was extremely important (Median=5; Min–Max=3–5), and 56.7% were very satisfied with using this approach (Median=4; Min–Max=2–5). Participants reported that they most commonly gained knowledge about client-centered practice through undergraduate education (45.2%), following publications (45.2%), and clinical practice (41.3%).

Participants were asked about the benefits of the client-centered approach, 69.6% stated that it activates the client during interventions, 57.7% indicated that it fosters client-therapist collaboration, and 59.6% reported that it enhances intervention effectiveness.

Participants indicated that they most commonly used the action to facilitate use of a client-centered approach in their interventions, with the most prevalent applications



**Figure 1.** Actions that facilitate the use of client-centered approaches.

Values indicate the percentage of participants reporting each action. Participants were allowed to select more than one option.

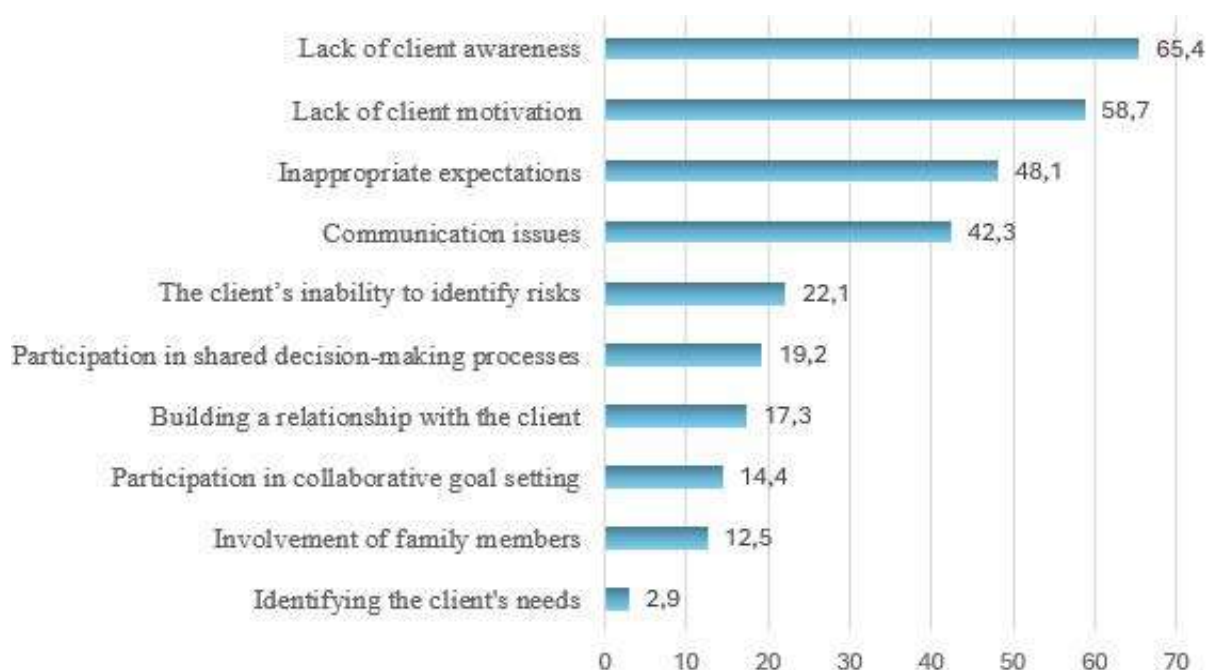


**Figure 2.** Tools that are used to facilitate the use of client-centered approaches.

Values indicate the percentage of participants reporting each action. Participants were allowed to select more than one option.

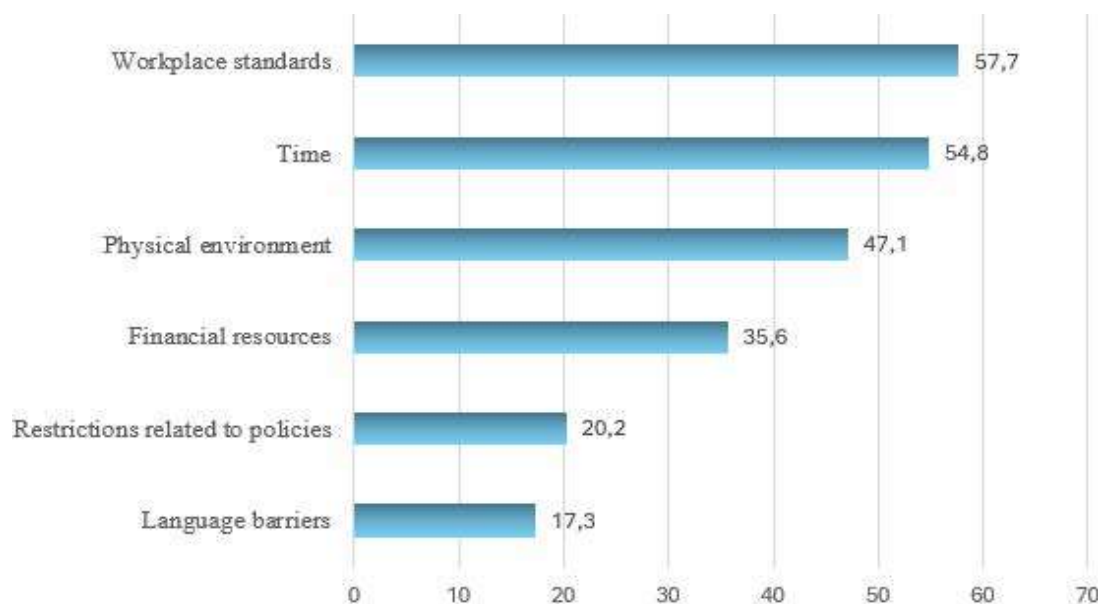
being the exploration of the client's occupational priorities (84.6%), the setting of goals in collaboration with the client (63.5%), and the establishment of strong communication with the client (48.1%). In terms of frequency, participants reported using these facilitation actions often (Median=4; Min-Max=1-5) (Fig 1).

Participants also reported that they used tools to facilitate a client-centered approach, relying on their past clinical experiences (72.1%), models of occupational therapy (43.3%), and assessments of activities of daily living (41.3%) to guide these practices. Similar to actions, the use of these tools was frequent among therapists (Median=4; Min-Max=1-5) (Fig. 2).



**Figure 3.** Challenges encountered when applying client-centered approaches.

Values indicate the percentage of participants reporting each action. Participants were allowed to select more than one option.



**Figure 4.** The biggest barriers when applying the client-centered approach.

Values indicate the percentage of participants reporting each action. Participants were allowed to select more than one option.

A survey of participants revealed that 47.1% of respondents encountered various challenges during the implementation of a client-centered approach. The frequency of encountering barriers was notable (Median=4; Min–Max=1–5). The most prevalent challenges reported were a lack of client awareness (65.4%) and client motivation (58.7%) (Fig. 3).

Participants identified the greatest barriers to the implementation of client-centered practices as workplace issues (57.7%), time constraints (54.8%), and the physical environment (47.1%) (Fig. 4).

Participants typically evaluated the effectiveness of client-centered approaches using qualitative and quantitative methods (69.2%). Furthermore, pre- and post-evaluations

(54.8%), the client's subjective feedback (16.3%), and assessments of occupational performance and satisfaction (10.6%) were identified as the most common evaluation tools for client-centered approaches. The responses to the open-ended question posed at the conclusion of the survey, which invited respondents to articulate their aspirations, were not sufficiently comprehensive to identify a common theme (5.76%).

## Discussion

The majority of the participating occupational therapists reported that each client had a fixed session length and a certain amount of time per session. However, approximately one quarter of the respondents reported a lack of time for each client, the absence of fixed numbers of clients throughout the day, and the revelation of the number of clients only on the day of the service. Participants reported that client-centered approaches were beneficial and that these approaches enabled the child to become a more active partner in the intervention. Furthermore, the facilitative actions employed by occupational therapists, which were aimed at assessing clients' priorities and desires regarding their occupation, were emphasized. It was also highlighted that experience gained through practice was frequently used as a facilitative tool when implementing client-centered approaches. Despite encountering challenges such as limited client awareness, occupational therapists identified workplace standards as the primary barrier to the implementation of client-centered approaches.

The participants of the study were primarily occupational therapists working in the field of pediatric rehabilitation. The results obtained from this study indicated that one-quarter of occupational therapists reported a lack of necessary time for clients and that the profile of clients who would attend therapy sessions could only be determined on the day of the session. Literature indicates the value of allowing parents of children receiving therapy to ask questions to help them understand the approaches and procedures followed during therapy.<sup>[15]</sup> It has been emphasized that time should be allocated to understand the needs and expectations of parents, discuss the child's development, and ensure adequate follow-up duration.

<sup>[16,17]</sup> Among the barriers to listening to the voices of children and adolescents are the limited time available to therapists and the fact that occupational therapists only sometimes utilize a formal goal-setting process.<sup>[18]</sup> The time constraints faced by the occupational therapists in the study sample and the uncertainty regarding the client profiles for therapy on that day may have limited the

mutual communication among therapists, parents, and children. Accordingly, insufficient time allocation, coupled with families' lack of knowledge about interventions and unmet expectations, were seen as factors that could hinder the development of pediatric occupational therapy in Türkiye, according to the participants' perceptions.

Thomas et al.<sup>[19]</sup> suggested that occupational therapists use a systematic approach based on client preferences as well as evidence and professional reasoning to improve client outcomes. Findings indicated that the occupational therapists participating in the study evaluated the child's priorities and preferences, and they perceived that the use of client-centered approaches led to the child becoming an active partner in the intervention. In addition, practical experience was identified as the most frequently used tool by the occupational therapists in this study sample when applying client-centered approaches. Various publications emphasize that in sensory integration interventions, an important area of occupational therapy, the child should be motivated and encouraged to participate in activity selection, with play preferred.<sup>[20]</sup> It has also been stated that occupational therapists working in pediatric occupational therapy should use clinical reasoning flexibly.<sup>[21]</sup> Haynes et al.<sup>[22]</sup> highlighted that clinical experience is one of the three essential components of evidence-based practice. In the field of pediatric occupational therapy, where the child's wishes and needs are of utmost importance, the fact that the occupational therapists in this study evaluated the priorities and preferences of the child and indicated the use of client-centered approaches to engage the child as an active partner is noteworthy. Field studies have shown that occupational therapists' client-centered behaviors have improved.<sup>[23]</sup> The finding that participants frequently reported using practical experience as a tool suggests that clinical experience is perceived as a necessary component, alongside theoretical knowledge, for evidence-based practice in client-centered interventions. Although the participating occupational therapists may not have extensive clinical experience, their internships starting from the 2<sup>nd</sup> year, according to the Turkish occupational therapy curriculum, may have laid the foundation for clinical experience among the therapists involved in the study.<sup>[10]</sup>

In this study, occupational therapists highlighted their concerns regarding clients' limited awareness. Curtis et al.<sup>[24]</sup> found very little evidence that the voices of children or adolescents receiving this service were heard when therapists set therapy goals and implemented interventions. This situation emerged as a significant issue, particularly among younger age groups with cognitive and

communication disabilities. The Canadian Occupational Performance Measure and Perceived Efficacy and Goal Setting were the most commonly used goal-setting tools for involving children and adolescents in the goal-setting process. These tools were essential for facilitating active participation. However, these methods required that children be of a certain age and/or possess a specific cognitive level, as well as have expressive language skills to participate in discussions. Children under the age of 8 often found it challenging to answer questions.<sup>[25,26]</sup> Furthermore, a systematic review examining the use of theoretical frameworks in goal-setting and the objectives of goal-setting in pediatric occupational therapy emphasized that older children might feel comfortable expressing their goals during family discussions with therapists, but many children would adhere to the goals set by their parents.

<sup>[18]</sup> Among the challenges faced when applying client-centered approaches, the low or nonexistent awareness of clients could be associated with the limited applicability of appropriate goal-setting tools for this population, as well as the fact that the participating occupational therapists primarily worked with children who had not yet achieved sufficient cognitive competence.

In this study, occupational therapists indicated that the biggest barrier to client-centered approaches was workplace standards. One study found that occupational therapists working in adult intensive care identified the number of staff in the work environment as the greatest barrier. In addition, the lack of rehabilitation resources was also cited as a barrier.<sup>[27]</sup> The literature identifies the lack of health insurance care costs, and the location of healthcare services as obstacles.<sup>[28,29]</sup> In Türkiye, the costs of approaches for each diagnosis are not covered by insurance, which may lead to occupational therapy sessions being unpaid. The authority for occupational therapists to provide treatment for limited diagnoses has only recently been established.<sup>[30]</sup> Similarly, although the profession of occupational therapy has been in existence for over 10 years in Türkiye, it does not appear feasible for occupational therapists to reach all individuals in need. Therefore, necessary measures must be taken at the national level to overcome the barriers related to workplace standards.

### Limitations and Future Research Directions

First, the representativeness of the sample was limited; due to the absence of a national registry, a convenience sample was recruited through association members. Second, the findings predominantly reflected the views of therapists working in pediatrics who did not yet have sufficient

clinical experience; therefore, the results represent the perspectives of this specific group and should be interpreted with caution regarding generalizability. Finally, this study presented a cross-sectional survey design; therefore, the findings consisted of the participants' self-reports and perceptions at that moment, rather than objective observations or clinical outcomes. To increase the generalizability of the findings, future studies could use larger samples that provide national-level representation and include different specialty areas and a wide range of experience. Furthermore, to objectively evaluate the relationship between therapist perceptions and actual clinical outcomes, the use of longitudinal research designs, such as direct observation, standardized clinical assessment tools, and pre-test/post-test designs, is important.

### Conclusion

The findings of this study offer important implications for occupational therapy practices in Türkiye. In clinical practice, the identification of facilitators, such as practice-based experience, as well as barriers, like limited client awareness, provides therapists with an evidence-based understanding of the current situation. The determination of workplace standards as the primary barrier strongly highlights that national authorities and health managers must develop systemic interventions to improve service quality and support client-centered approaches. Likewise, the emphasis on prioritizing client preferences and fieldwork experience reveals the importance of internships in occupational therapy education, suggesting that educators should strengthen these curriculum components to bridge the gap between theoretical ideals and clinical realities. Addressing these challenges is essential for the advancement of occupational therapy in Türkiye, and as similar challenges may arise in other contexts, the findings may also be relevant at a global level.

### Contribution to the Literature

This study contributes to the literature by being the first survey to examine the current status, applicability, and perceived effectiveness of client-centered approaches in occupational therapy practice in Türkiye, particularly within the field of pediatrics. This research reveals the gap between theoretical ideals and clinical realities, such as time constraints and lack of knowledge, with concrete findings. Through the specific barriers and facilitators it identifies, it also provides an evidence-based foundation for occupational therapy educators and health managers to develop interventions aimed at improving service quality.

**Ethics Committee Approval:** The Lokman Hekim University Scientific Research Ethics Committee granted approval for this study (date: 28.03.2024, number: 2024095).

**Informed Consent:** Electronic informed consent was obtained from all participants prior to participation in the survey.

**Conflict of Interest:** The authors declare no conflicts of interest.

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# The Relationship between Digital Addiction and Sensory Processing Patterns in University Students: An Occupational Therapy Perspective

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## Abstract

**Introduction:** Digital addiction is an emerging concern among university students and may be influenced by individual sensory processing patterns. Understanding this relationship offers new avenues for occupational therapy interventions that promote balanced digital engagement. This study aimed to examine the relationship between digital addiction and sensory processing patterns in university students and to determine whether specific sensory processing traits predict digital addiction severity.

**Methods:** The study was conducted online through self-administered surveys. A total of 117 university students aged 18–25 years who regularly used digital devices for at least 1 year participated in the study. Digital addiction scale and adolescent/adult sensory profile were administered. Data were analyzed using correlation and multiple regression analyses.

**Results:** Sensory sensitivity was positively correlated with all subdimensions of digital addiction and significantly predicted total digital addiction scores. Other sensory processing patterns were not significant predictors.

**Discussion and Conclusion:** University students with heightened sensory sensitivity are more vulnerable to digital addiction. Occupational therapy practitioners should incorporate sensory-informed strategies to address problematic digital engagement in young adults.

**Keywords:** Digital addiction; Occupational therapy; Sensory processing; Sensory sensitivity; University students

The growing ubiquity of digital technologies in daily life has given rise to behavioral health concerns, including digital addiction. Among university students, digital devices are widely used for education, socialization, and leisure. However, excessive and compulsive engagement with digital media can interfere with academic performance, emotional regulation, and participation

in meaningful daily activities, core domains within the scope of occupational therapy.<sup>[1,2]</sup>

Digital addiction, characterized by uncontrolled digital device use and associated functional impairments, has been linked to psychological outcomes such as anxiety, depression, and cognitive overload.<sup>[2–5]</sup> However, there is limited understanding of how digital addiction interacts

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with sensory processing patterns, a key area of focus in occupational therapy that influences how individuals interpret and respond to sensory input from their environment.<sup>[3,4]</sup> Prolonged digital exposure may disrupt sensory modulation by overloading specific channels (e.g., visual), leading to sensory sensitivity or avoidance behaviors.<sup>[6]</sup>

Emerging evidence suggests that individuals with heightened sensory sensitivity may be more vulnerable to digital overuse as they seek predictable, controllable environments.<sup>[7,8]</sup> This is particularly relevant in the university student population, who are navigating developmental transitions and often face academic stress, social adaptation challenges, and increased autonomy. These factors may compound the risk of maladaptive digital engagement and make this population particularly susceptible to its consequences.<sup>[9,10]</sup>

From an occupational therapy perspective, understanding the role of sensory processing in digital addiction can inform person-centered interventions aimed at improving digital habits, emotional regulation, and functional participation. However, there is a need for empirical research exploring these relationships among emerging adults.

The present study aims to examine the relationship between digital addiction and sensory processing patterns in university students, with a specific focus on whether sensory sensitivity predicts digital addiction levels.

## Materials and Methods

### Design

This study employed a cross-sectional, correlational design to examine the relationship between digital addiction and sensory processing patterns among university students. The research was guided by a quantitative framework consistent with occupational therapy's emphasis on person-environment interaction.

### Participants

The G\*Power (version 3.1) program was used to calculate the sample size to be included in the study. With an expected correlation coefficient of  $r=0.30$ , an alpha level of 0.05, and a statistical power of 0.90, the required sample size was calculated as at least 112 participants. A total of 117 university students (aged 18–25 years) were recruited through convenience sampling. Inclusion criteria were: (1) current enrollment in a university program, and (2) regular digital device use (e.g., smartphone, tablet, computer) for at least one year. Exclusion criteria included a self-reported

diagnosis of neurological or psychiatric conditions and any physical disability that could interfere with participation in daily activities. Participants voluntarily completed the online survey after providing informed consent. This study was approved by the Institutional Review Board of Lokman Hekim University (Approval No: 2025/130, Date: May 30, 2025). The study was conducted in accordance with principles of the Declaration of Helsinki.

### Measures

#### Demographic Information Form

Participants provided information on age, gender, academic program, year of study, average daily screen time, primary reasons for digital device use (e.g., education, social media, entertainment), and medication use.

#### Digital Addiction Scale (DAS)

The DAS is a 19-item Likert-type self-report scale that evaluates five dimensions of digital addiction: excessive use, relapse, disruption of daily life, mood regulation, and inability to stop.<sup>[11]</sup> Higher scores indicate higher levels of digital addiction. The internal consistency for the original scale is reported as  $\alpha=0.87$ .<sup>[11]</sup>

#### Adolescent/Adult Sensory Profile (AASP)

Based on Dunn's Sensory Processing Framework, the AASP (Brown and Dunn, 2002) is a 60-item self-report tool assessing individuals' sensory processing patterns across four quadrants: low registration, sensory seeking, sensory sensitivity, and sensation avoiding. Each item is rated on a 5-point Likert scale.<sup>[12]</sup> The Turkish adaptation was validated.<sup>[13]</sup>

### Procedure

Data collection occurred between June 2025 and July 2025 using an online survey format hosted on Google Forms. The survey link, including an informed consent statement, was distributed through university-affiliated social media groups and email platforms. All survey items were marked as required to minimize missing data. Data were securely stored in password-protected files on the researchers' institutional accounts.

### Data Analysis

Statistical analysis was performed using IBM Statistical Package for the Social Sciences Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (means, standard deviations [SD], frequencies, and percentages) were calculated to summarize demographic variables and scale scores. The Kolmogorov–Smirnov test was used

**Table 1.** Demographic information of university students

| Variables                     | Mean | SD   |
|-------------------------------|------|------|
| Age                           | 21.7 | 1.78 |
| Variables                     | n    | %    |
| Gender                        |      |      |
| Female                        | 90   | 77.0 |
| Male                          | 27   | 23.0 |
| Year                          |      |      |
| 1                             | 18   | 15.4 |
| 2                             | 25   | 21.4 |
| 3                             | 21   | 17.9 |
| 4                             | 53   | 45.3 |
| Screen time                   |      |      |
| <2 h                          | 6    | 5.1  |
| 2–5 h                         | 43   | 36.8 |
| More than 5 h                 | 68   | 58.1 |
| Purpose of digital device use |      |      |
| Education                     | 90   | 77.0 |
| Social media                  | 112  | 95.7 |
| Gaming                        | 48   | 41.0 |
| Watching series/movies        | 90   | 77.0 |
| Other                         | 8    | 6.8  |

SD: Standard deviation.

to assess normality. Pearson or Spearman correlation coefficients were calculated to examine relationships between sensory processing patterns and digital addiction scores, depending on data distribution. Multiple linear regression analysis was conducted to identify whether sensory processing patterns predicted digital addiction levels. In the multiple regression analysis, demographic variables (age, gender, screen time) were not included as covariates. The model examined only the direct predictive relationships between the four sensory processing dimensions and total digital addiction scores. The level of statistical significance was set at  $p < 0.05$ .

## Results

A total of 117 university students participated in the study. The mean age of the participants was 21.7 years ( $SD=1.78$ ), and the majority were female (77.0%). Most students (58.1%) reported using digital devices for more than 5 h/day, primarily for social media (95.7%), education (77.0%), and entertainment such as watching series or films (77.0%) (Table 1).

## Sensory Processing Patterns

Analysis of the AASP revealed that most participants scored within the “similar to most people” range across all four quadrants: sensation avoiding (47.0%), sensation seeking (67.5%), low registration (51.3%), and sensory sensitivity (49.6%). However, a considerable portion of the sample exhibited elevated scores in sensory sensitivity (33.3%) and sensation avoiding (29.9%), suggesting heightened reactivity to sensory stimuli in a significant subset of students (Table 2).

## Digital Addiction Levels

Participants’ scores on the DAS indicated moderate levels of digital addiction, with the highest mean score in the “inability to stop” subdimension ( $M=3.72$ ,  $SD=1.07$ ), followed by excessive use ( $M=2.85$ ,  $SD=0.83$ ), relapse ( $M=2.60$ ,  $SD=1.01$ ), mood regulation ( $M=2.34$ ,  $SD=0.74$ ), and disruption of daily life ( $M=2.27$ ,  $SD=0.87$ ). The overall mean digital addiction score was 2.72 ( $SD=0.68$ ), indicating moderate engagement with digital devices that may reflect problematic use (Table 3).

## Correlation Analysis

Correlation analysis demonstrated that sensory sensitivity was significantly and positively correlated with all subdimensions of digital addiction, including excessive use ( $r=0.346$ ,  $p < 0.001$ ), relapse ( $r=0.277$ ,  $p=0.002$ ), disruption of daily life ( $r=0.325$ ,  $p < 0.001$ ), mood regulation ( $r=0.203$ ,  $p=0.028$ ), and inability to stop ( $r=0.091$ ,  $p=0.329$ , not

**Table 2.** Distribution of adolescent Dunn sensory profile according to sensory processing subdimensions

|                            | Sensation avoiding |      | Sensation seeking |      | Low registration |      | Sensory sensitivity |      |
|----------------------------|--------------------|------|-------------------|------|------------------|------|---------------------|------|
|                            | n                  | %    | n                 | %    | n                | %    | n                   | %    |
| Much less than most people | 0                  | 0.0  | 0                 | 0.0  | 5                | 4.3  | 3                   | 2.6  |
| Less than most people      | 9                  | 7.7  | 31                | 26.5 | 33               | 28.2 | 2                   | 1.7  |
| Similar to most people     | 55                 | 47.0 | 79                | 67.5 | 60               | 51.3 | 58                  | 49.6 |
| More than most people      | 35                 | 29.9 | 6                 | 5.1  | 18               | 15.4 | 39                  | 33.3 |
| Much more than most people | 18                 | 15.4 | 1                 | 0.9  | 1                | 0.9  | 15                  | 12.8 |

**Table 3.** Descriptive statistics for the subdimensions of the digital addiction scale

| Subscales                | n   | Min | Max | Mean (SD)   |
|--------------------------|-----|-----|-----|-------------|
| Excessive use            | 117 | 1   | 5   | 2.85 (0.83) |
| Relapse                  | 117 | 1   | 5   | 2.60 (1.01) |
| Disruption of daily life | 117 | 1   | 5   | 2.27 (0.87) |
| Mood regulation          | 117 | 1   | 5   | 2.34 (0.74) |
| Inability to stop        | 117 | 1   | 5   | 3.72 (1.07) |
| Total                    | 117 | 1   | 5   | 2.72 (0.68) |

Min: Minimum; Max: Maximum; SD: Standard deviation.

significant). Sensation avoiding was also significantly associated with disruption of daily life ( $r=0.305$ ,  $p<0.001$ ) and mood regulation ( $r=0.335$ ,  $p<0.001$ ). Sensation seeking was only significantly correlated with the inability to stop ( $r=0.245$ ,  $p=0.008$ ). Low registration showed significant associations with disruption of daily life ( $r=0.308$ ,  $p<0.001$ ) and mood regulation ( $r=0.278$ ,  $p=0.002$ ) (Table 4).

### Regression Analysis

A multiple linear regression analysis was conducted to determine whether sensory processing patterns predicted overall digital addiction scores. The model was statistically significant ( $F(4,112)=4.300$ ,  $p=0.003$ ), explaining 13.3%

of the variance in digital addiction ( $R^2=0.133$ , Adjusted  $R^2=0.102$ ). Among the four sensory processing dimensions, only sensory sensitivity was a significant predictor of digital addiction ( $\beta=0.292$ ,  $p=0.028$ ). Other variables (sensation avoiding, sensation seeking, and low registration) did not significantly predict digital addiction (Table 5).

### Discussion

This study examined the relationship between digital addiction and sensory processing patterns in university students through an occupational therapy lens. The findings demonstrated that among the four sensory processing profiles, sensory sensitivity emerged as a significant predictor of digital addiction, while other profiles, such as sensation avoiding, low registration, and sensation seeking, were not statistically significant predictors in the regression model. These findings underscore the nuanced relationship between sensory modulation and problematic digital engagement in emerging adults.

This study uniquely establishes sensory sensitivity as a key predictor of digital addiction among university students within an occupational therapy context. This study is one of the first to objectively establish that sensory processing patterns, specifically heightened sensory sensitivity, significantly influence problematic digital involvement,

**Table 4.** Correlation between the digital addiction scale and the subdimensions of the adolescent Dunn sensory profile

| Dunn/DAS                 | Sensation avoiding |        | Sensation seeking |       | Low registration |        | Sensory sensitivity |        |
|--------------------------|--------------------|--------|-------------------|-------|------------------|--------|---------------------|--------|
|                          | r                  | p      | r                 | p     | r                | p      | r                   | p      |
| Excessive use            | 0.191*             | 0.039  | 0.162             | 0.080 | 0.132            | 0.154  | 0.346*              | <0.001 |
| Relapse                  | 0.176              | 0.058  | 0.141             | 0.129 | 0.123            | 0.187  | 0.277*              | 0.002  |
| Disruption of daily life | 0.305*             | <0.001 | 0.077             | 0.407 | 0.308*           | <0.001 | 0.325*              | <0.001 |
| Mood regulation          | 0.335*             | <0.001 | 0.177             | 0.057 | 0.278*           | 0.002  | 0.203*              | 0.028  |
| Inability to stop        | -0.051             | 0.588  | 0.245*            | 0.008 | -0.136           | 0.143  | 0.091               | 0.329  |
| Total                    | 0.260*             | 0.005  | 0.219*            | 0.017 | 0.193*           | 0.038  | 0.356*              | <0.001 |

\*:  $p<0.05$ . DAS: Digital addiction scale.**Table 5.** Multiple regression results related to the predictive level of the total digital addiction scale and subdimensions of the adolescent dunn sensory profile

| Variables           | B      | SE    | Beta   | t      | p      | 95% CI          | Tolerance | VIF   | Cohen's $f^2$ |
|---------------------|--------|-------|--------|--------|--------|-----------------|-----------|-------|---------------|
| Constant            | 1.441  | 0.378 | –      | 3.811  | <0.001 | (0.693, 2.189)  | –         | –     | –             |
| Sensation avoiding  | 0.067  | 0.098 | 0.084  | 0.686  | 0.494  | (-0.127, 0.261) | 0.520     | 1.924 | 0.004         |
| Sensation Seeking   | 0.111  | 0.110 | 0.091  | 1.002  | 0.319  | (-0.107, 0.329) | 0.933     | 1.072 | 0.006         |
| Low registration    | -0.036 | 0.096 | -0.041 | -0.371 | 0.711  | (-0.226, 0.154) | 0.636     | 1.573 | 0.001         |
| Sensory sensitivity | 0.237  | 0.107 | 0.292  | 2.221  | 0.028  | (0.026, 0.448)  | 0.449     | 2.229 | 0.044         |

SE: Standard error; CI: Confidence interval; VIF: Variance inflation factor. Model  $F(4,112)=4.300$ ,  $p=0.003$ ;  $R^2=0.133$ , Adjusted  $R^2=0.102$ .

despite prior research focusing on psychological and social aspects. This discovery enhances existing theoretical comprehension by proposing that individuals with sensory sensitivity may utilize digital gadgets for environmental control and sensory regulation, a viewpoint not before highlighted in the literature on digital addiction.

It is crucial to acknowledge that, although statistically significant, the correlation coefficients identified in this study were predominantly weak to moderate, indicating that sensory processing patterns account for only a limited fraction of the variance in digital addiction. The regression model accounted for 13.3% of the variance in digital addiction, suggesting that sensory processing patterns contribute a tiny yet significant percentage to the variability of digital addiction. This limited explanatory power highlights the multifaceted character of digital addiction. The residual 87% of variance is presumably ascribed to various factors, including personality traits (e.g., impulsivity, neuroticism), psychological conditions (e.g., depression, anxiety, loneliness), social influences (e.g., peer norms, social support), cognitive elements (e.g., self-regulation, executive function), and contextual variables (e.g., academic stress, living circumstances). The findings suggest that digital addiction is a multifaceted phenomenon shaped by various variables beyond sensory processing, highlighting the necessity for comprehensive, multidimensional strategies in study and rehabilitation.

Numerous studies indicate that sensory sensitivity is associated with challenges in emotional control and social functioning in university students. Studies indicate that individuals with increased sensory processing sensitivity exhibit more susceptibility to environmental stressors and may utilize digital technologies as coping strategies.

<sup>[7,8,14,15]</sup> This pattern is especially evident in university environments where students encounter various stresses, such as academic pressures, social changes, and environmental uncertainties. The relationship between sensory sensitivity and digital addiction is characterized by a positive correlation, indicating that higher levels of sensory sensitivity are associated with greater total digital addiction scores across various dimensions.<sup>[7]</sup> This suggests that university students exhibiting greater sensory sensitivity may engage more extensively with digital platforms, potentially as a coping mechanism for their heightened sensitivity to environmental stimuli.<sup>[8]</sup>

Nevertheless, the literature recognizes the intricacy of these relationships. Research suggests that although a correlation exists between digital addiction and sensory sensitivity, this association may not be uniformly relevant across all

circumstances or demographics. The correlation between sensory sensitivity and mental health disorders, such as sadness and anxiety, is intricate and exhibits considerable variability among individuals.<sup>[16]</sup> Elements beyond sensory sensitivity, including social support and flexibility to contextual changes, substantially influence the effect of digital involvement on mental well-being.<sup>[17]</sup> Evidence indicates that sensory sensitivity may provide advantages in specific settings, including heightened ambient awareness and increased depth of processing.<sup>[18,19]</sup> Moreover, other research indicates that sensory defensiveness and sensitivity may decrease with age, suggesting that various factors contribute to digital addiction and are not only reliant on sensory processing characteristics.<sup>[20]</sup> These nuanced findings underscore the necessity for person-centered methodologies that acknowledge individual differences in the manifestation and interaction of sensory processing features with digital engagement patterns.

The finding that university students report the highest average score for digital addiction in the "inability to stop" sub-dimension is supported by converging evidence highlighting the compulsive nature of digital engagement and loss of control associated with it. Studies indicate that students often recognize their inability to regulate their digital usage, significantly impacting their academic and personal lives. For instance, research has found that social networking addiction is linked to adverse academic performance, with excessive engagement disrupting educational commitments and demonstrating clear loss of control in students' interactions with digital technologies.<sup>[21]</sup> Similarly, patterns emerge where students with lower GPAs exhibit higher levels of digital addiction, reflecting compromised ability to manage digital consumption.<sup>[2]</sup>

However, alternative perspectives suggest a more nuanced understanding of this phenomenon. Some research indicates that personal psychological factors such as loneliness and shyness serve as significant predictors of smartphone addiction, raising questions about whether the inability to stop stems solely from compulsive behavior or from deeper emotional needs prompting continual connectivity.<sup>[22]</sup> Evidence also points to lower internet addiction prevalence being correlated with positive psychological trajectories, suggesting that self-regulation, environmental factors, and individual differences play critical roles.<sup>[5]</sup> Furthermore, perceptions of digital addiction among students are subject to personal interpretation and cultural contexts, emphasizing that behaviors must be contextualized within individual motivations and life situations rather than through a singular lens of loss of

control.<sup>[23]</sup> Research also highlights various pathways leading to smartphone addiction, emphasizing impulsivity and impulsive decision-making as major contributors rather than strict inability to stop.<sup>[24]</sup>

Evidence supports the assertion that sensory avoidance and low registration profiles among university students correlate significantly with specific sub-dimensions of the DAS, namely interference with daily life and emotional state. Research demonstrates that atypical sensory processing can disrupt daily functions and emotional stability among students. Studies investigating associations between sensory processing profiles and adaptive functioning indicate that sensory avoidance and low registration profiles are associated with various adverse outcomes, including difficulties in daily functioning and emotional regulation.<sup>[25]</sup> This suggests that students with heightened sensory avoidance may experience disturbances in their emotional state, potentially amplifying feelings of distress when engaging with digital technologies.

Additional research reveals significant relationships between sensory processing patterns and occupational engagement, with individuals reporting high levels of sensory avoidance experiencing challenges that interfere with their ability to engage in everyday activities.<sup>[26]</sup> Studies exploring psychometric properties of sensory profiles have found that low registration and sensory avoidance significantly affect self-regulation and coping strategies, ultimately influencing students' emotional well-being and capacity for engagement with digital tasks.<sup>[27]</sup>

Nevertheless, some studies indicate that the relationship between sensory processing profiles and digital addiction may not be uniform across all university students. While sensory processing differences exist, the relationship with behavioral patterns might vary, suggesting that not all forms of sensory avoidance directly lead to digital addiction-related difficulties.<sup>[28]</sup> In addition, factors such as loneliness and social anxiety can predict smartphone addiction, and these psychosocial factors may overshadow the impact of sensory profiles on digital behaviors.<sup>[29]</sup> Some findings suggest that self-efficacy plays a critical role in mood management, indicating that interventions promoting self-efficacy could be essential in addressing emotional states linked to digital usage, potentially independent of sensory processing patterns.<sup>[30]</sup>

The finding that a significant proportion of university students scored "more than most people" in sensory sensitivity and sensory avoidance is supported by research exploring sensory processing sensitivity among university student populations. Studies investigating the relationship

between sensory processing sensitivity and emotional difficulties have concluded that a substantial segment of university students demonstrated heightened sensory sensitivity, which correlated with emotional distress and challenges in daily functioning.<sup>[31]</sup> Reviews on the impact of sensory processing sensitivity on mental health emphasize that these traits are prevalent among students, with many reporting significant sensory sensitivity and avoidance behaviors that disrupt everyday functioning and emotional stability.<sup>[15]</sup> Research also indicates that sensory differences, particularly among female students, are significantly correlated with the need for support in managing emotional states and academic performance.<sup>[16]</sup>

However, contrasting evidence suggests variability in how sensory sensitivity manifests. Some research highlights that individuals with high sensory processing sensitivity might benefit from their heightened awareness, perceiving opportunities others might miss.<sup>[18]</sup> Systematic reviews reveal that sensory processing could correlate positively with aspects of well-being and quality of life, suggesting that some individuals with high sensory sensitivity may adapt by utilizing these sensitivities effectively.<sup>[19]</sup> These findings challenge the narrative that increased sensory sensitivity is uniformly problematic and instead suggest considerable variability in impact across individuals.

Occupational therapy interventions for university students with heightened sensory sensitivity may include: (1) Sensory diet implementation, involving the scheduling of regular sensory breaks throughout the day with activities such as deep pressure input (e.g., weighted blankets, compression clothing), proprioceptive activities (e.g., stretching, wall pushes), and calming vestibular input (e.g., gentle rocking, slow walking), which have been shown to support sensory regulation, attention, and behavioral outcomes;<sup>[32,33]</sup> (2) environmental modifications, including reducing visual clutter, using noise-canceling headphones, adjusting lighting, and creating designated low-stimulation zones to minimize sensory overload and enhance emotional regulation;<sup>[34,35]</sup> (3) Digital hygiene protocols, such as using blue light filters, enabling grayscale mode during evening hours, limiting vibrations and notifications, and practicing the 20-20-20 rule, which may help reduce sensory strain associated with prolonged digital engagement;<sup>[36]</sup> (4) Alternative engagement strategies, encouraging participation in non-digital occupations such as creative arts, crafts, gardening, and physical activities that provide meaningful sensory input while supporting emotional regulation and well-being;<sup>[37,38]</sup> and (5) mindfulness-based sensory awareness training, aimed at enhancing students'

awareness of sensory thresholds and teaching self-regulation strategies to prevent sensory overload, thereby supporting academic functioning and mental health.<sup>[34,35]</sup>

These interventions should be individualized based on comprehensive sensory assessment and should address the specific sensory profiles and digital use patterns of each student.

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design prevents the establishment of causal relationships between sensory processing patterns and digital addiction. Longitudinal research is needed to explore the directionality of this association over time. Second, the study relied on self-reported measures, which may introduce biases such as social desirability or inaccurate self-assessment. Third, the use of convenience sampling and online recruitment may limit the representativeness of the sample. Participants were not stratified by academic discipline (e.g., engineering, social sciences, health sciences), which may introduce selection bias as students from different fields may have varying patterns of digital device use and sensory processing characteristics. Future studies should employ stratified sampling methods to ensure broader generalizability across academic disciplines. Fourth, the sample comprised predominantly female participants (77.0%), which may introduce gender bias in the findings. Research suggests that sensory processing patterns and digital device use behaviors may differ between genders, with some studies indicating that females report higher sensory sensitivity and different patterns of social media engagement compared to males. Therefore, the observed relationships between sensory sensitivity and digital addiction may not generalize equally to male university students, and future research should ensure more balanced gender representation to examine potential gender-specific effects. Fifth, the regression model did not control for potentially relevant demographic covariates such as age, gender, and screen time, or for psychological variables such as stress levels, anxiety, impulsivity, or emotional regulation. These unmeasured variables may act as confounders or moderators in the relationship between sensory processing and digital addiction. Individual differences in these psychological traits may have a substantial influence on both digital behavior and sensory processing responses. Future research should employ hierarchical regression or structural equation modeling to account for these variables and better isolate the unique contribution of sensory processing patterns. Finally, although the AASP is a widely accepted tool, future studies may benefit from using

neurophysiological or observational methods to further validate sensory processing characteristics in relation to digital technology use.

## Conclusion

The findings of this study suggest that sensory sensitivity plays a significant role in predicting digital addiction among university students. Students who exhibit heightened sensory reactivity appear to be more vulnerable to the overstimulating and immersive nature of digital technologies. In addition, sensory avoidance and low registration patterns were associated with disruptions in daily functioning and emotional regulation, further underscoring the relevance of sensory processing in understanding problematic digital behavior. From an occupational therapy perspective, these findings highlight the importance of assessing sensory profiles when addressing digital overuse, particularly in young adult populations. Occupational therapists can develop individualized intervention strategies that support sensory modulation, including sensory diets, structured routines, and alternative engagement strategies that reduce reliance on digital devices. Incorporating sensory-informed practices into digital health interventions may enhance students' participation, academic performance, and emotional well-being.

Based on these findings, we recommend that university counseling centers and student health services incorporate sensory screening as part of digital wellness assessments. Specific interventions may include: (1) sensory diet planning to provide alternative sensory regulation strategies; (2) environmental modifications in study spaces to reduce sensory overload; (3) structured digital breaks incorporating sensory-based activities (e.g., mindfulness, progressive muscle relaxation, outdoor walks); (4) psychoeducation programs helping students recognize their sensory triggers and develop healthier coping mechanisms; and (5) collaboration between occupational therapists and counselors to develop individualized digital wellness plans. Youth counseling centers could implement group-based sensory modulation workshops combined with cognitive-behavioral strategies for digital habit formation.

Future occupational therapy research and practice should explore multimodal intervention models that integrate cognitive, sensory, and psychosocial elements to address digital addiction holistically. By recognizing the interplay between sensory processing and digital engagement, occupational therapists are uniquely positioned to promote balanced technology use and foster healthier occupational participation in the digital era.

**Ethics Committee Approval:** The Lokman Hekim University Ethics Committee granted approval for this study (date: 30.05.2025, number: 2025/130).

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## ORIGINAL ARTICLE

# Childhood Experiences, Emotional Intelligence, and the Maternal Role in Postpartum Women: A Cross-Sectional Study

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## Abstract

**Introduction:** The purpose of this study is to investigate the associations between childhood experiences, emotional intelligence levels, and maternal roles in postpartum women.

**Methods:** This study employed a cross-sectional design. The study population consisted of women aged 18–49 years living in Konya province who were within 2 months to 2 years postpartum. Data were collected using the Individual Identification Form, the Early Life Experiences Scale, Trait Emotional Intelligence Questionnaire–Short Form, and the Barkin Index of Maternal Function. The data obtained from the research were analyzed in the Statistical Package for the Social Sciences 25.0 program. Necessary permits were obtained before the work began. The STROBE checklist was taken into account in writing the study report.

**Results:** The study included 294 female participants. The mean scores of the participants were 33.20 for childhood experiences, 82.17 for emotional intelligence and 74.86 for maternal functioning, respectively. Regression analysis showed that the variables explained 12.5% of the variance.

**Discussion and Conclusion:** Research findings indicate a negative relationship between adverse childhood experiences and maternal functioning, and a positive relationship between emotional intelligence level and maternal functioning. These results suggest that considering women's early-life experiences and emotional intelligence levels may be clinically important in assessing and supporting maternal functioning during the post-natal period.

**Keywords:** Childhood experiences; Emotional intelligence; Maternal role

Motherhood is a period during which a baby is understood, and their needs are met. This includes the physiological and psychological changes that begin with pregnancy.<sup>[1]</sup> The role of motherhood has been defined as one of the most fundamental roles that women assume throughout their lives.<sup>[2]</sup> Becoming a mother is associated with physical, social and psychological

changes that can affect a woman's mental health, personal life, and family dynamics.<sup>[3]</sup> Other variables found to be important in performing the mother role include the mother's own parenting experiences, her relationship with her husband, previous experiences with children, and the events and policies in the mother's environment.<sup>[2]</sup>

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It is stated that women adapt to the role of motherhood in the postpartum period. During this period, mothers should continue their daily activities while trying to learn the role of motherhood and adapting to new situations in order to meet their baby's wants and needs.<sup>[4]</sup> The way mothers perceive and interact with their babies during this period shapes the basic structure of the mother–baby relationship in the future.<sup>[5]</sup> The first years of childhood have a significant impact on the child's life. During this period, positive interactions that children have with their mothers form the basis of children's multifaceted development.<sup>[6]</sup> Parents' emotion regulation skills have been shown to affect children's developmental processes in various ways.<sup>[7]</sup> Many studies have examined the effects of childhood traumas on individuals' emotion regulation skills.<sup>[8,9]</sup> In these studies, it has been observed that individuals who have experienced childhood trauma have difficulties in emotion regulation processes.<sup>[10]</sup> In this direction, the child's first experiences of the environment are often formed through the family. As the child gets older, social interactions in a wider area replace the family.<sup>[11]</sup> Children with negative physical and psychological development are usually reported to come from problematic families.<sup>[12]</sup> On the other hand, individuals with balanced and healthy growth come from families who are able to communicate more effectively and know the necessary approaches to raising children. Parents whose needs are not adequately met during childhood often exhibit indifferent parenting behaviors.<sup>[13]</sup> It was found that the neglectful parenting behaviors of parents who were exposed to neglect in their childhood were approximately 2 ½ times higher than those of non-neglected parents, whereas physically abusive parenting behaviors were 2 times higher.<sup>[7]</sup> When the literature is examined, although there are many studies addressing the role of motherhood, studies that jointly consider childhood experiences and emotional intelligence within the context of the maternal role are limited. Examining these factors together may contribute to a more comprehensive understanding of maternal role development during the postpartum period.

## Purpose

This study aimed to investigate the associations among childhood experiences, emotional intelligence levels, and the maternal role of women in the postpartum period.

## Materials and Methods

### Study Place and Design

The study was carried out using a cross-sectional research design and was conducted online with mothers residing

in Konya, Türkiye. The STROBE checklist was taken into account in the reporting of the study.

### Population and Sample of Research

The population of the study consisted of women aged 18–49 years living in Konya province who were within 2 months to 2 years postpartum. The G\*Power 3.1 package program was used to calculate the sample size. In the study conducted by Cankaya and Akin (2023), the sample size was determined as 294 people with an effect size of 0.19, 95% power and 5% margin of error based on the Barkin index of maternal function (BIMF) score.<sup>[14]</sup> Participants were recruited using a snowball sampling approach. Initially, mothers who voluntarily agreed to participate in the study were reached through online platforms, and subsequently, additional participants were included through referrals. Thus, the number of mothers included in the study increased gradually. Women aged 18–49 years, having at least one child, giving birth within at least 2 months, and volunteering to participate in the study were included. Individuals who were unable to read, write, speak and understand Turkish were excluded.

### Data Collection

Data were collected through an online questionnaire developed by the researchers using the Google Forms platform. Participants were recruited via the snowball sampling method, and the survey link was distributed through e-mail and social media channels. Before participation, women were informed about the purpose of the study, the voluntary nature of participation, the confidentiality of the data, and the use of the information solely for scientific purposes. Informed consent was obtained electronically at the beginning of the survey. The questionnaire required approximately 5–10 min to complete, and no identifying personal information was requested. All responses were stored in a secure digital environment accessible only to the research team to ensure data privacy and confidentiality.

### Data Collection Tools

Data were collected online using a structured questionnaire between January 30, 2025 and February 20, 2025.

### Individual Identification Form

This form was created by the researchers as a result of a literature review.<sup>[15]</sup>

### Early Life Experiences Scale (ELES)

The ELES, originally developed by Gilbert et al.,<sup>[16]</sup> was adapted into Turkish by Akin et al.,<sup>[17]</sup> who also conducted

its validity and reliability analyses. The scale comprises 15 items across three subdimensions: Devaluing (items 6, 7, and 9), Subjugating (items 1, 2, 3, 5, 10, and 12), and Threatening Memories (items 4, 8, 11, 13, 14, and 15). Items are rated on a 5-point Likert scale, with items 6, 7, and 9 reverse-coded. Total scores range between 15 and 75, with higher scores indicating greater levels of negative early life experiences. In the original adaptation study, the Cronbach's alpha was reported as 0.85, whereas in the current study, it was found to be 0.90.

### **Trait Emotional Intelligence Questionnaire-Short form (TEIQue-SF)**

The TEIQue-SF was developed by Petrides based on the conceptualization of emotional intelligence as a personality trait.<sup>[18]</sup> According to Deniz et al.,<sup>[19]</sup> the Turkish adaptation and psychometric evaluation of the scale were conducted. Adapted from the long form, the TEIQue-SF consists of 30 items rated on a 7-point Likert-type scale (1=strongly disagree and 7=strongly agree) and is designed to assess individuals' perceptions of their emotional competence. The scale includes four subscales: Subjective well-being, self-control, emotionality, and sociability. These dimensions have been shown to have significant negative correlations with neuroticism and positive correlations with personality traits such as extraversion, openness to experience, agreeableness, and conscientiousness.<sup>[19]</sup> Higher scores reflect greater emotional intelligence, and in the present study, the internal consistency coefficient for the total scale was 0.70.

### **BIMF**

The BIMF, developed by Barkin (2009), is designed to assess the functional status of mothers in the postpartum period.<sup>[20]</sup> The scale initially demonstrated strong internal consistency (Cronbach's  $\alpha=0.87$ ). The Turkish adaptation and psychometric evaluation were conducted by Aydın and Kukulcu (2018) with a sample of 235 mothers aged 18–40 years. In their study, the overall internal consistency was reported as 0.95. Subscale reliability coefficients were as follows: Self-Care (0.66), maternal psychology (0.71), infant care (0.62), social support (0.69), and adaptation to motherhood (0.50). The scale comprises 16 items rated on a 7-point Likert-type scale (0=completely disagree and 6=completely agree), yielding total scores between 0 and 96.<sup>[21]</sup> In this study, Cronbach's alpha coefficient was found to be 0.96. Subscale reliability coefficients were as follows: Self-care (0.81), maternal psychology (0.79), infant care (0.96), social support (0.86), and adaptation to motherhood (0.85).

### **Statistical Evaluation of the Data**

The data were analyzed using IBM Statistical Package for the Social Sciences Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as mean $\pm$ standard deviation for continuous variables and frequency (n) and percentage (%) for categorical variables. The normality of continuous variables was assessed using skewness and kurtosis values. Homogeneity of variances was evaluated using Levene's test. When the assumptions of normal distribution and homogeneity of variances were met, parametric tests were applied. Independent samples t-tests were used for comparisons between two groups, and one-way analysis of variance (ANOVA) was used for comparisons among three or more groups. When ANOVA results were statistically significant, Tukey's HSD post hoc test was performed to determine pairwise group differences. To determine the predictive effects of early life experiences and emotional intelligence on maternal functioning, multiple linear regression analysis was conducted. Multicollinearity was evaluated using tolerance and variance inflation factor values. Statistical significance was set at  $p<0.05$ .

### **Ethical Dimension of the Research**

Ethics committee permission dated January 30, 2025 and numbered 2025/037 was obtained from the KTO Karatay University Drug and Non-Medical Device Research Ethics Committee to conduct the research. The individuals participating in the study were informed about the purpose of the study, and their verbal and written permissions were obtained. Permission was obtained from the authors of the scale via e-mail. The research was carried out in line with the principles set out in the Declaration of Helsinki.

### **Results**

The study was conducted with 294 female participants. Most participants were aged 27–35 years (58.5%;  $n=172$ ), whereas 28.9% ( $n=85$ ) were aged 18–26, and 12.6% ( $n=37$ ) were aged 35 and above. The majority were university graduates (66.7%;  $n=196$ ), and 60.5% ( $n=178$ ) were unemployed. Regarding income status, 69.0% ( $n=203$ ) reported an average income level, 24.8% ( $n=73$ ) a good level, and 6.1% ( $n=18$ ) a poor level. Most participants lived in the city center (68.0%,  $n=200$ ) and had a nuclear family structure (91.8%,  $n=270$ ). The proportion of non-smokers was 84.7% ( $n=249$ ). Most spouses were aged 27–35 years (65.3%;  $n=192$ ) and were university graduates (57.5%;  $n=169$ ). The majority of participants married after

**Table 1.** Comparison of the descriptive characteristics of the participants and the mean scores of the BIMF, ELES, and TEIQue-SF (n=294)

| Variables                  | n   | %    | $\bar{X} \pm SD$<br>BIMF | $\bar{X} \pm SD$<br>ELES | $\bar{X} \pm SD$<br>TEIQue-SF |
|----------------------------|-----|------|--------------------------|--------------------------|-------------------------------|
| Age                        |     |      |                          |                          |                               |
| 18–26 <sup>a</sup>         | 85  | 28.9 | 77.20±11.02              | 34.69±13.80              | 82.28±14.15                   |
| 27–35 <sup>b</sup>         | 172 | 58.5 | 73.50±11.12              | 32.47±12.87              | 82.15±13.06                   |
| 35 and above <sup>ab</sup> | 37  | 12.6 | 75.83±9.97               | 33.21±11.27              | 82.02±14.86                   |
| F/p                        |     |      | F=3.410/ <b>p=0.03</b>   | F=0.836/p=0.43           | F=0.005/p=0.99                |
| Education status           |     |      |                          |                          |                               |
| Primary-secondary school   | 33  | 11.2 | 77.54±9.57               | 33.78±13.55              | 80.87±14.76                   |
| High school                | 65  | 22.1 | 75.09±12.40              | 34.09±12.43              | 81.29±16.09                   |
| University                 | 196 | 66.7 | 74.33±10.78              | 32.81±13.07              | 82.68±12.45                   |
| F/p                        |     |      | F=1.211/p=0.29           | F=0.273/p=0.76           | F=0.424/p=0.65                |
| Employment status          |     |      |                          |                          |                               |
| Yes                        | 116 | 39.5 | 74.18±11.22              | 34.42±13.35              | 81.52±12.69                   |
| No                         | 178 | 60.5 | 75.30±10.93              | 34.41±12.66              | 82.59±14.13                   |
| t/p                        |     |      | 0.855/p=0.39             | t=1.299/p=0.19           | t=0.66/p=0.51                 |
| Income status              |     |      |                          |                          |                               |
| Good <sup>a</sup>          | 73  | 24.8 | 75.94±11.78              | 30.61±10.96              | 85.75±13.59                   |
| Middle <sup>a</sup>        | 203 | 69.0 | 74.96±10.56              | 33.14±12.84              | 81.66±12.98                   |
| Bad <sup>b</sup>           | 18  | 6.1  | 69.33±12.27              | 44.44±16.21              | 73.38±15.72                   |
| F/p                        |     |      | F=2.643/p=0.073          | F=8.661/ <b>p=0.000</b>  | F=6.705/ <b>p=0.001</b>       |
| Place of residence         |     |      |                          |                          |                               |
| Province center            | 200 | 68.0 | 75.18±10.69              | 33.27±13.12              | 81.62±13.03                   |
| District center            | 94  | 32.0 | 74.18±11.78              | 33.07±12.66              | 83.35±14.65                   |
| t/p                        |     |      | t=0.72/p=0.46            | t=0.120/p=0.90           | t=1.020/p=0.30                |
| Family type                |     |      |                          |                          |                               |
| Nuclear family             | 270 | 91.8 | 74.74±11.08              | 33.51±12.93              | 82.00±13.51                   |
| Extended family            | 23  | 7.8  | 76.47±10.85              | 29.00±12.66              | 83.30±14.12                   |
| t/p                        |     |      | t=0.721/p=0.47           | t=1.608/p=0.10           | t=0.441/p=0.65                |
| Smoking                    |     |      |                          |                          |                               |
| Yes                        | 45  | 15.3 | 70.62±10.83              | 36.26±14.43              | 81.33±13.27                   |
| No                         | 249 | 84.7 | 75.63±10.93              | 32.65±12.62              | 82.32±13.64                   |
| t/p                        |     |      | t=2.832/ <b>p=0.005</b>  | t=1.727/p=0.08           | t=0.451/p=0.65                |
| Age of spouse              |     |      |                          |                          |                               |
| 18–26 <sup>a</sup>         | 36  | 12.2 | 80.52±8.77               | 32.38±12.46              | 81.69±13.57                   |
| 27–35 <sup>b</sup>         | 192 | 65.3 | 73.93±10.92              | 32.97±12.91              | 82.09±13.52                   |
| 35 and above <sup>b</sup>  | 66  | 22.4 | 74.46±11.71              | 34.31±13.46              | 82.65±13.90                   |
| F/p                        |     |      | F=5.621/ <b>p=0.004</b>  | F=0.343/p=0.71           | F=0.066/p=0.93                |
| Spouse's education status  |     |      |                          |                          |                               |
| Primary-secondary school   | 51  | 17.3 | 77.25±11.42              | 33.35±12.90              | 80.52±15.40                   |
| High school                | 74  | 25.2 | 73.86±10.28              | 34.45±13.41              | 81.27±14.37                   |
| University                 | 169 | 57.5 | 74.57±11.21              | 32.61±12.80              | 83.06±12.60                   |
| F/p                        |     |      | F=1.559/p=0.21           | F=0.523/p=0.59           | F=0.902/p=0.40                |

**Table 1 (cont.).** Comparison of the descriptive characteristics of the participants and the mean scores of the BIMF, ELES, and TEIQue-SF (n=294)

| Variables                     | n   | %    | $\bar{X} \pm SD$<br>BIMF | $\bar{X} \pm SD$<br>ELES | $\bar{X} \pm SD$<br>TEIQue-SF |
|-------------------------------|-----|------|--------------------------|--------------------------|-------------------------------|
| Form of marriage              |     |      |                          |                          |                               |
| By meeting and negotiating    | 236 | 80.3 | 74.32 $\pm$ 11.19        | 33.46 $\pm$ 13.44        | 82.02 $\pm$ 13.61             |
| Arranged marriage             | 58  | 19.7 | 77.06 $\pm$ 10.23        | 32.15 $\pm$ 10.78        | 82.75 $\pm$ 13.50             |
| t/p                           |     |      | t=1.702/p=0.09           | t=0.690/p=0.49           | t=0.366/p=0.45                |
| Duration of marriage          |     |      |                          |                          |                               |
| 0–5 year                      | 170 | 57.8 | 74.36 $\pm$ 10.96        | 33.68 $\pm$ 13.74        | 82.78 $\pm$ 12.71             |
| 5 years and above             | 124 | 42.2 | 75.54 $\pm$ 11.16        | 32.55 $\pm$ 11.81        | 81.33 $\pm$ 14.67             |
| t/p                           |     |      | t=0.907/p=0.36           | t=0.753/p=0.45           | t=0.909/p=0.36                |
| Assessing Physical appearance |     |      |                          |                          |                               |
| Good <sup>a</sup>             | 147 | 50.0 | 77.54 $\pm$ 10.68        | 31.35 $\pm$ 11.76        | 83.14 $\pm$ 13.35             |
| Middle <sup>b</sup>           | 121 | 41.2 | 72.93 $\pm$ 10.71        | 34.29 $\pm$ 13.70        | 80.41 $\pm$ 13.52             |
| Bada <sup>b</sup>             | 26  | 8.8  | 68.69 $\pm$ 10.60        | 38.61 $\pm$ 14.19        | 79.26 $\pm$ 13.89             |
| F/p                           |     |      | F=10.924/ <b>p=0.000</b> | F=4.291/ <b>p=0.015</b>  | F=3.198/p=0.042               |

a,b,c: Means with different superscripts differ significantly according to the Tukey HSD test ( $p < 0.05$ ). n: number, %: Percentage,  $\bar{X}$ : Mean; SD: Standard deviation; BIMF: Barkin index of maternal function; ELES: Early life experiences scale; TEIQue-SF: Trait emotional intelligence questionnaire–Short Form; t= Independent samples t-test; F: One-way analysis of variance test; P: Significance value.

meeting/dating (80.3%;  $n=236$ ), and 57.8% ( $n=170$ ) had been married for 0–5 years. Half of the participants rated their physical appearance as good (50.0%;  $n=147$ ), 41.2% ( $n=121$ ) as average, and 8.8% ( $n=26$ ) as poor. A comparison of Descriptive Characteristics of the Participants and the Mean Scores of BIMF, ELES, and TEIQue-SF ( $N: 294$ ) is given in Table 1. A significant difference was found in the BIMF scores across age groups ( $F[2, 292]=3.410$ ,  $p=0.03$ ), and participants aged 18–26 years scored significantly higher than participants aged 27–35 years. However, no significant difference was observed in the scores of BIMF and TEIQue-SF according to age groups ( $F=0.836$ ,  $p=0.43$  for BIMF;  $F=0.005$ ,  $p=0.99$  for TEIQue-SF). There were no significant differences between the scores of BIMF, ELES, and TEIQue-SF according to educational levels ( $F=1.211$ ,  $p=0.29$  for BIMF;  $F=0.273$ ,  $p=0.76$  for ELES;  $F=0.424$ ,  $p=0.65$  for TEIQue-SF).

There was no significant difference between working and non-working participants in the scores of BIMF, ELES, and TEIQue-SF ( $t=0.855$ ,  $p=0.39$  for BIMF;  $t=1.299$ ,  $p=0.19$  for ELES;  $t=0.66$ ,  $p=0.51$  for TEIQue-SF). According to perceived income status, no significant difference was found in maternal functioning scores ( $p > 0.05$ ). However, significant differences were observed in childhood trauma and emotion regulation difficulty scores. Participants who evaluated their income as poor had significantly higher childhood trauma and emotion regulation difficulty

scores compared to those reporting good or moderate income levels ( $p < 0.05$ ). No significant differences were found between the good and moderate income groups ( $p > 0.05$ ). No significant difference was found between the participants living in urban and rural areas in terms of BIMF, ELES and TEIQue-SF scores ( $t=0.72$ ,  $p=0.46$  for BIMF;  $t=0.120$ ,  $p=0.90$  for ELES;  $t=1.020$ ,  $p=0.30$  for TEIQue-SF).

There was no significant difference between participants from nuclear and extended families in terms of BIMF, ELES and TEIQue-SF scores ( $t=0.721$ ,  $p=0.47$  for BIMF;  $t=1.608$ ,  $p=0.10$  for ELES;  $t=0.441$ ,  $p=0.65$  for TEIQue-SF). Smokers had significantly lower BIMF scores than non-smokers ( $t=2.832$ ,  $p=0.005$ ), but no significant difference was found for ELES and TEIQue-SF scores ( $t=1.727$ ,  $p=0.08$  for ELES;  $t=0.451$ ,  $p=0.65$  for TEIQue-SF). A significant difference was found in BIMF scores according to spouse age ( $F[2, 292]=5.621$ ,  $p=0.004$ ). Post hoc analysis showed that participants whose spouses were aged 18–26 had higher BIMF scores. No significant difference was found in the ELES and TEIQue-SF scores according to the age of the partner ( $F=0.343$ ,  $p=0.71$  for ELES;  $F=12.066$ ,  $p=0.93$  for TEIQue-SF).

No significant difference was found in the scores of BIMF, ELES, and TEIQue-SF according to the educational level of the spouses ( $F=1.559$ ,  $p=0.21$  for BIMF;  $F=0.523$ ,  $p=0.59$  for ELES;  $F=0.902$ ,  $p=0.40$  for TEIQue-SF). There was no significant difference in the scores of BIMF, ELES, and TEIQue-SF according to the type of marriage ( $t=1.702$ ,

**Table 2.** Comparison of the Obstetric Characteristics of the Participants with the Mean Scores of BIMF, ELES, and TEIQue-SF (n=294)

| Variables                       | n   | %    | $\bar{X} \pm SD$<br>BIMF    | $\bar{X} \pm SD$<br>ELES   | $\bar{X} \pm SD$<br>TEIQue-SF |
|---------------------------------|-----|------|-----------------------------|----------------------------|-------------------------------|
| Baby's month                    |     |      |                             |                            |                               |
| 0–6 month                       | 133 | 45.2 | 76.06 $\pm$ 11.23           | 32.81 $\pm$ 13.12          | 80.82 $\pm$ 13.73             |
| 7–12 month                      | 80  | 27.2 | 73.77 $\pm$ 11.68           | 32.63 $\pm$ 12.75          | 84.33 $\pm$ 12.62             |
| 13–18 month                     | 52  | 17.7 | 73.34 $\pm$ 10.19           | 35.67 $\pm$ 13.31          | 82.48 $\pm$ 14.35             |
| 19–24 month                     | 29  | 9.9  | 75.06 $\pm$ 9.63            | 32.17 $\pm$ 12.17          | 81.82 $\pm$ 13.82             |
| F/p                             |     |      | F= 1.117/ p=0.34            | F= 0.506/p=0.50            | F= 1.131/p=0.337              |
| Relationship status with spouse |     |      |                             |                            |                               |
| Good <sup>a</sup>               | 240 | 81.6 | 76.35 $\pm$ 10.67           | 31.86 $\pm$ 12.17          | 82.65 $\pm$ 13.68             |
| Middle <sup>b</sup>             | 47  | 16.0 | 68.06 $\pm$ 10.37           | 38.78 $\pm$ 15.16          | 79.31 $\pm$ 13.13             |
| Bad <sup>a,b</sup>              | 7   | 2.4  | 69.42 $\pm$ 10.32           | 41.71 $\pm$ 11.33          | 84.71 $\pm$ 11.48             |
| F/p                             |     |      | F=12.906/ <b>p&lt;0.001</b> | F=7.407/ <b>p&lt;0.001</b> | F=1.318/p=0.26                |
| Number of pregnancy             |     |      |                             |                            |                               |
| 0–2                             | 225 | 76.5 | 74.73 $\pm$ 11.00           | 33.29 $\pm$ 12.95          | 81.44 $\pm$ 13.39             |
| 3 and above                     | 69  | 23.5 | 75.27 $\pm$ 11.24           | 32.91 $\pm$ 13.06          | 84.53 $\pm$ 13.97             |
| t/p                             |     |      | t=0.353/p=0.72              | t=0.215/p=0.83             | t=1.658/p=0.98                |
| Last form of pregnancy          |     |      |                             |                            |                               |
| Planned                         | 230 | 78.2 | 75.11 $\pm$ 10.80           | 33.44 $\pm$ 13.36          | 81.68 $\pm$ 13.39             |
| Unplanned                       | 64  | 21.8 | 73.96 $\pm$ 11.91           | 32.34 $\pm$ 11.43          | 83.93 $\pm$ 14.13             |
| t/p                             |     |      | t=0.732/p=0.46              | t=0.602/p=0.54             | t=1.176/p=0.24                |
| Last mode of delivery           |     |      |                             |                            |                               |
| Vaginal                         | 113 | 38.4 | 76.22 $\pm$ 11.28           | 33.77 $\pm$ 12.60          | 82.53 $\pm$ 12.47             |
| Cesarean section                | 181 | 61.6 | 74.01 $\pm$ 10.84           | 32.85 $\pm$ 13.19          | 81.95 $\pm$ 14.24             |
| t/p                             |     |      | t=1.670/p=0.09              | t=0.59/p=0.55              | t=0.356/p=0.72                |
| History of abortion/curettage   |     |      |                             |                            |                               |
| Yes                             | 71  | 24.1 | 74.08 $\pm$ 10.63           | 32.90 $\pm$ 13.02          | 82.90 $\pm$ 12.67             |
| No                              | 223 | 75.9 | 75.11 $\pm$ 11.18           | 33.30 $\pm$ 12.96          | 81.94 $\pm$ 13.86             |
| t/p                             |     |      | t=0.682/p=0.49              | t=0.228/p=0.82             | t=0.518/p=0.60                |
| Intervention in childbirth      |     |      |                             |                            |                               |
| Yes                             | 220 | 74.8 | 74.03 $\pm$ 11.18           | 33.80 $\pm$ 13.45          | 81.88 $\pm$ 13.58             |
| No                              | 74  | 25.2 | 77.33 $\pm$ 10.30           | 34.44 $\pm$ 11.25          | 83.00 $\pm$ 13.57             |
| t/p                             |     |      | <b>t=2.242/p=0.02</b>       | t=1.345/p=0.17             | t=0.625/p=0.53                |
| The baby's diet                 |     |      |                             |                            |                               |
| Breast milk                     | 161 | 54.8 | 75.33 $\pm$ 11.25           | 33.34 $\pm$ 12.90          | 83.32 $\pm$ 13.03             |
| Formula food                    | 27  | 9.2  | 75.62 $\pm$ 11.17           | 34.77 $\pm$ 13.48          | 79.18 $\pm$ 14.38             |
| Breast milk+supplementary food  | 57  | 19.4 | 73.49 $\pm$ 10.70           | 32.31 $\pm$ 12.96          | 80.49 $\pm$ 14.50             |
| Breast milk+formula             | 38  | 12.9 | 74.71 $\pm$ 10.94           | 35.52 $\pm$ 12.99          | 82.68 $\pm$ 13.29             |
| Formula+supplementary food      | 11  | 3.7  | 73.72 $\pm$ 11.04           | 34.36 $\pm$ 13.39          | 79.54 $\pm$ 15.50             |
| t/p                             |     |      | F=0.354/p=0.84              | F=0.510/p=0.72             | F=0.433/p=0.43                |
| Social support status           |     |      |                             |                            |                               |
| Yes                             | 217 | 73.8 | 77.37 $\pm$ 9.77            | 31.39 $\pm$ 11.73          | 83.59 $\pm$ 12.96             |
| No                              | 17  | 26.2 | 67.77 $\pm$ 11.39           | 38.31 $\pm$ 14.82          | 76.15 $\pm$ 14.50             |
| t/p                             |     |      | t=7.078/ <b>p=0.000</b>     | t=4.132/ <b>p=0.000</b>    | t=3.067/ <b>p=0.002</b>       |

**Table 2 (cont.).** Comparison of the Obstetric Characteristics of the Participants with the Mean Scores of BIMF, ELES, and TEIQue-SF (n=294)

| Variables               | n   | %    | $\bar{X} \pm SD$<br>BIMF | $\bar{X} \pm SD$<br>ELES | $\bar{X} \pm SD$<br>TEIQue-SF |
|-------------------------|-----|------|--------------------------|--------------------------|-------------------------------|
| Mother's health problem |     |      |                          |                          |                               |
| Yes                     | 34  | 11.6 | 75.50 $\pm$ 10.89        | 34.61 $\pm$ 16.04        | 88.85 $\pm$ 14.05             |
| No                      | 260 | 88.4 | 74.78 $\pm$ 11.08        | 33.02 $\pm$ 12.52        | 81.30 $\pm$ 13.28             |
| t/p                     |     |      | t=0.356/p=0.72           | t=0.67/p=0.52            | <b>t=3.096/p=0.002</b>        |
| Baby's sleep problem    |     |      |                          |                          |                               |
| Yes                     | 111 | 37.8 | 71.62 $\pm$ 11.74        | 34.43 $\pm$ 13.49        | 79.63 $\pm$ 13.97             |
| No                      | 183 | 62.2 | 76.83 $\pm$ 10.13        | 32.46 $\pm$ 12.59        | 83.71 $\pm$ 13.12             |
| t/p                     |     |      | <b>t=4.020/p=0.000</b>   | t=1.264/p=0.209          | t=2.525/p=0.012               |
| Mother's sleep problem  |     |      |                          |                          |                               |
| Yes                     | 124 | 42.2 | 71.42 $\pm$ 10.68        | 34.52 $\pm$ 12.74        | 80.12 $\pm$ 13.80             |
| No                      | 170 | 57.8 | 77.37 $\pm$ 10.65        | 32.24 $\pm$ 13.06        | 83.67 $\pm$ 13.23             |
| t/p                     |     |      | <b>t=1.718/p=0.000</b>   | t=1.491/p=0.137          | t=2.230/p=0.027               |

a,b,c: Means with different superscripts differ significantly according to the Tukey HSD test ( $p < 0.05$ ). n: Number; %: Percentage,  $\bar{X}$ : Mean; SD: Standard deviation; BIMF: Barkin index of maternal function; ELES: Early life experiences scale; TEIQue-SF: Trait emotional intelligence questionnaire–short form, t= Independent samples t-test; F: One-way analysis of variance test; P: Significance value.

$p=0.09$  for BIMF;  $t=0.690$ ,  $p=0.49$  for ELES;  $t=0.366$ ,  $p=0.45$  for TEIQue-SF). No significant difference was found in BIMF, ELES, and TEIQue-SF scores according to duration of marriage ( $t=0.907$ ,  $p=0.36$  for BIMF;  $t=0.753$ ,  $p=0.45$  for CDI;  $t=0.909$ ,  $p=0.36$  for TEIQue-SF). Significant differences were found in all three variables (BIMF, ELES, and TEIQue-SF) according to physical appearance assessment. Participants who rated their physical appearance as “good” had significantly higher BIMF ( $F=10.924$ ,  $p<0.001$ ), ELES ( $F=4.291$ ,  $p=0.015$ ), and TEIQue-SF ( $F=3.198$ ,  $p=0.042$ ) scores than those who rated their physical appearance as “average” or “poor” (Table 1).

Comparison of obstetric characteristics of the participants and the mean scores of BIMF, ELES, and TEIQue-SF (N: 294) is given in Table 2. When the mean scores were examined according to the baby's month variable, no significant difference was found between the groups in terms of BIMF, ELES, and TEIQue-SF ( $p>0.05$ ). Significant differences were observed in maternal functioning and childhood trauma scores according to relationship quality with the spouse. Women who evaluated their relationship as good had significantly higher maternal functioning scores compared to those reporting a moderate relationship ( $\bar{X}=8.29$ ,  $p<0.001$ ).

In addition, participants reporting good spousal relationships had significantly lower childhood trauma scores compared to those reporting moderate relationships ( $\bar{X}=-6.92$ ,  $p=0.002$ ). No significant differences were found in emotion regulation difficulty scores ( $p>0.05$ ).

No significant differences were found in BIMF, ELES and TEIQue-SF scores in the comparison made according to the number of pregnancies ( $p>0.05$ ). Similarly, no significant differences were observed in scale scores according to whether the last pregnancy was planned or unplanned or according to the type of birth ( $p>0.05$ ). There was no significant difference between the BIMF, ELES and TEIQue-SF scores of mothers with and without a history of abortion/curettage ( $p>0.05$ ). However, there was a significant difference in BIMF scores according to whether there was intervention at birth ( $p=0.02$ ). The BIMF score of mothers who did not receive intervention ( $\bar{X}=77.33$ ,  $SD=10.30$ ) was higher than that of mothers who received intervention. The effect of social support status on the BIMF, ELES, and TEIQue-SF scores was found to be significant ( $p<0.01$ ).

The BIMF score of mothers who received social support ( $\bar{X}=77.37$ ,  $SD=9.77$ ) was higher. A significant difference was found in TEIQue-SF scores between mothers with and without health problems, and the scores of mothers with health problems were higher ( $p=0.002$ ). Significant differences were found in the BIMF and TEIQue-SF scores according to the baby's sleep problems and the mother's sleep problems ( $p<0.05$ ). BIMF scores were higher in mothers without sleep problems ( $\bar{X}=77.37$ ,  $SD=10.65$ ) (Table 2).

Multiple Linear Regression Analysis of the Effect of ELES, TEIQue-SF on BIMF is shown in Table 3. When Table 3 is examined, the model is statistically significant,  $F(2, 291)=20.717$ ,  $p<0.001$ , and the independent variables

**Table 3.** Multiple linear regression analysis regarding the effect of ELES, TEIQue-SF on BIMF (n=294)

| Predictor | B      | SE    | B      | t      | p      | 95% CI for B     | Tolerance | VIF   |
|-----------|--------|-------|--------|--------|--------|------------------|-----------|-------|
| Constant  | 67.892 | 4.220 |        | 16.087 | <0.001 | (59.586, 76.199) |           |       |
| ELES      | 0.207  | 0.046 | -0.249 | -4.472 | <0.001 | (-0.299, -0.116) | 0.973     | 1.207 |
| TEIQue-SF | 0.170  | 0.044 | 0.213  | 3.838  | <0.001 | (0.083, 0.257)   | 0.973     | 1.207 |

Dependent variable=BIMF;  $R^2=0.125$ ; Adjustment  $R^2=0.119$ ;  $F(2, 291)=20.717$ ;  $p<0.001$ . SE: Standard errors; CI: Confidence interval; VIF: Variance inflation factor.

explain 12.5% of the total variance ( $R^2=0.125$ , adjusted  $R^2=0.119$ ). ELES ( $B=-0.207$ ,  $SE=0.046$ ,  $\beta=-0.249$ ,  $t=-4.472$ ,  $p<0.001$ ) has a negative and significant effect on BIMF. This result shows that an increase in ELES level leads to a decrease in the BIMF score. TEIQue-SF ( $B=0.170$ ,  $SE=0.044$ ,  $\beta=0.213$ ,  $t=3.838$ ,  $p<0.001$ ) has a positive and significant effect on BIMF. This shows that an increase in TEIQue-SF is associated with an increase in the BIMF score (Table 3).

## Discussion

This study examined the effects of postpartum women's childhood experiences and emotional intelligence levels on their role as mothers and discussed the possible contributions of these two important variables to motherhood.

Although the postpartum period offers an important opportunity for the mother's personal development, negative experiences during childhood can have a negative impact on parenting skills during this period.<sup>[22]</sup> The transition to motherhood involves adapting to physical changes, forming a maternal identity, and bonding with the baby. This process is particularly challenging for women who experienced emotional neglect in childhood.<sup>[23]</sup> In this context, it is clear that adaptation to motherhood is not only a biological process but also deeply connected to psychological and emotional history.

Our findings indicate that negative childhood experiences were significantly and negatively associated with maternal functioning ( $p<0.001$ ). In addition, there is a positive and statistically significant relationship between emotional intelligence levels and maternal functioning ( $p<0.001$ ). These findings suggest that individuals' past negative experiences may be associated with both their personal mental health and their parenting roles in later life. In particular, maternal functioning is closely related to an individual's emotional history and emotional competence levels. It is thought that this finding may be related to the long-term impact of adverse childhood experiences on emotion regulation and stress-coping capacities. Women who were exposed to emotional neglect or insecurity in early life may have greater difficulty adapting to the emotional demands of motherhood.

Our findings indicate that negative childhood experiences are negatively associated with maternal functioning, whereas higher emotional intelligence levels are positively associated with maternal functioning. Similar to our findings, Akintunde et al.<sup>[24]</sup> found that negative childhood experiences among 1<sup>st</sup>-time mothers were associated with dissatisfaction with motherhood. This finding supports the results of our current study and highlights the impact of negative childhood experiences on shaping the motherhood experience. In a study conducted by Mammadov and Şentürk Erenel,<sup>[22]</sup> it was found that mothers with high emotional intelligence performed their maternal roles more successfully. Priyam and Nath<sup>[9]</sup> conducted a cross-sectional observational study in East India and found that negative childhood experiences were significantly negatively associated with emotional management and relationship management ( $p<0.05$ ). These studies demonstrate that emotional intelligence is critical not only for individual adaptation but also for the healthy maintenance of complex social roles such as motherhood.<sup>[8,23]</sup> In addition, it is understood that the development of emotional intelligence is strongly influenced by the experiences an individual encounters during childhood. Similarly, the studies by Racine et al.<sup>[23]</sup> and Racine et al.,<sup>[8]</sup> also support these findings, showing that negative childhood experiences have lasting effects on an individual's emotional functioning and parenting competence. Thus, it is understood that an individual's past experiences are reflected not only in their inner world but also in the relationships they establish with their children. Consistent with the existing evidence in the literature, the findings of our study emphasize the importance of childhood experiences and the positive role of emotional intelligence in the development of maternal functioning. In this regard, our study shows that the fundamental building blocks shaping maternal functioning are closely related to an individual's past experiences and the impact of these experiences on emotional processes. In contrast, it can be said that mothers with high emotional intelligence levels can respond to the difficulties they encounter in the post-natal period more calmly and harmoniously, thereby enabling them to fulfill their maternal roles more effectively. Various studies have shown that individuals exposed to

adversity during childhood experience difficulties in various emotional processing and exhibit higher levels of reactivity, expressive suppression, and rumination.<sup>[23,25]</sup> At the same time, it has been found that higher levels of perceived maternal acceptance-rejection in adolescents are associated with lower levels of emotional intelligence.<sup>[5]</sup> These data suggest that emotional neglect or rejection experienced in childhood may be associated with difficulties in emotion regulation and with parenting patterns observed in later life. These findings reveal that emotional intelligence in motherhood is not merely a personal competency but also a fundamental component that directly influences the child's developmental process. According to previous studies, negative childhood experiences can lead to mental health problems and maladaptive parenting behaviors in adulthood.<sup>[26,27]</sup> This situation reveals that the negativity experienced by individuals during childhood does not remain in the past, but can also be reflected in their future parenting performance. Research based on Belsky's parenting model and personal development theory also supports this finding, suggesting that negative childhood experiences do not directly affect maternal functioning but rather indirectly through mediating variables such as psychological distress, lack of self-compassion, and social support. Within this framework, the findings of our study also show that maternal functioning is shaped not only by individual historical experiences but also by how these experiences are processed at the psychological and social levels. The relationship between maternal childhood difficulties and parenting stress, when evaluated together with the positive correlation between attachment styles and maternal functioning,<sup>[28]</sup> suggests that emotional deprivation experienced in childhood may increase stress levels during parenting and that this situation may negatively affect mother-child interaction. A systematic review showed that maternal adversity has serious negative effects on early childhood interactions.<sup>[29]</sup> Similarly, a meta-analysis revealed that these experiences have moderate negative effects on maternal mental health.<sup>[8]</sup>

In addition to all these results, the explanatory power of the regression model is relatively low ( $R^2=0.125$ ). This indicates that the perception of the maternal role may be related not only to the variables examined but also to numerous biopsychosocial factors. Therefore, although the model is statistically significant, its explanatory power is limited from a clinical and practical perspective.

In this context, our study supports the existing literature, indicating that negative childhood experiences are associated with maternal functioning and may be linked

to this relationship through various psychological and social pathways. This finding underscores the importance of holistic intervention approaches that consider not only individuals' past experiences but also focus on strengthening emotional skills and enhancing psychological resilience to support maternal functioning. In this regard, it is suggested that such supportive interventions should not be limited to the postpartum period, but may be more effective when initiated during pregnancy.

### Limitations

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design precludes any causal inferences regarding the relationships between childhood experiences, emotional intelligence, and maternal functioning. The observed associations reflect correlations at a single point in time and do not establish directionality. Second, the study employed a snowball sampling method, which is a non-probability sampling technique. Although the sample size was determined through power analysis, this recruitment strategy may limit the representativeness of the sample and reduce the generalizability of the findings to the broader population of postpartum women. Third, data were collected through self-report measures administered online. Self-reported data are subject to recall bias and social desirability bias, particularly when assessing early life experiences and maternal role perceptions. In addition, online data collection may have excluded women without internet access, potentially introducing selection bias.

Finally, the regression model explained a modest proportion of the variance in maternal functioning ( $R^2=0.125$ ), indicating that other unmeasured biological, psychological, and social factors may also contribute to maternal role functioning. Future studies incorporating longitudinal designs and additional contextual variables may provide a more comprehensive understanding of these relationships.

### Conclusion

It was found that negative childhood experiences decreased maternal functioning, whereas high levels of emotional intelligence increased it. In this direction, it is recommended that intervention programs offered by midwives and nurses, specially developed for the postpartum period, be designed in experimental-type studies with a focus on mothers' ability to process childhood traumas and increase their emotional intelligence levels. It is suggested that such programs may contribute to improvements in mothers' emotional well-being and their relationships with their children.

**Ethics Committee Approval:** The KTO Karatay University Drug and Non-Medical Device Research Ethics Committee granted approval for this study (date: 30.01.2025, number: 2025/037).

**Informed Consent:** The individuals participating in the study were informed that they could withdraw from the study at any time, and informed consent was obtained from the individuals.

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# Evaluation of Tooth Preparation in a Haptic Three-Dimensional Virtual Reality Dental Training Simulator: A Questionnaire Study

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## Abstract

**Introduction:** This study aimed to evaluate the use of a three-dimensional (3D) haptic virtual reality (VR) dental training simulator for tooth preparation practice in preclinical dental education.

**Methods:** Fifty-six 4<sup>th</sup>-year dental students at Lokman Hekim University used the Virteasy VR dental training simulator to perform a tooth preparation on the mandibular canine. Participants subsequently completed an 18-item questionnaire assessing four categories: Content, anatomy, applicability, and usability. Descriptive statistics and Fisher's exact test were used to analyze questionnaire responses and examine associations with demographic variables.

**Results:** Most participants rated the simulator positively in terms of content quality, anatomical accuracy, and usability. Female participants particularly highlighted its potential for future development and its ability to facilitate control over tooth preparation processes. Statistically significant correlations were found between specific questionnaire items, indicating parallel scoring trends among participants. In addition, students reported that the simulator enhanced clinical skills and reduced the gap between model practice and real patient scenarios. Most participants did not report discomfort, such as headaches, during use.

**Discussion and Conclusion:** The haptic 3D VR dental simulator is a valuable educational tool that complements traditional methods in dental education. It offers advantages such as reduced material waste, enhanced anatomical understanding, and opportunities for repeated practice.

**Keywords:** Dental education; Preclinical training; Tooth preparation; Virtual reality

Virtual reality (VR) is a three-dimensional (3D) computer-generated system that enables users to perceive, interact with, and experience immersion in a simulated setting. This system is used in entertainment

fields such as gaming and media, as well as in education and health.<sup>[1,2]</sup> The use of the system, especially in the field of education, has been reported to increase academic achievement.<sup>[3]</sup>

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In dental education, not only the acquisition of theoretical knowledge but also the development of fine motor skills is essential. Before treating patients in the clinic, students are expected to gain adequate competence through preclinical training.<sup>[4]</sup> One of the core practical competencies taught during this phase is tooth preparation.<sup>[5]</sup> This procedure requires substantial practice and experience to preserve tooth structure and to avoid pulp damage.<sup>[6]</sup> However, traditional training with typodonts or extracted teeth is limited by material costs, sterilization challenges, and the need for continuous supervision. These limitations highlight the need for innovative teaching tools that provide both efficiency and reproducibility.

VR-based training simulators have emerged as promising solutions to these challenges. They minimize the reliance on physical materials, potential sterilization issues when working with extracted teeth, reduce costs, and allow procedures to be repeated under standardized conditions.<sup>[7]</sup> Beyond technical practice, VR simulators also enable students to engage in self-assessment through immediate and end-of-procedure feedback, thereby promoting independent learning and skill refinement.<sup>[8]</sup> In addition, this application provides students with the opportunity to examine and learn the anatomy of the oral environment, a subject that can be challenging to observe and study. VR applications offer several advantages, such as the ability to perform operations repeatedly and the absence of occupational health and safety risks.<sup>[1]</sup> The literature claims that practical application videos and the use of microscopes, in addition to VR applications, aid students in developing their skills.<sup>[9,10]</sup>

This study aimed to evaluate the effectiveness of a haptic 3D VR training simulator in preclinical dental education. Specifically, it aimed to investigate students' experiences and perceptions regarding tooth preparation practice, focusing on how the simulator supported their learning, skill development, and self-assessment. The null hypothesis was that the VR simulator would not have a significant impact on students' evaluations and perceived educational benefits.

## Materials and Methods

The study investigating the use of a haptic 3D VR dental training simulator for tooth preparation in preclinical education was approved by the Lokman Hekim University Scientific Research Ethics Committee (Decision: 2023101, Date: 13.06.2023).

The study was carried out with the 4<sup>th</sup>-year dental students from the Faculty of Dentistry at Lokman Hekim University

who participated in the study. The inclusion criteria for this study required participants to be 4<sup>th</sup>-year dental students enrolled in preclinical courses, to have completed standard preclinical tooth preparation training on mannequins, and to have provided written informed consent. All participants had performed tooth preparation on real patients as part of clinical training. Exclusion criteria included having prior experience with the Virteasy VR dental simulator or having any physical or visual condition that would prevent effective use of the VR simulator. Participants were shown how to use various hardware components of the Virteasy (Laval, Pays De La Loire, France) haptic VR dental training simulator. Participants were then asked to answer all the questions in the questionnaire. The Lawshe technique was used to test content validity in the study, and five expert opinions were evaluated. The content validity index (CVI) value was calculated for each item in the study and obtained as 1.00. The minimum CVI for the five experts is 0.99. The calculated CVI value was compared to 0.99, and no items with low validity or requiring modification were found. To achieve the aim of this study, an original questionnaire was created, building on the foundations provided by the works of literature published in the same field.<sup>[1]</sup> Informed consent was obtained, and anonymity of responses was ensured.

The participants were asked to perform crown preparation of the right lower mandibular canine tooth without a time limit. On average, participants spent 20–30 min on the task. To record post-preparation experiences and opinions, the questionnaire was answered by the students. The questionnaire contained four sections: "content, anatomy, applicability, and usability." In the content section, the quality of the content of the training simulation was evaluated; in the anatomy section, the accuracy of the anatomical structure of the oral cavity and dental morphology during the practice was determined. In the applicability section, the attractiveness of the practical training was evaluated by determining the applicability and ease of use of the simulator for the practical training. In the usability section, the effects of practicing using the VR simulator felt by the participant and the realism similarity of the practice were reviewed. Each item was evaluated on a 5-point Likert scale ranging from 0 to 4, where 0 indicated "strongly disagree," 1 "disagree," 2 "neutral," 3 "agree," and 4 "strongly agree."

Analyses of the survey questions were carried out in the IBM Statistical Package for the Social Sciences 25 (IBM Corp, Armonk, NY, USA) program. The study used descriptive statistics (number and percentage) of the data. In addition

**Table 1.** The distribution of responses to the content section questions and their association with gender

| Content                                                                                                                | Scores | Total<br>n (%) | Female<br>n (%) | Male<br>n (%) | p      |
|------------------------------------------------------------------------------------------------------------------------|--------|----------------|-----------------|---------------|--------|
| Q1- Is the accuracy of the tooth preparation simulator acceptable when compared to the actual clinical results?        | 0      | 2 (3.5)        | 0 (0.0)         | 2 (100.0)     | 0.359  |
|                                                                                                                        | 1      | 9 (15.8)       | 7 (77.8)        | 2 (22.2)      |        |
|                                                                                                                        | 2      | 17 (31.6)      | 12 (70.6)       | 5 (29.4)      |        |
|                                                                                                                        | 3      | 16 (28.1)      | 11 (68.8)       | 5 (31.3)      |        |
|                                                                                                                        | 4      | 12 (21.1)      | 7 (58.3)        | 5 (41.7)      |        |
| Q2- Is it possible to check the whole process of the tooth preparation in the simulator?                               | 0      | 3 (5.3)        | 0 (0.0)         | 3 (100.0)     | 0.042* |
|                                                                                                                        | 1      | 10 (17.5)      | 9 (90.0)        | 1 (10.0)      |        |
|                                                                                                                        | 2      | 15 (28.1)      | 10 (66.7)       | 5 (33.3)      |        |
|                                                                                                                        | 3      | 16 (28.1)      | 12 (75.0)       | 4 (25.0)      |        |
|                                                                                                                        | 4      | 12 (21.1)      | 6 (50.0)        | 6 (50.0)      |        |
| Q3- Is the practice of using HMDs more beneficial when compared to traditional practice (using dentiforms)?            | 0      | 7 (12.3)       | 4 (57.1)        | 3 (42.9)      | 0.938  |
|                                                                                                                        | 1      | 7 (12.3)       | 5 (71.4)        | 2 (28.6)      |        |
|                                                                                                                        | 2      | 13 (24.6)      | 9 (69.2)        | 4 (30.8)      |        |
|                                                                                                                        | 3      | 17 (29.8)      | 12 (70.6)       | 5 (29.4)      |        |
|                                                                                                                        | 4      | 12 (21.1)      | 7 (58.3)        | 5 (41.7)      |        |
| Q4- Is the practice of using haptic devices more beneficial when compared to the existing practice (using dentiforms)? | 0      | 2 (3.5)        | 0 (0.0)         | 2 (100.0)     | 0.359  |
|                                                                                                                        | 1      | 12 (21.1)      | 10 (77.8)       | 2 (22.2)      |        |
|                                                                                                                        | 2      | 10 (15.8)      | 7 (70.6)        | 3 (29.4)      |        |
|                                                                                                                        | 3      | 17 (31.6)      | 11 (68.8)       | 6 (31.3)      |        |
|                                                                                                                        | 4      | 15 (28.1)      | 9 (58.3)        | 6 (41.7)      |        |

\*: p&lt;0.05. HMD: Head mount display.

to descriptive statistics, potential associations between survey responses and gender were also examined. Fisher's exact test was used to evaluate associations between categorical variables when the assumptions required for the chi-square test were not met. A one-sample chi-square test was applied to test the differences between the proportions of responses to categorical variables. The level of statistical significance was set at  $p<0.05$ . The study was conducted in accordance with the Declaration of Helsinki.

## Results

A total of fifty-six 4<sup>th</sup>-year dental students (37 females, 19 males) attended the study. When the demographic characteristics of the participants were analyzed, 66.1% of the participants were female and 33.9% were male. 94.7% of the participants were between 20 and 23 years old, and 5.3% were between 18 and 20 years old. Among the questions in the "content" section of the questionnaire, Q1 (Is the accuracy of the dental preparation simulator acceptable when compared to actual clinical practice results?) was rated as score 2 by 31.6%, and Q4 (How would you rate the effectiveness of the use of dental simulators

in preclinical education in the acquisition of clinical skills?) was rated as score 3 by 31.6% (Table 1). In the "Anatomy" section of the questionnaire, Q7 (A 3D anatomical model is likely to be helpful in understanding anatomy) was marked at score 3 with the highest rate of 40.4% (Table 2). In the "applicability" section of the questionnaire, Q13 (the tooth preparation simulator is likely to be further developed in the future) was recorded at score 4 with the highest percentage of 47.4% (Table 3). Finally, in the "Usability" section of the questionnaire, 45.6% answered score 3 to Q17 (I did not feel pain, dizziness, or headache when I practiced) (Table 4).

In determining the association between the questions in the questionnaire, the scores given to the questions Q3 (Is the application of VR-based simulation technology more useful in developing students' preclinical skills compared to the current traditional practice?) and Q11 (I think that the current dental education curriculum should include the application using the VR simulator) in the applicability section were compared with Fisher's exact test, and a statistically significant association was found between the answers ( $p<0.05$ ). 57% of those who gave a score of 0 to

**Table 2.** The distribution of responses to the anatomy section questions and their association with gender

| Anatomy                                                                                  | Scores | Total<br>n (%) | Female<br>n (%) | Male<br>n (%) | p     |
|------------------------------------------------------------------------------------------|--------|----------------|-----------------|---------------|-------|
| Q5- The structure of the tooth corresponds to the real anatomical structure.             | 0      | 0 (0.0)        | 0 (0.0)         | 0 (0.0)       | 0.330 |
|                                                                                          | 1      | 6 (12.3)       | 4 (66.7)        | 2 (33.3)      |       |
|                                                                                          | 2      | 14 (24.6)      | 12 (85.7)       | 2 (14.3)      |       |
|                                                                                          | 3      | 18 (31.6)      | 10 (55.6)       | 8 (44.4)      |       |
|                                                                                          | 4      | 18 (31.6)      | 11 (61.1)       | 7 (38.9)      |       |
| Q6- The shape of the teeth is similar to the actual patient.                             | 0      | 0 (0.0)        | 0 (0.0)         | 0 (0.0)       | 0.956 |
|                                                                                          | 1      | 1 (1.8)        | 1 (100.0)       | 0 (0.0)       |       |
|                                                                                          | 2      | 13 (22.8)      | 8 (66.7)        | 4 (33.3)      |       |
|                                                                                          | 3      | 22 (38.6)      | 15 (68.2)       | 7 (31.8)      |       |
|                                                                                          | 4      | 21 (36.8)      | 13 (61.9)       | 8 (38.1)      |       |
| Q7- A three-dimensional anatomic model is likely to be helpful in understanding anatomy. | 0      | 0 (0)          | 0 (0)           | 0 (0)         | 0.799 |
|                                                                                          | 1      | 4 (7.1)        | 3 (75.0)        | 1 (25.0)      |       |
|                                                                                          | 2      | 7 (12.5)       | 4 (57.1)        | 3 (42.9)      |       |
|                                                                                          | 3      | 23 (41.0)      | 14 (60.9)       | 9 (39.1)      |       |
|                                                                                          | 4      | 22 (39.2)      | 16 (72.7)       | 6 (27.3)      |       |

question Q3 also gave a score of 0 to question Q11. Again, 100% of those who answered score 4 to question Q3 also answered score 4 to question Q11 (Table 5). In addition, as a result of the analysis of the scores given to the questions Q4 (how would you evaluate the effectiveness of the use of dental simulators in preclinical education in the acquisition of clinical skills?), and Q10 (the use of a VR simulator is useful to reduce the difference between clinical practice in real patients and model practice) with Fisher's exact test, a statistically significant association was determined between the answers ( $p < 0.05$ ). 100% of those who answered a score of 0 to question Q4 also answered a score of 0 to question Q10. In answering these questions in Tables 5 and 6, parallelism was found in the scoring of the participants.

A significant difference was found between gender and questions Q2 (is it possible to control the whole process of tooth preparation in the simulator?) and Q13 (there is a possibility of further development of the tooth preparation simulator in the future) ( $p < 0.05$ ) (Tables 1 and 3). Female participants significantly stated that it is possible to control the whole process of tooth preparation in the simulator and that there is a possibility of further development of simulators for tooth preparation in the future compared to male participants.

## Discussion

This study aimed to evaluate students' perceptions of a haptic 3D VR dental training simulator in preclinical tooth preparation practice and to examine its perceived educational

value in comparison with traditional training methods. The null hypothesis, which stated that the use of the VR simulator would not significantly influence students' evaluations and perceived educational benefits, was rejected. The findings demonstrated statistically significant associations among several questionnaire items and generally positive student perceptions regarding the simulator's content quality, anatomical representation, applicability, and usability. These results suggest that the integration of haptic VR simulation into preclinical dental education may enhance students' learning experiences and support skill development.

In the present study, students who performed tooth preparation using a VR simulator evaluated their experiences under four categories: Content, anatomy, applicability, and usability. The transition from preclinical to clinical education in dentistry is the most important and exciting moment during the student period. At this point, the profession commences its professional practice. Dental practices perform procedures that demand a high level of hand sensitivity and experience. To gain the ability to perform procedures in a very small area, students must first work in structures that mimic the patient's intraoral environment and gain experience. In this way, it is aimed to increase adaptation and success during the transition from preclinical to clinical training.<sup>[11]</sup>

Today, there are many digital technologies such as VR devices, augmented reality, mixed reality, and extended reality that are increasingly integrated into dental education.<sup>[12,13]</sup> It is important to evaluate the contribution

**Table 3.** The distribution of responses to the applicability section questions and their association with gender

| Applicability                                                                                                     | Scores | Total<br>n (%) | Female<br>n (%) | Male<br>n (%) | p      |
|-------------------------------------------------------------------------------------------------------------------|--------|----------------|-----------------|---------------|--------|
| Q8- The process of practicing with the simulator is interesting.                                                  | 0      | 1 (1.8)        | 1 (100.0)       | 0 (0.0)       | 0.853  |
|                                                                                                                   | 1      | 5 (8.8)        | 4 (80.0)        | 1 (20.0)      |        |
|                                                                                                                   | 2      | 9 (15.8)       | 7 (77.8)        | 2 (22.2)      |        |
|                                                                                                                   | 3      | 18 (33.3)      | 11 (61.1)       | 7 (38.9)      |        |
|                                                                                                                   | 4      | 23 (40.4)      | 14 (60.9)       | 9 (39.1)      |        |
| Q9- It is beneficial for learning the tooth preparation process.                                                  | 0      | 4 (7.0)        | 2 (50.0)        | 2 (50.0)      | 0.812  |
|                                                                                                                   | 1      | 6 (10.5)       | 5 (83.3)        | 1 (16.7)      |        |
|                                                                                                                   | 2      | 10 (19.3)      | 6 (60.0)        | 4 (40.0)      |        |
|                                                                                                                   | 3      | 17 (29.8)      | 12 (70.6)       | 5 (29.4)      |        |
|                                                                                                                   | 4      | 19 (33.3)      | 12 (63.2)       | 7 (36.8)      |        |
| Q10- Using this VR simulator is helpful to reduce the gap between clinical in actual patients and model practice. | 0      | 7 (12.3)       | 5 (71.4)        | 2 (28.6)      | 1.000  |
|                                                                                                                   | 1      | 4 (7.0)        | 3 (75.0)        | 1 (25.0)      |        |
|                                                                                                                   | 2      | 8 (14.0)       | 5 (62.5)        | 3 (37.5)      |        |
|                                                                                                                   | 3      | 18 (33.3)      | 12 (66.7)       | 6 (33.3)      |        |
|                                                                                                                   | 4      | 19 (33.3)      | 12 (63.2)       | 7 (36.8)      |        |
| Q11- I think that the existing dental education curriculum should include the practice using the VR simulator.    | 0      | 6 (10.5)       | 3 (50.0)        | 3 (50.0)      | 0.588  |
|                                                                                                                   | 1      | 4 (7.0)        | 4 (100.0)       | 0 (0.0)       |        |
|                                                                                                                   | 2      | 10 (17.5)      | 7 (70.0)        | 3 (30.0)      |        |
|                                                                                                                   | 3      | 17 (31.6)      | 10 (58.8)       | 7 (41.2)      |        |
|                                                                                                                   | 4      | 19 (33.3)      | 13 (68.4)       | 6 (31.6)      |        |
| Q12- I want to learn other dental practices using VR simulator.                                                   | 0      | 3 (5.3)        | 1 (33.3)        | 2 (66.7)      | 0.494  |
|                                                                                                                   | 1      | 4 (7.0)        | 4 (100.0)       | 0 (0.0)       |        |
|                                                                                                                   | 2      | 9 (17.5)       | 6 (66.7)        | 3 (33.3)      |        |
|                                                                                                                   | 3      | 20 (35.1)      | 14 (70.0)       | 6 (30.0)      |        |
|                                                                                                                   | 4      | 20 (35.1)      | 12 (60.0)       | 8 (40.0)      |        |
| Q13- There is a possibility of future development of the tooth preparation simulator.                             | 0      | 1 (1.8)        | 1 (100.0)       | 0 (0.0)       | 0.041* |
|                                                                                                                   | 1      | 2 (3.5)        | 0 (0.0)         | 2 (100.0)     |        |
|                                                                                                                   | 2      | 8 (14.0)       | 8 (100.0)       | 0 (0.0)       |        |
|                                                                                                                   | 3      | 19 (33.3)      | 11 (61.1)       | 7 (38.9)      |        |
|                                                                                                                   | 4      | 27 (47.4)      | 17 (63.0)       | 10 (37.0)     |        |

\*: p&lt;0.05. VR: Virtual reality.

of these developing digital systems to the education of students, and there are many studies in the literature on the application and results of these technologies.<sup>[14,15]</sup> Similar to the present study results, in other studies, the use of VR haptic dental simulators has advantages such as students being able to practice safely and independently with these devices, standardization of the education received, patient safety, and reduction of waste materials.<sup>[16,17]</sup> The system can be used in many dental disciplines such as endodontics, pedodontics, and prosthodontics. Dental education is a continuous process, and distance education is not possible.

In the event of a global pandemic such as COVID-19, it is very important to use VR haptic simulation technologies so that education is not affected.<sup>[18]</sup> In addition, thanks to this technology, there are situations where it is possible to train and practice outside of the faculty's teaching hours.<sup>[12]</sup>

In dental education, extracted teeth are frequently used as educational material. However, as a result of the developments in dentistry and the awareness of patients, the tendency to protect teeth and keep them in the mouth has increased. Therefore, it will become more and more difficult to find extracted teeth used as training material

**Table 4.** The distribution of responses to the usability section questions and their association with gender

| Usability                                                                                       | Scores | Total<br>n (%) | Female<br>n (%) | Male<br>n (%) | p     |
|-------------------------------------------------------------------------------------------------|--------|----------------|-----------------|---------------|-------|
| Q14- In practice, HMD felt comfortable.                                                         | 0      | 3 (5.3)        | 0 (0.0)         | 3 (100.0)     | 0.128 |
|                                                                                                 | 1      | 5 (8.8)        | 4 (80.0)        | 1 (20.0)      |       |
|                                                                                                 | 2      | 9 (15.8)       | 5 (55.6)        | 4 (44.4)      |       |
|                                                                                                 | 3      | 25 (43.9)      | 18 (75.0)       | 6 (25.0)      |       |
|                                                                                                 | 4      | 15 (26.3)      | 10 (66.7)       | 5 (33.3)      |       |
| Q15- The quality of the video at the time of practice is good.                                  | 0      | 1 (1.8)        | 0 (0.0)         | 1 (100.0)     | 0.439 |
|                                                                                                 | 1      | 3 (5.3)        | 1 (33.3)        | 2 (66.7)      |       |
|                                                                                                 | 2      | 12 (21.1)      | 9 (75.0)        | 3 (25.0)      |       |
|                                                                                                 | 3      | 24 (42.1)      | 16 (66.7)       | 8 (33.3)      |       |
|                                                                                                 | 4      | 17 (29.8)      | 11 (68.8)       | 5 (31.3)      |       |
| Q16- The operation using the haptic device is similar to the operation of the actual handpiece. | 0      | 4 (7.0)        | 3 (75.0)        | 1 (25.0)      | 0.502 |
|                                                                                                 | 1      | 5 (8.8)        | 2 (40.0)        | 3 (60.0)      |       |
|                                                                                                 | 2      | 13 (22.8)      | 7 (53.8)        | 6 (46.2)      |       |
|                                                                                                 | 3      | 17 (29.8)      | 13 (76.5)       | 4 (23.5)      |       |
|                                                                                                 | 4      | 18 (31.6)      | 12 (70.6)       | 5 (29.4)      |       |
| Q17- I did not feel aching, dizziness, or headache when I practiced.                            | 0      | 0 (0)          | 0 (0)           | 0 (0)         | 0.716 |
|                                                                                                 | 1      | 4 (7.0)        | 3 (75.0)        | 1 (25.0)      |       |
|                                                                                                 | 2      | 4 (7.0)        | 3 (75.0)        | 1 (25.0)      |       |
|                                                                                                 | 3      | 26 (45.6)      | 18 (72.0)       | 7 (28.0)      |       |
|                                                                                                 | 4      | 23 (40.4)      | 13 (56.5)       | 10 (43.5)     |       |
| Q18- Practice using the VR simulator seemed comfortable.                                        | 0      | 5 (8.8)        | 2 (40.0)        | 3 (60.0)      | 0.133 |
|                                                                                                 | 1      | 6 (10.5)       | 6 (100.0)       | 0 (0.0)       |       |
|                                                                                                 | 2      | 9 (15.8)       | 7 (77.8)        | 2 (22.2)      |       |
|                                                                                                 | 3      | 21 (36.8)      | 14 (70.0)       | 6 (30.0)      |       |
|                                                                                                 | 4      | 16 (28.1)      | 8 (50.0)        | 8 (50.0)      |       |

HMD: Head mount display; VR: Virtual reality.

**Table 5.** The distributions of individuals' responses to the 'Is the practice of using HMDs more beneficial when compared to traditional practice (using dentifforms)?' and 'I think that the existing dental education curriculum should include the practice using the VR simulator' questions and the association between them

|                                                                                                                | Scores | Q3- Is the practice of using HMDs more beneficial when compared to traditional practice (using dentifforms)? |            |            |            |            | p       |
|----------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------|------------|------------|------------|------------|---------|
|                                                                                                                |        | 0<br>n (%)                                                                                                   | 1<br>n (%) | 2<br>n (%) | 3<br>n (%) | 4<br>n (%) |         |
| Q11- I think that the existing dental education curriculum should include the practice using the VR simulator. | 0      | 4 (57.1)                                                                                                     | 1 (14.3)   | 0 (0.0)    | 1 (5.9)    | 0 (0.0)    | <0.001* |
|                                                                                                                | 1      | 2 (28.6)                                                                                                     | 0 (0.0)    | 2 (14.3)   | 0 (0.0)    | 0 (0.0)    |         |
|                                                                                                                | 2      | 0 (0.0)                                                                                                      | 1 (14.3)   | 3 (21.4)   | 6 (35.3)   | 0 (0.0)    |         |
|                                                                                                                | 3      | 0 (0.0)                                                                                                      | 3 (42.9)   | 7 (50.0)   | 8 (47.1)   | 0 (0.0)    |         |
|                                                                                                                | 4      | 1 (14.3)                                                                                                     | 2 (28.6)   | 2 (14.3)   | 2 (11.8)   | 12 (100)   |         |

\*: p&lt;0.05. HMD: Head mount display; VR: Virtual reality.

and to use them in applications. There are studies indicating that VR haptic simulation training has an equivalent effect on extracted teeth in improving minimally invasive caries

cleaning, providing equal benefit to traditional simulations.<sup>[19-23]</sup> On the other hand, some studies have shown an improvement in manual dexterity with the use of VR. There

**Table 6.** The distributions of individuals' responses to the "Is the practice of using haptic devices more beneficial when compared to existing practice (using dentiforms)? "and" Using this VR simulator is helpful to reduce the gap between clinical in actual patients and model practice" questions and the association between them

|                                                                                                                   | Scores | Q4- Is the practice of using haptic devices more beneficial when compared to the existing practice (using dentiforms)? |            |            |            |            | p       |
|-------------------------------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------------------------------------------------|------------|------------|------------|------------|---------|
|                                                                                                                   |        | 0<br>n (%)                                                                                                             | 1<br>n (%) | 2<br>n (%) | 3<br>n (%) | 4<br>n (%) |         |
| Q10- Using this VR simulator is helpful to reduce the gap between clinical in actual patients and model practice. | 0      | 2 (100)                                                                                                                | 3 (25.0)   | 0 (0.0)    | 2 (11.1)   | 0 (0.0)    | <0.001* |
|                                                                                                                   | 1      | 0 (0.0)                                                                                                                | 1 (8.3)    | 2 (22.2)   | 1 (5.6)    | 0 (0.0)    |         |
|                                                                                                                   | 2      | 0 (0.0)                                                                                                                | 3 (25.0)   | 1 (11.1)   | 3 (16.7)   | 1 (6.3)    |         |
|                                                                                                                   | 3      | 0 (0.0)                                                                                                                | 3 (25.0)   | 3 (33.3)   | 10 (55.6)  | 3 (18.8)   |         |
|                                                                                                                   | 4      | 0 (0.0)                                                                                                                | 2 (16.7)   | 3 (33.3)   | 2 (11.1)   | 12 (75.0)  |         |

\*: p&lt;0.05. VR: Virtual reality.

are also studies in the literature that recommend the VR method be used in combination with mannequin models rather than instead of traditional mannequin models.<sup>[24,25]</sup> In the current study, more than half of the students found the VR-based simulation more useful than the traditional method. They also stated that the simulator contributed to understanding the anatomy of the region they studied.

In the present study, the participants, especially the female students, believed that the simulator could be improved in the future. As the application develops, it is thought that it will provide more benefits as an educational material. Such technological systems are very interesting and motivating for a generation that is intertwined with digital games.<sup>[26,27]</sup>

The fact that the system allows for an objective assessment and repetition will increase the number of training hours and lead the student to a better point in the learning curve. In addition, it is thought that the benefit of the system will increase as the simulated scenarios get closer to reality. In the current study, a significant portion of the students had the idea that the use of dental simulators in preclinical education would increase their skills in the clinic. In studies in which repeated applications were evaluated, it was reported that the duration was shortened, virtual cavity performance increased, and the perception of errors improved.<sup>[11]</sup> Similarly, in the current study, more than half of the students reported that their clinical skills would increase with the use of simulators. Female students believed this idea more than male students.

Studies have been conducted on head-mounted displays in simulator training. Within the studies, participants were asked whether they felt visual discomfort, and findings of eye pain, nausea, and headache were reported.<sup>[28]</sup> In the current study, the majority of participants (n=49) reported that they did not feel a headache during the application

(Q17). More than half of the participants also found the app comfortable to use (n=37) (Q18).

The contribution of this study is its structured evaluation of student experiences across four dimensions (content, anatomy, applicability, and usability) within a preclinical setting. While many previous studies have focused primarily on technical performance, the present research provides insights into how VR simulation may influence students' perception of anatomy, clinical applicability, and motivation, offering a complementary perspective to the existing literature.

The present study found that female participants reported higher agreement than males regarding the controllability of the simulator (Q2) and the potential for its future development (Q13). This finding aligns with observations in dental education that gender may influence attitudes toward technology-enhanced learning. For example, Nassani et al.<sup>[29]</sup> reported that gendered differences exist in responses to technology teaching in dentistry, indicating potential variation in acceptance and engagement. Similarly, in a recent VR clinical observation study, women showed significantly greater procedural understanding scores than men in the VR group (p=0.007).<sup>[30]</sup>

However, the present study has several limitations that should be considered when interpreting these findings. The questionnaire was applied to a limited population, and the number of female participants was greater, which could have biased the results. In addition, the simulator was used only for a limited experience, which restricts the generalizability of the findings. It is possible that repeated or routine use of the simulator in dental training might positively influence students' scoring and reduce such gender-related differences. Therefore, the gender differences observed in the present study should be

interpreted with caution, and future research with larger, gender-balanced cohorts and repeated simulator exposure is needed to validate these trends.

## Conclusion

The study revealed that the students were optimistic about the advancement of these technologies and believed that this situation would enhance dentistry education. However, it is thought that VR technology is not yet used as a stand-alone educational material, but it is a very important and complementary educational tool, and its continuous use for all branches of dentistry will increase success.

**Ethics Committee Approval:** The Lokman Hekim University Scientific Research Ethics Committee granted approval for this study (date: 13.06.2023, number: 2023101).

**Informed Consent:** Written informed consent was obtained.

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# Comparative Evaluation of *Aloe vera* Gel and Conventional Denture Cleansers on Color Stability and Translucency of Acrylic Resin Teeth: An *In Vitro* Study

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## Abstract

**Introduction:** This *in vitro* study aimed to evaluate and compare the stain removal efficacy and translucency effects of different denture cleansers, including *Aloe vera* (AV) gel, on coffee-stained acrylic resin teeth.

**Methods:** Fifty maxillary right central incisor acrylic teeth (shade A2) were stained with a coffee solution and then divided into five groups (n=10): Corega Cleaner-C, Corega Whiteness (CW), Protefix-P, AV gel, and distilled water-D. Each group underwent six 90-min immersion cycles simulating 6 months of clinical use. Color changes ( $\Delta E_{00}$ ) and translucency parameters (TP) were measured using a spectrophotometer. Data were analyzed using one-way analysis of variance (ANOVA), Tukey's honestly significant difference, and paired t-tests.

**Results:** Color stability and the TP were calculated. ANOVA revealed no statistically significant difference in color stability between the groups ( $p=0.367$ ). For TP analyses, while no significant difference was observed among TP1 groups ( $p=0.565$ ), a statistically significant difference was found among TP2 groups ( $p<0.05$ ). The AV group differed significantly from the other groups in TP2. Paired t-tests showed a significant difference in translucency values, with a decrease in the CW group ( $p=0.039$ ) and an increase in the AV group ( $p=0.007$ ).

**Discussion and Conclusion:** AV gel was as effective as conventional denture cleansers in removing stains from acrylic resin teeth and was the only agent that preserved or enhanced translucency. Given its natural composition, biocompatibility, and minimal effect on optical properties, AV gel may be considered a clinically valuable alternative, especially for patients with high aesthetic expectations or sensitivity to chemical agents.

**Keywords:** *Aloe vera* gel; Artificial teeth; Color stability; Denture cleansers; Translucency

With the global increase in life expectancy, the proportion of elderly individuals has risen significantly. Consequently, the prevalence of edentulism and the use of complete dentures have also increased.

[1] This trend has led to heightened aesthetic demands

and expectations across all areas of dentistry, including removable prosthodontics. In this context, the selection of artificial teeth is of critical importance, as their stain resistance and color stability significantly influence the overall aesthetics of prosthetic appliances.[2] Acrylic resin

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teeth offer several advantages, such as reduced weight, superior chemical bonding with the denture base, and enhanced fracture resistance.<sup>[3,4]</sup> However, they are also more susceptible to wear and discoloration.<sup>[2]</sup> Among the key factors affecting patient satisfaction with removable dentures is the color stability of artificial teeth. A noticeable color mismatch between artificial and natural teeth can result in an unsatisfactory aesthetic outcome, particularly in cases involving removable partial dentures.<sup>[5]</sup>

Discoloration of artificial teeth may result from inadequate oral hygiene and exposure to staining agents. Previous studies have demonstrated that artificial teeth exposed to commonly consumed staining substances, such as coffee, red wine, and tea, exhibit varying degrees of color change, ranging from subtle to significant.<sup>[2,3]</sup> To address extrinsic staining on dentures and artificial teeth, both mechanical and chemical cleaning methods can be employed.<sup>[6]</sup> A variety of chemical denture cleansers are available, including sodium perborate, alkaline hypochlorites, alkaline peroxides, chlorhexidine gluconate, acids, enzymes, and other disinfectants.<sup>[7]</sup> Several studies have evaluated the effectiveness of different denture cleaning agents in removing stains from acrylic resin materials by measuring changes in optical density.<sup>[8,9]</sup> Although findings suggest that most denture cleansers possess stain-removing capabilities, the efficacy of a given product largely depends on its chemical formulation.<sup>[9]</sup>

*Aloe vera* (AV) is an herbal substance traditionally used for various medicinal purposes. It is environmentally friendly, biodegradable, cost-effective, and readily available. Due to these advantages, AV has found widespread application in dentistry. Its potential use as a disinfectant and anti-plaque agent – with minimal or no reported side effects – along with its anti-candidal properties and effectiveness in preventing denture stomatitis, makes it a promising alternative in prosthetic dentistry.<sup>[10]</sup> However, there is limited information regarding the effects of AV gel on the color stability of acrylic resin teeth in comparison to conventional denture cleansers.<sup>[11]</sup> Furthermore, to date, no studies have been identified in the literature that evaluate the stain removal efficacy of AV gel on discolored acrylic teeth.

Color stability is a critical property of many dental materials and can be quantitatively assessed using spectrophotometry or digital colorimetry. The American Dental Association recommends the use of the CIE L\*, a\*, and b\* color system for such digital evaluations.<sup>[12]</sup> In addition to color stability, translucency is another essential

parameter influencing the aesthetic performance of dental materials. Translucency refers to the ability of a material to transmit light while simultaneously scattering it, thereby preventing clear visualization of objects through the material. Like color stability, translucency can be measured using spectrophotometric and colorimetric methods.<sup>[13,14]</sup> Despite the significance of these properties, there is limited data available on how denture cleansers affect the translucency of acrylic resin teeth. Therefore, the aim of this study is to investigate the effects of various denture cleansers on both the color stability and translucency of colored acrylic teeth. The null hypothesis of this study is that there are no statistically significant differences in color stability and translucency among the tested denture cleansers.

## Materials and Methods

This study was conducted at Giresun University Faculty of Dentistry, Department of Prosthodontics, and as this was an *in vitro* investigation, no ethical committee approval was necessary. In the study, maxillary right central incisor acrylic teeth (shade A2) were used, along with three commercially available denture cleansers. Details of the materials used in this study are given in Table 1. Each acrylic tooth was individually numbered, and initial color measurements were obtained before immersion ( $T_0$ ). These baseline color values were recorded against grey, black, and white backgrounds under standardized D65 illumination using a spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Bad Säckingen, Germany). All measurements were performed on the middle third of the labial surface of each specimen, as this region provides the most representative optical characteristics of anterior acrylic teeth.

The coffee staining solution was prepared by dissolving one tablespoon of granulated coffee (Tchibo, Hamburg, Germany) in 200 mL of water, following the manufacturer's instructions. The acrylic specimens were then immersed in the coffee solution and placed in an incubator (Nuve EN 55, Esetron, Ankara, Türkiye) for 6 days to simulate a 1-month daily exposure period (1 month=1 day).<sup>[15]</sup> During the 6-day staining period, the coffee solution was periodically mixed to maintain homogeneity and prevent sedimentation of pigments. Following the staining process, the specimens were removed from the coffee solution, rinsed thoroughly with distilled water, and air-dried. Subsequent color measurements ( $T_1$ ) were performed under the same standardized conditions as the baseline. For each specimen, color readings were taken three times, and the average values of L1\*, a1\*, and b1\* were calculated.

**Table 1.** Materials evaluated in the present study

| Material              | Product                                   | Manufacturer                             | Active ingredients                                                                                                                                                                                                                                     |
|-----------------------|-------------------------------------------|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acrylic denture teeth | NT Optima-A2                              | Toros Dental, Antalya, Türkiye           | Polymethyl methacrylate                                                                                                                                                                                                                                |
| Coffee solution       | Coffee                                    | Tchibo, Hamburg, Germany                 | Granulated coffee                                                                                                                                                                                                                                      |
| Denture cleanser      | Corega tooth cleanser (Group 1)           | Stafford Miller Ltd., Waterford, Ireland | Potassium monopersulfate, sodium bicarbonate, sodium carbonate, sodium carbonate peroxide, TAED, sodium benzoate, polyethylene Glycol-180, sodium lauryl sulfoacetate, polyvinylpyrrolidone/vinyl acetate copolymer, sodium, aroma, colorants          |
|                       | Corega whitening tooth cleanser (Group 2) | Stafford Miller Ltd., Waterford, Ireland | Sodium bicarbonate, citric acid, potassium caroate, sodium carbonate peroxide, sodium carbonate, TAED, sodium benzoate, polyethylene glycol-180, sodium lauryl sulfoacetate, polyvinylpyrrolidone/vinyl acetate copolymer, CI 42090, CI 73015.         |
|                       | Protefix tooth cleanser (Group 3)         | Helago-Pharma GmbH, Erfstadt, Germany    | Sodium bicarbonate, citric acid, potassium caroate, sodium carbonate, sodium carbonate peroxide, TAED, sodium benzoate, poly ethylene glycol-180, sodium lauryl sulfate, Polyvinylpyrrolidone/Vinyl Acetate copolymer, aroma, cellulose gum, colorants |
| Aloe Vera gel         | Ekel Natural (Group 4)                    | Newyork, Paris                           | Aloe vera leaf extract, glycerin, water                                                                                                                                                                                                                |
| Distilled water       | Distilled water (Group 5)                 | –                                        | H <sub>2</sub> O                                                                                                                                                                                                                                       |

CI: Colour index; TAED: Tetraacetythylenediamine.

The acrylic teeth were randomly assigned to five groups (n=10) based on the cleansing method used: Corega (Cleaner) [C], Corega (Whiteness) [CW], Protefix [P], AV, and distilled water [D]. For Groups C, CW, and P, effervescent cleansing solutions were prepared according to the manufacturers' instructions by dissolving one tablet in 200 mL of warm tap water (40°C). Each specimen underwent six immersion cycles, each lasting 90 min, to simulate 6 months of use (total immersion time: 9 h). Similarly, specimens in the AV and D groups were subjected to six 90-min immersion cycles under the same simulated time frame. After each cycle, the cleansing solutions were discarded, and the specimens were rinsed thoroughly under running water. At the conclusion of the final cycle, all specimens were rinsed with distilled water for 3 min, air-dried, and immediately assessed for color stability to prevent dehydration. Final color measurements (T2) were obtained using a spectrophotometer on grey, black, and white backgrounds, under standardized conditions.

The color differences of the specimens were calculated using the following formula CIEDE2000 (2:1:1) ( $\Delta E_{00}$ ):

$$\Delta E_{00} = [(\Delta L' / K_L S_L)^2 + (\Delta C' / K_C S_C)^2 + (\Delta H' / K_H S_H)^2 + R_T (\Delta C' / K_C S_C) (\Delta H' / K_H S_H)]^{1/2}$$

Where  $\Delta L_0$ ,  $\Delta C_0$ , and  $\Delta H_0$  are the differences in lightness, chroma, and hue between the two specimens that were compared.  $S_L$ ,  $S_C$ , and  $S_H$  are the weighting functions for the lightness, chroma, and hue components, respectively.

$K_L$ ,  $K_C$ , and  $K_H$  are the parametric factors to be adjusted according to different viewing parameters. In the current study,  $K_L=2$ ,  $K_C$ , and  $K_H$  were set to 1.<sup>[16]</sup>

The translucency differences of the specimens were calculated using the following translucency parameter (TP):

$$TP = [(L_b - L_w)^2 + (a_b - a_w)^2 + (b_b - b_w)^2]^{1/2}$$

Where L, a, and b are the color space indicators. The b and w denote black- and- white backgrounds.<sup>[16]</sup>

Data were analyzed using the Statistical Package for the Social Sciences (SPSS Inc., Version 23, Chicago, IL, USA). The Shapiro–Wilk test was used to assess the normality of the data distribution for color difference ( $\Delta E_{00}$ ) and TP values within each group. For intergroup comparisons of color changes ( $\Delta E_1$  and  $\Delta E_2$ ) and translucency values (TP<sub>1</sub> and TP<sub>2</sub>), one-way analysis of variance (ANOVA) was employed. When statistically significant differences were detected among the groups, Tukey's honestly significant difference (HSD) *post hoc* test was applied to identify specific group differences. In addition, paired sample t-tests were conducted to compare intra-group translucency changes before and after the cleaning procedures (TP<sub>1</sub> vs. TP<sub>2</sub>). All data were reported as means±standard deviations.

## Results

A total of fifty maxillary right central incisor acrylic teeth (shade A2) were used, along with three commercially

**Table 2.** The means and standard deviations of color differences

| Groups       | C         | CW        | p         | AV        | D         |
|--------------|-----------|-----------|-----------|-----------|-----------|
| $\Delta E_1$ | 1.83±0.55 | 1.81±0.55 | 1.95±0.63 | 1.80±0.39 | 1.96±0.47 |
| $\Delta E_2$ | 0.94±0.39 | 0.95±0.41 | 0.87±0.46 | 1.02±0.35 | 0.67±0.21 |

CW: Corega whiteness; AV: *Aloe vera*.

**Table 3.** The means and standard deviations of translucency parameters

| Groups          | C                       | CW                      | P                       | AV                      | D                       |
|-----------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| TP <sub>1</sub> | 0.87±0.30 <sup>Aa</sup> | 0.82±0.18 <sup>Aa</sup> | 0.94±0.26 <sup>Aa</sup> | 0.78±0.21 <sup>Aa</sup> | 0.79±0.13 <sup>Aa</sup> |
| TP <sub>2</sub> | 0.77±0.29 <sup>Aa</sup> | 0.61±0.20 <sup>Ab</sup> | 0.72±0.25 <sup>Aa</sup> | 1.15±0.21 <sup>Bb</sup> | 0.71±0.19 <sup>Aa</sup> |

Superscript uppercase letters in rows show differences between dental cleaners. Superscript lowercase letters in the column show differences between the Translucency Parameters. No significant differences were found between groups with the same letter ( $p < 0.05$ ). CW: Corega whiteness; AV: *Aloe vera*.

available denture cleansers, AV gel, and distilled water, as outlined in Table 1. Table 2 presents the mean and standard deviation values for the color differences between baseline and post-staining measurements ( $\Delta E_1$ :  $T_0-T_1$ ), and between post-staining and post-cleaning measurements ( $\Delta E_2$ :  $T_1-T_2$ ) for all test groups.

Following immersion in the coffee solution, all groups exhibited color changes exceeding the clinically acceptable threshold ( $\Delta E_{00} > 1.8$ ), indicating perceptible discoloration. After application of the cleansing methods, a visually perceptible improvement in color ( $\Delta E_{00} > 0.8$ ) was observed in all groups except for the distilled water group.<sup>[17]</sup>

The Shapiro–Wilk test confirmed that the data were normally distributed. One-way ANOVA was conducted to assess differences in color stability ( $\Delta E$  values) among the groups, revealing no statistically significant differences ( $p = 0.367$ ).

For translucency analysis, Shapiro–Wilk test results indicated that both TP<sub>1</sub> (translucency after staining) and TP<sub>2</sub> (translucency after cleaning) values were normally distributed. One-way ANOVA showed no statistically significant differences among TP<sub>1</sub> values ( $p = 0.565$ ). However, a statistically significant difference was observed among the TP<sub>2</sub> groups ( $p < 0.05$ ). Tukey's HSD *post hoc* test identified the AV group as being significantly different from the other groups.

A paired t-test was used to evaluate intra-group differences in translucency before and after cleansing. Statistically significant changes in translucency were found in the Corega Whiteness (CW) group ( $p = 0.039$ ) and the AV group ( $p = 0.007$ ). No significant differences were observed in the remaining groups ( $p > 0.05$ ).

The means and standard deviations for TP<sub>1</sub> and TP<sub>2</sub> values are summarized in Table 3.

## Discussion

In the present study, acrylic resin teeth were stained using a coffee solution and subsequently subjected to cleaning protocols involving various commercial denture cleansers, distilled water, and AV gel. The effectiveness of each cleansing method was evaluated by assessing color differences ( $\Delta E$ ) and changes in TP. Based on the results, the null hypothesis – stating that there would be no significant differences in color stability and translucency among the tested denture cleansers – was partially rejected. Although no statistically significant differences were found among the groups in color stability ( $\Delta E$ ), significant differences were observed in translucency changes, TP, particularly following the use of AV gel and CW. These findings suggest that while most cleansing agents performed similarly in stain removal, their impact on the translucency of acrylic resin teeth may vary significantly. These findings indicate that AV gel is not only a natural and biocompatible alternative to chemical cleansers but also comparable in terms of color stability. The highest  $\Delta E_2$  value observed in the AV group supports its potential as an effective stain-removing agent. This may encourage the broader use of plant-based products in prosthetic hygiene, particularly among patients who prefer biocompatible options or exhibit sensitivity to chemical agents.

Extrinsic factors, such as the absorption and the absorption of stains from external sources, continue to present significant challenges to the aesthetic longevity of dental restorations. Numerous studies have evaluated the discoloration of acrylic denture teeth when exposed to various staining agents, including beverages such as coffee, cola, black tea, orange juice, and red wine, as well as food colorants like tartrazine and erythrosine.<sup>[18–21]</sup> Among these, coffee has been consistently identified as the most

potent staining agent. Due to its strong chromogenic potential and widespread consumption in daily life, the coffee solution was selected as the staining medium in the present study.<sup>[22]</sup> In this study, all groups exhibited  $\Delta E$  values exceeding the clinically acceptable threshold following coffee immersion, reaffirming the high staining potential of coffee on acrylic teeth. This emphasizes the importance of using effective cleansers for patients who consume chromogenic beverages frequently.

Patients have access to a variety of agents for cleaning dentures, including effervescent cleansing tablets, chlorhexidine gluconate, glutaraldehyde, sodium perborate, povidone-iodine, and neutral soap, which can be used either after each removal or as part of a daily hygiene routine.<sup>[23,24]</sup> In addition to these conventional options, natural products such as AV gel, white vinegar, coconut oil, and olive oil have also been suggested as economical alternatives for denture hygiene.<sup>[25,26]</sup> Mahboub et al.<sup>[11]</sup> evaluated the discoloration effects of chlorhexidine and AV gel on acrylic teeth and concluded that AV gel was an acceptable agent for denture cleaning. However, there is still a lack of studies specifically investigating the stain-removal efficacy of AV gel. The stain-removal effectiveness of Corega tablets has been documented, although prior research primarily compared chemical and mechanical cleaning methods.<sup>[27]</sup> In the present study, three types of effervescent denture cleansers with different active ingredients, AV gel – known for its disinfectant properties and minimal reported side effects – and distilled water as a control group were evaluated. An immersion technique was applied uniformly across all groups to assess their effects on stained acrylic denture teeth. Notably, in addition to the color change observed in the AV group, an increase in translucency following cleaning was also detected. While other groups demonstrated a decrease in TP values, the AV group showed improved translucency. This suggests that AV may possess surface-preserving or even optical-enhancing properties. Such an effect could be particularly advantageous when treating patients with high aesthetic expectations. Moreover, AV gel may be more suitable for patients with chemical sensitivities, xerostomia, or systemic conditions in which mucosal tolerance and material biocompatibility are important.

Researchers have reported that the CIEDE2000 ( $\Delta E_{00}$ ) formula offers improved accuracy and sensitivity in evaluating color differences compared to the older CIELAB system.<sup>[16]</sup> Therefore, in the present study, color differences ( $\Delta E_{00}$ ) were calculated using the CIEDE2000 formula. According to established thresholds, the perceptibility

threshold and acceptability threshold for CIEDE2000 are  $\Delta E_{00}=0.8$  and  $\Delta E_{00}=1.8$ , respectively.<sup>[28]</sup> Among the groups tested, the AV group demonstrated the highest stain removal efficacy. This effect may be attributed to the presence of saponin, a high-molecular-weight glycoside found in AV gel, known for its cleansing and surfactant properties.<sup>[29]</sup> Although saponins appear to play a major role, other constituents of the gel may also have minor supporting effects. Moreover, the ability of AV gel to remove stains effectively without compromising – and even enhancing – translucency supports its aesthetic advantages in removable prosthodontics. For long-term clinical success, cleansing agents must not only be effective but also preserve the optical properties of dental materials. AV appears to meet both criteria.

Translucency plays a critical role in the aesthetic and natural appearance of artificial teeth; therefore, clinicians should consider this parameter alongside color stability when selecting or evaluating dental materials. A higher TP value indicates greater translucency and reduced opacity. For tooth-colored restorative materials, TP<sub>00</sub> values of  $\leq 2.6$  are considered clinically acceptable.<sup>[30]</sup> In the present study, TP<sub>00</sub> values decreased in all groups following the cleaning procedures, with the exception of the AV group, which showed no reduction in translucency. Notably, the CW group exhibited a significantly greater decrease in TP compared to the other groups. The notable drop in translucency observed in the CW group may be due to the abrasive or acidic components, such as citric acid and sodium carbonate peroxide, in its formula, which might have altered the surface integrity of the acrylic teeth. The cleansing ability of AV gel is primarily attributed to its natural surfactant content. These components may also contribute to maintaining surface gloss and integrity, explaining the increased translucency observed in this group. This result underlines the need to balance cleaning power with preservation of material aesthetics, especially in patients requiring long-term prosthetic use. Despite these differences, all groups remained within the acceptable translucency threshold.

A limitation of this study is the absence of thermal aging, which could potentially influence both stain-removal efficacy and translucency outcomes. Moreover, the antimicrobial or plaque-removal efficacy of the cleansing agents, particularly AV gel, was not assessed. Additionally, this *in vitro* study did not simulate the mechanical forces or dynamic oral conditions such as brushing, salivary enzymes, temperature fluctuations, or dietary variations, all of which may influence the long-term optical properties of acrylic

resin teeth. The study also focused solely on a single tooth shade (A2) and one type of acrylic resin tooth, which limits the generalizability of the findings across other materials, shades, or denture tooth brands. Differences in polymer composition, cross-linking density, and surface finish among manufacturers may influence optical outcomes such as color stability and translucency, and similar findings may not be directly extrapolated to other brands. Moreover, variations among different shade scales or systems may also influence the optical outcomes. Further research is warranted to explore the long-term optical, antibacterial, and microbiological effects of AV gel on denture materials under simulated or real-life oral conditions.

## Conclusion

Within the limitations of this *in vitro* study, all tested denture cleansers removed more stains from acrylic resin teeth than distilled water, with AV gel showing the highest level of color improvement, although the differences were not statistically significant. Only AV gel preserved or slightly increased translucency, while all other cleansers caused a decrease, most notably with CW. Clinically, these findings highlight AV gel as a biocompatible, cost-effective, and esthetically favorable denture-cleansing option, especially for patients with high aesthetic demands or sensitivities to chemical agents. Its ability to effectively remove stains while maintaining the optical properties of acrylic teeth supports its inclusion in daily denture hygiene protocols.

Given its demonstrated biocompatibility and cleaning efficacy, AV gel holds potential for incorporation into future denture cleanser formulations. However, additional studies on formulation optimization, product stability, and antimicrobial performance are necessary before commercial application.

**Ethics Committee Approval:** As this study was an *in vitro* investigation conducted in the field of prosthodontics, ethics committee approval was not required.

**Informed Consent:** Informed consent was not required because this was an *in vitro* study and did not involve human participants.

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# Voice and Hearing Outcomes in Nasopharyngeal Cancer Survivors: A Cross-Sectional Evaluation

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## Abstract

**Introduction:** The study aims to evaluate and compare the voice and hearing outcomes in nasopharyngeal cancer survivors treated with radiotherapy (RT) or chemoradiotherapy with a healthy control group.

**Methods:** This cross-sectional study recruited 21 patients with a history of nasopharyngeal carcinoma (NPC) who received RT or chemoradiotherapy and 19 control subjects matched for age. Voice evaluation was performed using perceptual and acoustic measures, and hearing function was assessed using pure tone audiometry.

**Results:** The NPC group exhibited significantly poorer voice quality, as indicated by higher perceptual scores (GRBAS scale), higher self-reported voice handicap (voice handicap index - 10 scale), and increased frequency perturbation (%jitter) compared to the control group. Significant differences were also observed in other acoustic parameters, including fundamental frequency, amplitude perturbation (% shimmer), and noise-to-harmonic ratio. Hearing loss was more prevalent in the nasopharyngeal cancer group, particularly at high frequencies. Some correlations were observed between certain acoustic voice parameters and hearing thresholds, particularly in the nasopharyngeal cancer group. However, a consistent pattern across all parameters was not evident.

**Discussion and Conclusion:** Nasopharyngeal cancer survivors treated with RT or chemoradiotherapy experience significant voice and hearing impairments compared to healthy controls. These findings highlight the importance of routine voice and hearing evaluations for this patient population.

**Keywords:** Cancer; Hearing; Nasopharynx; Radiotherapy; Voice

The nasopharynx is a unique anatomical site that influences both hearing and voice, and its disorders can disrupt communication by altering any or both of these

two functions. Different nasopharyngeal pathologies are studied for problems of hearing and voice, and examining these in nasopharyngeal cancer survivors could add to our

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knowledge to understand the physiology of hearing, voice, and the relationship between them.

Nasopharyngeal carcinoma (NPC) is a relatively uncommon cancer and 70% of the cases are seen in East and Southeast Asia, while the incidence rate is 0.4/100,000 in the Caucasian population.<sup>[1]</sup> The primary treatment for NPC is radiotherapy (RT), often combined with chemotherapy (CT) based on the stage.<sup>[2]</sup> These treatments, while effective, pose challenges due to their impact on auditory and vocal functions. Communication problems affecting quality of life are observed in NPC patients, stemming either from the tumor itself or therapy side effects. The effects of RT on the external ear, middle ear, and inner ear can result from changes such as fibrosis and neural loss following cell damage.<sup>[3,4]</sup> Side effects occurring 90 days after the end of RT are defined as late side effects.<sup>[5]</sup> In addition, because RT targets both the primary nasopharyngeal site and the adjacent neck regions to address potential lymphatic metastases, RT-induced tissue damage often extends across broader anatomical areas. The most common side effect of neck irradiation is xerostomia, a result of diminished salivary function, which can significantly alter the human voice.<sup>[6]</sup>

Most of the studies on NPC survivors are focused on hearing problems. In general, the studies of the voice of these patients are limited to a small number of cases in non-laryngeal head-and-neck cancer studies. It is recognized that the voices of post-RT non-laryngeal cancer patients may be compromised more than the voices of post-RT early glottic cancer patients.<sup>[7]</sup> There is a need for voice evaluation data according to anatomical localization after RT/completed RT (CRT), as discussed in the literature<sup>[8]</sup> in terms of nasopharyngeal localization.

There are several possible explanations for how the RT affects voice in NPC patients. Radiation may affect either the phonation changing the biomechanical properties of the vocal folds or the resonance by altering the whole vocal tract.<sup>[9]</sup> Furthermore, the side effects involving the cortical brain and tracts down to the cranial nerves, although thought to be clinically rare previously, have been shown to be quite effective in voice changes in NPC patients.<sup>[10]</sup> In addition, it is established that hearing loss (HL) affects the voice in different patient groups.<sup>[11,12]</sup>

Today, with more tailored treatment modalities and the increase in successful treatments, there is an increase in the number of survivors seeking help for their voice and/or hearing problems. Even after the successful treatment of NPC, the problems affecting the quality

of life of these individuals are observed.<sup>[13]</sup> Successful treatment of NPC is achieved. To reach the level of success in the field of rehabilitation, especially for voice and hearing problems, studies need to be done to clarify the problems of the survivors.

The study's purpose is to answer the following clinical question: "Among patients with post-RT NPC, does the voice characteristics and hearing, when compared with a group of individuals without any RT history, are different?" It is hypothesized that long-term voice and hearing outcomes after treatment of NPC subjects are different from the control subjects. This study aimed to estimate and compare clinician- and patient-reported voice perception, acoustic parameters, and audiometric findings between subjects who received RT for NPC and those who did not. In addition, the effects of HL on the aforementioned voice parameters were investigated and compared between the two groups using these data.

## Materials and Methods

The study was conducted as a cross-sectional evaluation to compare voice and hearing outcomes between NPC survivors and a healthy control group. The sample for the study group (NPC group) consisted of subjects who completed curative-intent RT or chemoradiotherapy during the specified study period and presented for long-term follow-up and were examined for follow-up visits in the otorhinolaryngology outpatient clinic of a tertiary hospital. All outcome measures, including voice analysis and audiologic assessments, were collected at a single point in time during these follow-up visits. To minimize selection bias, all consecutive patients who visited the clinic during the study period and met the inclusion and exclusion criteria described below were included in this cross-sectional study. Hospital staff and patient companions, who matched this study group in terms of age, and who had no complaints/signs related to hearing and voice problems before, were recruited as the control group. This study was approved by the Ankara Yıldırım Beyazıt University (Date: 21.11.2018, Decision no: 12). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Data collection of the study was conducted between November 2018 and January 2020. Individuals in both the study group and the control group were included voluntarily by explaining the purpose of the study. The data were collected after obtaining their informed consent. All consecutive NPC survivors who had RT or CRT

at the tertiary care center were screened initially. To ensure a homogenous study group and minimize confounding factors, specific selection criteria were applied. The inclusion criteria for the study group were:

- Being male
- Aged 19–55 years<sup>[4]</sup>
- Being a non-smoker or having quit smoking for at least 1 year at the time of assessment
- Being at least 3-month post-treatment.

The criteria for exclusion from the study group were:

- History of surgical treatment for NPC
- History of chronic otitis media before the diagnosis of NPC
- History of HL noticed/diagnosed before the disease (except for the initial otological signs and symptoms leading to the NPC diagnosis)
- History of additional treatment for recurrent/residual cancer after initial diagnosis and treatment
- Vocal fold mobility disorder detected by routine nasopharyngolaryngoscopy in the follow-up examination

The criteria for exclusion from both groups were:

- Being female
- Age outside 19–55 years range
- Current smoking (or has quit in the last year)
- History of having comorbid diseases (systemic diseases, such as diabetes mellitus) or using medications that will cause hearing or voice problems
- History of otological intervention (myringotomy, pressure equalizing tube placement, myringoplasty/tympanoplasty, or further otological/neuro-otological surgery)
- Having any experience using a hearing aid
- Any complaint/diagnosis related to voice, history of voice surgery, or comorbid condition that may affect voice (including history of thyroidectomy, basal ganglia diseases).

To compare the NPC group with control subjects in terms of acoustic analysis, subjects with vocal fold mobility disorders were excluded, as these disorders cause asymmetries in vocal fold tension that may affect pitch, vocal fatigue, and intensity of phonation. The ages of the individuals in the study and control groups; the stages of the individuals in the study group at the time of diagnosis, the status of receiving RT and/or CRT, the status of receiving additional

CT, the time from treatment to the date of evaluation in months, having a complaint of “dry mouth” (xerostomia grading according to Common Terminology Criteria for Adverse Effects Version 3 – CTCAE v3.0) were recorded.<sup>[5]</sup>

## Voice Analysis

The procedures and the tasks expected to be completed were explained to the subjects by the researcher, with examples. Voice samples of subjects were obtained in the audiometric booth with the “Audio Technica AT2005USB dynamic microphone” and “Audacity v.2.2.0 software” program. The recording format is uncompressed digital recording (.wav extension), sampling rate 44 100 Hz, quantization (bit resolution) 16 bit, and recorded in mono-channel. The distance between the microphone and the mouth was recorded as 5 cm. In the booth, after a short conversation about their daily activities, subjects were asked to sit upright but in a comfortable position, breathe comfortably, and read the first paragraph of the “Diyet Passage,” a standard phonetically balanced Turkish text for voice studies, at a comfortable pitch and loudness.<sup>[14]</sup> After that, they were asked to pronounce the open-mid back unrounded vowel (/ʌ/) for at least 3 seconds at modal phonation (typical pattern of vocal fold vibration used in normal speech production, characterized by balanced tension and airflow). After three repetitions, the recording, which was thought to best reflect the individual’s voice, was kept in the computer for acoustic analysis.

After taking samples for voice analysis, individuals who were taken out of the cabin were asked to fill in the printed version of the voice handicap index-10 (VHI-10) scale, of which Turkish validity and reliability had been evaluated before.<sup>[15]</sup> VHI-10 measures the patient’s subjective assessment of voice-related quality of life. The total score was recorded.

Perceptual voice evaluation was made by the GRBAS scale based on the passage readings, and the results were recorded. The GRBAS scale evaluates voice quality based on five perceptual parameters. These were rated by a researcher experienced in voice studies for over 10 years.

Audio recording samples of the vowel /ʌ/ were analyzed in a computer using the “Customized Praat” version<sup>[16]</sup> based on Praat software (<http://www.fon.hum.uva.nl/praat/>, version 4.8, Paul Boersma and David Weenik, Phonetic Sciences Department, University of Amsterdam). A mid-2-second segment of each sample was analyzed. Fundamental frequency (F0), jitter and shimmer percentage values of individuals, and the average Noise-Harmonic ratio (NHR) were calculated.

## Otological Examination and Audiological Tests

An otoscopic examination was performed before the audiological tests. It was confirmed that no pathology in the external ear canal that would affect the audiological test result, and there was no tympanic membrane perforation. An acoustic immittance test was performed with the Maico MA 34 Tympanometry device with a 226 Hz probe tone. Pure tone audiometry was performed in a soundproof audiometry booth with the Resonance r37a Audiometer device. Airway hearing was assessed in the range of 500–6000 Hz using supra-aural headphones (TDH-39). Bone conduction hearing measurement was assessed in the range of 500–4000 Hz with a B71 bone transducer/P-333 head circle. Pure tone averages (PTA) were calculated by taking 500, 1000, 2000, and 4000 Hz hearing threshold averages. Degree of HL was classified according to a scale previously defined for late complication classification.<sup>[17]</sup> The minimum of the air conduction hearing thresholds (and PTA) of both ears was selected for each subject to make a correlation analysis between the hearing threshold level and the acoustic analysis data of the subject's voice.

## Statistical Analysis

Descriptive statistics were given as median, interquartile range, minimum, maximum, frequency, and percentage. The conformity of continuous variables to the normal distribution was evaluated with the Shapiro–Wilk test. Comparisons between groups of continuous variables were made with Mann–Whitney U-test in the independent groups.

A primary methodological consideration was the potential interdependence of data from two ears of the same subject. To maintain the statistical assumption of independent observations for intergroup comparisons, a two-step approach was adopted. First, hearing thresholds from all ears were presented for descriptive purposes only. Second, for all analytical intergroup comparisons and correlation analyses, the better ear, defined as the ear with the lower PTA, was selected for each subject (patient and control groups). The linear relationship between the variables was evaluated with Spearman's correlation test. A  $p < 0.05$  was accepted for statistical significance. Statistical analysis was done with IBM Statistical Package for the Social Sciences version 21.0 (IBM Corp. Released 2012. Armonk, NY, USA) program.

## Results

Twenty-one subjects who received NPC treatment (RT or CRT) in the study group and 19 subjects in the control group participated in the study. All subjects were male.

The median age of the study group was 46 (21–55) years, while the median age of the control group was 45 (18–55) years. The median time from the end of treatment to the evaluation date of the subjects in the study group was 48 (3–225) months. All subjects in the study group had grade 1 xerostomia described as "Symptomatic (e.g., dry or thick saliva) without significant dietary alteration," according to the CTCAE v5.0. None of the control subjects had dry mouth or thick saliva complaints.

At the time of diagnosis, 76.2% of the subjects ( $n=16$ ) in the study group were recorded as the advanced stage (Stages III, IVa, IVb; 57.1%, 14.3%, 4.8%, respectively). Five subjects (23.8%) were recorded as Stage II, and there was no Stage I subject. Of all cases in the study group, 71.5% ( $n=15$ ) received concurrent CT, and 19% ( $n=4$ ) received adjuvant CT. Two subjects (9.5%) did not receive any CT. A total of 240 mg/m<sup>2</sup> cisplatin were administered as the CT agent, divided into weekly doses, to the subjects receiving treatment in the center where the study was conducted.

As the number of subjects falling into some stages was low, the voice evaluation and hearing evaluation data of the study group were not statistically examined according to the NPC stages. Since the vast majority of patients received concomitant CRT and the number of subjects in the RT-only and adjuvant CRT subgroups was insufficient for a separate statistical comparison, the study group was evaluated as a single entity regardless of the specific treatment modality.

All patients were treated with intensity-modulated RT. Gross tumor volume for the primary tumor and involved cervical lymph nodes was delineated using positron emission tomography-computed tomography and MRI. The clinical target volume (CTV) encompassed the GTV plus a 1–1.5 cm margin, the entire nasopharyngeal region, and all lymph-node areas with metastatic involvement. Planning target volumes were generated by expanding the CTV by 0.5 cm. The prescribed radiation dose was 69.96 Gy (2.12 Gy/fraction, once daily) for the GTV and 54–60 Gy (1.63–2 Gy/fraction, once daily) for the CTV. In addition, organs at risk – including the brainstem, spinal cord, parotid glands, eyes, optic chiasm, optic nerves, cochleae, middle ear, and inner ear structures – were contoured on the planning CT.

The voice evaluation data of the study group and the control group and the statistical significance of the difference between the data are shown in Table 1. Perceptual assessment (GRBAS scale scores), voice self-assessment (VHI - 10 scores), and acoustic analysis data of individuals were statistically significantly different between the two groups. To speak with the normative values, the VHI-10 score was higher than 11 (which is the cut-off value of the pathological finding), in

**Table 1.** Voice evaluation data of subjects

|                | NPC group<br>(n=21) median<br>(IQR) [min-max] | Control group<br>(n=19) median<br>(IQR) [min-max] | p     |
|----------------|-----------------------------------------------|---------------------------------------------------|-------|
| GRBAS          | 4 (3)<br>[2–13]                               | 2 (2)<br>[0–7]                                    | 0.002 |
| VHI – 10       | 9 (19)<br>[0–38]                              | 1 (6)<br>[0–21]                                   | 0.004 |
| F <sub>0</sub> | 122.61 (38.31)<br>[96.6–219.8]                | 135.03 (17.87)<br>[105.9–211.9]                   | 0.039 |
| % jitter       | 0.490 (0.485)<br>[0.21–3.90]                  | 0.271 (0.151)<br>[0.15–2.01]                      | 0.000 |
| % shimmer      | 1.879 (1.543)<br>[0.94–14.90]                 | 1.514 (0.734)<br>[0.67–6.20]                      | 0.039 |
| Mean NHR       | 0.0079 (0.0082)<br>[0.002–0.274]              | 0.0033 (0.0037)<br>[0.001–0.048]                  | 0.003 |

NPC: Nasopharyngeal carcinoma; IQR: Interquartile range; Min: Minimum; Max: Maximum; GRBAS: Grade roughness breathiness asthenia scale score; VHI-10: Vocal handicap index – 10 score; F<sub>0</sub>: Fundamental frequency; NHR: Noise-to-harmonic ratio.

10 of 21 individuals in the study group. In the control group, 3 out of 19 individuals had a VHI-10 score higher than 11. The NPC group exhibited significantly higher jitter values compared to controls ( $p < 0.001$ ; Table 1). We could not compare our acoustic measurements to any cut-off points defined by previous literature data, which would vary with the recording conditions and individual factors (age, sex, race, ethnicity, dialect, geographic location).<sup>[18]</sup>

Air conduction (AC) PTA was <25 dB in 18 of 42 ears in the study group. Mild HL (AC 26–40 dB) was detected in a total of 14 ears (sensorineural HL in 5 ears, conductive HL in 5 ears, and mixed HL in 4 ears). Moderate HL (AC 41–55 dB) was detected in a total of 8 ears (sensorineural HL in 4 ears and mixed HL in 4 ears). Severe HL (AC 56–70 dB) was not detected. There was sensorineural HL in two ears with profound HL (AC >71 dB).

According to the HL type, there was sensorineural HL in 11 ears, conductive HL in 5 ears, and mixed HL in 8 ears.

HL (>25 dB air-conduction threshold) was detected at low-frequency hearing thresholds (500–1000–2000 Hz) in 20 (47.6%) of 42 ears of study subjects. HL at high-frequency hearing thresholds (4000–6000 Hz) was detected in 37 (88%) of them.

In the control group, AC was found to be <25 dB in 36 of 38 ears, and mild mixed HL is present in the other two ears. Air and bone conduction thresholds and PTA were depicted for the ears of two groups in Table 2.

**Table 2.** Pure tone audiometry data of the ears in dB

|                     | NPC group<br>(42 years) median<br>(IQR) [min-max] | Control group<br>(38 years) median<br>(IQR) [min-max] |
|---------------------|---------------------------------------------------|-------------------------------------------------------|
| A500 Hz             | 15 (20)<br>[0–65]                                 | 10 (6)<br>[0–40]                                      |
| A1000 Hz            | 20 (23)<br>[0–65]                                 | 10 (10)<br>[0–25]                                     |
| A2000 Hz            | 20 (21)<br>[0–70]                                 | 10 (11)<br>[0–35]                                     |
| A4000 Hz            | 47.5 (40)<br>[5–100]                              | 22.5 (25)<br>[0–65]                                   |
| A6000 Hz            | 52.5 (36)<br>[10–110]                             | 22.5 (30)<br>[0–60]                                   |
| B500 Hz             | 10 (20)<br>[0–45]                                 | 5 (10)<br>[0–40]                                      |
| B1000 Hz            | 15 (15)<br>[0–45]                                 | 10 (6)<br>[0–20]                                      |
| B2000 Hz            | 12.5 (20)<br>[5–60]                               | 5 (30)<br>[0–30]                                      |
| B4000 Hz            | 40 (30)<br>[5–75]                                 | 20 (25)<br>[0–60]                                     |
| Air conduction PTA  | 27 (21)<br>[6–75]                                 | 15 (10)<br>[0–31]                                     |
| Bone conduction PTA | 18.75 (14)<br>[8–51]                              | 11.25 (10)<br>[0–25]                                  |

NPC: Nasopharyngeal carcinoma; IQR: Interquartile range; Min: Minimum; Max: Maximum; PTA: Pure tone average; A: Air conduction threshold; B: Bone conduction threshold.

The minimum of the air conduction hearing thresholds (and PTA) of both ears selected for each subject, to represent the better-ear, is shown in Table 3, and is statistically significantly different between the two groups, except for 3 of the 10 parameters.

Correlations between voice evaluation data are shown in Table 4. Both in the study group and control group, GRBAS was correlated with F<sub>0</sub>, whereas VHI-10 score was correlated with %shimmer and mean NHR. There was also a strong correlation between the GRBAS score and the VHI-10 scores in the NPC group ( $r_s = 0.498$ ,  $p = 0.022$ ).

For the association between hearing status and voice, voice parameters were analyzed according to the degree of HL. The distributions of the voice evaluation data were the same across the hearing level degrees in both groups. Further analysis was conducted. The correlations between voice evaluation data and audiometric data are shown in Table 5.

**Table 3.** The air conduction hearing thresholds (and PTA) of the better ear for each subject in dB

| Minimum thresholds (dB) | NPC group (n=21)       |                | Control group (n=19)   |                | p                |
|-------------------------|------------------------|----------------|------------------------|----------------|------------------|
|                         | Median (IQR) [min-max] | M±SD           | Median (IQR) [min-max] | M±SD           |                  |
| A500 Hz                 | 10 (20)<br>0–60        | 16.43<br>14.15 | 5 (5)<br>[0–20]        | 7.89<br>5.84   | <b>0.027</b>     |
| A1000 Hz                | 15 (18)<br>0–65        | 17.38<br>15.05 | 10 (10)<br>[0–25]      | 7.63<br>6.53   | <b>0.012</b>     |
| A2000 Hz                | 15 (20)<br>0–70        | 18.81<br>16.65 | 10 (10)<br>[0–30]      | 10.53<br>8.31  | 0.088            |
| A4000 Hz                | 40 (43)<br>5–95        | 44.05<br>24.11 | 20 (25)<br>[0–55]      | 16.46<br>14.98 | <b>0.004</b>     |
| A6000 Hz                | 45 (35)<br>10–110      | 47.86<br>26.39 | 15 (25)<br>[0–15]      | 20.00<br>16.41 | <b>&lt;0.001</b> |
| B500 Hz                 | 10 (8)<br>0–35         | 11.67<br>9.26  | 5 (10)<br>[0–15]       | 5.26<br>4.55   | <b>0.016</b>     |
| B1000 Hz                | 10 (10)<br>0–45        | 12.38<br>12.00 | 5 (10)<br>[0–15]       | 6.32<br>4.66   | 0.088            |
| B2000 Hz                | 10 (35)<br>5–70        | 16.19<br>14.13 | 5 (5)<br>[0–30]        | 8.68<br>7.23   | 0.078            |
| B4000 Hz                | 40 (35)<br>5–70        | 36.43<br>19.31 | 15 (20)<br>[0–50]      | 19.74<br>14.57 | <b>0.005</b>     |
| Air conduction PTA      | 21 (19)<br>[6–73]      | 25.20<br>15.70 | 11 (11)<br>[0–25]      | 12.79<br>6.63  | <b>0.002</b>     |

NPC: Nasopharyngeal carcinoma; IQR: Interquartile range; Min: Minimum; Max: Maximum; M: Mean; SD: Standard deviation; PTA: Pure tone average; A: Air conduction threshold; B: Bone conduction threshold.

In the NPC study group, there were relations between some frequency parameters and some audiometric thresholds (F0: 1000 Hz, 4000 Hz air conduction thresholds and 1000 Hz bone conduction threshold, %jitter: Minimum PTA, 2000 Hz, 4000 Hz, 6000 Hz air conduction thresholds and 2000 Hz bone conduction threshold), whereas there was no such relationship in the control group.

A relationship was found between the GRBAS score and only 1000 Hz bone conduction thresholds in the NPC study group. No relationship with GRBAS score was found in the control group.

While there was no relationship between VHI-10 scores and audiometric data in the NPC study group, there was a relationship between VHI-10 scores and the following thresholds of the control group: 4000 Hz and 6000 Hz air conduction thresholds and 4000 Hz bone conduction thresholds.

## Discussion

This study aimed to investigate the long-term impact of RT on voice characteristics and hearing in patients with NPC. We hypothesized that NPC patients who underwent RT would exhibit significant differences in voice and hearing compared to a healthy control group. This study sought to estimate and compare voice perception (clinician and patient-reported), acoustic voice measures, and audiometric data between individuals with and without a history of RT for NPC, while also investigating the impact of HL on these voice parameters in both groups. Due to the nature of our data, we interpret our findings as a cross-sectional assessment of the presence of voice and hearing impairments in long-term NPC survivors rather than a strict analysis of the long-term impact or temporal progression of RT/CRT. In this respect, we aimed to ensure consistency between our stated aim and the limitations imposed by the study design.

Our findings revealed significant differences in voice characteristics between the NPC group and the control group. Perceptual assessments (GRBAS), patient-reported outcomes (VHI-10), and objective acoustic measures (e.g., jitter, shimmer, NHR) all indicated poorer voice quality in the NPC group.

The relationship between nasal and nasopharyngeal pathologies (allergic rhinitis, adenoid hypertrophy, and the conditions that cause velopharyngeal insufficiency such as cleft palate) and voice disorders has been the subject of many studies.<sup>[19,20]</sup> It has been determined that diseases of this anatomic site, which is generally accepted as related to the resonance component of the voice, affect not only the resonance but also other components of the voice. Parameters, including F0, which is related to the phonation component of the voice, are found to be affected.<sup>[19]</sup> Many explanatory mechanisms, from upper respiratory tract reflexes to hyper-functional voice and related problems that develop to compensate for increased intraoral pressure, have been presented as hypotheses. However, it has not been possible to reach a clear judgment on this issue yet.

Even non-cancerous pathologies of the region that is the subject of this study can cause such disorders, while the addition of treatment with side effects such as RT complicates the situation even more.

When compared with normal individuals of the same age and sex, it has been shown that the individuals who have undergone wide-field RT due to non-laryngeal tumors of the head and neck have significant vocal dysfunction.<sup>[7,21]</sup> When the voice values of individuals who received narrow-field RT directly to the larynx for early-stage glottic tumors and those who received wide-field RT for non-laryngeal

**Table 4.** Correlations between voice evaluation data

|          | NPC group (n=21) |              |              |          |              | Control group (n=19) |              |              |          |       |
|----------|------------------|--------------|--------------|----------|--------------|----------------------|--------------|--------------|----------|-------|
|          | F <sub>0</sub>   | %jit         | %shim        | Mean NHR | GRBAS        | F <sub>0</sub>       | %jit         | %shim        | Mean NHR | GRBAS |
| %jit     | -0.201           |              |              |          |              | -0.218               |              |              |          |       |
|          | 0.382            |              |              |          |              | 0.371                |              |              |          |       |
| %shim    | 0.250            | <b>0.561</b> |              |          |              | 0.242                | 0.419        |              |          |       |
|          | 0.274            | <b>0.008</b> |              |          |              | 0.318                | 0.074        |              |          |       |
| Mean NHR | 0.049            | <b>0.662</b> | <b>0.854</b> |          |              | -0.228               | <b>0.859</b> | <b>0.530</b> |          |       |
|          | 0.832            | <b>0.001</b> | <b>0.000</b> |          |              | 0.347                | <b>0.000</b> | <b>0.020</b> |          |       |
| GRBAS    | 0.409            | 0.352        | 0.249        | 0.311    |              | 0.455                | -0.037       | -0.118       | -0.287   |       |
|          | 0.065            | 0.117        | 0.277        | 0.170    |              | 0.050                | 0.879        | 0.631        | 0.233    |       |
| VHI10    | 0.242            | 0.115        | 0.430        | 0.333    | <b>0.498</b> | 0.289                | 0.268        | <b>0.784</b> | 0.410    | 0.064 |
|          | 0.290            | 0.621        | 0.052        | 0.140    | <b>0.022</b> | 0.231                | 0.268        | <b>0.000</b> | 0.081    | 0.795 |

Spearman's rho (top) and p-value (bottom) are presented in each cell. NPC: Nasopharyngeal carcinoma; IQR: Interquartile range; SD: Standard deviation; GRBAS: Grade roughness breathiness asthenia scale score; VHI-10: Vocal handicap index – 10 score; F<sub>0</sub>: Fundamental frequency; NHR: Noise-to-harmonic ratio.

**Table 5.** Correlations between voice evaluation data and pure tone audiometry data of the better ear

| Min. values (dB) | NPC group (n=21) |               |        |          |              |        | Control group (n=19) |        |        |          |        |              |
|------------------|------------------|---------------|--------|----------|--------------|--------|----------------------|--------|--------|----------|--------|--------------|
|                  | F <sub>0</sub>   | %jit          | %shim  | Mean NHR | GRBAS        | VHI10  | F <sub>0</sub>       | %jit   | %shim  | Mean NHR | GRBAS  | VHI10        |
| PTA              | 0.413            | <b>-0.543</b> | -0.007 | 0.025    | 0.068        | 0.181  | -0.264               | 0.093  | 0.210  | 0.197    | -0.060 | 0.251        |
|                  | 0.063            | <b>0.011</b>  | 0.975  | 0.913    | 0.770        | 0.431  | 0.274                | 0.706  | 0.389  | 0.420    | 0.807  | 0.299        |
| A500             | 0.198            | -0.431        | -0.100 | -0.080   | 0.121        | 0.245  | -0.148               | 0.131  | -0.056 | -0.131   | 0.416  | -0.061       |
|                  | 0.390            | 0.051         | 0.665  | 0.729    | 0.601        | 0.285  | 0.547                | 0.593  | 0.820  | 0.594    | 0.076  | 0.803        |
| A1000            | <b>0.446</b>     | -0.379        | -0.004 | 0.034    | 0.278        | 0.320  | -0.309               | 0.148  | -0.105 | 0.122    | 0.132  | -0.237       |
|                  | <b>0.043</b>     | 0.090         | 0.986  | 0.885    | 0.222        | 0.157  | 0.197                | 0.546  | 0.669  | 0.618    | 0.589  | 0.329        |
| A2000            | 0.309            | <b>-0.533</b> | -0.018 | -0.058   | 0.061        | 0.212  | -0.326               | -0.067 | 0.048  | 0.000    | -0.213 | 0.008        |
|                  | 0.173            | <b>0.013</b>  | 0.937  | 0.801    | 0.794        | 0.356  | 0.173                | 0.784  | 0.846  | 1.000    | 0.382  | 0.975        |
| A4000            | <b>0.494</b>     | <b>-0.515</b> | 0.110  | 0.065    | 0.004        | 0.051  | -0.032               | 0.081  | 0.332  | 0.251    | 0.060  | <b>0.520</b> |
|                  | <b>0.023</b>     | <b>0.017</b>  | 0.634  | 0.781    | 0.985        | 0.825  | 0.896                | 0.742  | 0.165  | 0.299    | 0.806  | <b>0.022</b> |
| A6000            | 0.356            | <b>-0.610</b> | -0.129 | -0.210   | -0.105       | -0.054 | 0.032                | 0.328  | 0.411  | 0.405    | 0.228  | <b>0.556</b> |
|                  | 0.114            | <b>0.003</b>  | 0.577  | 0.361    | 0.651        | 0.817  | 0.897                | 0.170  | 0.081  | 0.086    | 0.349  | <b>0.014</b> |
| B500             | 0.110            | -0.039        | 0.046  | 0.089    | 0.366        | 0.325  | 0.014                | -0.046 | -0.150 | -0.156   | 0.329  | 0.047        |
|                  | 0.636            | 0.867         | 0.842  | 0.703    | 0.103        | 0.150  | 0.955                | 0.851  | 0.539  | 0.523    | 0.169  | 0.849        |
| B1000            | <b>0.502</b>     | -0.135        | 0.206  | 0.183    | <b>0.468</b> | 0.268  | -0.242               | 0.130  | -0.164 | 0.166    | 0.152  | -0.071       |
|                  | <b>0.020</b>     | 0.558         | 0.371  | 0.428    | <b>0.032</b> | 0.240  | 0.319                | 0.596  | 0.501  | 0.498    | 0.535  | 0.772        |
| B2000            | 0.364            | <b>-0.608</b> | -0.084 | -0.194   | -0.077       | 0.035  | -0.215               | -0.174 | -0.145 | -0.120   | -0.245 | -0.021       |
|                  | 0.105            | <b>0.003</b>  | 0.718  | 0.400    | 0.739        | 0.880  | 0.378                | 0.475  | 0.555  | 0.626    | 0.311  | 0.931        |
| B4000            | 0.428            | -0.334        | 0.131  | 0.133    | 0.024        | -0.044 | 0.073                | 0.130  | 0.326  | 0.296    | 0.091  | <b>0.619</b> |
|                  | 0.053            | 0.139         | 0.570  | 0.566    | 0.917        | 0.848  | 0.768                | 0.596  | 0.174  | 0.218    | 0.713  | <b>0.005</b> |

Spearman's rho (top) and p-value (bottom) are presented in each cell. NPC: Nasopharyngeal carcinoma; IQR: Interquartile range; SD: standard deviation; GRBAS: Grade roughness breathiness asthenia scale score; VHI-10: Vocal handicap index – 10 score; F<sub>0</sub>: Fundamental frequency; NHR: Noise-to-harmonic ratio; PTA: Pure tone average; A: Air conduction threshold; B: Bone conduction threshold.

head-and-neck tumors were compared, it was reported that wide-field RT application caused more changes in the voice due to non-laryngeal primary in terms of voice quality.<sup>[7]</sup>

The most common side effect of NPC treatment is xerostomia. Although not within the RT field, the larynx is exposed to radiation as its proximity to neck structures. Platinum-based

antineoplastic drugs used in locoregionally advanced disease are neurotoxic. CT exacerbates salivary dysfunction, worsening xerostomia.<sup>[17]</sup> Therefore, the development of xerostomia causes a lack of lubrication, affecting vocal function.

In addition, soft tissue changes such as fibrosis, telangiectasia, atrophy, edema, and lymphatic drainage changes caused by RT affect the vocal tract and extra-laryngeal muscles. The side effects involving the cortical brain and tracts down to the cranial nerves, although thought to be clinically rare previously, have been shown to be quite effective in voice changes in NPC patients.<sup>[10]</sup> The resulting voice disorders affect the quality of life after treatment by disrupting communication.

In summary, from a voice perspective, the results of this study align with previous studies demonstrating vocal dysfunction following radiation therapy for head-and-neck cancers, particularly in non-laryngeal tumors.<sup>[7,9,22]</sup> However, our study extends these findings by providing a comprehensive assessment of voice characteristics in a relatively large number of NPC patients.

Furthermore, the NPC group exhibited significantly higher rates of HL compared to the control group. Pure tone audiometry revealed a high prevalence of HL, particularly at high frequencies, in the NPC group. These findings align with prior reports of late auditory complications from RT, including sensorineural and mixed HL.<sup>[4,23]</sup>

Otological side effects occurring after the treatment of NPC have been classified by many scales. The Radiation Therapy Oncology Group (RTOG) late toxicity classification was made according to air conduction PTA values. The RTOG and other toxicity scales, including LENT-SOMA and the CTCAE, are not fully compatible and show limited consistency with otolaryngology-based HL classifications. Therefore, additional staging systems were applied to assess post-treatment hearing outcomes.<sup>[4,17]</sup> The observed rates of HL in our study were lower than some previously reported rates. This discrepancy may be attributed to factors such as the inclusion criteria (e.g., age range) and the definition of HL used in this study.

In light of all these data, to be able to evaluate the hearing data after NPC in a healthy way, it would be appropriate to standardize the findings in the studies, to determine the approximate values with prospective studies, and to regularly evaluate the individuals in terms of ear and hearing, starting from the pre-treatment period. It has been observed that the toxicity staging scales commonly used by RT and medical oncology clinics may not match the evaluation criteria of otolaryngology clinics that treat these ear-related side effects.

Notably, the relationship between voice and hearing characteristics of the subjects was complex. While some correlations were observed between certain acoustic parameters and hearing thresholds, particularly in the NPC group, a consistent pattern across all parameters was not evident.

Voice disorders are a common complaint seen at a rate of 30% throughout life. HL is also seen in around 20% of the general population. Although it is suggested that HL may be involved in the pathophysiology of voice disorders, there is insufficient data on this subject.<sup>[24]</sup> It was found that auditory timbre discrimination and high timbre accuracy in professional vocalists confirm the relationship between hearing and voice quality.<sup>[25]</sup> In a recent study, it was reported that women with voice disorders have impairments in auditory processing, which determines their ability to distinguish voice patterns associated with the timbre of the voice.<sup>[26]</sup>

These findings suggest that the mechanisms underlying voice and hearing changes in NPC patients may be multifaceted and may not necessarily be directly linked. It is plausible that both voice and hearing impairments are primarily driven by the effects of radiation therapy on the vocal and auditory systems, respectively.

This study has several limitations. A key limitation of this study is its retrospective design with cross-sectional outcome assessment. While this approach provides valuable data on the prevalence of long-term voice and HL among survivors, its reliance on single post-treatment measurements inherently precludes observation of the temporal course or progression of these functional changes. Consequently, we cannot definitively establish a cause-and-effect relationship between specific therapeutic factors and the measured outcomes. Furthermore, including only patients who maintained adherence to long-term follow-up may have introduced selection bias, potentially underestimating true morbidity rates in the broader NPC survivor population. A similar limitation stems from the heterogeneity of the study population in terms of both NPC disease staging and treatment modalities. Due to the small number of participants in certain stages and treatment subgroups (such as those receiving RT alone or adjuvant CRT), we were unable to statistically analyze voice and hearing outcomes separately by stage or treatment type. Consequently, our findings represent the aggregate outcome of a diverse group of long-term survivors, which may obscure specific correlations between disease severity or specific treatment combinations and observed functional deficits. Second, the perceptual voice assessment was conducted by a single evaluator, which may introduce subjective bias. Third, the

study did not include stroboscopic or aerodynamic voice assessments, which could have provided further insights into vocal fold function. Finally, information on the specific RT techniques and doses received by the patients was limited. The strengths of this study include the relatively large sample size, the evaluation of late-term side effects, the inclusion of both subjective and objective voice assessments, and the comprehensive evaluation of hearing function. This study's comprehensive assessment of both voice and hearing outcomes in NPC survivors fills a gap in the existing literature.

## Conclusion

This study demonstrates that NPC patients who undergo RT may experience significant long-term voice and hearing impairments. While the exact mechanisms underlying these impairments remain to be fully elucidated, the findings highlight the importance of routine voice and hearing assessments in the long-term follow-up of NPC patients. Early identification of these impairments can facilitate timely intervention and improve the quality of life for these individuals. Future prospective studies with larger sample sizes and detailed information on treatment modalities are warranted to further investigate the long-term effects of RT on voice and hearing in NPC patients.

**Ethics Committee Approval:** The Ankara Yıldırım Beyazıt University Ethics Committee granted approval for this study (date: 21.11.2018, number: 12).

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# Factors Influencing Human Papillomavirus Information Level and Vaccination Decision Among Nursing Students: A Cross-Sectional Study

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## Abstract

**Introduction:** Screening and vaccination against human papillomavirus (HPV) play a critical role in preventing cervical cancer. This study aimed to assess nursing students' knowledge of HPV, their vaccination status, and the factors influencing their level of knowledge.

**Methods:** This cross-sectional study was conducted online through Google Forms with participation from 593 nursing students. Data were collected using the HPV Knowledge Scale (HPV-KS). Data were analyzed using the Statistical Package for the Social Sciences version 25.0. Descriptive statistics were calculated, and normality was assessed with the Kolmogorov–Smirnov test. As the data were not normally distributed, non-parametric tests (Mann–Whitney U and Kruskal–Wallis) were used for group comparisons. Effect sizes were calculated. Statistical significance was set at  $p < 0.05$ .

**Results:** The mean HPV-KS total score was  $13.06 \pm 6.47$ . Among the students, 89% had prior knowledge about HPV, 81.8% about HPV screening, and 86.7% about HPV immunization. The HPV-KS total score differed significantly according to age, father's education level, place of residence, academic year, and opinions regarding the inclusion of the HPV vaccine in the national immunization schedule. No significant differences in total HPV-KS scores were observed according to gender, mother's education level, perceived income status, or HPV vaccination status. Gender was associated only with the HPV test/screening knowledge subscale, with higher scores among female students.

**Discussion and Conclusion:** Nursing students demonstrated insufficient knowledge and low vaccination rates regarding HPV. Integrating the HPV vaccine into the national immunization schedule and providing it free of charge may enhance awareness and contribute to preventing HPV-related diseases.

**Keywords:** Human papillomavirus; Human papillomavirus vaccine; Knowledge; Nursing

Human papillomavirus (HPV) includes nearly 200 subtypes that infect cutaneous and mucosal cells. In both sexes, HPV can lead to genital and non-genital warts, as well as anal and oropharyngeal cancers. Thirteen high-risk HPV types are implicated in cervical cancer, with HPV 16

and 18 alone accounting for 70% of cases. These types also contribute to penile cancer in men.<sup>[1]</sup> HPV infection is most commonly observed within the first decade after the onset of sexual activity and is frequently diagnosed between the ages of 15 and 25 in Western countries.<sup>[2]</sup> Women in Sub-

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Saharan Africa have the highest prevalence of cervical HPV at 24%, succeeded by Latin America and the Caribbean at 16%, Eastern Europe at 14%, and Southeast Asia at 14%.

<sup>[3]</sup> The frequency of occurrence in men varies significantly depending on sexual orientation.<sup>[4]</sup> According to the Ministry of Health's 2018 data, cervical carcinoma is the tenth most common type of carcinoma among women.<sup>[5]</sup>

Vaccination is the most effective method for preventing HPV-related cancers.<sup>[6]</sup> HPV vaccines are recommended before the onset of sexual activity and are most effective between ages 9 and 14.<sup>[7]</sup> The Centers for Disease Control and Prevention recommends administering two doses of the HPV vaccine to children aged 11 and 12 years, with the first dose as early as 9 years old and the second dose 6–12 months later; and three doses to children aged 15 and older.<sup>[8,9]</sup> There are three different HPV vaccines. These are Cervarix, Gardasil, and Gardasil 9.<sup>[10,11]</sup> Despite being included in national immunization programs in many high-income countries, the HPV vaccine is not part of Türkiye's routine vaccination schedule, and this absence – combined with cost-related barriers – reduces vaccination rates.<sup>[11]</sup>

As future healthcare professionals, nursing students play a critical role in health promotion and vaccination advocacy. Therefore, understanding their knowledge of HPV and their attitudes toward HPV vaccination is essential. This study aimed to evaluate the HPV knowledge levels, vaccination status, and related factors influencing these outcomes among nursing students.

## Materials and Methods

### Study Design

This study was designed as a descriptive cross-sectional study. This cross-sectional study was reported in accordance with the STROBE reporting guidelines.

### Study Sample

This cross-sectional study was conducted between May and July 2024 at two universities located in different provinces in Türkiye. The target population consisted of all undergraduate nursing students enrolled in these universities during the 2023–2024 academic year.

The inclusion criteria were: Being 18 years of age or older, being enrolled in a nursing program, being able to speak and understand Turkish, and providing informed consent.

An a priori power analysis was performed using G\*Power software. Assuming a Type I error rate ( $\alpha$ ) of 0.05 and a statistical power of 80%, the sample size calculation was based on the mean HPV knowledge scores reported by

Özdemir et al.<sup>[12]</sup> (female:  $15.50 \pm 8.84$ ; male:  $13.47 \pm 9.03$ ).<sup>[12]</sup> According to this analysis, a minimum of 482 students (241 female and 241 male).

A convenience sampling method was used. All eligible nursing students were invited to participate in the study through institutional communication channels (e.g., student WhatsApp groups and/or university e-mail lists). Participation was voluntary, and no randomization procedure was applied. Students who agreed to participate completed the online questionnaire.

A total of 1535 nursing students were invited to participate in the study. Of these, 855 (55.7%) declined participation. Among the 680 students who agreed to participate, 87 (12.8%) were excluded due to incomplete questionnaires. The final analytical sample consisted of 593 students, yielding a response rate of 38.6% (593/1535) (Fig. 1). Data were not collected from the 942 students who did not respond; therefore, potential differences between respondents and non-respondents could not be evaluated.

Since a convenience sampling method and an online self-report survey were used, the study may be subject to selection bias and self-reporting bias. Voluntary participation may have resulted in the overrepresentation of students with greater interest or awareness regarding HPV. In addition, as the data were collected through an online survey, response bias related to internet access and willingness to participate cannot be ruled out.

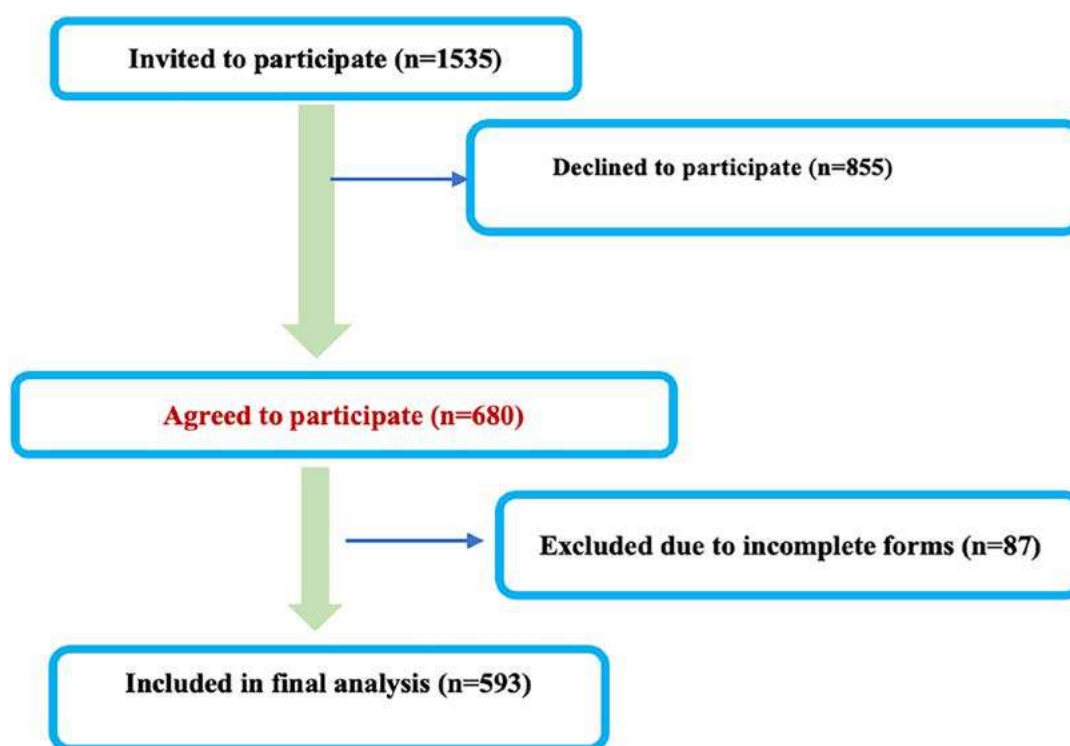
### Data Collection Tools

Data were collected using an online questionnaire created via Google Forms. Before accessing the survey, participants were required to provide informed consent by selecting the statement: "I have read, understood, and agree to participate in the study." The survey was anonymous, and no identifying information was collected.

The study utilized the Introductory Information Form and the HPV Knowledge Scale (HPV-KS) to assess participants' sociodemographic characteristics and HPV knowledge levels. Permission to use the scale was obtained from the original author.

Introductory Information Form: The form comprises 15 questions addressing students' sociodemographic factors, including age, gender, and class, as well as details on HPV infection and vaccination.<sup>[10,11,13–15]</sup>

HPV-KS: In 2023, Demir Bozkurt and Özdemir<sup>[16]</sup> assessed the validity and reliability of the Waller et al.<sup>[17]</sup> measure, created in 2013. HPV knowledge, the HPV test, the HPV vaccine, and the HPV vaccination program are assessed by



**Figure 1.** Flow diagram of participant inclusion process.

33 items and four sub-dimensions. Correct responses are rated “1,” while wrong and “I don’t know” replies receive “0.” Scale scores are 0–33. High scores indicate knowledge of HPV screening and vaccination.

Independent variables included demographic (age, gender, class year), socioeconomic (mother’s and father’s education level, perceived family income), and contextual factors (place of residence during education, HPV awareness, HPV vaccination status, and opinion on inclusion of HPV vaccine in the national immunization schedule). The dependent variable was the HPV-KS total and sub-dimension scores.

### Data Analysis

Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM SPSS Statistics 25, IBM Corp, Armonk, NY, USA). Descriptive statistics (mean, standard deviation, median, minimum, and maximum) were calculated. The data’s normal distribution was assessed utilizing the Kolmogorov–Smirnov Test. Non-parametric techniques were employed for data exhibiting a non-normal distribution. The Mann–Whitney U test was used to compare score distributions between two independent groups, whereas the Kruskal–Wallis test was used for comparisons among more than two independent groups. When the Kruskal–Wallis test indicated a statistically significant difference, post hoc pairwise comparisons

were conducted using the Mann–Whitney U test with Bonferroni adjustment to control for multiple comparisons. In addition, effect sizes for Mann–Whitney U tests ( $r$ ) and Kruskal–Wallis tests ( $\eta^2$ : eta-squared) were calculated. In assessing effect sizes, guideline values were considered:  $r$ , 0.10 small effect, 0.30 medium effect, 0.50 large effect;  $\eta^2$  (eta-squared), 0.01 small effect, 0.06 medium effect, 0.14 large effect (Pautz et al.,<sup>[18]</sup> 2018; Steyn,<sup>[19]</sup> 2012). The study assessed the significance level of the findings at a 95% confidence interval and a  $p < 0.05$ .

### Ethical Considerations

Ethical approval was obtained from the Non-invasive Research Ethics Committee of the Dokuz Eylül University (No. 2024/16-24, Date: 8 May 2024). In addition, institutional permissions were obtained from the nursing departments of the two different universities where the research was conducted. The research was conducted voluntarily, and informed consent was obtained from participants through Google Forms. During the data collection process, participants’ personal data and email addresses were not collected. No identifiable personal data were collected.

### Results

A total of 593 nursing students accessed and completed the online questionnaire. All respondents met the

inclusion criteria, and none were excluded due to missing data; therefore, all 593 participants were included in the final analysis.

About 80.4% of the study's participants are aged 18–22, and 71.5% are female (n=424). 1.3% of mothers and 5.2% of fathers have a university education or higher. When the perception of the family's monthly income level was questioned, 26% evaluated their income as less than their expenses. It has been determined that during their educational processes, 73% of the students stayed in student dormitories, 12.8% stayed in their family's home, and 14.2% stayed in student houses. The majority of students are 1<sup>st</sup>-year students, comprising 37.6% (Table 1).

It was established that 89% of students were aware of HPV infection, 81.8% were familiar with HPV screening, and 86.7% had knowledge of HPV vaccination before. When the HPV knowledge status of nursing students was evaluated, it was found that 6.6% did not have information on where HPV is seen. It was ascertained that 6.7% of the students were unaware of the recipients of the HPV vaccination. About 96.5% have not been vaccinated against HPV (n=572). As a reason for not getting vaccinated, 21.7% of the students reported that they had no information about the vaccine. However, 69.1% of the students indicated that they would like to get vaccinated if given the opportunity. 76.7% supported including the HPV vaccination in the national immunization routine, while 19.1% were unsure (Table 2).

The mean HPV-KS score was calculated as  $13.06 \pm 6.47$ . Sub-dimension scores were as follows: General HPV knowledge ( $7.95 \pm 3.57$ ), HPV test/screening knowledge ( $2.38 \pm 1.98$ ), HPV vaccine knowledge ( $1.33 \pm 1.18$ ), and HPV vaccination program knowledge ( $1.39 \pm 1.47$ ) (Table 2).

When evaluating the changes in the total and sub-dimension mean scores of HPV-KS according to the age classification of nursing students, it was observed that the mean scores of those aged 23 and above were significantly higher than those of the 18–22 age group. Effect sizes for Mann–Whitney U tests were small across all subdimensions ( $r=0.10$ – $0.16$ ), indicating limited practical significance despite statistical differences between age groups. A statistically significant difference has been found between gender and the mean score of the HPV Test/Screening Knowledge sub-dimension ( $U=29548.500$ ,  $p=0.001$ ). Mothers' education levels were significantly associated with the mean General HPV Knowledge subscale score ( $KW=10.631$ ,  $p=0.031$ ). With further analysis, it was found that this difference was due to the mother's education level being non-literate and high school graduate. Significant differences in General HPV

**Table 1.** Introductory characteristics of nursing students (n=593)

| Characteristics                                           | n   | %    |
|-----------------------------------------------------------|-----|------|
| Age                                                       |     |      |
| 18–22                                                     | 477 | 80.4 |
| 23 years and older                                        | 116 | 19.6 |
| Gender                                                    |     |      |
| Female                                                    | 424 | 71.5 |
| Male                                                      | 169 | 28.5 |
| Mother's education level                                  |     |      |
| Not literate                                              | 84  | 14.2 |
| Elementary school graduate                                | 48  | 8.1  |
| Middle school graduate                                    | 368 | 62.1 |
| High school graduate                                      | 85  | 14.3 |
| University graduate and above                             | 8   | 1.3  |
| Father's education level                                  |     |      |
| Not literate                                              | 14  | 2.4  |
| Elementary school graduate                                | 38  | 6.4  |
| Middle school graduate                                    | 381 | 64.2 |
| High school graduate                                      | 129 | 21.8 |
| University graduate and above                             | 31  | 5.2  |
| The family's perception of their monthly income situation |     |      |
| Income is less than expenses                              | 154 | 26.0 |
| Income equals expenses                                    | 363 | 61.2 |
| Income exceeds expenses                                   | 76  | 12.8 |
| Accommodation during the education period                 |     |      |
| Student dormitory                                         | 433 | 73.0 |
| Family home                                               | 76  | 12.8 |
| Student home                                              | 84  | 14.2 |
| Academic year                                             |     |      |
| 1 <sup>st</sup> grade                                     | 223 | 37.6 |
| 2 <sup>nd</sup> grade                                     | 147 | 24.8 |
| 3 <sup>rd</sup> grade                                     | 100 | 16.9 |
| 4 <sup>th</sup> grade                                     | 123 | 20.7 |

Knowledge, HPV Test/Screening Knowledge, and overall scores were observed according to the father's education level. Students whose fathers had a university education or higher demonstrated significantly higher scores compared to other education groups. Perceived family monthly income showed no significant relationship with HPV-KS total and subdimension mean scores ( $p>0.05$ ).

In the advanced analysis conducted to examine the association between place of residence and the General HPV Knowledge sub-dimension during the educational process on the General HPV Knowledge sub-dimension

**Table 2.** HPV awareness, vaccination-related characteristics, and HPV-KS scores among nursing students

|                                                                                        | n              | %                       |
|----------------------------------------------------------------------------------------|----------------|-------------------------|
| Have you ever heard of HPV?                                                            |                |                         |
| Yes                                                                                    | 528            | 89.0                    |
| No                                                                                     | 65             | 11.0                    |
| Have you ever heard of the HPV test?                                                   |                |                         |
| Yes                                                                                    | 485            | 81.8                    |
| No                                                                                     | 108            | 18.2                    |
| Have you ever heard of the HPV vaccine?                                                |                |                         |
| Yes                                                                                    | 514            | 86.7                    |
| No                                                                                     | 79             | 13.3                    |
| Who is HPV found in?                                                                   |                |                         |
| Sexually active women                                                                  | 39             | 6.6                     |
| Sexually active men                                                                    | 8              | 1.3                     |
| Sexually active women and men                                                          | 507            | 85.5                    |
| I don't know                                                                           | 39             | 6.6                     |
| Who should receive the HPV vaccine?                                                    |                |                         |
| Only women                                                                             | 52             | 8.8                     |
| Both women and men                                                                     | 501            | 84.5                    |
| I don't know                                                                           | 40             | 6.7                     |
| Did you get the HPV vaccine?                                                           |                |                         |
| Yes                                                                                    | 21             | 3.5                     |
| No                                                                                     | 572            | 96.5                    |
| What is your reason for not getting the HPV vaccine?†                                  |                |                         |
| I have no knowledge about the vaccine                                                  | 124            | 21.7                    |
| The high cost of the fee                                                               | 227            | 39.7                    |
| The side effects of the vaccine                                                        | 20             | 3.5                     |
| I'm not in the risk group                                                              | 180            | 31.5                    |
| I didn't think of it/I forgot                                                          | 21             | 3.6                     |
| If you had the chance, would you get the HPV vaccine?                                  |                |                         |
| Yes                                                                                    | 410            | 69.1                    |
| No                                                                                     | 51             | 8.6                     |
| I am ambivalent                                                                        | 132            | 22.3                    |
| Do you think the HPV vaccine should be included in the national immunization schedule? |                |                         |
| Yes                                                                                    | 455            | 76.7                    |
| No                                                                                     | 25             | 4.2                     |
| I am ambivalent                                                                        | 113            | 19.1                    |
|                                                                                        | <b>Mean±SD</b> | <b>Median (min-max)</b> |
| HPV-KS                                                                                 |                |                         |
| General HPV Knowledge                                                                  | 7.95±3.57      | 9.00 (0.00–16.00)       |
| HPV Test/Screening Knowledge                                                           | 2.38±1.98      | 2.00 (0.00–6.00)        |
| HPV Vaccine Knowledge                                                                  | 1.33±1.18      | 1.00 (0.00–5.00)        |
| HPV Vaccination Program Knowledge                                                      | 1.39±1.47      | 1.00 (0.00–6.00)        |
| Total                                                                                  | 13.06±6.47     | 14.00 (0.00–33.00)      |

†: Percentages were calculated among students who had not received the HPV vaccine (n=572). SD: Standard deviation; HPV: Human papillomavirus.

**Table 3.** Mean total and sub-dimension scores of HPV-KS according to the introductory characteristics of nursing students and their knowledge status of human papilloma virus (n=593)

| Descriptive features                                      | HPV-KS                                 |                                        |                                      |                                             |                                        |
|-----------------------------------------------------------|----------------------------------------|----------------------------------------|--------------------------------------|---------------------------------------------|----------------------------------------|
|                                                           | General HPV knowledge mean±SD          | HPV test/screening knowledge mean±SD   | HPV vaccine knowledge mean±SD        | HPV vaccination program information mean±SD | Total mean±SD                          |
| Age                                                       |                                        |                                        |                                      |                                             |                                        |
| 18–22                                                     | 7.74±3.69                              | 2.24±1.95                              | 1.27±1.15                            | 1.29±1.42                                   | 12.55±6.49                             |
| 23 years and older                                        | 8.82±2.91                              | 2.93±2.05                              | 1.59±1.27                            | 1.81±1.56                                   | 15.17±5.98                             |
|                                                           | U=23629.500,<br>p=0.014*, r=0.10       | U=22302.500,<br>p=0.001*, r=0.14       | U=23632.500,<br>p=0.011*, r=0.10     | U=22088.500<br>p=0.000*, r=0.16             | U=21553.000,<br>p=0.000*, r=0.16       |
| Gender                                                    |                                        |                                        |                                      |                                             |                                        |
| Female                                                    | 8.01±3.24                              | 2.54±1.92                              | 1.35±1.08                            | 1.33±1.36                                   | 13.24±5.85                             |
| Male                                                      | 7.79±4.31                              | 1.98±2.10                              | 1.27±1.41                            | 1.55±1.70                                   | 12.60±7.82                             |
|                                                           | U=35550.000,<br>p=0.881, r=0.01        | U=29548.500,<br>p=0.001*, r=0.14       | U=32535.500,<br>p=0.069, r=0.08      | U=34610.500,<br>p=0.502, r=0.03             | U=32677.000,<br>p=0.094, r=0.07        |
| Mother's education level                                  |                                        |                                        |                                      |                                             |                                        |
| Not literate                                              | 7.53±3.72                              | 2.10±2.11                              | 1.28±1.14                            | 1.28±1.54                                   | 12.21±6.80                             |
| Elementary school graduate                                | 7.58±4.06                              | 2.43±1.87                              | 1.27±1.19                            | 1.60±1.59                                   | 12.89±6.82                             |
| Middle school graduate                                    | 7.82±3.53                              | 2.34±1.94                              | 1.33±1.18                            | 1.35±1.41                                   | 12.86±6.36                             |
| High school graduate                                      | 8.95±3.29                              | 2.69±2.08                              | 1.40±1.19                            | 1.47±1.49                                   | 14.51±6.34                             |
| University graduate and above                             | 9.75±1.28                              | 3.37±1.92                              | 1.62±1.68                            | 2.12±2.03                                   | 16.87±5.27                             |
|                                                           | KW=10.631,<br>p=0.031*, $\eta^2=0.011$ | KW=6.163,<br>p=0.187, $\eta^2=0.003$   | KW=0.565,<br>p=0.967, $\eta^2=0$     | KW=3.333,<br>p=0.504, $\eta^2=0$            | KW=8.912,<br>p=0.063, $\eta^2=0.008$   |
| Father's education level                                  |                                        |                                        |                                      |                                             |                                        |
| Not literate                                              | 4.42±4.56                              | 2.57±2.79                              | 1.21±1.25                            | 1.57±1.94                                   | 9.78±8.93                              |
| Elementary school graduate                                | 8.00±4.36                              | 2.18±1.91                              | 1.44±1.24                            | 1.55±1.67                                   | 13.18±7.45                             |
| Middle school graduate                                    | 7.73±3.62                              | 2.26±1.95                              | 1.26±1.16                            | 1.27±1.39                                   | 12.54±6.49                             |
| High school graduate                                      | 8.48±3.03                              | 2.46±1.96                              | 1.42±1.22                            | 1.49±1.46                                   | 13.87±5.76                             |
| University graduate and above                             | 9.93±1.73                              | 3.64±1.81                              | 1.74±1.15                            | 2.12±1.74                                   | 17.45±4.15                             |
|                                                           | KW=20.839,<br>p=0.000*, $\eta^2=0.029$ | KW=14.364,<br>p=0.006*, $\eta^2=0.018$ | KW=7.035,<br>p=0.134, $\eta^2=0.005$ | KW=9.462, p=0.051,<br>$\eta^2=0.009$        | KW=23.792,<br>p=0.000*, $\eta^2=0.034$ |
| The family's perception of their monthly income situation |                                        |                                        |                                      |                                             |                                        |
| Income is less than expenses                              | 8.15±3.62                              | 2.36±2.05                              | 1.45±1.35                            | 1.42±1.57                                   | 13.40±6.90                             |
| Income equals expenses                                    | 7.75±3.61                              | 2.34±1.95                              | 1.27±1.10                            | 1.33±1.40                                   | 12.71±6.35                             |
| Income exceeds expenses                                   | 8.50±3.25                              | 2.57±2.06                              | 1.35±1.17                            | 1.61±1.53                                   | 14.05±6.06                             |
|                                                           | KW=3.087,<br>p=0.214, $\eta^2=0.002$   | KW=0.911,<br>p=0.634, $\eta^2=0$       | KW=0.910,<br>p=0.634, $\eta^2=0$     | KW=2.475,<br>p=0.290, $\eta^2=0.001$        | KW=3.717,<br>p=0.156, $\eta^2=0.003$   |
| Accommodation during the education period                 |                                        |                                        |                                      |                                             |                                        |
| Student dormitory                                         | 7.67±3.66                              | 2.30±1.97                              | 1.29±1.15                            | 1.33±1.39                                   | 12.60±6.45                             |
| Family home                                               | 8.55±3.16                              | 2.43±1.97                              | 1.27±1.15                            | 1.32±1.52                                   | 13.59±5.73                             |
| Student home                                              | 8.85±3.28                              | 2.78±2.06                              | 1.58±1.36                            | 1.78±1.74                                   | 14.96±6.88                             |
|                                                           | KW=6.325,<br>p=0.042*, $\eta^2=0.007$  | KW=3.460,<br>p=0.177, $\eta^2=0.002$   | KW=2.774,<br>p=0.250, $\eta^2=0.001$ | KW=4.551,<br>p=0.103, $\eta^2=0.004$        | KW=6.562,<br>p=0.038*, $\eta^2=0.008$  |

**Table 3 (cont.).** Mean total and sub-dimension scores of HPV-KS according to the introductory characteristics of nursing students and their knowledge status of human papilloma virus (n=593)

| Descriptive features                                                                   | HPV-KS                              |                                      |                                     |                                             |                                     |
|----------------------------------------------------------------------------------------|-------------------------------------|--------------------------------------|-------------------------------------|---------------------------------------------|-------------------------------------|
|                                                                                        | General HPV knowledge mean±SD       | HPV test/screening knowledge mean±SD | HPV vaccine knowledge mean±SD       | HPV vaccination program information mean±SD | Total mean±SD                       |
| Academic year                                                                          |                                     |                                      |                                     |                                             |                                     |
| 1st grade                                                                              | 6.08±4.07                           | 1.65±1.79                            | 1.02±1.13                           | 1.03±1.32                                   | 9.80±6.76                           |
| 2nd grade                                                                              | 8.82±2.54                           | 2.42±1.94                            | 1.29±1.13                           | 1.25±1.37                                   | 13.80±4.92                          |
| 3rd grade                                                                              | 9.59±3.00                           | 3.22±1.90                            | 1.79±1.28                           | 2.14±1.74                                   | 16.74±6.25                          |
| 4th grade                                                                              | 8.95±2.53                           | 2.97±1.99                            | 1.56±1.10                           | 1.60±1.34                                   | 15.10±4.89                          |
|                                                                                        | KW=87.897, p=0.000*, $\eta^2=0.144$ | KW=58.291, p=0.000*, $\eta^2=0.094$  | KW=36.495, p=0.000*, $\eta^2=0.057$ | KW=43.183, p=0.000*, $\eta^2=0.068$         | KW=94.991, p=0.000*, $\eta^2=0.156$ |
| Did you get the HPV vaccine?                                                           |                                     |                                      |                                     |                                             |                                     |
| Yes                                                                                    | 8.04±4.35                           | 1.95±2.06                            | 0.76±1.09                           | 1.38±1.32                                   | 12.14±6.95                          |
| No                                                                                     | 7.94±3.55                           | 2.39±1.98                            | 1.35±1.18                           | 1.39±1.47                                   | 13.09±6.46                          |
|                                                                                        | U=5275.000, p=0.338, r=0            | U=5240.500, p=0.312, r=0             | U=4262.500, p=0.018*, r=0.097       | U=5859.500, p=0.844, r=0                    | U=5926.500, p=0.918, r=0            |
| Do you think the HPV vaccine should be included in the national immunization schedule? |                                     |                                      |                                     |                                             |                                     |
| Yes                                                                                    | 8.54±3.00                           | 2.60±1.95                            | 1.42±1.18                           | 1.47±1.46                                   | 14.05±5.87                          |
| No                                                                                     | 6.52±4.63                           | 2.20±2.19                            | 1.56±1.38                           | 1.72±2.09                                   | 12.00±8.13                          |
| I am ambivalent                                                                        | 5.89±4.51                           | 1.52±1.87                            | 0.92±1.05                           | 0.98±1.26                                   | 9.32±7.01                           |
|                                                                                        | KW=30.959, p=0.000*, $\eta^2=0.049$ | KW=28.930, p=0.000*, $\eta^2=0.046$  | KW=15.997, p=0.000*, $\eta^2=0.024$ | KW=12.350, p=0.000*, $\eta^2=0.018$         | KW=39.973, p=0.000*, $\eta^2=0.064$ |

\*: p<0.05. U=Mann-Whitney U test; KW= Kruskal-Wallis test; r=Effect size (0.10 small effect, 0.30 medium effect, 0.50 large effect);  $\eta^2$ =Eta-squared (0.01 small effect, 0.06 medium effect, 0.14 large effect); HPV: Human papillomavirus; SD: Standard deviation.

(U=15609.500, p=0.038) and the total score mean (U=15110.000, p=0.014), it was determined that the difference was observed between students living in dormitories and those living in student houses. Statistically significant difference was found across academic years in all sub-dimensions and the total score. Overall, mean scores increased progressively with advancing academic year. Academic year showed the strongest effect among all variables, demonstrating large effect sizes for general HPV knowledge ( $\eta^2=0.144$ ) and total scores ( $\eta^2=0.156$ ), and moderate effect sizes for test/screening knowledge ( $\eta^2=0.094$ ) and vaccination program knowledge ( $\eta^2=0.068$ ). The mean score of the HPV Vaccination Knowledge sub-dimension varied significantly according to HPV vaccination status (U=4262.500, p=0.018). Perspectives on including the HPV vaccine in the national immunization protocol were moderate effect size in the overall HPV-KS ( $\eta^2=0.064$ ). The difference has been attributed to those who responded "yes" and "undecided" over the incorporation of the vaccine into the immunization Protocol (Table 3).

## Discussion

This study aimed to evaluate nursing students' HPV knowledge, vaccination status, and factors associated with HPV knowledge. Although awareness of HPV infection, screening, and vaccination exceeded 80%, detailed knowledge levels were limited, as reflected by low overall and sub-dimension HPV-KS scores. Total HPV-KS scores varied significantly according to age, father's education level, place of residence, academic year, and opinions regarding the inclusion of the HPV vaccine in the national immunization schedule. Gender differences were observed only in the HPV test/screening knowledge subscale. Despite high awareness, HPV vaccination rates were extremely low and were frequently attributed by students to a lack of information and cost-related barriers.

High awareness levels are consistent with previous studies among university students in Türkiye and other countries. [12-14,20-23] However, similar to previous research, [12,21,24] overall knowledge scores remained low, indicating persistent informational gaps despite widespread exposure to HPV-related content.

Older students demonstrated higher knowledge levels, consistent with findings from Liu et al.,<sup>[10]</sup> although not all Turkish studies reported such an association.<sup>[12,15,21]</sup> Female students showed higher knowledge regarding HPV testing and screening, which aligns with prior research.<sup>[10,11,12,13,20]</sup> This pattern may be related to the strong association between HPV and cervical cancer and the focus on women in national screening programs in Türkiye.

Higher parental education was associated with greater HPV knowledge, supporting findings from both Turkish and international studies.<sup>[15,21,25]</sup> Parents with greater health literacy may be more likely to expose their children to accurate information and model health-promoting behaviors, which may explain this association. In contrast, perceived income level was not related to knowledge in our sample, possibly due to limited income variability and the exclusion of HPV vaccination from the national immunization schedule.

Students living in shared houses had significantly higher HPV knowledge than those residing in dormitories. Çakır et al.<sup>[21]</sup> similarly reported higher awareness among students living in shared houses. Other studies found no significant relationship between living arrangements and HPV knowledge.<sup>[12,15]</sup> Students living in shared houses may have better financial resources, more private study environments, and greater access to individual internet services, potentially facilitating easier access to reliable information.

Knowledge levels increased significantly with academic year, particularly among 3<sup>rd</sup>-year students. This finding is consistent with research among medical students, where knowledge increased with grade level.<sup>[12]</sup> Emre et al.<sup>[20]</sup> also found higher HPV vaccine knowledge among second-year students and above. In our study setting, women's health and reproductive health courses are offered during the third year, which may be related to the higher knowledge levels observed in this group.

Interestingly, students who were not vaccinated had higher HPV vaccine knowledge scores than vaccinated students, although the number of vaccinated participants was extremely small. The most common reasons for not receiving the vaccine were its high cost, the perception of low personal risk, and a lack of information. These findings are consistent with earlier research.<sup>[13,20,26,27]</sup> Some studies reported that higher knowledge increases willingness to be vaccinated,<sup>[12,14]</sup> while others found no relationship between vaccination status and knowledge.<sup>[15]</sup> Given the low HPV vaccination rates in Türkiye, largely due to the

vaccine not being included in the national immunization schedule, the pattern observed in our study is unsurprising. Globally, many countries include HPV vaccination in routine immunization programs for adolescent girls and boys.<sup>[28]</sup> Previous studies from Türkiye similarly reported strong support for national inclusion despite a considerable proportion of undecided individuals.<sup>[14,20]</sup> In our study, students who supported the inclusion of HPV vaccination in the national immunization schedule had higher HPV knowledge scores than those who were undecided.

Although several sociodemographic variables were statistically associated with HPV knowledge levels, the effect sizes of these associations were generally small, suggesting limited practical significance. In contrast, the academic year demonstrated a comparatively larger effect size, highlighting the potential contribution of formal nursing education to the development of HPV-related knowledge. Taken together, these findings suggest that structured educational exposure may play an important role in differentiating knowledge levels among nursing students.

## Limitations

This study has several limitations. First, its cross-sectional design does not allow for establishing causal relationships between variables. Second, the use of convenience sampling and voluntary participation may have introduced selection bias, as students who were more interested in HPV or vaccination may have been more likely to participate. The study was conducted among nursing students from only two universities, which may limit the generalizability of the findings to students from different regions or institutions with diverse socio-cultural backgrounds. Data were collected through self-reported online measures, which may be subject to social desirability and recall bias. The use of an online survey may also have limited participation to students with internet access and may have contributed to non-response bias. Furthermore, although statistically significant differences were identified, most effect sizes were small, limiting the practical significance of several findings. Finally, potential confounding factors in HPV knowledge level and vaccination status could not be statistically controlled, which constitutes a methodological limitation.

Future research using longitudinal designs, multi-center sampling approaches, and analytical models that account for potential confounders would help clarify the determinants of HPV knowledge and vaccination behaviors among nursing students.

## Conclusion

Nursing students demonstrated limited knowledge regarding HPV despite high levels of awareness. Knowledge levels were associated with several demographic and educational factors, with academic year emerging as a particularly relevant contributor. Students who supported the inclusion of HPV vaccination in the national immunization schedule exhibited higher knowledge levels and more favorable attitudes, underscoring the relationship between knowledge and policy perceptions.

These findings emphasize the importance of strengthening HPV-related education within undergraduate nursing curricula and promoting early and sustained exposure to accurate information. Given that HPV vaccination is included in the national immunization programs of many countries, its integration into Türkiye's routine vaccination schedule and provision free of charge may contribute to reducing disease burden and improving public awareness. Future research should further explore the underlying reasons for vaccine hesitancy or indecision among nursing students and evaluate the effectiveness of curriculum-based interventions aimed at improving HPV knowledge and vaccination uptake.

**Ethics Committee Approval:** The Dokuz Eylül University Non-invasive Research Ethics Committee granted approval for this study (date: 08.05.2024, number: 2024/16-24).

**Informed Consent:** The purpose, scope, confidentiality principles, and voluntary nature of the study were explained to all participants on the introductory page of the online questionnaire. No identifying or personal information was collected. By voluntarily completing the online questionnaire, participants were considered to have provided online informed consent.

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# The Relationship between Sexual Function and Sexual Health Literacy in Women

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## Abstract

**Introduction:** This study aimed to examine the relationship between sexual function and sexual health literacy in women.

**Methods:** A descriptive and cross-sectional study was conducted with 286 women. Data were collected using the Female Sexual Function Index (FSFI) and the sexual health literacy scale (SHLS). Statistical analyses included t-test, analysis of variance, and Pearson correlation.

**Results:** Significant differences were observed in the sexual desire and satisfaction sub-dimensions based on age ( $p=0.045$  and  $p=0.043$ ). Married women had lower sexual desire scores compared to single women ( $p<0.001$ ). A significant association was found between educational level and sexual health literacy; university graduates had higher SHLS scores ( $p<0.001$ ). Similarly, women with higher income had better sexual health literacy ( $p=0.010$ ). Working women had significantly higher scores in the sexual knowledge and attitude sub-dimensions than non-working women ( $p=0.004$  and  $p=0.005$ ). Smokers showed lower levels of sexual desire ( $p=0.013$ ). A weak but significant negative correlation was found between sexual desire and the total SHLS score ( $r=-0.129$ ,  $p<0.05$ ), and between satisfaction and sexual behavior ( $r=-0.149$ ,  $p<0.05$ ). However, no correlation was found between the total FSFI and SHLS scores ( $r=-0.056$ ,  $p>0.05$ ).

**Discussion and Conclusion:** The study reveals a relationship between women's sexual function, sexual health literacy, and certain sociodemographic characteristics. Although the correlations are weak, specific sub-dimensions of sexual health literacy are significantly associated with sexual function. Further research is recommended to explore these relationships in more depth.

**Keywords:** Female sexual functioning; Sexual health literacy; Sexuality

Although sexuality is influenced by physiological, social, and sexual experiences, it remains a significant concept throughout all stages of a woman's life.<sup>[1]</sup> Sexuality encompasses experiences in attitudes, thoughts, roles, fantasies, emotions, desires, behaviors, beliefs, values, practices, and relationships.<sup>[2]</sup> Sexual function is directly related to women's sexual health and marital satisfaction.<sup>[3]</sup>

Female sexual function is a biopsychosocial phenomenon that includes psychological, sociocultural, biological, and interpersonal factors.<sup>[4]</sup> Sexual problems and their negative effects on sexual health are among the primary health concerns for women of reproductive age.<sup>[5]</sup> Misinformation and misconceptions can adversely affect individuals' sexual lives regardless of gender, leading to feelings of

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guilt and inadequacy.<sup>[6]</sup> Sexual dysfunction may result from biological problems, psychological or interpersonal issues, or a combination of both. In Türkiye, many sexual problems stem from a lack of sexual education, indicating the crucial need for awareness and proper guidance.<sup>[7,8]</sup> Health literacy is a key factor in enhancing sexual health.<sup>[9]</sup> The World Health Organization defines sexual health literacy as the ability of individuals to understand information related to sexual health, apply it in their daily lives, protect themselves against sexually transmitted infections, and gain various benefits that go beyond just health.<sup>[10]</sup> For this reason, increasing the level of health literacy is of great importance for the improvement of sexual health.<sup>[9,11]</sup>

In a study, following the implementation of a sexual health education program, women in the intervention group showed significant improvement in the female sexual function index (FSFI) scores – specifically in arousal, desire, satisfaction, orgasm, pain, and total scores – compared to the control group. However, no significant difference was found between the intervention and control groups in post-test scores related to sexual attitudes. Nonetheless, a significant change in sexual attitudes was observed when comparing the pre-test and post-test mean scores within the intervention group.<sup>[12]</sup>

Another study found that despite an adequate level of sexual health literacy among participating women, there were deficiencies in their sexual function. Therefore, tailored educational programs should be developed and implemented to support sexual function in this population.<sup>[13]</sup>

In another study, it was observed that more than half of the participants had low health literacy, and a significant relationship existed between health literacy and sexual function. Although numerous studies have demonstrated a link between sexual function and health literacy, there is a limited number of investigations that thoroughly examine the impact of health literacy on women's sexual function in the literature.<sup>[14]</sup> Within this context, the present study aims to emphasize the importance of health literacy, contribute to the improvement of women's sexual function, and address this gap in the literature.

## Materials and Methods

This study was conducted as a descriptive study to examine the relationship between women's sexual function and sexual health literacy. The sample of the study was selected using a convenient sampling method. Data were collected through an online survey, which was shared via social media platforms. The study included married and single women

who met the inclusion criteria and voluntarily agreed to participate. Before starting the questionnaire, participants were asked to read and approve an informed consent form. The inclusion criteria for the study consisted of women aged between 18 and 45 years who were literate, Turkish-speaking, not currently pregnant, and with no current or previous diagnosis of a gynecological disease. Participants were also required to be active social media users, own a smartphone, and have no psychological disorders that could interfere with their ability to participate. The exclusion criteria included a history of gynecological surgery (past or present) and a history of psychological illness.

The population of the study consisted of women aged 18–45 during this period. The sample was formed from individuals who met the predetermined inclusion criteria. The sample size was calculated using the GPower 3.0.10 software. An effect size of 0.31 was used based on previous studies with similar variables and study designs. With a significance level of 0.05 and a power of 80%, the required minimum sample size was calculated as 260 participants.<sup>[15]</sup> In addition, considering a potential 10% data loss, a total of 286 women were included in the study.

No artificial intelligence (AI)-based technologies were used in the analysis or writing of this study.

## Data Collection Tools

The data were collected using the “Personal Information Form,” the “Female Sexual Function Index (FSFI),” and the “Sexual Health Literacy Scale (SHLS).” The data collection was conducted through an online questionnaire created by the researchers using Google Forms.

## Personal Information Form

The form consists of 16 items developed by the researchers based on a literature review. It includes questions regarding participants' sociodemographic characteristics (such as age, educational level, employment status, spouse's educational level, etc.), harmful habits, and women's obstetric and gynecological characteristics.<sup>[16]</sup>

## FSFI

The FSFI was developed by Rosen et al.<sup>[17]</sup> in 2000 to evaluate women's sexual function within a multidimensional framework. This scale consists of 19 items and measures sexual function experienced by participants over the past 4 weeks. It assesses six different domains: Desire, arousal, lubrication, orgasm, sexual satisfaction, and pain. The Turkish adaptation was carried out by Aygin and Eti Aslan<sup>[18]</sup> in 2005. According to validity and reliability studies, the FSFI

is a valid and reliable tool for use among Turkish women. A total score of 26.55 or below indicates the presence of female sexual dysfunction. The Cronbach's alpha values for the subdomains ranged between 0.89 and 0.98, while the overall scale reliability was reported as 0.98.

## SHLS

The SHLS was developed by Üstgörül to measure individuals' levels of sexual health literacy. The scale consists of 17 items and is administered using a five-point Likert-type rating system. It includes two subdimensions: "Sexual knowledge" and "sexual attitude." Items 13 through 17 are reverse scored. The total score ranges from 17 to 85, with higher scores indicating a higher level of sexual health literacy. In the development phase, reliability analysis showed a Cronbach's alpha coefficient of 0.88 for the overall scale.<sup>[19]</sup>

## Data Collection

The research data were collected through an online questionnaire created by the researchers using Google Forms. The questionnaire was distributed to participants via social media platforms. Before starting the data collection process, informed consent was obtained online from women who voluntarily agreed to participate in the study. All data collection procedures were carried out by the researcher in an online environment.

## Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as frequencies (n) and percentages (%). The normality of data distribution was assessed using appropriate statistical tests. Parametric tests, including the independent samples t-test and one-way analysis of variance, were applied to data demonstrating normal distribution. For data that deviated from normality, non-parametric methods such as the Mann-Whitney U test and Kruskal-Wallis test were employed. Correlation analysis was conducted to examine the relationships between variables.

## Ethical Considerations

Ethical approval for this study was obtained from the Selçuk University Ethics Committee (Approval No:2024/1322, Date: December 25, 2024). Participant consent was obtained by informing women that participation was voluntary and by including a checkbox stating "I agree to participate in the study." Permission to use the scales employed in the study was obtained from their developers

via e-mail. The study was conducted in accordance with the principles of the Declaration of Helsinki.

## Results

This study examined the relationship between women's sexual function and sexual health literacy. Significant differences were found in sexual desire ( $p=0.045$ ) and satisfaction ( $p=0.043$ ) subscales across age groups, with women aged 18–23 showing lower desire scores and those aged 30–35 having higher total FSFI scores ( $p=0.005$ ). SHLS scores also varied by age, highest in the 24–29 group ( $p=0.002$ ) (Appendix 1, Table 1).

Married women scored lower in sexual desire than single women ( $p<0.001$ ). Education level was significantly associated with SHLS scores; university graduates had higher literacy ( $p<0.001$ ), while women with only primary education reported higher satisfaction ( $p=0.030$ ). Women with university-educated spouses and higher income levels had significantly higher SHLS scores ( $p=0.001$  and  $p=0.010$ , respectively). Employed women had higher FSFI total scores, though not statistically significant ( $p=0.078$ ), but showed significantly higher scores in sexual knowledge and attitude subdomains ( $p=0.004$  and  $p=0.005$ ) (Appendix 1). The mean total FSFI and SHLS scores of the participants were  $68.12\pm15.51$  and  $54.91\pm11.38$ , respectively (Table 2).

Smoking one or more packs per day was linked to lower sexual desire scores ( $p=0.013$ ). A weak negative correlation existed between overall sexual function and sexual health literacy, particularly between sexual desire and total SHLS ( $r=-0.129$ ,  $p<0.05$ ). However, the overall correlation between total FSFI and SHLS scores was not significant ( $r=-0.056$ ,  $p>0.05$ ) (Table 3).

The findings suggest that sexual health literacy influences some aspects of sexual function but not the overall function. Education, income, and marital status also significantly affect sexual health literacy.

## Discussion

This study provides important insights into women's sexual function and sexual health literacy. The participants were found to have adequate levels in both areas. Although the overall levels were sufficient, the findings indicate that variations exist across specific subdimensions. A weak and negative relationship was observed between sexual function and sexual health literacy. This unexpected direction of association may be related to increased awareness leading to more critical self-evaluation of sexual experiences. However, Dehghankar et al.<sup>[13]</sup> reported a positive association between

**Table 1.** Comparison of women's sociodemographic characteristics with SHLS mean scores

| Variables                            | n   | %    | Sexual knowledge<br>subdimension<br>mean±SD median (Q1–Q3) | Sexual attitude<br>subdimension<br>mean±SD median (Q1–Q3) | SHLS total score<br>mean±SD median<br>(Q1–Q3) |
|--------------------------------------|-----|------|------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------|
| Age groups*                          |     |      |                                                            |                                                           |                                               |
| 18–23                                | 19  | 6.6  | 32.26±8.14<br>32.00 (26.00–37.00)                          | 14.84±6.13<br>15.00 (11.00–21.00)                         | 47.10±10.07<br>48.00 (37.00–54.00)            |
| 24–29                                | 110 | 38.5 | 39.68±10.02<br>40.00 (32.00–46.25)                         | 17.63±4.75<br>18.00 (15.00–20.00)                         | 57.31±11.07<br>56.50 (50.00–65.00)            |
| 30–35                                | 71  | 24.8 | 38.78±8.37<br>40.00 (33.00–44.00)                          | 16.71±4.90<br>17.00 (13.00–20.00)                         | 55.50±10.75<br>57.00 (47.00–63.00)            |
| 36–41                                | 47  | 16.4 | 37.72±9.87<br>38.00 (29.00–48.00)                          | 16.23±5.01<br>16.00 (12.00–20.00)                         | 53.95±12.13<br>55.00 (44.00–61)               |
| 42 years and older                   | 39  | 23.6 | 35.20±9.67<br>33.00 (28.00–44.00)                          | 16.82±4.79<br>18.00 (14.00–20.00)                         | 52.02±11.08<br>51.00 (43.00–61.00)            |
| p                                    |     |      | <b>0.007</b>                                               | 0.250                                                     | <b>0.002</b>                                  |
| Marital status**                     |     |      |                                                            |                                                           |                                               |
| Married                              | 279 | 97.6 | 38.11±9.57<br>38.00 (31.00–45.00)                          | 16.94±4.95<br>18.00 (14.00–20.00)                         | 55.05±11.43<br>55.00 (47.00–64.00)            |
| Single                               | 7   | 2.4  | 34.85±11.68<br>31.00 (29.00–36.00)                         | 14.42±4.82<br>15.00 (13.00–16.00)                         | 49.28±7.36<br>46.00 (45.00–51.00)             |
| p                                    |     |      | 0.183                                                      | 0.160                                                     | 0.129                                         |
| Educational background               |     |      |                                                            |                                                           |                                               |
| Primary education                    | 24  | 8.4  | 33.54±7.71<br>30.50 (27.25–39.75)                          | 12.79±5.49<br>12.00 (8.25–18.00)                          | 46.33±10.22<br>44.50 (37.00–55.00)            |
| Secondary education                  | 86  | 30.1 | 35.94±9.49<br>36.00 (29.75–43.25)                          | 15.84±5.06<br>16.00 (12.00–20.00)                         | 51.79±10.31<br>52.00 (44.00–57.25)            |
| University education and above       | 176 | 61.5 | 39.67±9.56<br>40.50 (32.25–47.00)                          | 17.94±4.44<br>18.00 (15.00–20.00)                         | 57.61±11.10<br>58.00 (50.00–68.75)            |
| p                                    |     |      | <b>0.001</b>                                               | <b>&lt;0.001</b>                                          | <b>&lt;0.001</b>                              |
| Your spouse's educational background |     |      |                                                            |                                                           |                                               |
| Primary education                    | 23  | 8.0  | 36.52±9.79<br>33.00 (28.00–46.00)                          | 12.13±5.56<br>11.00 (7.00–18.00)                          | 48.65±12.10<br>46.00 (37.00–60.00)            |
| Secondary education                  | 98  | 34.3 | 36.59±9.60<br>37.00 (30.75–44.00)                          | 16.34±5.17<br>17.00 (13.00–20.00)                         | 52.93±10.99<br>53.00 (44.75–58.25)            |
| University education and above       | 165 | 57.7 | 39.10±9.53<br>36.00 (29.75–43.25)                          | 17.86±4.30<br>16.00 (12.00–20.00)                         | 56.96±11.04<br>52.00 (44.00–57.25)            |
| p                                    |     |      | 0.136                                                      | <b>&lt;0.001</b>                                          | <b>0.001</b>                                  |
| Your income status                   |     |      |                                                            |                                                           |                                               |
| Income less than expenses            | 67  | 23.4 | 36.55±10.56<br>36.00 (29.00–46.00)                         | 15.97±5.15<br>17.00 (12.00–20.00)                         | 52.52±11.88<br>51.00 (44.00–63.00)            |
| Income equal to expenses             | 169 | 59.1 | 38.02±8.87<br>37.00 (31.50–44.00)                          | 16.67±4.88<br>17.00 (14.00–20.00)                         | 54.70±10.95<br>54.00 (47.00–62.00)            |
| Income greater than expenses         | 50  | 17.5 | 40.04±10.53<br>42.00 (31.00–48.00)                         | 18.80±4.53<br>20.00 (15.00–22.25)                         | 58.84±11.33<br>59.50 (49.75–66.00)            |
| p                                    |     |      | 0.122                                                      | <b>0.005</b>                                              | <b>0.010</b>                                  |
| Your employment status               |     |      |                                                            |                                                           |                                               |
| Yes                                  | 136 | 47.6 | 39.86±9.98<br>41.00 (32.00–47.00)                          | 17.80±4.44<br>18.00 (15.00–20.00)                         | 57.66±11.63<br>58.00 (49.00–65.00)            |
| No                                   | 150 | 52.4 | 36.38±9.00<br>36.50 (30.00–43.25)                          | 16.04±5.26<br>17.00 (12.00–20.00)                         | 52.42±10.58<br>52.50 (45.00–59.25)            |
| p                                    |     |      | <b>0.004</b>                                               | <b>0.005</b>                                              | <b>&lt;0.001</b>                              |

**Table 1 (cont.).** Comparison of women's sociodemographic characteristics with SHLS mean scores

| Variables                                           | n   | %    | Sexual knowledge<br>subdimension<br>mean±SD median (Q1–Q3) | Sexual attitude<br>subdimension<br>mean±SD median (Q1–Q3) | SHLS total score<br>mean±SD median<br>(Q1–Q3) |
|-----------------------------------------------------|-----|------|------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------|
| Your spouse's employment status                     |     |      |                                                            |                                                           |                                               |
| Yes                                                 | 274 | 95.8 | 38.02±9.67<br>37.50 (31.00–45.00)                          | 17.00±4.87<br>18.00 (14.00–20.00)                         | 55.02±11.27<br>55.00 (46.00–64.00)            |
| No                                                  | 12  | 4.2  | 38.33±8.79<br>39.00 (29.50–45.25)                          | 14.16±6.36<br>16.50 (6.50–20.00)                          | 52.50±13.97<br>55.00 (36.50–61.75)            |
| p                                                   |     |      | 0.939                                                      | 0.202                                                     | 0.625                                         |
| Your chronic disease status                         |     |      |                                                            |                                                           |                                               |
| Yes                                                 | 37  | 12.9 | 39.94±8.43<br>38.00 (33.50–46.50)                          | 16.13±4.88<br>17.00 (12.50–19.50)                         | 56.08±11.04<br>53.00 (46.50–65.00)            |
| No                                                  | 249 | 87.1 | 37.75±9.77<br>37.00 (30.00–45.00)                          | 16.99±4.97<br>18.00 (15.00–20.00)                         | 54.74±11.44<br>55.00 (46.00–63.50)            |
| p                                                   |     |      | 0.179                                                      | 0.247                                                     | 0.536                                         |
| Your gynecological conditions or<br>medical history |     |      |                                                            |                                                           |                                               |
| Yes                                                 | 24  | 8.4  | 34.83±9.95<br>33.50 (29.25–40.50)                          | 18.16±4.28<br>18.00 (15.25–21.00)                         | 53.00±11.37<br>52.00 (45.25–59.75)            |
| No                                                  | 262 | 91.6 | 38.32±9.55<br>38.00 (31.00–45.00)                          | 16.76±5.01<br>17.00 (14.00–20.00)                         | 55.09±11.38<br>55.00 (46.75–64.00)            |
| p                                                   |     |      | 0.097                                                      | 0.207                                                     | 0.331                                         |
| Your smoking status                                 |     |      |                                                            |                                                           |                                               |
| Never                                               | 211 | 73.8 | 37.53±9.78<br>37.00 (30.00–45.00)                          | 16.93±4.59<br>18.00 (15.00–20.00)                         | 54.46±11.54<br>53.00 (45.00–64.00)            |
| Half a pack per day                                 | 62  | 21.7 | 38.51±9.06<br>38.00 (32.75–44.00)                          | 16.56±6.07<br>17.50 (11.75–21.00)                         | 55.08±11.02<br>54.50 (49.00–61.50)            |
| One pack or more per day                            | 13  | 4.5  | 43.92±7.98<br>43.00 (39.50–50.00)                          | 17.53±5.15<br>18.00 (15.00–20.00)                         | 61.46±8.66<br>61.00 (57.00–69.50)             |
| p                                                   |     |      | 0.068                                                      | 0.814                                                     | 0.064                                         |
| Your menstrual frequency                            |     |      |                                                            |                                                           |                                               |
| Once a month                                        | 267 | 93.4 | 38.19±9.46<br>38.00 (31.00–45.00)                          | 16.86±4.93<br>18.00 (14.00–20.00)                         | 55.06±11.30<br>55.00 (47.00–64.00)            |
| Once every 2–3 months                               | 11  | 3.8  | 34.81±11.37<br>35.00 (24.00–46.00)                         | 16.45±5.39<br>17.00 (12.00–20.00)                         | 51.27±12.78<br>47.00 (41.00–65.00)            |
| Never                                               | 7   | 2.4  | 36.00±13.39<br>42.00 (22.00–45.00)                         | 19.42±4.35<br>18.00 (17.00–25.00)                         | 55.42±13.68<br>60.00 (42.00–62.00)            |
| p                                                   |     |      | 0.711                                                      | 0.281                                                     | 0.720                                         |

SD: Standard deviation; FSFI: Female sexual function index; SHLS: Sexual health literacy scale.

these two variables. Similarly, another study indicated that increased awareness and education in the field of sexual health had a positive impact on sexual function and contributed to an improved quality of life among couples.<sup>[19]</sup>

During pregnancy, it has also been shown that as sexual health literacy increases, pregnant women's attitudes toward sexuality become more positive.<sup>[15]</sup> Although the current study did not include pregnant women, these findings support the broader role of sexual health literacy in shaping sexual attitudes across different life

stages. In the current study, a relationship was observed between women's socio-demographic characteristics and their levels of sexual function and sexual health literacy. Consistent with previous studies, factors such as duration of marriage, education level, employment status, frequency of sexual intercourse within the last week, and hormonal changes have been found to significantly affect women's sexual function.<sup>[13,14,20–23]</sup> These results emphasize that sexual function is influenced by a complex interaction of biological, psychological, and social factors.

**Table 2.** Women's mean FSFI and SHLS scores

| Sexual desire sub-dimension mean±SD | Sexual arousal sub-dimension mean±SD | Lubrication subdimension mean±SD | Orgasm subdimension mean±SD | Satisfaction subdimension mean±SD | Pain discomfort subdimension mean±SD | FSFI total score mean±SD | Sexual knowledge subdimension mean±SD | Sexual attitude subdimension mean±SD | SHLS total score mean±SD |
|-------------------------------------|--------------------------------------|----------------------------------|-----------------------------|-----------------------------------|--------------------------------------|--------------------------|---------------------------------------|--------------------------------------|--------------------------|
| 6.08±1.85                           | 13.66±4.36                           | 15.32±4.14                       | 11.03±2.93                  | 8.74±3.31                         | 13.26±4.02                           | 68.12±15.51              | 38.03±9.62                            | 16.88±4.96                           | 54.91±11.38              |

SD: Standard deviation; FSFI: Female sexual function index; SHLS: Sexual health literacy scale.

**Table 3.** Correlation between women's total FSFI scores and total SHLS scores

| Scales                                 | Sexual knowledge subdimension (r-value) | Sexual attitude subdimension (r-value) | SHLS total score (r-value) |
|----------------------------------------|-----------------------------------------|----------------------------------------|----------------------------|
| Sexual desire subdimension (r-value)   | -0.097                                  | -0.101                                 | -0.129*                    |
| Sexual arousal subdimension (r-value)  | -0.104                                  | -0.091                                 | -0.113                     |
| Lubrication subdimension (r-value)     | -0.055                                  | -0.015                                 | -0.044                     |
| Orgasm subdimension (r-value)          | 0.028                                   | -0.037                                 | 0.020                      |
| Satisfaction subdimension (r-value)    | 0.058                                   | -0.149*                                | -0.100                     |
| Pain discomfort subdimension (r-value) | 0.026                                   | 0.154*                                 | 0.100                      |
| FSFI total score (r-value)             | -0.066                                  | -0.031                                 | -0.056                     |

\*: p&lt;0.05. SD: Standard deviation; FSFI: Female sexual function index; SHLS: Sexual health literacy scale.

This study found a weak association between sexual health literacy and women's sexual function. Although the strength of the association was limited, the presence of a statistically significant relationship suggests that sexual health literacy may influence specific aspects of sexual function rather than overall functioning. Factors such as education, income, and marital status were observed to influence health literacy levels.<sup>[24]</sup> The findings suggest that programs aimed at improving sexual health literacy may positively impact women's sexual function and quality of life. However, further comprehensive studies using diverse methods are needed to better understand this relationship.<sup>[25]</sup>

A study conducted among young Muslim women aged 18–25 in western Türkiye explored the relationship between the frequency and duration of masturbation and sexual health literacy. According to Karaahmet and Bilgiç,<sup>[26]</sup> increased masturbation habits were linked to higher levels of sexual health knowledge and sexual function among women. These findings highlight the potential role of personal sexual experiences in shaping both sexual knowledge and functional outcomes. In addition, research by Bahrapour et al.<sup>[20]</sup> revealed an inverse relationship between sexual health literacy and pregnancy, while factors such as parity, women's occupations, and their spouses' occupations showed significant associations with sexual health literacy levels. In a study conducted in Türkiye to assess sexual health literacy among women aged 18–49, literacy levels were found to be relatively low. Factors influencing sexual

health literacy included marital status, education level, age, employment status, family type, age at marriage, income, and parents' educational background.<sup>[27]</sup>

A study revealed that women's levels of sexual health literacy were significantly associated with their access to sexual health information sources, their perception of the adequacy of this information, and their ability to communicate about sexual matters within the family.<sup>[28]</sup> This finding supports the importance of accessible, accurate, and culturally appropriate sexual health information in improving literacy levels. When these studies are evaluated collectively, it becomes evident that the factors affecting women's sexual function and sexual health literacy are multilayered and influenced by cultural, individual, and environmental dynamics. Therefore, interventions aimed at improving sexual health literacy should adopt a holistic and context-sensitive approach.

### Strengths and Limitations

This study is significant as one of the few investigations examining the relationship between sexual function and sexual health literacy among women using an online survey method. While the online data collection allowed access to a broad participant pool, limiting participation to individuals with internet access may restrict the representativeness of the sample. In addition, including only female participants limits the generalizability of the findings to other demographic groups.

## Conclusion

The study revealed a relationship between women's sexual function, sexual health literacy, and certain sociodemographic characteristics. Although the correlations were weak, significant associations were found between specific sub-dimensions of sexual health literacy and sexual function, suggesting the need for further in-depth research.

**Ethics Committee Approval:** The Selçuk University Ethics Committee granted approval for this study (date: 25.12.2024, number: 2024/1322).

**Informed Consent:** Before starting the questionnaire, participants were asked to read and approve an informed consent form.

**Conflict of Interest:** None declared.

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**Authorship Contributions:** Concept: İE, BA; Design: İE, BA; Supervision: İE, BA; Data Collection or Processing: İE, BA; Analysis or Interpretation: İE, BA; Literature Search: İE; Writing: İE; Critical Review: İE, BA.

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**Appendix 1.** Comparison of women's sociodemographic characteristics with FSFI mean scores

| Variables                            | n   | %    | Sexual desire<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Sexual arousal<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Lubrication<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Orgasm<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Satisfaction<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Pain discomfort<br>subdimension<br>mean±SD<br>median (Q1–Q3) | FSFI total score<br>mean±SD<br>median (Q1–Q3) |
|--------------------------------------|-----|------|------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------|
| Age groups*                          |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| 18–23                                | 19  | 6.6  | 6.21±1.90<br>6.00 (4.00–7.00)                              | 13.73±4.96<br>13.00 (12–17)                                 | 14.78±4.96<br>16.00 (13–16)                              | 9.73±4.05<br>10.00 (7.00–12.00)                     | 8.94±4.51<br>9.00 (6.00–12.00)                            | 11.21±4.74<br>12.00 (9.00–14.00)                             | 64.63±20.43<br>67.00 (58.00–72.00)            |
| 24–29                                | 110 | 38.5 | 5.70±1.77<br>6.00 (4.00–7.00)                              | 13.07±4.05<br>13.00 (11.00–15.00)                           | 15.01±4.16<br>16.00 (13.00–18.00)                        | 10.82±2.93<br>11.00 (10.00–13.00)                   | 8.10±2.91<br>8.00 (6.00–9.00)                             | 12.77±4.34<br>14.00 (10.00–16.00)                            | 65.50±14.67<br>67.00 (61.00–74.25)            |
| 30–35                                | 71  | 24.8 | 6.40±1.61<br>6.00 (6.00–7.00)                              | 14.46±4.15<br>14.00 (12.00–17.00)                           | 16.22±3.28<br>16.00 (15.00–18.00)                        | 11.63±2.51<br>12.00 (10.00–13.00)                   | 9.53±3.30<br>9.00 (7.00–12.00)                            | 14.14±3.60<br>14.00 (12–18)                                  | 72.40±13.13<br>73.00 (66.00–77.00)            |
| 36–41                                | 47  | 16.4 | 6.04±1.92<br>6.00 (5.00–7.00)                              | 14.02±4.40<br>13.00 (11.00–17.00)                           | 15.40±3.94<br>16.00 (14.00–17.00)                        | 11.34±2.84<br>11.00 (10.00–13.00)                   | 9.12±3.52<br>9.00 (6.00–11.00)                            | 13.78±4.08<br>14.00 (12.00–18.00)                            | 69.72±15.23<br>70.00 (62.00–80.00)            |
| 42 years and older                   | 39  | 23.6 | 6.53±2.22<br>6.00 (5.00–8.00)                              | 13.38±5.13<br>13.00 (11.00–17.00)                           | 14.74±5.10<br>16.00 (12.00–17.00)                        | 10.82±3.00<br>11.00 (10.00–13.00)                   | 8.56±3.25<br>8.00 (7.00–10.00)                            | 13.43±4.62<br>14.00 (12.00–18.00)                            | 67.48±18.08<br>69.00 (63.00–77.00)            |
| p                                    |     |      | <b>0.045</b>                                               | 0.217                                                       | 0.508                                                    | 0.224                                               | <b>0.043</b>                                              | 0.059                                                        | <b>0.005</b>                                  |
| Marital status**                     |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Married                              | 279 | 97.6 | 6.00±1.80<br>6.00 (5.00–7.00)                              | 13.65±4.18<br>13.00 (11.00–16.00)                           | 15.35±3.92<br>16.00 (14.00–17.00)                        | 11.05±2.78<br>11.00 (10.00–13.00)                   | 8.72±3.18<br>9.00 (6.00–10.00)                            | 13.33±4.13<br>14.00 (12.00–17.00)                            | 68.13±14.52<br>69.00 (63.00–76.00)            |
| Single                               | 7   | 2.4  | 9.00±1.41<br>10.00 (7.00–10.00)                            | 14.00±9.64<br>17.00 (4.00–24.00)                            | 14.14±10.00<br>15.00 (4.00–24.00)                        | 10.28±7.11<br>12.00 (3.00–18.00)                    | 9.85±7.08<br>9.00 (3.00–18.00)                            | 10.42±7.23<br>12.00 (3.00–18.00)                             | 67.71±40.64<br>72.00 (27.00–112.00)           |
| p                                    |     |      | <b>&lt;0.001</b>                                           | 0.693                                                       | 0.918                                                    | 0.817                                               | 0.410                                                     | 0.881                                                        | 0.812                                         |
| Educational background               |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Primary education                    | 24  | 8.4  | 5.58±2.14<br>5.50 (4.00–7.00)                              | 13.62±4.95<br>13.00 (10.50–16.75)                           | 15.00±4.65<br>16.00 (13.00–17.00)                        | 10.45±3.37<br>11.00 (9.25–12.00)                    | 9.12±3.15<br>9.00 (7.25–11.00)                            | 11.91±4.13<br>12 (9.25–15.00)                                | 65.70±17.66<br>67.50 (58.00–77.50)            |
| Secondary education                  | 86  | 30.1 | 6.30±1.80<br>6.00 (5.00–7.00)                              | 13.80±4.50<br>14.00 (11.00–17.00)                           | 15.41±4.54<br>16.00 (12.75–18.00)                        | 11.06±3.20<br>11.00 (10.00–13.00)                   | 9.18±3.62<br>9.00 (7.00–12.00)                            | 12.79±4.15<br>13.50 (11.75–15.00)                            | 68.56±17.16<br>69.00 (62.75–76.25)            |
| University education and above       | 176 | 61.5 | 6.03±1.83<br>6.00 (5.00–7.00)                              | 13.59±4.23<br>13.00 (11.00–16.00)                           | 15.32±3.87<br>16.00 (14.00–17.00)                        | 11.10±2.74<br>11.00 (10.00–13.00)                   | 8.48±3.16<br>8.00 (6.00–9.00)                             | 13.68±4.26<br>14.00 (12.00–18.00)                            | 68.23±14.38<br>69.00 (63.00–76.00)            |
| p                                    |     |      | 0.245                                                      | 0.715                                                       | 0.948                                                    | 0.748                                               | 0.081                                                     | <b>0.030</b>                                                 | 0.653                                         |
| Your spouse's educational background |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Primary education                    | 23  | 8.0  | 6.08±2.06<br>6.00 (4.00–7.00)                              | 13.17±4.74<br>13.00 (12.00–16.00)                           | 14.78±5.08<br>16.00 (12.00–19.00)                        | 10.78±3.67<br>12.00 (10.00–14.00)                   | 8.60±2.91<br>9.00 (7.00–11.00)                            | 12.47±4.77<br>13.00 (12.00–15.00)                            | 65.91±19.23<br>74.00 (58.00–79.00)            |
| Secondary education                  | 98  | 34.3 | 6.22±1.73<br>6.00 (5.00–7.00)                              | 14.28±4.29<br>14.00 (12.00–17.00)                           | 15.82±3.91<br>16.00 (14.00–18.25)                        | 11.23±2.80<br>11.00 (10.00–13.00)                   | 9.26±3.49<br>9.00 (7.00–12.00)                            | 12.76±3.83<br>13.00 (11.00–15.00)                            | 69.60±14.31<br>69.00 (63.75–76.25)            |
| University education and above       | 165 | 57.7 | 5.99±1.90<br>6.00 (5.00–7.00)                              | 13.35±4.33<br>14.00 (11.00–17.00)                           | 15.10±4.12<br>16.00 (12.75–18.00)                        | 10.95±2.91<br>11.00 (10.00–13.00)                   | 8.46±3.23<br>9.00 (7.00–12.00)                            | 13.67±4.37<br>13.50 (11.75–15.00)                            | 67.55±15.65<br>69.00 (62.75–76.25)            |
| p                                    |     |      | 0.659                                                      | 0.125                                                       | 0.546                                                    | 0.749                                               | 0.126                                                     | <b>0.037</b>                                                 | 0.705                                         |

**Appendix 1 (cont.).** Comparison of women's sociodemographic characteristics with FSFI mean scores

| Variables                                        | n   | %    | Sexual desire<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Sexual arousal<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Lubrication<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Orgasm<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Satisfaction<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Pain discomfort<br>subdimension<br>mean±SD<br>median (Q1–Q3) | FSFI total score<br>mean±SD<br>median (Q1–Q3) |
|--------------------------------------------------|-----|------|------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------|
| Your income status                               |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Income less than expenses                        | 67  | 23.4 | 6.10±1.83<br>6.00 (5.00–7.00)                              | 13.89±4.43<br>14.00 (11.00–17.00)                           | 16.07±4.57<br>16.00 (14.00–19.00)                        | 11.07±3.29<br>12.00 (10.00–13.00)                   | 9.20±3.91<br>9.00 (7.00–12.00)                            | 12.79±4.17<br>13.00 (11.00–16.00)                            | 69.14±18.07<br>71.00 (63.00–77.00)            |
| Income equal to expenses                         | 169 | 59.1 | 6.07±1.86<br>6.00 (5.00–7.00)                              | 13.71±4.27<br>13.00 (11.00–16.50)                           | 15.06±3.97<br>16.00 (13.00–17.00)                        | 11.07±2.82<br>11.00 (10.00–13.00)                   | 8.66±3.05<br>9.00 (6.00–10.00)                            | 13.27±4.11<br>14.00 (12.00–17.00)                            | 67.86±14.71<br>68.00 (62.00–75.50)            |
| Income greater than expenses                     | 50  | 17.5 | 6.06±1.89<br>6.00 (4.00–7.00)                              | 13.18±4.60<br>13.00 (10.00–16.25)                           | 15.22±4.02<br>16.00 (14.00–18.00)                        | 10.86±2.87<br>11.50 (10.00–13.00)                   | 8.42±3.27<br>8.00 (6.00–10.00)                            | 13.86±4.74<br>15.00 (10.75–18.00)                            | 67.60±14.67<br>69.50 (62.00–77.25)            |
| p                                                |     |      | 0.934                                                      | 0.478                                                       | 0.119                                                    | 0.925                                               | 0.592                                                     | 0.144                                                        | 0.639                                         |
| Your employment status                           |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Yes                                              | 136 | 47.6 | 6.25±1.80<br>6.00 (5.00–7.00)                              | 14.11±4.33<br>14.00 (11.00–17.00)                           | 15.52±3.80<br>16.00 (14.00–18.00)                        | 11.47±2.82<br>12.00 (10.00–13.00)                   | 8.75±3.33<br>8.50 (6.00–10.00)                            | 13.59±4.09<br>14.00 (12.00–17.75)                            | 69.72±14.71<br>71.00 (62.25–78.00)            |
| No                                               | 150 | 52.4 | 5.92±1.89<br>6.00 (4.75–7.00)                              | 13.24±4.36<br>13.00 (11.00–15.25)                           | 15.14±4.43<br>16.00 (13.00–17.00)                        | 10.64±2.99<br>11.00 (10.00–12.00)                   | 8.74±3.29<br>9.00 (6.00–10.25)                            | 12.96±4.36<br>13.50 (11.75–17.00)                            | 66.67±16.11<br>68.00 (62.00–75.00)            |
| p                                                |     |      | 0.100                                                      | 0.123                                                       | 0.645                                                    | <b>0.014</b>                                        | 0.655                                                     | 0.192                                                        | 0.078                                         |
| Your spouse's employment status                  |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Yes                                              | 274 | 95.8 | 6.09±1.81<br>6.00 (5.00–7.00)                              | 13.66±4.34<br>14.00 (11.00–17.00)                           | 15.30±4.12<br>16.00 (13.00–18.00)                        | 11.05±2.90<br>11.00 (10.00–13.00)                   | 8.74±3.30<br>9.00 (6.00–10.00)                            | 13.23±4.22<br>14.00 (12.00–17.00)                            | 68.09±15.33<br>69.00 (62.75–76.00)            |
| No                                               | 12  | 4.2  | 5.83±2.72<br>5.00 (4.00–9.00)                              | 13.66±4.92<br>12.00 (11.25–16.00)                           | 15.83±4.64<br>16.00 (16.00–17.75)                        | 10.75±3.86<br>11.00 (7.75–13.00)                    | 8.83±3.71<br>8.50 (7.00–9.00)                             | 13.91±4.69<br>14.50 (12.00–18.00)                            | 68.83±19.97<br>67.50 (58.00–79.25)            |
| p                                                |     |      | 0.325                                                      | 0.889                                                       | 0.509                                                    | 0.722                                               | 0.993                                                     | 0.508                                                        | 0.829                                         |
| Your chronic disease status                      |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Yes                                              | 37  | 12.9 | 6.18±2.03<br>6.00 (5.00–7.00)                              | 13.27±5.07<br>13.00 (11.00–16.00)                           | 14.64±4.88<br>15.00 (13.00–17.50)                        | 11.16±3.08<br>11.00 (10.00–13.00)                   | 8.94±3.53<br>9.00 (6.50–10.00)                            | 12.78±4.35<br>13.00 (11.00–16.00)                            | 67.00±17.96<br>69.00 (59.50–76.50)            |
| No                                               | 249 | 87.1 | 6.06±1.83<br>6.00 (5.00–7.00)                              | 13.71±4.25<br>14.00 (11.00–17.00)                           | 15.42±4.01<br>16.00 (14.00–18.00)                        | 11.02±2.92<br>11.00 (10.00–13.00)                   | 8.71±3.28<br>9.00 (6.00–10.00)                            | 13.33±4.22<br>14.00 (12.00–17.00)                            | 68.28±15.14<br>69.00 (63.00–76.00)            |
| p                                                |     |      | 0.910                                                      | 0.477                                                       | 0.350                                                    | 0.780                                               | 0.654                                                     | 0.439                                                        | 0.648                                         |
| Your gynecological conditions or medical history |     |      |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Yes                                              | 24  | 8.4  | 5.95±1.70<br>6.00 (4.00–7.00)                              | 12.91±4.31<br>13.50 (11.25–15.75)                           | 14.37±4.44<br>15.50 (14.00–17.00)                        | 10.62±3.22<br>11.00 (10.25–12.75)                   | 8.41±3.14<br>9.00 (6.25–10.75)                            | 12.95±4.57<br>13.00 (12.00–17.50)                            | 65.25±16.91<br>69.00 (63.00–76.00)            |
| No                                               | 262 | 91.6 | 6.09±1.87<br>6.00 (5.00–7.00)                              | 13.72±4.37<br>13.50 (11.00–17.00)                           | 15.41±4.10<br>16.00 (13.00–18.00)                        | 11.07±2.91<br>11.00 (10.00–13.00)                   | 8.77±3.33<br>9.00 (6.00–10.00)                            | 13.29±4.21<br>14.00 (12.00–17.00)                            | 68.38±15.38<br>69.00 (62.00–76.00)            |
| p                                                |     |      | 0.644                                                      | 0.647                                                       | 0.375                                                    | 0.832                                               | 0.919                                                     | 0.740                                                        | 0.724                                         |

**Appendix 1 (cont.).** Comparison of women's sociodemographic characteristics with FSFI mean scores

| Variables                   | n   | %            | Sexual desire<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Sexual arousal<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Lubrication<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Orgasm<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Satisfaction<br>subdimension<br>mean±SD<br>median (Q1–Q3) | Pain discomfort<br>subdimension<br>mean±SD<br>median (Q1–Q3) | FSFI total score<br>mean±SD<br>median (Q1–Q3) |
|-----------------------------|-----|--------------|------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------|
| Your smoking status         |     |              |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Never                       | 211 | 73.8         | 6.09±1.73<br>6.00 (5.00–7.00)                              | 13.90±4.22<br>14.00 (11.00–17.00)                           | 15.44±3.95<br>16.00 (14.00–18.00)                        | 11.15±2.77<br>12.00 (10.00–13.00)                   | 8.71±3.14<br>9.00 (6.00–10.00)                            | 13.36±4.07<br>14.00 (12.00–17.00)                            | 68.67±14.46<br>70.00 (63.00–76.00)            |
| Half a pack per day         | 62  | 21.7         | 6.30±2.10<br>6.50 (4.75–8.00)                              | 13.01±4.90<br>12.50 (10.75–16.00)                           | 14.96±4.83<br>16.00 (13.00–18.00)                        | 10.59±3.48<br>11.00 (10.00–12.00)                   | 8.91±3.88<br>9.00 (6.00–11.00)                            | 12.69±4.77<br>13.00 (10.75–18.00)                            | 66.50±18.63<br>66.00 (59.75–76.00)            |
| One pack or more<br>per day | 13  | 4.5          | 4.69±2.05<br>4.00 (3.00–6.00)                              | 12.76±3.70<br>12.00 (11.00–13.00)                           | 15.23±3.65<br>16.00 (13.00–17.00)                        | 11.30±2.75<br>11.00 (10.00–12.50)                   | 8.46±3.15<br>8.00 (6.00–9.00)                             | 14.38±4.13<br>15.00 (12.00–18.00)                            | 66.84±16.32<br>66.00 (60.00–69.50)            |
| p                           |     | <b>0.013</b> | 0.099                                                      | 0.099                                                       | 0.624                                                    | 0.170                                               | 0.796                                                     | 0.400                                                        | 0.151                                         |
| Your menstrual<br>frequency |     |              |                                                            |                                                             |                                                          |                                                     |                                                           |                                                              |                                               |
| Once a month                | 267 | 93.4         | 6.03±1.81<br>6.00 (5.00–7.00)                              | 13.55±4.26<br>13.00 (11.00–16.00)                           | 15.24±4.06<br>16.00 (13.00–17.00)                        | 10.99±2.89<br>11.00 (10.00–13.00)                   | 8.67±3.26<br>9.00 (6.00–10.00)                            | 13.28±4.20<br>14.00 (12.00–17.00)                            | 67.78±15.19<br>69.00 (62.00–76.00)            |
| Once every 2–3<br>months    | 11  | 3.8          | 6.90±1.70<br>7.00 (6.00–8.00)                              | 15.54±4.56<br>16.00 (14.00–17.00)                           | 16.72±4.40<br>18.00 (16.00–19.00)                        | 11.45±3.44<br>12.00 (11.00–14.00)                   | 9.18±2.89<br>9.00 (8.00–12.00)                            | 13.18±4.95<br>13.00 (11.00–18.00)                            | 73.00±16.74<br>76.73 (73.00–85.00)            |
| Never                       | 7   | 2.4          | 7.00±3.00<br>6.00 (4.00–10.00)                             | 14.57±7.48<br>12.00 (10.00–24.00)                           | 16.57±6.52<br>16.00 (16.00–23.00)                        | 12.00±4.32<br>13.00 (11.00–15.00)                   | 11.00±5.22<br>10.00 (8.00–17.00)                          | 12.85±5.52<br>15.00 (8.00–18.00)                             | 74.00±25.09<br>74.00 (67.00–97.00)            |
| p                           |     | 0.219        | 0.258                                                      | 0.258                                                       | 0.080                                                    | 0.250                                               | 0.354                                                     | 0.924                                                        | 0.076                                         |

\*: Kruskal–Wallis Test; \*\*: Mann–Whitney U Test; SD: Standard deviation; FSFI: Female sexual function index.

# Midwifery Students' Perceptions of Clinical Learning Experiences and Assertiveness Levels: The Serial Mediating Role of Anxiety and Stress

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## Abstract

**Introduction:** This study aimed to examine the relationship between midwifery students' perceptions of clinical learning experiences and assertiveness levels through a serial mediation analysis involving anxiety and stress.

**Methods:** This descriptive, cross-sectional, and correlational study included midwifery students in the 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> years of study at a university in eastern Türkiye. Data were collected using the Student Introduction Form, Perceptions of Clinical Learning Experiences Scale, the Voltan-Acar Assertiveness Inventory, the State Anxiety Inventory, and the Clinical Stress Questionnaire (CSQ).

**Results:** The sample comprised 239 midwifery students. Students demonstrated low levels of clinical learning experience perceptions and assertiveness ( $44.65 \pm 12.03$ ;  $89.73 \pm 26.93$ ), as well as moderate levels of anxiety and stress ( $46.30 \pm 8.63$ ;  $53.32 \pm 14.53$ ). A statistically significant positive correlation was identified between CSQ scores and trait anxiety scale scores ( $\beta = 0.343$ ,  $p < 0.001$ ). State anxiety, clinical learning environment, and self-determination scale scores collectively explained 16.3% of the variance in CSQ scores ( $R^2 = 0.163$ ).

**Discussion and Conclusion:** The findings indicate that moderate levels of anxiety and stress adversely affect perceptions of clinical learning experiences among midwifery students and are associated with lower perceptions of clinical learning experiences and assertiveness levels. The quantitative model revealed that anxiety and stress serially mediated the association between clinical learning experience perceptions and assertiveness, elucidating the mechanisms underlying these relationships.

**Keywords:** Anxiety; Assertiveness; Clinical; Midwifery; Student

Midwifery programs are structured to equip students with essential clinical competencies required for effective performance as professional midwives in future practice.<sup>[1]</sup> In such countries as New Zealand, Germany,

and Australia, clinical practice constitutes 50% of the midwifery curriculum.<sup>[2]</sup> In Türkiye, clinical practice exceeds this proportion and represents a substantially larger component of the curriculum.<sup>[3,4]</sup> Given that approximately

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half of undergraduate midwifery education occurs in clinical settings, assessment of assertiveness in relation to clinical experiences is essential.<sup>[5]</sup>

Assertiveness plays a central role not only in daily interpersonal relationships but also in professional practice. The ability of midwifery students to form strong and therapeutic relationships with individuals under care is closely linked to elevated assertiveness levels. Students who demonstrate assertive behaviors can advocate fairly and effectively for personal rights and for the rights of patients.<sup>[6]</sup> Assertiveness constitutes a skill that must be cultivated in midwifery education and contributes to enhanced personal confidence. In addition, midwifery students have been reported to experience moderate levels of anxiety and stress during early clinical practice.<sup>[7]</sup>

Furthermore, the literature highlights a gap in understanding how clinical environments and instructor behaviors influence psychological well-being and skill development among students. Several studies indicate a need for further research on the mediating effects of anxiety and stress in the relationship between perceptions of clinical learning experiences and assertiveness levels.<sup>[5,8,9]</sup> It is hypothesized that negative perceptions of the clinical environment may elevate stress and anxiety, which may subsequently diminish assertiveness, thereby contributing to clinical underperformance. Examination of this multifaceted relationship is essential to enhance the quality of clinical midwifery education.

The primary aim of this study was to assess midwifery students' perceptions of clinical learning experiences, assertiveness levels, and levels of anxiety, concern, and stress. The secondary aim was to examine the serial mediating roles of anxiety and stress in the relationship between perceptions of clinical learning experiences and assertiveness levels.

## Materials and Methods

### Study Place and Design

Data collection was conducted between March and November 2024 at a university located in eastern Türkiye. A cross-sectional survey design was utilized and structured within the framework of Structural Equation Modeling (SEM) to assess midwifery students' perceptions of clinical learning experiences, assertiveness, anxiety, and stress levels, and to examine the relationships among these variables. The relational screening model constitutes a descriptive approach used to identify whether two or

more variables demonstrate a statistically significant association and to determine whether and how the variables change in relation to one another.<sup>[10]</sup>

### Research Type

This study is a descriptive, cross-sectional, and correlational research.

### Research Questions

1. How do midwifery students perceive their clinical learning experiences?
2. What is the assertiveness level of midwifery students?
3. How prevalent is anxiety among midwifery students in the context of clinical training?
4. How do midwifery students perceive their levels of stress in relation to their training experiences?
5. How do anxiety and stress function as serial mediations between students' perceptions of clinical learning environments and their assertiveness levels?

### Study Population and Sampling

The study population comprised 2<sup>nd</sup>-, 3<sup>rd</sup>-, and 4<sup>th</sup>-year midwifery students who were participating in clinical practice at the Faculty of Health Sciences, Şırnak University (n=349) in eastern Türkiye. The required sample size was calculated using a 95% confidence level, a 5% margin of error, and 80% statistical power, yielding a minimum requirement of 153 students. The study was completed with 239 midwifery students through quota sampling, corresponding to 68.4% of the population. Data collection was conducted between March and November 2024.

Quota sampling is similar to stratified sampling in that it involves selecting participants from a population divided into distinct subgroups. However, unlike stratified sampling, which employs random selection within each subgroup, quota sampling relies on convenience-based methods to select participants from each subgroup. To ensure response validity, predetermined selection criteria are applied following identification of the target population. This approach is referred to as controlled quota sampling.<sup>[11]</sup>

### Inclusion Criteria

Participants were 2<sup>nd</sup>-, 3<sup>rd</sup>-, and 4<sup>th</sup>-year midwifery students who had attended theoretical courses and clinical placements and who voluntarily agreed to participate.

## Exclusion Criteria

Students in the 1<sup>st</sup> year (n=64), those who did not attend the course and clinical practice (n=15), and those who did not volunteer to participate (n=85) were excluded from the study.

## Data Collection Tools

Data were collected using the Student Introduction Form, the Perceptions of Clinical Learning Experiences Scale (CLES), the Voltan-Acar Assertiveness Inventory (VAAI), the State Anxiety Inventory (SAI), and the Clinical Stress Questionnaire (CSQ).

## Student Introduction Form

The form was developed by researchers based on the related literature<sup>[9,12,13]</sup> and consists of six questions addressing age, gender, year of study, duration of clinical experience, most recent clinical placement, and current academic grade point average.

## Perceptions of CLES

The scale was developed by Griffiths et al.<sup>[2]</sup> and adapted to Turkish society by Güneş Ayyıldız and Demirelöz Akyüz.<sup>[14]</sup> The instrument assesses how midwifery students perceive the clinical learning environment, including the role and impact of instructors on the learning process. The present study focused solely on perceptions of clinical learning experiences; therefore, only the perception component of the CLES was utilized. Items are scored from 1 (Strongly disagree) to 4 (Strongly agree). The scale has no cutoff score. Scores range from a minimum of 26 to a maximum of 104, with higher scores indicating increased perceptions of clinical learning experiences.

In the original scale, the Cronbach's alpha coefficient for the perception of CLES was 0.92.<sup>[2]</sup> In this study, the Cronbach's alpha coefficient for the perception of CLES was 0.90.

## VAAI

The scale was developed by Voltan-Acar and Öğretmen for Turkish society to measure assertiveness. The instrument consists of 28 items and utilizes a 6-point Likert structure, with response options ranging from 6 (very descriptive of me) to 1 (not at all descriptive of me). The minimum score is 28, and the maximum score is 168. Higher scores indicate greater assertiveness, whereas lower scores correspond to increased passiveness. Increases in scale scores signify heightened assertiveness levels. The Cronbach's alpha coefficient of the original scale was 0.78,<sup>[15]</sup> and was calculated as 0.82 in the present study.

## SAI

Spielberger et al.<sup>[16]</sup> developed the State-Trait Anxiety Inventory to independently measure state and trait anxiety levels based on the "Two-Factor Theory of Anxiety". The scale was adapted to Turkish by Oner.<sup>[17]</sup> The present study utilized only the State Anxiety Scale (SAI). The SAI consists of 20 items and is scored on a 4-point Likert scale. In the SAI, individuals assess how they "feel at the moment" (at a given moment and under specific conditions). Total scores range from 20 to 80, with higher scores indicating increased anxiety levels. Scores of 60 or above indicate anxiety levels that exceed normal limits.

In the Turkish form, the Cronbach's alpha coefficient for the SAI ranged from 0.94 to 0.96.<sup>[17]</sup> In the present study, the Cronbach's alpha coefficient for the SAI was 0.87.

## CSQ

The scale was developed by Pagana and adapted to Turkish society by Sendir and Acaroğlu.<sup>[18,19]</sup> The instrument measures initial levels of stress (including threat and challenge) experienced by nursing students on the 1<sup>st</sup> day of clinical practice. It is a 20-item, 5-point Likert-type questionnaire. Each item is scored from 0 ("not at all") to 4 ("very much"). The minimum total score is 0, and the maximum score is 80. Lower scores indicate lower stress levels, whereas higher scores reflect increased stress levels.

The Cronbach's alpha coefficient of the Turkish version of the scale was 0.70,<sup>[19]</sup> whereas it was calculated as 0.72 in the present study.

## Data Collection

Data were collected between March and November 2024. Participants were informed about the aim of the study, and questionnaire forms were distributed for completion. Data collection was conducted through face-to-face interviews in the clinical setting. Interviews were scheduled in an appropriate environment and time frame after the lunch break and lasted approximately 25–30 min. Researchers were present in the clinics 2 days/week during working hours for data collection.

## Ethical Aspect

Before data collection, ethical approval was obtained from the Scientific Research Ethics Committee of Şırnak University (Date: December 07, 2023; Approval No: 2023/82972) in eastern Türkiye. Students who volunteered to participate provided verbal and written informed consent in accordance with ethical guidelines. Participants were

informed that the information obtained from the study would not be disclosed to any third parties, institutions, or organizations. None of the researchers had a teaching or evaluative role with respect to the participating students; therefore, no power imbalance or academic pressure was present during recruitment or data collection. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki.

## Data Analysis

Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) V23 and IBM AMOS V24 (Version 23.0, SPSS Inc., Chicago, IL, USA). Normality was assessed using the Shapiro–Wilk test and Q-Q plot inspections. Based on these evaluations, the data demonstrated normal distribution. Descriptive statistical methods were employed to evaluate midwifery students' perceptions of clinical learning experiences and their assertiveness, anxiety, and stress levels. These analyses were conducted to fulfill the primary objective of the study, which involved assessing the levels of the variables under investigation.

To address the secondary objective of the study, inferential analyses were conducted. Pearson's correlation analysis was used to examine the relationships among the study variables.<sup>[20]</sup> SEM was then applied to test the proposed SEM. This model was selected because the study aimed to examine whether anxiety and stress sequentially mediate the relationship between midwifery students' perceptions of clinical learning experiences and their assertiveness levels.

The significance of direct and indirect effects was evaluated using a bootstrapping procedure with 5,000 resamples and a 95% confidence interval. Bootstrapping was preferred as it is widely recommended for mediation analyses due to its robustness in estimating indirect effects and its reduced sensitivity to violations of normality assumptions. Statistical significance was set at  $p < 0.05$ .

## Results

### Participant Characteristics

The mean age of participating students was  $21.32 \pm 1.65$  years. A total of 57% resided in the city center, and 40% were in the 3<sup>rd</sup> year of study. In addition, 56% had 15 weeks or more of clinical experience, 72% had completed clinical practice in internal medicine units, and 49% had an academic grade point average in the 3.50–3.01 range (Table 1).

**Table 1.** Distribution and means of students' demographic data (n=239)

| Demographic data                     | n           | %                       |
|--------------------------------------|-------------|-------------------------|
| Place of residence                   |             |                         |
| City                                 | 136         | 57                      |
| Town                                 | 79          | 33                      |
| Village                              | 24          | 10                      |
| Year                                 |             |                         |
| 2 <sup>nd</sup> year                 | 92          | 38                      |
| 3 <sup>rd</sup> year                 | 95          | 40                      |
| 4 <sup>th</sup> year                 | 52          | 22                      |
| Duration of clinical experience      |             |                         |
| 15 weeks and over                    | 133         | 56                      |
| 8–14 weeks                           | 106         | 44                      |
| Clinic of the most recent experience |             |                         |
| Surgical units                       | 60          | 25                      |
| Internal units                       | 173         | 72                      |
| Intensive care units                 | 6           | 3                       |
| Academic grade point average         |             |                         |
| 4.00–3.51                            | 7           | 3                       |
| 3.50–3.01                            | 116         | 49                      |
| 3.00–2.51                            | 101         | 42                      |
| 2.50–2.26                            | 9           | 4                       |
| 2.25–2.01                            | 3           | 1                       |
| 2.00–1.01                            | 3           | 1                       |
|                                      | <b>M±SD</b> | <b>Median (min–max)</b> |
| Age (years)                          | 21.32±1.65  | 21 (18–33)              |

n: Total sample size; n: Number of participants; %: Percentage; M: Mean; SD: Standard deviation; Min: Minimum; Max: Maximum.

### Scale Scores

Students' mean score on the SAI was  $46.30 \pm 8.63$ , and the mean score on the CSQ was  $53.32 \pm 14.53$ . The mean score on the VAAI was  $89.73 \pm 26.93$ . The mean score on the perception of CLES was  $44.65 \pm 12.03$  (Table 2).

### The Relationship between Scales

A statistically significant positive correlation was identified between state anxiety scores and CSQ scores among the participating midwifery students ( $r = 0.385$ ;  $p < 0.001$ ). Conversely, state anxiety scores were negatively correlated with assertiveness scale scores ( $r = -0.288$ ;  $p < 0.001$ ). In addition, a statistically significant negative relationship was observed between state anxiety scores and perception of CLES scores ( $r = -0.270$ ;  $p < 0.001$ ).

**Table 2.** Mean scale score (n=239)

| Scales | Mean±SD     | Median (min-max) |
|--------|-------------|------------------|
| SAI    | 46.30±8.63  | 46 (20–80)       |
| CSQ    | 53.32±14.53 | 54 (20–100)      |
| VAAI   | 89.73±26.93 | 90 (28–168)      |
| CLES   | 44.65±12.03 | 48 (13–52)       |

M: Mean; SD: Standard deviation; Min: Minimum; Max: Maximum; SAI: State anxiety inventory; CSQ: Clinical stress questionnaire; VAAI: Voltan-Acar assertiveness inventory; CLES: Perceptions of clinical learning experiences scale.

A statistically significant positive correlation was observed between CSQ scores and assertiveness scores ( $r=0.212$ ;  $p=0.001$ ). The findings also demonstrated a statistically significant positive association between clinical stress levels and perceptions of the clinical learning environment as measured by the CLES scale ( $r=0.216$ ;  $p=0.001$ ).

A statistically significant positive relationship was found between assertiveness scale scores and perceptions of the CLES ( $r=0.539$ ;  $p<0.001$ ) (Table 3).

### SEM Results

The analysis revealed a statistically significant negative correlation between assertiveness levels and state anxiety scores ( $\beta=-0.155$ ;  $p=0.005$ ). A one-unit increase in state anxiety scores corresponded to a 0.481-point decrease in assertiveness scores ( $B=-0.481$ ).

The findings indicated a statistically significant negative correlation between assertiveness levels and perceptions of the clinical learning environment, as measured by the CLES ( $\beta=-0.745$ ;  $p<0.001$ ). A one-unit increase in perception of CLES scores corresponded to a 1.663-point decrease in assertiveness scale scores ( $B=-1.663$ ).

Perception of CLES scores had no statistically significant effect on CSQ scores ( $p=0.215$ ). A statistically significant positive correlation was observed between CSQ scores and SAI scores ( $\beta=0.343$ ;  $p<0.001$ ). A one-unit increase in SAI scores corresponded to a 0.577-point increase in CSQ

**Table 3.** Correlations among mean scale scores

| Scales | SAI | CSQ              | VAAI             | CLES             |
|--------|-----|------------------|------------------|------------------|
| SAI    |     |                  |                  |                  |
| r      | 1   | 0.385**          | -0.288**         | -0.270**         |
| p      |     | <b>&lt;0.001</b> | <b>&lt;0.001</b> | <b>&lt;0.001</b> |
| CSQ    |     |                  |                  |                  |
| r      |     | 1                | 0.212**          | 0.216**          |
| p      |     |                  | <b>0.001</b>     | <b>0.001</b>     |
| VAAI   |     |                  |                  |                  |
| r      |     |                  | 1                | 0.539**          |
| p      |     |                  |                  | <b>&lt;0.001</b> |
| CLES   |     |                  |                  |                  |
| r      |     |                  |                  | 1                |
| p      |     |                  |                  |                  |

\*\* $p<0.01$ . r: Pearson correlation coefficient; p: Significance level; SAI: State anxiety inventory; CSQ: Clinical stress questionnaire; VAAI: Voltan-acar assertiveness inventory; CLES: Perceptions of clinical learning experiences scale.

scores ( $B=0.577$ ). Assertiveness scale scores demonstrated no statistically significant effect on CSQ scores ( $p=0.357$ ). Perception of CLES scores and assertiveness scale scores collectively explained 16.3% of the variance in CSQ scores ( $R^2=0.163$ ) (Table 4).

The serial mediation model was applied to the research questions, as shown in Figure 1. Model fit indices demonstrated a good fit to the data: CMIN=1.928, DF=2, CMIN/DF=0.964, RMSEA=0.030, CFI=0.999, NFI=0.997, TLI=0.999, AGFI=0.996, and GFI=0.997.

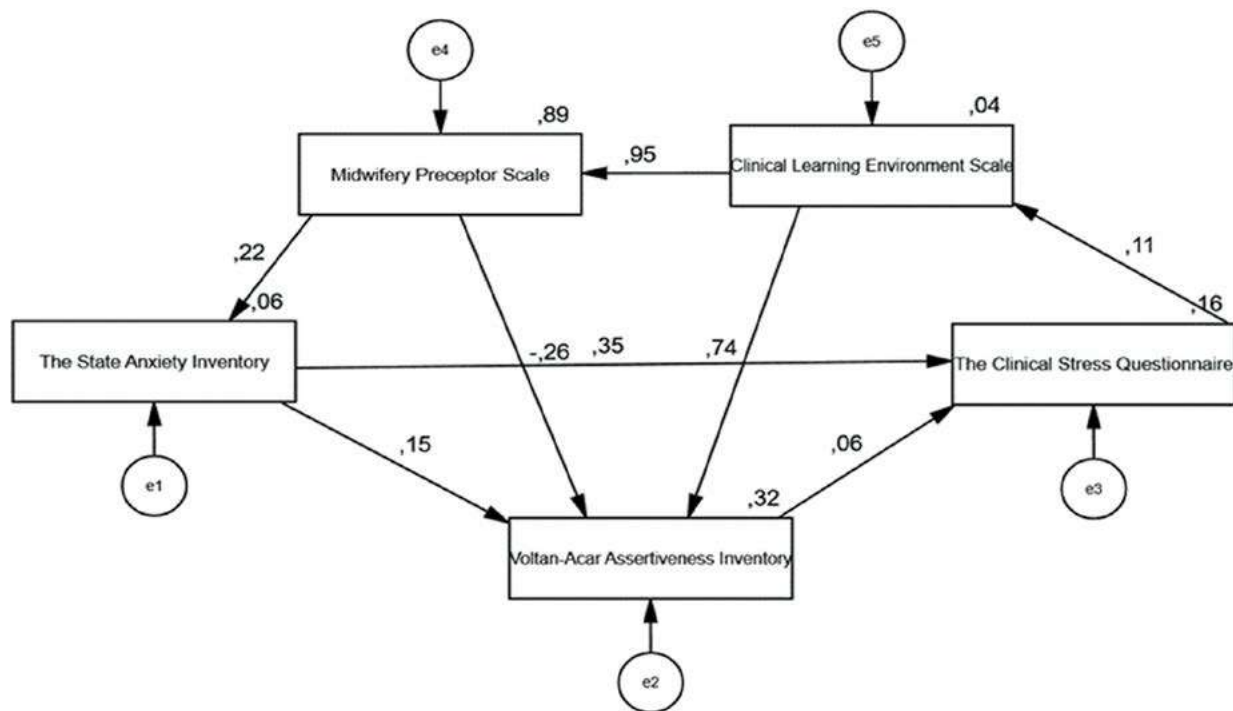
### Discussion

The findings indicate that the relationship between perceptions of the clinical learning experience and assertiveness levels is directly mediated by stress and anxiety. Clinical stress was influenced by state anxiety, perceptions of the clinical learning environment, and assertiveness levels. These findings are discussed in further detail below.

**Table 4.** PATH analysis results

| Outcome variable | Predictor | B      | $\beta$ | SE    | CR     | p                | R <sup>2</sup> |
|------------------|-----------|--------|---------|-------|--------|------------------|----------------|
| VAAI             | SAI       | -0.481 | -0.155  | 0.173 | -2.785 | <b>0.005</b>     | 0.315          |
| VAAI             | CLES      | -1.663 | -0.745  | 0.369 | -4.508 | <b>&lt;0.001</b> |                |
| CSQ              | CLES      | 0.106  | 0.088   | 0.085 | 1.240  | 0.215            | 0.163          |
| CSQ              | SAI       | 0.577  | 0.343   | 0.104 | 5.535  | <b>&lt;0.001</b> |                |
| CSQ              | VAAI      | 0.035  | 0.066   | 0.039 | 0.920  | 0.357            |                |

B: Unstandardized coefficient;  $\beta$ : Standardized coefficient; SE: Standard error; CR: Critical ratio; R<sup>2</sup>: Regression coefficient; SAI: State anxiety inventory; CSQ: Clinical stress questionnaire; VAAI: Voltan-acar assertiveness inventory; CLES: Perceptions of clinical learning experiences scale.



**Figure 1.** Standardized path coefficients.

In the study, midwifery students demonstrated moderate levels of state anxiety and clinical stress, low levels of assertiveness, and moderate perceptions of clinical learning experiences. A study reporting that assertiveness and psychological empowerment among nursing and midwifery students were at moderate levels also identified a positive and significant correlation between the variables.<sup>[12]</sup> Perceptions of clinical learning experiences are influenced by positive instructor attitudes.<sup>[21,22]</sup> Although a negative relationship between stress and assertiveness would be expected within the theoretical framework, a positive association was identified in this study. This finding suggests that assertiveness may have emerged as a coping strategy under stress. In this respect, improved management of stress and anxiety may lead to higher levels of assertiveness among students.

Research examining students' perceptions of clinical learning environments and instructors across diverse sample populations consistently indicates that both are generally evaluated as adequate.<sup>[21,22]</sup> It has been reported that midwifery students in Türkiye hold highly positive perceptions of their clinical learning experiences, particularly with respect to the development of clinical skills.<sup>[13]</sup> Despite these reported findings, students in the present study appeared to experience psychological factors at levels capable of influencing clinical education processes, suggesting that such factors may play a role in learning.

Midwifery students may encounter stressful experiences, particularly in relation to instructor characteristics and the clinical environment, which may affect theoretical and practical skill development. A study conducted in Iran found that midwifery students experienced considerable stress in clinical settings and that instructor-related factors contributed substantially to this stress.<sup>[9]</sup> Ziba et al.<sup>[23]</sup> reported that frequent contact and supervision from dedicated instructors positively influenced the clinical perceptions of nursing and midwifery students. These varied findings highlight the need to further investigate the influence of instructors on students' anxiety levels.

Low self-confidence combined with high anxiety may lead to decreased performance and limited learning and creativity among midwifery students.<sup>[24]</sup> In the present study, a one-unit increase in state anxiety scores corresponded to a 0.481-point decrease in assertiveness scores. Prior studies have reported that nursing and midwifery students experience detrimental latent anxiety and that anxiety levels tend to decrease as assertiveness levels increase. Low levels of anxiety may have constructive effects, whereas moderate to high levels may produce adverse outcomes.<sup>[9,24]</sup> The study revealed that as perceptions of clinical learning experiences improved, assertiveness levels decreased significantly. A systematic review evaluating challenges encountered by nursing and midwifery students in

clinical settings identified key difficulties, including a lack of support systems, instructor attitudes, and insufficient learning motivation.<sup>[6]</sup> Problem-solving skills and self-confidence improve as assertiveness increases.<sup>[25]</sup> Strong adaptation to clinical environments positively influences assertiveness among midwifery students. The literature notes that students supported by instructors tend to be more motivated to learn, have higher satisfaction, and demonstrate stronger professional commitment.<sup>[26,27]</sup> Studies conducted in Türkiye indicate that clinical instructors exert a positive influence on the professional development of midwifery students.<sup>[13,28]</sup>

A one-unit increase in SAI scores corresponded to a 0.577-point increase in CSQ scores. Studies conducted in Türkiye report that midwifery students experience high levels of state anxiety and stress during early clinical experiences, and that these levels tend to decrease with increasing experience.<sup>[7]</sup> Midwifery and nursing students have been reported to experience stress primarily due to clinical and academic environments.<sup>[8]</sup> A study emphasizing the direct mediating effect of clinical practice stress between the clinical learning environment and satisfaction with clinical practice suggested that environmental adjustments and stress reduction are necessary.<sup>[29,30]</sup>

According to the findings, part of the variation in clinical stress levels could be explained by clinical learning environment experiences and assertiveness levels, supporting the primary research question of the study. The present study constitutes the first attempt to examine whether anxiety and stress serve as serial mediators in the relationship between perceptions of clinical learning experiences and assertiveness levels among midwifery students. The results indicated that anxiety and stress functioned as serial mediators in this relationship. Although anxiety and stress assumed a meaningful mediating role in the relationship between clinical learning experiences and assertiveness, the explanatory power of the model remained limited. This suggests that assertiveness constitutes a multidimensional construct that cannot be explained solely through clinical learning experiences, anxiety, and stress among midwifery students. Variables such as personality traits, self-efficacy, clinical attitudes, clinical mentor support, and cultural factors may also play substantial roles. The study additionally provides a theoretical framework concerning psychological processes and clinical learning experiences among students. In this context, the development of initiatives aimed at strengthening assertiveness skills through the

creation of safe learning environments by educators may contribute positively to educational processes.

## Limitations

The present study has several limitations. First, data were collected using self-report scales; therefore, the possibility of artificial associations between variables due to response tendencies should be considered, and the potential influence of the data collection method on the findings should be taken into account. Second, participants were recruited from a single institution in eastern Türkiye. Inclusion of more diverse populations or larger samples would increase generalizability. Finally, the study employed a cross-sectional design, making it difficult to establish cause-effect relationships. Experimental and cohort studies are recommended to further explore relationships among these variables in the future.

## Conclusion

The findings indicate that elevated anxiety and stress adversely affect perceptions of clinical learning experiences among midwifery students and are associated with lower assertiveness levels. The study revealed that anxiety and stress serially mediated the association between clinical learning experience perceptions and assertiveness, elucidating the mechanisms underlying these relationships. This study constitutes the first attempt to introduce a quantitative model defining the relationship between clinical learning experiences, anxiety, stress, and assertiveness levels among midwifery students. Given the substantial number of midwifery students in contemporary educational settings, the present study provides a meaningful contribution to the related literature.

Based on the findings, integration of stress management programs into midwifery education, including mindfulness training or coping skills workshops, may reduce anxiety and stress levels. Implementation of supportive mentorship or preceptorship interventions in clinical settings may also enhance confidence, assertiveness, and perceptions of clinical learning experiences.

**Ethics Committee Approval:** The Şırnak University Scientific Clinical Research Ethics Committee granted approval for this study (date: 07.12.2023, number: 2023/82972).

**Informed Consent:** Students who volunteered to participate provided verbal and written informed consent in accordance with ethical guidelines. Participants were informed that the information obtained from the study would not be disclosed to any third parties, institutions, or organizations.

**Conflict of Interest:** The authors declare that there is no conflict of interest regarding the conduct or publication of this study. Furthermore, we confirm that this manuscript has not been published previously in any language, has not been accepted for publication elsewhere, and is not under simultaneous consideration by any other journal.

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# Factors Associated with Nurses' Intention to Apply Current Guidelines for Medication Administration through Feeding Tube: Application of the Theory of Planned Behavior

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## Abstract

**Introduction:** Administering medication through a feeding tube is difficult. To avoid tube obstruction, ensure therapeutic effectiveness, and decrease drug toxicity, protocols for delivering medication through a feeding tube must be followed. This study aimed to identify factors associated with the intention (INT) of nurses to apply the current guidelines for medications administered through feeding tubes.

**Methods:** In this cross-sectional study, a paper-based survey was conducted among nurses working at the state hospital who have experience in administering medication to patients using feeding tubes. A valid and reliable Turkish scale based on the theory of planned behavior was used to identify factors associated with the INT score by a multiple linear regression model.

**Results:** One hundred and forty-nine participants (response rate: 80.0%) completed a paper-based survey. Although 85.2% of the participants reported administering medications according to the guidelines, only 34.9%, 22.8%, and 33.6%, respectively, knew that modified-release tablets, enteric-coated tablets, and film-coated tablets should not be crushed. Among participants, 42.2% had not previously received training on administering medication through a tube. The higher scores of attitudes, past behavior (PB), and subjective norm (SN) were associated with higher INT scores.

**Discussion and Conclusion:** Positive attitudes, positive PB, and positive SNs were associated with nurses' INTs to apply the current guidelines for medications administered through feeding tubes. These factors should be considered when developing interventions to promote the application of the current guidelines. Sustained collaboration among healthcare providers will promote appropriate drug utilization and improve patient care in hospital settings.

**Keywords:** Current guidelines; Enteral feeding tubes; Nurse; Theory of planned behavior

Oral feeding is unfeasible, especially in critically ill patients, because of intubation, deep sedation, and various comorbidities. In this patient population, nutritional support and the administration of medications, vital parts

of medical care, are frequently administered through enteral routes. The administration of drugs to patients receiving enteral nutrition presents complexities and is a significant concern in clinical practice. Not taking the right

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precautions when giving drugs along with enteral nutrition or inappropriate dosage form selection for administration through enteral feeding tubes (EFT) can cause problems such as tube occlusion, reduced effectiveness of the treatment, and diarrhea.<sup>[1]</sup> Prior studies have identified inadequate knowledge of dosage forms among healthcare professionals and insufficient collaboration among them as the main factors leading to medication administration errors related to EFT.<sup>[2,3]</sup>

Enhancing the quality of medication administration with EFT is crucial for critically ill patients. Although the American Society for Parenteral and Enteral Nutrition and the European Society for Clinical Nutrition and Metabolism guidelines outline the procedures for administering medications through feeding tubes, adherence to these guidelines is low.<sup>[4,5]</sup> Errors in the administration of medications through EFT complicate patient management. According to the study, hospitalized patients utilize EFT between 43% and 80% of the time.<sup>[1]</sup> Walther et al.<sup>[6]</sup> investigated the administration and prescription of medications administered through EFT in neurology and neurosurgery intensive care units. Nursing personnel indicated that 44% of modified-release medications administered through EFT were administered improperly. Previous investigations indicated that healthcare workers in an education program had a limited understanding of medications administered through EFT guidelines.<sup>[7,8]</sup> Hossaini Alhashemi et al.<sup>[9]</sup> conducted similar research, revealing that fewer than 20% of participants were aware of how to smash solid dosage forms prior to the teaching intervention.

Psychosocial models may help identify critical determinants of individuals' intentions (INTs). Several behavior models have been used to investigate barriers to the implementation of medical practice or health behavior change, including the theory of goal-oriented behaviors and the transtheoretical model of behavior change.<sup>[10,11]</sup> The theory of planned behavior (TPB) is often used to predict behavior. TPB was developed by Ajzen, who proposes that human behavior is primarily determined by behavioral INT, which reflects an individual's motivation to perform a specific action. INT is shaped by three key constructs: attitude toward the behavior, subjective norms (SNs), and perceived behavioral control (PBC). Attitude refers to a person's positive or negative evaluation of performing the behavior; SNs involve perceived social pressure from significant others; and PBC reflects one's belief in their ability to perform the behavior.<sup>[12]</sup> Together, these factors predict INT, while PBC may also directly influence actual behavior. TPB is widely used to understand and predict health-related and clinical

behaviors across various settings.<sup>[13–15]</sup> TPB is deemed the most appropriate model for this study, which investigates nurses' INTs to implement the current guidelines for medications administered through feeding tubes.

Medication administration procedures are primarily the responsibility of nurses. This study aimed to identify factors associated with the INT of nurses to apply the current guidelines for medications administered through feeding tubes.

## Materials and Methods

### Study Type, Setting, and Subjects

The study was conducted with nurses working at the state hospital in Eskişehir between September 2024 and May 2025, who were willing to participate in the study and had experience in administering medication to patients using feeding tubes. The survey was carried out following face-to-face interviews with nurses conducted by the clinical pharmacist.

The study was approved by the Non-Interventional Clinical Trials Ethics Committee Anadolu University (Date: 09.08.2024, No: 768031), ensuring adherence to the principles outlined in the Declaration of Helsinki 1975, revised Hong Kong 1989. The participants signed a written informed consent form.

### Data Collection

The survey consisted of three sections. The first section was about the participants' demographic information (age, gender, educational status, and years of experience in a hospital) and experiences (administering medications via the feeding tube according to current guidelines and receiving training on drug administration via enteral tube).

The second section was related to general knowledge on drug administration through a feeding tube, including the crushing of tablets (conventional tablet, modified-release tablet, enteric-coated tablet, film-coated tablet, and sublingual tablet), the administration of capsule-form preparations through a feeding tube, and the preferred method in case of a feeding tube blockage. The dosage form of pharmaceutical medications influences their compatibility with feeding tubes. Immediate-release tablets should be crushed and dissolved in water for administration. Do not crush or split film-coated, enteric-coated, or modified-release formulations, as such actions may alter the release mechanism of the medication, potentially reducing its efficacy or increasing toxicity and

harm. Diluting liquid drugs with clear tap water prior to administration may mitigate blockage. While it is possible to open and combine capsules with water, water may not always serve as an advantageous medium. Enteric-coated or granule/pellet capsules may be opened; however, crushing them is not recommended.<sup>[2]</sup>

The first and second sections of the survey were developed based on the literature on drug administration through feeding tubes by two clinical pharmacists and one nurse experienced in administering medication through a feeding tube.<sup>[16–18]</sup>

The third section included a TPB-based questionnaire. The survey consists of 35 items and was developed in accordance with the TPB literature and a guidebook designed for health services researchers conducting TPB studies.<sup>[19–21]</sup> The survey comprises 35 items that evaluate attitude (ATT; 3 items), (SN; 5 items), perceived behavioral control (PBC; 5 items), past behavior (PB; 13 items), and (INT; 9 items). The items were assessed using a 5-point Likert scale, from strongly disagree (1) to strongly agree (5), for the constructs of ATT, SN, PBC, and INT. In this context, positive/high frequency refers to the percentage of agreement, which is the sum of those who strongly agree and agree. Conversely, negative/low frequency indicates the percentage of disagreement, encompassing those who strongly disagree, disagree, and are neutral. PB items were evaluated using a 5-point Likert scale, with responses ranging from never (1) to regularly (5). In this context, positive/high frequency indicates the percentage of responses identified as regularly and often, whereas negative/low frequency signifies the percentage of responses categorized as never, occasionally, and sometimes.

The processes of Turkish translation and cultural adaptation followed the guidelines established by the International Society for Pharmacoeconomics and Outcomes Research.<sup>[22]</sup> The expert panel included two clinical pharmacists and one nurse who assessed the content validity of the TPB-based survey. The expert panel clarified and structured the components of the TPB framework and conducted translations and backtranslations for linguistic adaptation. A pilot study involving 20 nurses was conducted to assess the clarity of all items.<sup>[23]</sup> A minimum of 12 participants was required for the pilot study. The data of the participants in the pilot study were not included in the study. A minimum of 30 nurses, not part of the study dataset, were required for test-retest analysis to complete assessments at baseline and again 2 weeks later.<sup>[24]</sup> In addition, test-retest analysis was conducted with 40 nurses (response rate 95.0%) at a 2-week interval to assess the temporal stability of the TPB-

based subdimensions. The purpose of this analysis was to evaluate the stability of construct-level measurements over time and to justify the aggregation of item scores within each subdimension, rather than to establish a newly validated scale. The intraclass correlation coefficient was 0.82, indicating strong reliability ( $p < 0.001$ ).

Cronbach's alpha for the total TPB-based questionnaire was 0.98, demonstrating a high level of reliability. Cronbach's alpha values were 0.60 for attitude, 0.75 for SN, 0.66 for PBC, 0.84 for PB, and 0.88 for INT.

The time required to complete the survey was approximately 10–15 min.

### Sample Size

Sample size determination depends on statistical power analysis. The analysis requires a clear definition of the study design and the anticipated effect size.<sup>[25]</sup> A moderate effect size, indicated by a multiple R of approximately 0.3, is a plausible assumption for TPB studies utilizing a multiple regression methodology.<sup>[26]</sup> A sample size of 80 is typically regarded as adequate.<sup>[27]</sup> Rashidian et al.<sup>[28]</sup> assert that a sample size >148 respondents is sufficient to employ the TPB. Analysis was performed on 149 responses from hospital nurses. We employed Soper's Calculator for post hoc Statistical Power in Multiple Regression to evaluate the sufficiency of our sample size. The analysis using Soper's calculator confirmed that the sample size was sufficient for the four latent variables on the TPB questionnaire, yielding an  $R^2$  of 0.47 and a sample size of 149, with an observed statistical power of 0.99.<sup>[29]</sup>

### Statistical Analysis

An academic biostatistician employed R (4.4.1, <https://cran.r-project.org>) and SPSS for Windows 23.0 (Chicago, IL) to conduct data analysis. The Kolmogorov-Smirnov and Levene's tests were used to assess data normality and variance homogeneity. The descriptive statistics were presented as mean  $\pm$  SD, median (25<sup>th</sup>–75<sup>th</sup> percentile), and frequencies (percentages) as applicable. The Student's t-test or One-way analysis of variance (ANOVA) was utilized to compare groups for continuous variables. Following one-way ANOVA, post hoc multiple comparisons were conducted using Tukey's honestly significant difference test. Variables with  $p < 0.20$  were selected as candidates for the multiple linear regression model.<sup>[30]</sup> Multiple linear regression models were developed utilizing stepwise regression due to the consistent distribution of the residuals. Variance inflation factors for each predictor were used to evaluate multicollinearity. The Durbin-Watson test statistic

**Table 1.** Demographic characteristics and experiences of the participants

| Variables                                                                               | Participants (n=149) |      |
|-----------------------------------------------------------------------------------------|----------------------|------|
|                                                                                         | n                    | %    |
| Age (year)                                                                              | 38 (30–45)           |      |
| Gender                                                                                  |                      |      |
| Female                                                                                  | 122                  | 81.9 |
| Male                                                                                    | 27                   | 18.1 |
| Educational status                                                                      |                      |      |
| Associate's degree                                                                      | 14                   | 9.4  |
| Bachelor's degree                                                                       | 117                  | 78.5 |
| Master degree                                                                           | 11                   | 7.4  |
| PhD degree                                                                              | 7                    | 4.7  |
| Years of experience in hospital (year)                                                  |                      |      |
| <5                                                                                      | 15                   | 10.1 |
| 5–10                                                                                    | 41                   | 27.5 |
| 10–15                                                                                   | 29                   | 19.5 |
| 15–20                                                                                   | 9                    | 6    |
| >20                                                                                     | 55                   | 36.9 |
| Do you administer medications via the feeding tube according to the current guidelines? |                      |      |
| Yes                                                                                     | 127                  | 85.2 |
| No                                                                                      | 22                   | 14.8 |
| Have you received training on drug administration via enteral tube?                     |                      |      |
| Yes                                                                                     | 86                   | 57.7 |
| No                                                                                      | 63                   | 42.3 |

PhD: Doctor of Philosophy; Data are presented as median (25–75%) or frequency (percent).

was used to assess residual autocorrelation. The Cronbach's alpha coefficients of these sub-dimensions indicate the internal consistency of the scale. The acceptable range for Cronbach's alpha is 0.6–0.8.<sup>[31]</sup> Accepted level of statistical significance:  $p < 0.05$ .

## Results

One hundred forty-nine participants (response rate: 80.0%) completed a paper-based survey. The median age of the participants (25th percentile–75th percentile) was 38 years (30–45), and 122 of them (81.9%) were female. Nearly 40% of participants had worked in the hospital for more than 20 years. Among participants, 85.2% reported administering medication through a feeding tube in accordance with current guidelines. However, 42.2% had not received training on drug administration through enteral tube. Table 1 presents the characteristics of the participants.

Only 34.9%, 22.8%, and 33.6% of participants knew that modified-release tablets, enteric-coated tablets, or film-coated tablets generally could not be crushed, respectively. However, most of the participants (76.7%) were aware that the sublingual tablet could not be crushed. 22.1% of participants knew the capsule should not be opened, so it could not be given through a feeding tube, and 7.4% knew it would be crushed and mixed with water before use. When the feeding tube was blocked, 69.1% of participants preferred to rinse the tube with warm water, 56.4% chose to replace the tube, 29.5% wanted to increase the pressure inside the tube using a syringe, 14.8% opted for a mixture of sodium bicarbonate and pancreatic enzymes, and 11.4% suggested using cola (Table 2).

Table 3 presents the subscales and their descriptive statistics. Most of the participants thought that "It is important to crush the drugs separately, mix them with water separately, and wash the tube after each medication application to eliminate drug-related problems (91.95%)" and "Administering drugs through a feeding tube according to current guidelines will significantly benefit patients' treatment outcomes (92.62%)". Compared to the other items in the attitude category, the number of participants who thought that "It's important to wait at least 30 min after eating before administering the medication through the feeding tube" was lower (72.48%).

In the SN category, 88.59% of the participants stated that it was important for the person providing patient care to accept the training given about drugs administered via the feeding tube. 74.5% of participants reported that the doctor supported them in training the caregiver regarding the administration of drugs through a feeding tube. However, about half of the participants (40.94%) indicated that the caregiver would not prefer to administer the drug to the patients instead of them.

In terms of PBC, 122 (81.88%) participants reported having the necessary knowledge and skills to give drugs through a feeding tube, but 76 (51.0%) said that following the current guidelines would make it hard for them to do this, and 70 (46.98%) said it would be difficult for them to find information about how to crush or split the drugs.

In PBs, most of the participants (91.95%) washed the tube before and after administering the medication, but 62.42% (93) administered it after mixing it with food. About 40% of participants checked the suitability of crushing/splitting medications, referred to the relevant guidelines (43.62%), conducted a literature review on the suitability of crushing/splitting medications (40.27%),

**Table 2.** Questions regarding knowledge of nurse (n=149)

| Questions                                                                                                                   | n   | %    |
|-----------------------------------------------------------------------------------------------------------------------------|-----|------|
| Which of the following tablets do you crush and give to the patient?                                                        |     |      |
| Conventional tablet                                                                                                         | 94  | 63.1 |
| Modified-release tablet                                                                                                     | 97  | 65.1 |
| Enteric-coated tablet                                                                                                       | 115 | 77.2 |
| Film-coated tablet                                                                                                          | 99  | 66.4 |
| Sublingual tablet                                                                                                           | 35  | 23.5 |
| How to administer capsule-form preparations through a feeding tube?                                                         |     |      |
| Capsules should not be opened, therefore it is not appropriate to administer them through a feeding tube                    | 33  | 22.1 |
| The capsules can be crushed and mixed with water before application                                                         | 11  | 7.4  |
| The capsules can be opened and mixed with water before application                                                          | 59  | 39.6 |
| The capsules can be opened, crushed until the contents turn into powder, and then mixed with water for application          | 46  | 30.9 |
| In the case of a feeding tube blockage, which of the following methods would you prefer? (Multiple options can be selected) |     |      |
| Increasing the pressure inside the tube using a syringe                                                                     | 44  | 29.5 |
| Rinsing the tube with warm water                                                                                            | 103 | 69.1 |
| Application of cola (carbonated beverage)                                                                                   | 17  | 11.4 |
| Application of the sodium bicarbonate pancreatic enzyme mixture                                                             | 22  | 14.8 |
| Tube replacement                                                                                                            | 84  | 56.4 |

and consulted a pharmacist (40.27%) or a doctor (42.95%) about the suitability of crushing/splitting medications.

Over 65% of participants indicated their INT to apply the current guidelines for medications administered through feeding tubes in response to questions regarding INT.

According to the results of the Kolmogorov-Smirnov goodness-of-fit test, it was found to be 0.031 and  $p=0.200$  for studentized residuals, and it can be said that the residues were normally distributed. The scatter plot of studentized residuals against predicted values shows a random spread around zero, indicating that the assumption of homoscedasticity (constant variance) is met and that there is no systematic error in the model. We can conclude that the model is sufficient since the scatter plot of studentized deleted residuals against predicted values shows a random distribution around zero.

According to the univariate analysis results, gender, years of experience in a hospital, attitude, SN, and PB ( $p<0.2$ ) were selected as candidates for the multiple linear regression model, while educational status, and PBC ( $p>0.2$ ) were not selected. Table 4 presents the results of a multiple linear regression analysis examining the factors associated with the total INT score. Attitude ( $p<0.001$ ), SN ( $p=0.021$ ), and PB ( $p=0.013$ ) were significantly associated with the total INT score (Table 4). Each 1-point increase in the attitude score corresponded to a 0.481-point increase in the INT score, while each 1-point increase in

the SN score resulted in a 0.158-point increase in INT. Each 1-point increase in PB score corresponded to a 0.160-point increase in the INT to apply the current guidelines for medications administered through feeding tubes. The adjusted  $R^2=0.470$ , indicating that the independent variables explained 47.0% of the variation in INT.

Discussion

The study focuses on the factors that influence nurses' INT to implement current guidelines for medications delivered through feeding tubes. Research indicates that nurses' positive attitudes, favorable PBs, and optimistic beliefs regarding their peers and other healthcare professionals are associated with an increased INT to act.

Modified-release, enteric-coated, and film-coated tablets could not be crushed, however <50% of the participants knew this. Most participants (76.7%) knew the sublingual tablet could not be crushed. The literature evaluating dosage forms administered through EFT indicates a high prevalence of inappropriate enteric-coated, extended-release, and controlled-release formulations, ranging from 9.5% to 79.3%.<sup>[32,33]</sup> Demirkan et al.<sup>[2]</sup> demonstrated that only 17% of nurses were aware that enteric-coated tablets should not be crushed owing to the risk of tube occlusion and lack of efficacy when they are administered through feeding tube. Gül-Koçoğlu Kinal et al.<sup>[1]</sup> reported that nurses had a low level of knowledge about dosage form selection.

**Table 3.** Survey statements and descriptive statistics (n=149)

| Construct                           | Survey statement                                                                                                                                                                                                                                                                                                   | Median (IQR) | Mean±SD   | Positive/ high frequency n (%) | Negative/ low frequency n (%) |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------|--------------------------------|-------------------------------|
| <b>Attitude</b>                     |                                                                                                                                                                                                                                                                                                                    |              |           |                                |                               |
| ATT1                                | I think it's important to wait at least 30 min after eating before administering the medication through the feeding tube                                                                                                                                                                                           | 4 (2)        | 3.88±0.95 | 108 (72.48)                    | 41 (27.52)                    |
| ATT2                                | In cases where multiple drugs need to be administered, I believe it is important to crush the drugs separately, mix them with water separately, and wash the tube after each medication application to eliminate drug-related problems (toxicity, reduced drug efficacy, drug stability, drug interactions, etc.). | 4 (1)        | 4.32±0.70 | 137 (91.95)                    | 12 (8.05)                     |
| ATT3                                | I believe that administering drugs through a feeding tube according to current guidelines will significantly benefit patients' treatment outcomes.                                                                                                                                                                 | 4 (1)        | 4.30±0.69 | 138 (92.62)                    | 11 (7.38)                     |
| <b>Subjective norm</b>              |                                                                                                                                                                                                                                                                                                                    |              |           |                                |                               |
| SN1                                 | The doctors I work with accept my responsibility for administering drug to patients with feeding tubes                                                                                                                                                                                                             | 4 (0)        | 3.93±0.88 | 115 (77.18)                    | 34 (22.82)                    |
| SN2                                 | The doctors I work with support me in providing training to the person caring for the patient regarding drugs administered through a feeding tube                                                                                                                                                                  | 4 (1)        | 3.93±0.85 | 111 (74.50)                    | 38 (25.50)                    |
| SN3                                 | The person providing care to the patient prefers that I administer the drug to the patients instead of them                                                                                                                                                                                                        | 4 (1)        | 3.56±0.93 | 88 (59.06)                     | 61 (40.94)                    |
| SN4                                 | It is important to me that the person providing care to the patient accepts the training I provided regarding the drugs given through the feeding tube                                                                                                                                                             | 4 (1)        | 4.15±0.80 | 132 (88.59)                    | 17 (11.41)                    |
| SN5                                 | What my colleagues and other healthcare workers think about the service I provide is important to me                                                                                                                                                                                                               | 4 (0)        | 3.92±0.92 | 120 (80.54)                    | 29 (19.46)                    |
| <b>Perceived behavioral control</b> |                                                                                                                                                                                                                                                                                                                    |              |           |                                |                               |
| PBC1                                | I have the necessary knowledge and skills to administer drug through a feeding tube                                                                                                                                                                                                                                | 4 (1)        | 4.05±0.76 | 122 (81.88)                    | 27 (18.12)                    |
| PBC2                                | I have the necessary training to administer drug through a feeding tube                                                                                                                                                                                                                                            | 4 (1)        | 3.85±0.85 | 104 (69.80)                    | 45 (30.20)                    |
| PBC3                                | I have up-to-date guideline information when administering drug through a feeding tube                                                                                                                                                                                                                             | 4 (1)        | 3.51±0.98 | 79 (53.02)                     | 70 (46.98)                    |
| PBC4                                | According to the current guidelines, administering the drug through the feeding tube will be difficult for me                                                                                                                                                                                                      | 4 (1)        | 3.37±0.93 | 76 (51)                        | 73 (49)                       |
| PBC5                                | It will be difficult for me to look up drug information sources (guides, Rx Media Pharma, etc.) regarding the crushing/splitting of drugs                                                                                                                                                                          | 3 (2)        | 3.26±1.02 | 70 (46.98)                     | 79 (53.02)                    |
| <b>Intention</b>                    |                                                                                                                                                                                                                                                                                                                    |              |           |                                |                               |
| INT1                                | I intend to wait at least 30 min after eating before administering the drug through the feeding tube                                                                                                                                                                                                               | 4 (2)        | 3.87±0.95 | 107 (71.81)                    | 42 (28.19)                    |
| INT2                                | I intend to wash the tube before and after administering the drug through the feeding tube                                                                                                                                                                                                                         | 4 (1)        | 4.29±0.72 | 137 (91.95)                    | 12 (8.05)                     |
| INT3                                | In cases where multiple drugs need to be administered, I intend to crush the drugs separately, mix each with water separately, and wash the tube after each drug administration                                                                                                                                    | 4 (1)        | 4.01±0.90 | 115 (77.18)                    | 34 (22.82)                    |
| INT4                                | I intend to refer to the relevant guidelines for the suitability of crushing/splitting drugs                                                                                                                                                                                                                       | 4 (0)        | 3.99±0.75 | 119 (79.87)                    | 30 (20.13)                    |
| INT5                                | I intend to conduct a literature review on the suitability of crushing/splitting drugs                                                                                                                                                                                                                             | 4 (1)        | 3.83±0.87 | 101 (67.79)                    | 48 (32.21)                    |
| INT6                                | I intend to consult the pharmacist about the suitability of crushing/splitting the drugs                                                                                                                                                                                                                           | 4 (1)        | 3.78±0.90 | 104 (69.80)                    | 45 (30.20)                    |
| INT7                                | I intend to consult a doctor regarding the suitability of crushing/splitting the drugs                                                                                                                                                                                                                             | 4 (1)        | 3.72±0.89 | 101 (67.79)                    | 48 (32.21)                    |
| INT8                                | I intend to consult my colleague regarding the suitability of crushing/splitting the drugs                                                                                                                                                                                                                         | 4 (0)        | 3.96±0.72 | 122 (81.88)                    | 27 (18.12)                    |
| INT9                                | I intend to provide training on the drugs administered through a feeding tube to the person caring for the patient                                                                                                                                                                                                 | 4 (0)        | 3.97±0.83 | 121 (81.21)                    | 28 (18.79)                    |

**Table 3 (cont.).** Survey statements and descriptive statistics (n=149)

| Construct     | Survey statement                                                                                                                                                                   | Median (IQR) | Mean±SD   | Positive/ high frequency n (%) | Negative/ low frequency n (%) |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------|--------------------------------|-------------------------------|
| Past behavior |                                                                                                                                                                                    |              |           |                                |                               |
| PB1           | Taking a break from feeding for at least 30 min before administering the medication through the feeding tube                                                                       | 4 (2)        | 3.59±1.25 | 89 (59.73)                     | 60 (40.27)                    |
| PB2           | Washing the tube before and after administering the medication through the feeding tube                                                                                            | 5 (1)        | 4.43±0.73 | 137 (91.95)                    | 12 (8.05)                     |
| PB3           | In cases where multiple medications need to be administered, crush the medications separately, mix each with water separately, and wash the tube after each medication application | 4 (2)        | 3.97±1.11 | 111 (74.50)                    | 38 (25.50)                    |
| PB4           | Administering the medication after mixing it with food                                                                                                                             | 4 (2)        | 3.84±1.23 | 93 (62.42)                     | 56 (37.58)                    |
| PB5           | Crush the two medications separately, mix each with water separately, and apply them one after the other immediately                                                               | 3 (2)        | 3.12±1.15 | 60 (40.27)                     | 89 (59.73)                    |
| PB6           | Crushing two medications together and mixing them with water for application                                                                                                       | 3 (3)        | 3.41±1.24 | 71 (47.65)                     | 78 (52.35)                    |
| PB7           | To check the suitability of crushing/splitting medications, refer to the Rx Media Pharma drug information database                                                                 | 3 (2)        | 3.04±1.28 | 93 (62.42)                     | 56 (37.58)                    |
| PB8           | To check the suitability of crushing/splitting medications, refer to the relevant guidelines                                                                                       | 3 (2)        | 3.20±1.21 | 65 (43.62)                     | 84 (56.38)                    |
| PB9           | Conducting a literature review on the suitability of crushing/splitting medications                                                                                                | 3 (2)        | 3.10±1.25 | 60 (40.27)                     | 89 (59.73)                    |
| PB10          | Consulting a pharmacist about the suitability of crushing/splitting medications                                                                                                    | 3 (2)        | 3.12±1.22 | 60 (40.27)                     | 89 (59.73)                    |
| PB11          | Consult a doctor to determine the suitability of crushing/splitting medications.                                                                                                   | 3 (2)        | 3.21±1.19 | 64 (42.95)                     | 85 (57.05)                    |
| PB12          | Consulting my colleague about the suitability of crushing/splitting medications                                                                                                    | 4 (1)        | 3.60±1.05 | 87 (58.39)                     | 62 (41.61)                    |
| PB13          | Providing training on medications administered through a feeding tube to the caregiver                                                                                             | 4 (2)        | 3.61±1.20 | 93 (62.42)                     | 56 (37.58)                    |

IQR: Interquartile range; SD: Standard deviation; SN: Subjective norm; PBC: Perceived behavioral control; PB: Past behavior; INT: Intention.

**Table 4.** Multiple linear regression analysis predicting participants' intentions to apply the current guidelines for medications administered via feeding tubes

| Factors         | Unstandardized coefficients |       | Standardized coefficients |        | Collinearity statistics |
|-----------------|-----------------------------|-------|---------------------------|--------|-------------------------|
|                 | B                           | SE    | Beta                      | p      |                         |
| Constant        | 0.288                       | 0.355 | –                         | 0.419  | –                       |
| Attitude        | 0.481                       | 0.071 | 0.470                     | <0.001 | 1.314                   |
| Past behavior   | 0.160                       | 0.064 | 0.183                     | 0.013  | 1.421                   |
| Subjective norm | 0.158                       | 0.068 | 0.155                     | 0.021  | 1.197                   |

R=0.686; R<sup>2</sup>=0.470; Durbin-Watson=1.859; F=37.99; p<0.001. Multiple stepwise linear regression model: Gender, years of experience in a hospital, attitude, subjective norm, and past behavior were adjusted. SE: Standard error; VIF: Variance inflation factors.

Abu-Hdaib et al.<sup>[32]</sup> indicated that nurses have insufficient knowledge regarding the identification of dosage forms. The inadequate understanding of nurses regarding specific drug formulations poses a risk to patient safety, as improper crushing of these preparations may result in adverse outcomes, including mortality. Nurses should be

trained on administering medication through the tube in accordance with the guidelines.

In the present study, in terms of attitudes, almost all nurses thought that administering drugs through a feeding tube in accordance with current guidelines would significantly improve patients' treatment outcomes. Findings based on

the TPB generally identify attitude as the most significant predictor of INT.<sup>[13]</sup> Lapkin et al.<sup>[14]</sup> demonstrated that nurses' attitudes are the primary predictor of INTs to engage in practices that promote medication safety and collaborative efforts. This study confirms previous findings, demonstrating that attitude significantly and positively predicts nurses' high INTs.

The SN items assessed nurses' perceptions of the opinions held by other health professionals, patients, and family members regarding the application of current guidelines for medications administered through feeding tubes. The SN was associated with adherence to current guidelines for medications administered through feeding tubes in this study. This study aligns with the results of Lapkin et al.,<sup>[14]</sup> which indicated that students who view nursing staff and clinical preceptors as helpful and who expect that errors will not result in punishment do not fear reporting mistakes.<sup>[14]</sup> Furthermore, Ben-Natan et al.'s<sup>[15]</sup> study indicated that social pressure from peers and clinical preceptors influenced students' INTs to disclose prescription errors. Likewise, another study revealed that 63–84% of nurses refrained from reporting prescription errors due to adverse reactions from managers and colleagues.<sup>[34]</sup>

The results indicate that PBC did not significantly predict the INT to implement current guidelines for medications administered through feeding tubes. In contrast to our results, Ben-Natan et al.<sup>[15]</sup> identified an association between nurses' knowledge regarding the reporting of medication errors and their PBC as well as their INT to report. In addition, Ekayani et al.<sup>[35]</sup> indicated that PBC significantly influenced nurses' INT to report adverse events. In the studies conducted, it was observed that as healthcare workers' self-confidence increased, there was a rise in their INT to provide more accurate services in many areas of healthcare.<sup>[36,37]</sup> This study operationalized PBC as necessity and ease/difficulty. Unmeasured factors like controllability and enabling environments could have changed the model's construct relevance. These factors may have contributed to non-significant results. The role of PBC in medication guidelines for feeding tubes needs further study.

Similar to attitude and subject norm in this study, the PB construct was a significant predictor of INT to apply current guidelines for medications administered through feeding tubes. Most participants (91.95%) cleaned the tube before and after providing the drug; however, 62.42% mixed it with food for administration. Only 40% of nurses crushed the two medications separately, mixed each with water separately, and applied them one after the other immediately. About 40% of participants assessed the suitability of crushing/

splitting medications, referred to relevant guidelines, conducted a literature review, and consulted a pharmacist or doctor. Guidelines for the safe administration of medications through an EFT are available,<sup>[4,5]</sup> however researches suggest that nurses frequently do not follow them.<sup>[38]</sup> Studies show that there is an ongoing problem with following flushing and separate administration guidelines: only 5–43% of healthcare providers flush between medications, and 18–51% give drugs separately.<sup>[33]</sup> Gül-Koçoğlu Kinal et al.<sup>[11]</sup> indicated that nurses had a moderate level of knowledge about drug administration through feeding tubes.<sup>[11]</sup> The primary reason is that nurses lack time to access the correct information source. Nurses consulting pharmacists who are experts in medication will enable them to obtain quick and accurate information.

The adjusted  $R^2$  value of 0.47 indicated that the model explained 47% of the variance in behavioral INT. Although the adjusted  $R^2$  value is not sufficiently high, this situation is consistent with the literature. In behavioral and social sciences, and particularly within the framework of the TPB, this level of explained variance is generally considered substantial. Meta-analytic reviews consistently showed that TPB models explain between 30% and 45% of the variance in INT across domains. For instance, Armitage and Conner, in a comprehensive meta-analysis of TPB studies, reported a mean  $R^2$  of approximately 39% for INT.<sup>[39]</sup> Similarly, McEachan et al.<sup>[13]</sup> found that TPB variables explained around 44% of the variance in INT in health-related behaviors. Therefore, the adjusted  $R^2$  of 0.47 observed in the present study is not only consistent with prior TPB research but slightly exceeds the average explanatory power reported in large-scale meta-analyses.

## Limitations

This study has certain limitations. The study involved a limited number of nurses during the designated period; nonetheless, the participant count met the required sample size. Consequently, social desirability bias may exist. Implementing a study that investigates actual behavior and employs random sample techniques may enhance its validity and the generalizability of its findings.

## Conclusion

This study is the first investigation in Türkiye assessing nurses' INTs to adhere to current guidelines for medications administered through feeding tubes, framed within the TPB. The findings indicate serious consequences for developing and implementing strategies aimed at improving nurses' adherence to guidelines for the safe administration of

medications via EFT. Research indicated that nurses' positive attitudes, favorable PBs, and optimistic perceptions of their peers and other healthcare professionals correlated with elevated INT scores.

Nurses should exercise heightened caution when selecting medications for administration through a feeding tube, considering the altered pharmacological efficacy and safety profiles, as well as the potential risk of tube occlusion. Pharmacists are healthcare professionals who offer insights into the physicochemical, pharmacokinetic, and pharmacodynamic characteristics of drugs, along with issues related to stability, incompatibility, and the availability of different pharmaceutical dosage forms in the market. A sustained collaboration among healthcare providers will promote appropriate drug utilization and improve patient care in hospital settings.

**Ethics Committee Approval:** The Anadolu University Non-Interventional Clinical Trials Ethics Committee granted approval for this study (date: 09.08.2024, number: 768031).

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# Pregnant Women's Reasons for Using Mobile Applications, Trust Levels, and Integration into Daily Life: A Turkish Case Study

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## Abstract

**Introduction:** Mobile health (mHealth) applications are increasingly used in pregnancy for information access, symptom tracking, and self-management. However, variability in content quality and concerns about privacy and usability may affect women's engagement. This study aimed to describe pregnant women's reasons for using pregnancy-focused mHealth applications in Türkiye, assess trust in app content, and examine how these tools are integrated into daily life.

**Methods:** This descriptive cross-sectional study was conducted between June 2025 and September 2025 with 544 pregnant women who had used at least one pregnancy-related mobile application. Data were collected using a researcher-developed questionnaire covering sociodemographic and obstetric characteristics, reasons and patterns of app use, trust in app content, and integration of apps into daily routines. Descriptive statistics were used for analysis.

**Results:** Participants had a mean age of  $30.10 \pm 5.83$  years, and a mean gestational age (weeks) of  $23.94 \pm 9.58$ . The primary reasons for app use were pregnancy tracking (44.7%) and information seeking (43.4%). Social media was the most common source of app discovery (77.2%). While 66.9% considered app information reliable, most preferred physicians' advice when conflicts occurred. Reported benefits included quick information access and easier monitoring, whereas 51.1% reported increased anxiety.

**Discussion and Conclusion:** mHealth use among pregnant women in Türkiye is widespread; however, gaps remain between information acquisition and behavioral change. Integrating app curation, digital health-literacy counseling, notification management, and clear privacy guidance into nursing practice may enhance the safe and effective use of mHealth as a complementary component of antenatal care.

**Keywords:** Activities of daily living; Mobile applications; Patient satisfaction; Pregnancy; Smartphones; Türkiye

Pregnancy is a physiological yet transformative period during which women's information needs increase and self-management skills gain critical importance. With the rapid expansion of digital technologies, mobile health

(mHealth) applications have become widely used tools for accessing pregnancy-related information, tracking symptoms, and regulating daily routines.<sup>[1,2]</sup> Evidence suggests that such applications may support antenatal

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follow-up, enhance self-care behaviors, and improve adherence to recommended practices.<sup>[3–5]</sup> However, commercial pregnancy apps vary considerably in scientific accuracy, content quality, and user safety, which may limit their clinical benefit and lead to inconsistent user experiences.<sup>[6]</sup> This variability underscores the need to reconsider how digital tools can be safely and effectively integrated into routine maternal care.

Nurses play a pivotal role in guiding pregnant women to reliable information sources, translating digital information into individualized care plans, and monitoring behavioral changes. Within this framework, nurses act as a clinical interface by curating trustworthy applications and evaluating and strengthening digital health literacy. In addition, they incorporate app-derived data – such as symptom logs, physical activity, sleep, and nutrition – into face-to-face consultations.<sup>[7]</sup> eHealth literacy is central to this process, and instruments such as the eHEALS scale help assess a user's ability to interpret and appropriately use digital information.<sup>[8]</sup>

Privacy, data protection, and transparency also strongly shape pregnant women's trust in and continued use of pregnancy-related mHealth applications. Concerns related to data sharing, commercial advertisements, and ambiguous scientific sources may influence engagement and perceived usefulness.<sup>[2,6]</sup> Prior studies indicate that clear consent procedures, data minimization, secure authentication, and appropriate notification management help reduce information overload and strengthen trust.<sup>[1,4,5,8]</sup>

Considering the growing digital penetration in Türkiye, understanding how pregnant women engage with pregnancy-related mHealth applications – why they use them, how much they trust them, and how they integrate them into daily life – has become increasingly important. Recent research emphasizes the need for culturally appropriate, evidence-based digital tools with personalized content and improved usability, guided when necessary by healthcare professionals.<sup>[9–12]</sup> International recommendations, including the World Health Organization Digital Health Guidelines, further highlight the importance of validated, privacy-protective, and clinically integrated digital interventions in maternal care.<sup>[13,14]</sup>

In this context, the present study aims to describe pregnant women's reasons for using pregnancy-related mHealth applications in Türkiye, their trust levels, and how these applications are integrated into daily life. The findings are expected to support the development of nursing

practices incorporating digital health-literacy counseling, institution-approved app curation, notification hygiene, and privacy-focused guidance, thereby positioning mHealth as a complementary component of antenatal care.

## Materials and Methods

### Study Design

This descriptive and cross-sectional study examined the use of pregnancy-related mobile health (mHealth) applications among pregnant women in Türkiye. The research questions were as follows:

1. What are the purposes and frequencies of pregnancy-related mHealth application use among pregnant women?
2. What is the level of trust in the information provided by these applications?
3. What perceived positive and negative effects of these applications on daily life are reported by pregnant women?

### Setting and Sample

The study was conducted in Türkiye between June 2025 and September 2025 with a sample of 544 pregnant women who had internet access and had used at least one pregnancy-related mHealth application. Because a non-probabilistic purposive and snowball sampling approach was used, formal sample size or power calculations were not performed; instead, the final sample size was determined based on feasibility and participant accessibility during the study period.

Inclusion criteria: age  $\geq 18$  years; ongoing pregnancy; use of at least one pregnancy-related mobile application; Turkish literacy. Exclusion criteria: not currently pregnant and/or not using a mobile application; unwillingness to participate.

### Data Collection

Data were collected using an online survey distributed through social media platforms and pregnancy-related online communities. All items were mandatory to minimize missing data.

### Data Collection Tools

Based on a comprehensive literature review, a 32-item questionnaire was developed to assess mHealth use during pregnancy.<sup>[1,3,7,9,10,12,14]</sup> Content validity was confirmed by expert review (I-CVI: 0.83–1.00; S-CVI:

0.94), and the tool was piloted with 20 pregnant women. Data obtained from the pilot study were used only to refine the questionnaire and were not included in the final analysis. As the instrument was developed as a multidimensional structured questionnaire assessing conceptually distinct domains rather than a single latent construct, the items were analyzed individually; therefore, internal consistency analysis (e.g., Cronbach's alpha) was not applicable. The final survey comprised four sections: (i) Sociodemographic and obstetric variables (age, education, marital and employment status, gestational week, parity, history of miscarriage/preterm birth, current high-risk status); (ii) Reasons and patterns of mobile-application use (device type, daily use time, app types/names, purpose and frequency of use, proportion of content enacted, partner sharing, social-media referral, effects on decision-making); (iii) Trust and perceptions; (iv) Integration into daily life and perceived effects (behavior change, birth preparation, sense of control/empowerment, anxiety, most useful features, trust in physician vs. app, perceived effectiveness, motivation, facilitators, and areas for improvement). Multiple-choice items allowed more than one response where appropriate.

### Data Analysis

Analyses were performed using IBM Statistical Package for the Social Sciences Statistics, Version 27 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean $\pm$ standard deviation where appropriate, and categorical variables were presented as number (n) and percentage (%). For multiple-response items, percentages were calculated at the participant level (i.e., the denominator was the number of respondents to the item). Sociodemographic and obstetric variables were summarized using descriptive statistics.

In addition to descriptive analyses, exploratory inferential analyses were conducted to examine potential associations between selected variables. Chi-square tests were used to assess relationships between categorical variables. Furthermore, binary logistic regression analysis was performed to identify predictors of reported behavioral change. Odds ratios (OR) with 95% confidence intervals (CI) were calculated to estimate the strength of associations. Variables included in the logistic regression model were selected based on theoretical relevance to the outcome variable and their direct association with mobile health (mHealth) application use. Specifically, trust in app information, frequency of application use, and anxiety related to app use were considered key

variables reflecting participants' cognitive engagement with application content, intensity of exposure to digital information, and emotional responses to mHealth use during pregnancy. Sociodemographic and obstetric variables such as gestational trimester, education level, parity, previous miscarriage/preterm birth history, and high-risk pregnancy status were examined separately using chi-square analyses rather than being included in the regression model. A  $p < 0.05$  was considered statistically significant. These inferential analyses were interpreted as exploratory and were used to provide additional insight into patterns observed in the descriptive findings.

### Ethical Considerations

The study was approved by the Scientific Research and Publication Ethics Committee of Istanbul Health and Technology University (Approval No: 08-08, Date: May 2025). The first page of the online questionnaire provided information about the purpose of the study, the voluntary nature of participation, participant anonymity, and data confidentiality. Electronic informed consent was obtained from all participants before they began the survey. The study was conducted in accordance with the principles of the Declaration of Helsinki.

### Results

The study included 544 pregnant women with a mean age of  $30.10 \pm 5.83$  years and a mean gestational age of  $23.94 \pm 9.58$  weeks. Participants were predominantly university educated and mostly in their first pregnancy, while a relatively small proportion reported a current high-risk pregnancy (Table 1).

Participants reported frequent use of pregnancy-related mHealth applications, primarily for pregnancy tracking, information seeking, and lifestyle-related guidance. Several widely used commercial applications were preferred, and app engagement was often notification-driven, with varying levels of content implementation. Social media emerged as the main channel for app discovery (Table 2).

Overall, participants expressed moderate-to-high trust in the information provided by applications, although physician recommendations were consistently preferred when conflicting advice occurred. Trust was most strongly influenced by perceived privacy and security measures, scientific accuracy, and professional recommendations, while approximately half of the participants reported data security concerns (Table 3).

**Table 1.** Sociodemographic and obstetric characteristics of participants (n=544)

| Variable                  | n                  | %    |
|---------------------------|--------------------|------|
| Age (min–max), mean±SD    | (20–40) 30.10±5.83 |      |
| Education level           |                    |      |
| Primary school            | 27                 | 5.0  |
| Middle school             | 21                 | 3.9  |
| High school               | 147                | 27.0 |
| University                | 293                | 53.9 |
| Postgraduate              | 56                 | 10.3 |
| Employment status         |                    |      |
| Employed                  | 197                | 36.2 |
| Unemployed                | 155                | 28.5 |
| Homemaker                 | 192                | 35.3 |
| Gestational week, mean±SD | 23.94±9.57         |      |
| Number of pregnancies     |                    |      |
| One                       | 358                | 65.8 |
| Two                       | 111                | 20.4 |
| Three or more             | 75                 | 13.8 |
| High-risk pregnancy       |                    |      |
| Yes                       | 49                 | 9.0  |
| No                        | 495                | 91.0 |

n: number; %: Percentage; SD: Standard deviation.

Regarding integration into daily life, some participants reported positive behavioral changes – particularly in stress management, sleep habits, physical activity, and diet – whereas others indicated no noticeable change. Emotional responses to app use were mixed, with a substantial proportion reporting increased anxiety despite perceived informational benefits. Technical issues, time burden, and data security concerns were commonly identified as barriers, and participants emphasized the need for improved usability, personalization, and technical support (Table 4).

A statistically significant association was observed between perceived trust in app information and reported behavioral change ( $\chi^2=8.92$ ,  $p=0.032$ ). Participants expressing higher levels of trust were more likely to report positive health-related behavioral adaptations compared to those with lower trust levels. This finding suggests that perceived reliability may influence the integration of digital health information into daily self-care behaviors during pregnancy (Table 5).

A statistically significant association was found between perceived trust in app information and anxiety related to app use ( $\chi^2=11.1$ ,  $p=0.026$ ), indicating that the likelihood

of reporting increased anxiety differed across trust-level categories (Table 6).

Binary logistic regression analysis was performed to assess whether trust in app information, frequency of app use, and anxiety independently predicted behavioral change among participants. The model demonstrated that trust and anxiety were significant predictors of behavioral change, whereas frequency of use was not statistically significant. As perceived trust in the app content increased, the likelihood of reporting behavioral change increased significantly ( $\beta=0.180$ ,  $OR=1.20$ , 95%  $CI: 1.02–1.40$ ,  $p=0.027$ ). In other words, each one-point increase in trust level was associated with approximately a 20% increase in the odds of reporting behavioral change. Conversely, higher anxiety related to app use was associated with a decreased likelihood of behavioral change ( $\beta=-0.366$ ,  $OR=0.69$ , 95%  $CI: 0.49–0.98$ ,  $p=0.039$ ). Participants experiencing anxiety had approximately 31% lower odds of reporting behavioral change compared to those without anxiety. Overall, these findings indicate that emotional and cognitive responses to app content may play a more critical role in shaping behavioral adaptation than the frequency of app use itself (Table 7).

Chi-square analyses were performed to examine the association between increased anxiety and selected obstetric and sociodemographic variables (Table 8). A statistically significant association was found between gestational trimester and increased anxiety ( $\chi^2=6.91$ ,  $p=0.032$ ). In addition, education level was significantly associated with anxiety ( $\chi^2=9.70$ ,  $p=0.046$ ). Parity (number of pregnancies) also showed a significant association with anxiety ( $\chi^2=7.82$ ,  $p=0.021$ ). Furthermore, previous miscarriage/preterm birth history was significantly associated with increased anxiety ( $\chi^2=4.13$ ,  $p=0.041$ ). No statistically significant association was observed between high-risk pregnancy status and increased anxiety ( $\chi^2=0.21$ ,  $p=0.644$ ) (Table 8).

## Discussion

This study demonstrates that digitally connected pregnant women in Türkiye frequently use mobile health (mHealth) applications; however, the extent to which they translate app-based information into sustained behavioral change appears limited. The demographic characteristics of the sample – particularly the mean age and gestational week, the predominance of first pregnancies, and the high proportion of university-educated participants – suggest that the findings largely reflect the experiences of digitally literate, second-trimester users. This context helps

**Table 2.** Use of mobile health applications: Reasons and habits (n=544)

| Item/question                                       | Category                           | n   | %    |
|-----------------------------------------------------|------------------------------------|-----|------|
| Devices used for mobile health apps                 | Smartphone                         | 174 | 32.0 |
|                                                     | Tablet                             | 185 | 34.0 |
|                                                     | Computer                           | 185 | 34.0 |
| Average daily use of mobile devices                 | <1 h                               | 38  | 7.0  |
|                                                     | 1–3 h                              | 341 | 62.7 |
|                                                     | 3–5 h                              | 109 | 20.0 |
|                                                     | More than 5 h                      | 56  | 10.3 |
| Purpose of mobile health app use <sup>†</sup>       | Pregnancy tracking                 | 243 | 44.7 |
|                                                     | Nutrition guidance                 | 220 | 40.4 |
|                                                     | Exercise programs                  | 219 | 40.3 |
|                                                     | Prenatal education and information | 230 | 42.3 |
|                                                     | Baby monitoring                    | 225 | 41.4 |
| Which apps do you use most frequently? <sup>†</sup> | Baby center                        | 173 | 31.8 |
|                                                     | My pregnancy tracker               | 173 | 31.8 |
|                                                     | Piquq                              | 169 | 31.1 |
|                                                     | What to expect                     | 168 | 30.9 |
|                                                     | Preglife                           | 164 | 30.1 |
|                                                     | Happy mom                          | 166 | 30.5 |
|                                                     | Pregnancy+                         | 160 | 29.4 |
|                                                     | Countdown to birth                 | 161 | 29.6 |
|                                                     | Elika pregnancy                    | 152 | 27.9 |
|                                                     | Miracle mom                        | 147 | 27.0 |
| Main purposes of app use <sup>†</sup>               | Tracking pregnancy progress        | 230 | 42.3 |
|                                                     | Acquiring health information       | 236 | 43.4 |
|                                                     | Learning about childbirth          | 227 | 41.7 |
|                                                     | Communicating with professionals   | 221 | 40.6 |
|                                                     | Monitoring diet and exercise       | 229 | 42.1 |
| How often do you check the app?                     | Once per week                      | 110 | 20.2 |
|                                                     | Several times per week             | 101 | 18.6 |
|                                                     | Once per day                       | 108 | 19.9 |
|                                                     | More than once per day             | 106 | 19.5 |
|                                                     | Whenever notified                  | 119 | 21.9 |
| How much of the app content do you apply?           | None                               | 127 | 23.3 |
|                                                     | Part of it                         | 139 | 25.6 |
|                                                     | Most of it                         | 145 | 26.8 |
|                                                     | All                                | 133 | 24.4 |
| Sharing app content with partner                    | Yes                                | 175 | 32.2 |
|                                                     | No                                 | 191 | 35.1 |
|                                                     | Rarely                             | 178 | 32.7 |
| Downloaded via social media recommendation          | Yes                                | 420 | 77.2 |
|                                                     | No                                 | 124 | 22.8 |
| Effect of apps on decision-making                   | More conscious decisions           | 96  | 17.6 |
|                                                     | Some effect                        | 178 | 32.7 |
|                                                     | No effect                          | 189 | 34.7 |
|                                                     | Makes decisions unclear            | 81  | 14.9 |

†: Multiple responses possible; percentages may exceed 100; n: number; %: Percentage.

**Table 3.** Trust and perception toward mobile health applications (n=544)

| Item                                                                  | Category                               | n   | %    |
|-----------------------------------------------------------------------|----------------------------------------|-----|------|
| I find the information provided in the apps reliable                  | Strongly disagree                      | 27  | 5.0  |
|                                                                       | Disagree                               | 50  | 9.2  |
|                                                                       | Neutral                                | 103 | 18.9 |
|                                                                       | Agree                                  | 222 | 40.8 |
|                                                                       | Strongly agree                         | 142 | 26.1 |
| When app content conflicts with my doctor's advice, I trust my doctor | Strongly disagree                      | 18  | 3.3  |
|                                                                       | Disagree                               | 58  | 10.7 |
|                                                                       | Neutral                                | 108 | 19.9 |
|                                                                       | Agree                                  | 222 | 40.8 |
|                                                                       | Strongly agree                         | 138 | 25.4 |
| The app content is based on scientific evidence                       | Strongly disagree                      | 24  | 4.4  |
|                                                                       | Disagree                               | 61  | 11.2 |
|                                                                       | Neutral                                | 97  | 17.8 |
|                                                                       | Agree                                  | 229 | 42.1 |
|                                                                       | Strongly agree                         | 133 | 24.4 |
| The apps help me monitor pregnancy more consciously                   | Strongly disagree                      | 19  | 3.5  |
|                                                                       | Disagree                               | 56  | 10.3 |
|                                                                       | Neutral                                | 110 | 20.2 |
|                                                                       | Agree                                  | 240 | 44.1 |
|                                                                       | Strongly agree                         | 119 | 21.9 |
| The content is unbiased and ad-free                                   | Strongly disagree                      | 19  | 3.5  |
|                                                                       | Disagree                               | 48  | 8.8  |
|                                                                       | Neutral                                | 98  | 18.0 |
|                                                                       | Agree                                  | 213 | 39.2 |
|                                                                       | Strongly agree                         | 166 | 30.5 |
| The app information positively affects my mood                        | Strongly disagree                      | 31  | 5.7  |
|                                                                       | Disagree                               | 149 | 27.4 |
|                                                                       | Neutral                                | 199 | 36.6 |
|                                                                       | Agree                                  | 128 | 23.5 |
|                                                                       | Strongly agree                         | 37  | 6.8  |
| Factors influencing trust <sup>†</sup>                                | Recommendation by health professionals | 280 | 51.5 |
|                                                                       | User reviews and ratings               | 261 | 48.0 |
|                                                                       | Scientific accuracy                    | 267 | 49.1 |
|                                                                       | Privacy and security measures          | 283 | 52.0 |
| Do you have security concerns?                                        | Yes                                    | 273 | 50.2 |
|                                                                       | No                                     | 271 | 49.8 |

†: Multiple responses possible; percentages may exceed 100. n: number, %: Percentage.

explain several patterns observed in the study, including the prominence of social media as a discovery channel, relatively high perceived reliability of app content, and the persistence of a knowledge–action gap despite high levels of engagement.<sup>[8,10,15]</sup>

When compared with international findings, the patterns of pregnancy-related mHealth application use observed in Türkiye show broad similarities as well as some contextual differences. Consistent with studies conducted in Australia, Europe, and other high-income settings, pregnant women

**Table 4.** Integration and impact of mobile applications on daily life (n=544)

| Item                                                           | Category                           | n   | %    |
|----------------------------------------------------------------|------------------------------------|-----|------|
| Changes in daily life due to app use†                          | Change in diet                     | 143 | 26.3 |
|                                                                | Started exercising                 | 155 | 28.5 |
|                                                                | Paid more attention to sleep       | 156 | 28.7 |
|                                                                | Managed stress better              | 159 | 29.2 |
|                                                                | No change                          | 208 | 38.2 |
| Did the information you learned affect your birth preparation? | Yes                                | 123 | 22.6 |
|                                                                | No                                 | 284 | 52.2 |
|                                                                | Partly                             | 137 | 25.2 |
| Did app use make you feel stronger/in control?                 | Yes                                | 127 | 23.3 |
|                                                                | No                                 | 289 | 53.1 |
|                                                                | Neutral                            | 128 | 23.5 |
| Does app content increase your anxiety?                        | Yes                                | 278 | 51.1 |
|                                                                | No                                 | 266 | 48.9 |
| Most beneficial aspects of appst                               | Easy access to information         | 243 | 44.7 |
|                                                                | Tracking my own process            | 232 | 42.6 |
|                                                                | Strengthening maternal feelings    | 219 | 40.3 |
|                                                                | Saving time                        | 228 | 41.9 |
|                                                                | Reducing worry and stress          | 230 | 42.3 |
| Have you trusted apps instead of health professionals?         | Yes, a few times                   | 142 | 26.1 |
|                                                                | No                                 | 257 | 47.2 |
|                                                                | Unsure                             | 145 | 26.7 |
| How effective were apps in addressing your knowledge gaps?     | Very effective                     | 83  | 15.3 |
|                                                                | Effective                          | 200 | 36.8 |
|                                                                | Somewhat effective                 | 167 | 30.7 |
|                                                                | Ineffective                        | 94  | 17.3 |
| Motivation for starting to use appst                           | Health professional recommendation | 285 | 52.4 |
|                                                                | Personal concerns                  | 273 | 50.2 |
|                                                                | Other users' suggestions           | 280 | 51.5 |
|                                                                | Useful content                     | 267 | 49.1 |
| How much do apps make daily life easier?                       | Not at all                         | 15  | 2.8  |
|                                                                | Slightly                           | 135 | 24.8 |
|                                                                | Moderately                         | 248 | 45.6 |
|                                                                | Very much                          | 146 | 26.8 |
| Main difficulties in integrating apps into daily lifet         | Complexity of the app              | 205 | 37.7 |
|                                                                | Insufficient information           | 226 | 41.5 |
|                                                                | Technical issues                   | 234 | 43.0 |
|                                                                | Time-consuming                     | 230 | 42.3 |
|                                                                | Data security concerns             | 237 | 43.6 |
| Areas for improvement†                                         | User-friendly interface            | 290 | 53.3 |
|                                                                | More personalized content          | 284 | 52.2 |
|                                                                | Safer data management              | 276 | 50.7 |
|                                                                | Enhanced technical support         | 285 | 52.4 |

†: Multiple responses possible; percentages may exceed 100. n: number, %: Percentage.

**Table 5.** Association between trust in app information and behavioral change

| Variable: I find the information provided in the apps reliable |                          |                       |
|----------------------------------------------------------------|--------------------------|-----------------------|
| Trust level                                                    | No behavioral change (n) | Behavioral change (n) |
| Strongly disagree                                              | 9                        | 18                    |
| Disagree                                                       | 18                       | 32                    |
| Neutral                                                        | 41                       | 62                    |
| Agree                                                          | 90                       | 132                   |
| Strongly agree                                                 | 50                       | 92                    |
| $\chi^2=8.92$ ; $p=0.032$ .                                    |                          |                       |

**Table 6.** Association between trust in app information and anxiety increase

| Variable: I find the information provided in the apps reliable |                           |                       |
|----------------------------------------------------------------|---------------------------|-----------------------|
| Trust level                                                    | Anxiety not increased (n) | Anxiety increased (n) |
| Strongly disagree                                              | 8                         | 19                    |
| Disagree                                                       | 29                        | 21                    |
| Neutral                                                        | 53                        | 50                    |
| Agree                                                          | 109                       | 113                   |
| Strongly agree                                                 | 67                        | 75                    |
| $\chi^2=11.1$ ; $p=0.026$ .                                    |                           |                       |

**Table 7.** Logistic regression analysis predicting behavioral change

| Variable  | $\beta$ | SE    | OR (Exp $\beta$ ) | 95% CI    | p     |
|-----------|---------|-------|-------------------|-----------|-------|
| Trust     | 0.180   | 0.081 | 1.20              | 1.02–1.40 | 0.027 |
| Frequency | -0.004  | 0.062 | 0.996             | 0.88–1.12 | 0.943 |
| Anxiety   | -0.366  | 0.178 | 0.69              | 0.49–0.98 | 0.039 |

SE: Standard error; OR: Odds ratio; CI: Confidence interval. Behavioral change was coded as 1=change reported; 0=no change. OR values >1 indicate increased odds, whereas OR values <1 indicate reduced odds of behavioral change.

**Table 8.** Associations between increased anxiety and obstetric and sociodemographic characteristics

| Variable                           | Category            | Anxiety (Yes) n | Anxiety (No) n | $\chi^2$ | p     |
|------------------------------------|---------------------|-----------------|----------------|----------|-------|
| Trimester                          | 1 <sup>st</sup>     | 57              | 43             | 6.91     | 0.032 |
|                                    | 2 <sup>nd</sup>     | 116             | 107            |          |       |
|                                    | 3 <sup>rd</sup>     | 105             | 116            |          |       |
| High-risk pregnancy                | Yes                 | 23              | 26             | 0.21     | 0.644 |
|                                    | No                  | 255             | 240            |          |       |
| Education level                    | Primary school      | 12              | 15             | 9.70     | 0.046 |
|                                    | Middle school       | 8               | 13             |          |       |
|                                    | High school         | 75              | 72             |          |       |
|                                    | Bachelor's degree   | 155             | 138            |          |       |
| Parity                             | Postgraduate degree | 28              | 28             | 7.82     | 0.021 |
|                                    | 1                   | 177             | 181            |          |       |
|                                    | 2                   | 59              | 52             |          |       |
| Previous miscarriage/preterm birth | 3+                  | 42              | 33             | 4.13     | 0.041 |
|                                    | Yes                 | 51              | 55             |          |       |
|                                    | No                  | 227             | 211            |          |       |

primarily use mobile applications for information seeking, pregnancy tracking, and lifestyle-related guidance, and often discover these tools through digital platforms and social media.<sup>[1,2,16]</sup> Across countries, trust in app content is generally reported as moderate to high; however, in line with international evidence, professional medical advice remains the primary reference point when conflicting information arises.<sup>[2,6,17]</sup>

Participants' frequent use of applications for information seeking, pregnancy monitoring, and notification-driven checking aligns with prior research identifying education, monitoring, and reminders as core features of pregnancy-related applications.<sup>[2,5,10]</sup> The influence of social media-based recommendations also reflects broader trends in maternal health information pathways, where digital platforms increasingly shape how pregnant women

access and evaluate health information.<sup>[11,16]</sup> However, only a minority of participants reported implementing most or all of the information obtained from these applications, suggesting limitations related to usability, personalization, and practical applicability. Similar observations have been reported in studies indicating that many commercial pregnancy applications lack tailored guidance or culturally appropriate content.<sup>[6,9,18]</sup>

In addition, exploratory analyses were conducted to examine potential relationships between trust in app information, behavioral change, anxiety, and selected sociodemographic and obstetric variables. Given the non-probabilistic sampling approach and the absence of predefined hypotheses, these analyses were interpreted cautiously and were intended to provide additional insight into patterns observed in the descriptive findings.

A substantial proportion of participants reported increased anxiety related to mobile application use. This finding is consistent with international studies examining intensive digital exposure during pregnancy.<sup>[14,19,20]</sup> Emotional responses to digital health tools may vary depending on factors such as digital health literacy, notification frequency, application design, and the extent to which digital tools are integrated into routine clinical care. Similarly, the limited translation of app-based information into sustained behavioral change observed in this study aligns with global research suggesting that pregnancy-related mobile applications often function primarily as informational and supportive resources rather than as independent drivers of health behavior change.<sup>[2,6,10]</sup>

Although most participants perceived app information as reliable, concerns related to privacy, advertising, and scientific accuracy indicate a complex trust environment. The preference for physicians' advice when conflicting information arises reinforces the role of mobile applications as complementary rather than substitutive components of antenatal care.<sup>[2,6,12]</sup> International recommendations also highlight the importance of transparent privacy safeguards, evidence-based content, and validation mechanisms to strengthen trust in digital maternal health tools.<sup>[13,17]</sup>

The widespread adoption of pregnancy applications alongside notable privacy concerns underscores the importance of secure data practices in digital health. Limited translation of digital information into behavioral outcomes is also consistent with global evidence showing that commercial pregnancy applications vary considerably in scientific rigor and may not consistently influence maternal health indicators.<sup>[2,3,6,10]</sup> The variability in perceived effects on decision-making – ranging from improved awareness to confusion – may reflect cognitive overload, a recognized

challenge in digital health environments where excessive or poorly structured information can overwhelm users.<sup>[14,21]</sup> Strategies such as simplifying information architecture, prioritizing key recommendations, and clarifying symptom thresholds may help reduce this burden.

Exploratory analyses in this study revealed a significant association between perceived trust in app information and reported behavioral change. Participants who considered the information provided by mobile applications reliable were more likely to report adopting health-related behavioral modifications. This finding suggests that the perceived credibility of digital health information may influence whether pregnant women translate app-based knowledge into practical self-care behaviors. Previous studies examining pregnancy-related mobile applications similarly report that trust in app content – particularly when perceived as evidence-based – facilitates adherence to recommended practices such as nutrition monitoring, physical activity, and symptom tracking.<sup>[2,6,22]</sup>

A statistically significant relationship was also identified between perceived trust in application information and increased anxiety related to app use. Although greater trust may encourage engagement and behavioral adaptation, emotional responses to digital information can vary across users. Previous research has shown that extensive exposure to online pregnancy information may simultaneously enhance perceived control while increasing anxiety, particularly when applications emphasize risk-related content or deliver frequent notifications.<sup>[14,19,21,23]</sup> These findings suggest that while trusted digital information may support self-management, excessive or poorly contextualized information may contribute to psychological distress in some users.

Logistic regression analysis further indicated that trust in app information and anxiety were significant predictors of behavioral change, whereas frequency of application use was not statistically significant. Increased trust was associated with a higher likelihood of reporting behavioral change, while anxiety was associated with a reduced likelihood of such change. These results suggest that cognitive and emotional responses to digital health information may play a more important role in shaping behavioral adaptation than simple exposure to mobile applications. Similar findings have been reported in studies linking certain smartphone usage patterns during pregnancy with higher anxiety levels.<sup>[24]</sup>

Furthermore, increased anxiety related to mobile application use was significantly associated with

gestational trimester, education level, parity, and a history of miscarriage or preterm birth. These findings align with previous literature indicating that psychological responses to pregnancy information may vary depending on reproductive experience and perceived vulnerability during pregnancy. Women with previous adverse pregnancy outcomes or those experiencing pregnancy for the first time may demonstrate greater sensitivity to health-related information obtained from digital sources.<sup>[10,25,26]</sup>

Taken together, these findings highlight that both trust in digital health information and emotional responses to mobile applications play key roles in determining the effectiveness of pregnancy-related mHealth tools. While trusted applications may encourage beneficial behavioral adaptations, excessive exposure to digital information may also contribute to anxiety among some users. In this context, nurses and midwives play an important role as intermediaries between pregnant women and digital health technologies. Strengthening digital health literacy, recommending evidence-based applications, and integrating app-derived information into antenatal consultations may help ensure safer and more effective use of mHealth tools during pregnancy. Personalized digital counseling and guidance on notification management and privacy protection may further support informed decision-making while reducing information overload. Evidence suggesting that structured professional support improves self-monitoring, emotional regulation, and preparation for childbirth reinforces the importance of professional oversight when incorporating digital technologies into maternal care.<sup>[4,5,12,19,20,25]</sup>

In this study, several limitations should be considered. Participants were at different gestational stages, which may have influenced patterns of mHealth application use, levels of trust in app content, and perceived effects. The exclusive use of online data collection and the relatively high proportion of highly educated participants may have contributed to selection bias by favoring women who are more digitally engaged and comfortable with mobile technologies, thereby limiting the generalizability of the findings. Self-reported data are subject to potential recall and social desirability biases. Treating mHealth applications as a single category may obscure substantial heterogeneity in content quality and functionality. Moreover, the study did not assess clinical outcomes such as antenatal care adherence or maternal–infant health indicators. Unmeasured factors – including digital literacy, prior digital experience, and mental health status – may also have influenced the findings.

## Conclusion

This study shows that pregnant women in Türkiye actively use mobile health (mHealth) applications; however, a gap remains between accessing digital information and translating it into consistent behavioral change. Although these applications are widely used for information seeking and pregnancy monitoring, frequent notification-driven engagement does not necessarily result in meaningful application of health information in daily life.

While many participants reported moderate-to-high trust in app content, ongoing concerns regarding privacy, usability, and information reliability highlight the limitations of relying solely on digital tools during pregnancy. The strong preference for physicians' guidance when conflicting information arises reinforces the view that mHealth applications should function as complementary tools rather than replacements for professional antenatal care.

These findings suggest that integrating evidence-based mHealth applications into antenatal care with appropriate professional guidance – particularly through digital health literacy support and app recommendation by healthcare professionals – may help improve the safe and effective use of digital technologies during pregnancy.

**Ethics Committee Approval:** The Istanbul Health and Technology University Scientific Research and Publication Ethics Committee granted approval for this study (date: 07.05.2025, number: 08-08).

**Informed Consent:** All participants provided electronic informed consent before participation.

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# Variations in the Indications for Cone-Beam Computed Tomography among Dental Departments

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## Abstract

**Introduction:** Cone-beam computed tomography (CBCT) has developed into the acknowledged standard for three-dimensional imaging of hard tissues in dentomaxillofacial radiology. CBCT should be utilized only in line with proper clinical indications due to the use of ionizing radiation in imaging. This study aims to analyze the purposes for CBCT requests in patients presented to the faculty of dentistry and to assess the compliance of these requests.

**Methods:** This retrospective study included the CBCT requests with documented clinical indications, obtained between January and December 2024 from eight clinical departments. Demographic data (age and sex), the requesting department, and the indication for imaging were analyzed. Statistical evaluation was performed using Chi-square and Fisher's exact tests to assess differences among departments and age groups, with a significance level set at  $p < 0.05$ .

**Results:** A total of 1299 CBCT indications belonging to 1352 patients were evaluated in the study. It was determined that CBCT was most frequently requested for implant planning (54.3%), followed by lesion evaluation (16.4%) and impacted teeth (16.1%). The departments submitting the highest number of requests were oral and maxillofacial surgery (43.3%), periodontology (30.5%), and oral and maxillofacial radiology (12.2%), respectively. A statistically significant difference was observed in the distribution of CBCT request indications across clinical departments.

**Discussion and Conclusion:** CBCT requests are mostly oriented toward the indications specified by SedentexCT at the present time. However, more systematic approach to this issue and training of the personnel is recommended to avoid unnecessary radiation exposure.

**Keywords:** Cone-beam computed tomography; Dental implants; Radiation protection

Imaging methods play an important role in diagnosis and monitoring of oral diseases and treatment planning.<sup>[1]</sup> Conventional methods (panoramic, periapical radiography, etc.) can provide two-dimensional (2D) imaging and limitations such as magnification, superposition, artifact, and distortion are present in

these methods. Remarkable progress has been made in the field of three-dimensional (3D) radiographic imaging (such as stereoscopy and computed tomography [CT]). However, its limited accessibility, high cost, and relatively high radiation dose levels have caused the limited use of CT in the dental field.<sup>[2]</sup>

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Cone-beam CT (CBCT) systems designed specifically for imaging the maxillofacial area have become available for use to dental professionals since the end of the 1990's and have recently gained widespread popularity. With the development of new devices featuring more advanced imaging potential, CBCT has developed into the acknowledged standard for three-dimensional imaging of hard tissues in dentomaxillofacial radiology.<sup>[3]</sup> CBCT is an imaging technique developed primarily for implant dentistry. However, as its availability and accessibility have increased, it has been commonly exploited in all fields of dentistry.<sup>[4]</sup>

CBCT can guide diagnostic, operative, and monitoring processes along with treatment planning and it is a remarkably useful imaging method for examination of bone and dental structures.<sup>[4–6]</sup> Therefore, it is frequently requested for examination before maxillofacial and dental implant surgeries or diagnosis of benign/malignant tumors and bone pathologies.<sup>[7]</sup> It offers important diagnostic advantages to dental professionals, especially for complex anatomical structures and cases requiring surgical planning.<sup>[5,8,9]</sup> CBCT should be considered when the additional information obtained is expected to contribute to diagnosis and treatment planning or to improve clinical management, particularly in cases where 2D radiography is inconclusive.<sup>[10]</sup>

The necessity of using CBCT in accordance with appropriate clinical indications has been emphasized in the literature. The use of ionizing radiation in medical imaging has always been important in terms of radiation protection for personnel, patients and environment, and it has been recommended that the “As Low As Diagnostically Acceptable (ALADA)” principle should be followed. European Academy of Dentomaxillofacial Radiology has also recommended, as a common rule, that the field of view in imaging should be restricted only to the related area and the view should always contain the whole area.<sup>[3]</sup> The method that provides the most convenient radiographic information with the lowest radiation dose should be used in imaging process.<sup>[11]</sup> In 2009, EADMR published the guideline titled “Basic Principles for Use of Dental Cone-Beam Computed Tomography.” Article 18 of this guideline includes the following statement:<sup>[12]</sup> “Dentists responsible for CBCT facilities who have not previously received “adequate theoretical and practical training” should undergo a period of additional theoretical and practical training that has been validated by an academic institution (University or equivalent). Where national specialist qualifications in DMFR exist, the design and delivery of CBCT training

programs should involve a DMF Radiologist.” This statement was supported by the SedentexCT project and published by the European Commission with formal approval.<sup>[13]</sup>

Receiving training on the use of new imaging equipment and techniques is an essential part of efficient radiation protection. As with all imaging techniques, efforts should be made to obtain diagnostically sufficient images using the lowest possible radiation dose in CBCT as well. Therefore, the ALADA principle should be adopted and the difference between the risks of radiation amounts required to obtain “reasonable” and “good” quality images should be evaluated.<sup>[14]</sup>

The aim of this study is to investigate the indications for CBCT imaging requests in patients presented to the faculty of dentistry, and to estimate the compatibility of these requests with the indications recommended by SedentexCT.

## Materials and Methods

### Study Place and Design

This retrospective and descriptive study was conducted in the Department of oral and maxillofacial radiology (OMFR). CBCT requests obtained between January and December 2024 were – retrospectively – evaluated. The patients' demographic variables such as sex, age groups, and other related characteristics were recorded.

### Ethical Approval

This study was approved by the Gülhane Scientific Research Ethics Committee of the University of Health Sciences (Date: May 6, 2025; Decision no: 2025-242) and was conducted in accordance with the principles of the Declaration of Helsinki.

### Patients and Data Collection

A total of 1299 valid CBCT records were included in the analysis. Data were extracted from institutional radiological records and comprised patient demographics (sex and age), clinical departments requesting CBCT imaging, and indications for imaging. All data were anonymized before analysis.

### Diagnostic Criteria

CBCT imaging indications were classified according to predefined clinical request categories recorded in the radiology request system. These indications were grouped into five main categories based on clinical purpose.

## Definitions

Age was transformed into an ordinal variable by categorizing patients into four clinically meaningful age groups. Sex, CBCT indication, and the requesting clinical department were treated as nominal variables. Imaging indications and requesting departments were each classified into five categories for analytical purposes.

CBCT imaging indications were classified into five groups according to SedentexCT Evidence-Based Guidelines in 2011:<sup>[15]</sup>

1. Tooth abnormalities (based on number, shape, size, and position)
2. Impacted teeth
3. Endodontic pathologies (root-canal pathologies, thickening of the lamina dura, hypercementosis, etc.)
4. Bone pathologies
5. Other indications (dental implant treatment planning, craniofacial abnormalities, cleft lip and palate, trauma, root fractures, alveolar fractures, etc.).

## Inclusion Criteria

CBCT requests obtained within the study period (January–December 2024) with complete demographic information, clearly defined imaging indications, and identifiable requesting clinical departments were included in the study.

## Exclusion Criteria

Records with missing or incomplete demographic data, unclear or unspecified imaging indications, or duplicate entries were excluded from the analysis.

## Clinical, Surgical, and Laboratory Investigations

As this study was retrospective and radiology-based, no additional clinical, surgical, or laboratory investigations were performed. Only existing CBCT imaging requests and associated metadata were evaluated.

## Statistical Analysis

The distributional properties of the variables were examined using the Kolmogorov–Smirnov test; however, due to the categorical structure of the data, the parametric assumptions were not met. Consequently, non-parametric and categorical data analysis methods were employed throughout the study.

Chi-square ( $\chi^2$ ) tests were employed to examine the associations between departments and reasons for CBCT requests, with assumptions verified through expected cell

counts. Expected counts were found to be less than five in 16% (four cells) of the tables. Since this proportion remained below the 20% threshold, meeting the robustness criteria for the standard Chi-square test, primary interpretations were based on Pearson Chi-square results. Furthermore, to confirm the reliability of the findings, Fisher's Exact Test results were reported using Monte Carlo simulation (10,000 samples, 99% CI). Due to the table dimensions being larger than 2×2, Cramer's V coefficient was utilized to evaluate the effect size. Following a significant overall  $\chi^2$  test result ( $p < 0.05$ ), a log-linear model was applied to localize the source of the association. Subsequently, 10 pairwise comparisons (1 df) were performed among the  $k=5$  primary request reason categories. To control Type I errors arising from multiple comparisons,  $p$ -values were adjusted using the Bonferroni procedure; effects are summarized by odds ratios with 99.5% confidence intervals, equivalent to a significance level of  $\alpha=0.05/10$ .

To evaluate the strength of associations, Cramer's V and Phi coefficients were calculated for nominal variables, enabling the study to report not only the presence but also the magnitude of relationships.

In addition, to provide a more comprehensive understanding of the direction and strength of associations between variables, a supplementary correlation analysis was performed.

A post hoc power analysis was conducted using G\*Power version 3.1.9.7 (Heinrich Heine University, Düsseldorf, Germany) based on the Pearson Chi-square statistic of the primary analysis ( $\chi^2=1156.046$ ,  $df=91$ ,  $n=1299$ ). With a significance level of  $\alpha=0.05$ , the achieved power ( $1-\beta$ ) was  $>0.99$ .

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) for Windows, Version 25.0 (SPSS Inc., IL, USA).  $p < 0.05$  was considered statistically significant.

## Results

An analysis of the demographic and clinical characteristics of the 1352 patients evaluated in this study revealed a broad age distribution (Table 1). The 46–60 age group, representing 34.1% of the sample, constituted the largest proportion of patients. This was followed by individuals aged 0–30 years (31.1%), those aged 31–45 years (20.1%), and patients aged 61 years and older (14.7%). These findings indicate that CBCT requests predominantly concentrate within the middle-aged and older adult populations.

With respect to sex, female patients accounted for 56.1% of the sample, whereas males represented 43.9%. This find-

**Table 1.** The descriptive statistics of the patients

| Variables             | Groups                                           | Frequency | Percentage | Cumulative percentage |
|-----------------------|--------------------------------------------------|-----------|------------|-----------------------|
| Age                   | 0–30                                             | 420       | 31.1       | 31.1                  |
|                       | 31–45                                            | 272       | 20.1       | 51.2                  |
|                       | 46–60                                            | 461       | 34.1       | 85.3                  |
|                       | 61+                                              | 199       | 14.7       | 100                   |
|                       | Total                                            | 1352      | 100        |                       |
| Sex                   | Female                                           | 759       | 56.1       | 56.1                  |
|                       | Male                                             | 593       | 43.9       | 100                   |
|                       | Total                                            | 1352      | 100        | 100                   |
| Imaging Indication    | Implant                                          | 734       | 54.3       | 54.3                  |
|                       | Impacted Tooth and Impacted Tooth with Pathology | 217       | 16.1       | 70.3                  |
|                       | Lesion                                           | 222       | 16.4       | 86.8                  |
|                       | Maxillary Sinus                                  | 48        | 3.6        | 90.3                  |
|                       | Other*                                           | 78        | 5.8        | 96.1                  |
|                       | Total                                            | 1299      | 96.1       | 96.1                  |
|                       | Unclassified**                                   | 53        | 3.9        | 3.9                   |
|                       | Overall total                                    | 1352      | 100        | 100                   |
| Requesting department | Oral and maxillofacial surgery                   | 586       | 43.3       | 43.3                  |
|                       | Periodontology                                   | 413       | 30.5       | 73.9                  |
|                       | Oral and maxillofacial radiology                 | 165       | 12.2       | 86.1                  |
|                       | Orthodontics                                     | 124       | 9.2        | 95.2                  |
|                       | Other***                                         | 64        | 4.8        | 100                   |
|                       | Total                                            | 1352      | 100        |                       |

\*: Other imaging indications include condylar and temporomandibular joint disorders, root fractures, root canal resorption, post-operative evaluation and complications, tooth and jaw morphology, trauma, foreign bodies, cleft lip and palate, and orthognathic surgery. \*\*: Unclassified refers to CBCT requests without a clearly defined clinical indication in the imaging records and, therefore, could not be assigned to a specific category. \*\*\*: Other requesting departments include endodontics, pedodontics, prosthetic dental treatment, and restorative dental treatment.

ing indicates that CBCT examinations were requested relatively more frequently for female patients.

A total of 1299 CBCT indications were evaluated in the study. The most frequent indication was implant planning, comprising 54.3% of all requests. Lesion evaluation ranked second with 16.4%, followed by the assessment of impacted and pathologically impacted teeth at 16.1%. Maxillary sinus assessment accounted for 3.6%, while requests categorized as "other" constituted 5.8% of the total. This distribution highlights that CBCT is most commonly used in clinical practice for surgical planning, particularly before implant procedures. When the clinical departments initiating CBCT requests were examined, the majority originated from the department of oral and maxillofacial surgery (OMFS), accounting for 43.3% of all requests. This was followed by the department of periodontology (30.5%), the department of OMFR (12.2%), and the department of orthodontics (9.2%). Requests from other clinical units represented 4.8% of the

total. These findings demonstrate that CBCT is most intensively used in surgical and periodontal diagnostic–treatment workflows.

Overall, the results of this study illustrate that CBCT is a key imaging modality particularly favored for implant planning, surgical assessment, and periodontal treatment procedures. An evaluation of CBCT request indications by sex showed that implant planning was the most frequent indication in both female and male patients (Table 2). A total of 58.5% of female patients (n=425) and 53.9% of male patients (n=309) underwent CBCT imaging for implant-related procedures, indicating that implant procedures represent the primary field of application for both sexes.

CBCT requests for impacted or pathologically impacted teeth were observed in 17.9% of women (n=130) and 15.2% of men (n=87). This distribution suggests that CBCT examinations for the evaluation of impacted teeth were requested more frequently for female patients.

**Table 2.** Distribution of imaging indications by sex (n/%)

| Indication                                       | Sex    |       |      |       | Total |       |
|--------------------------------------------------|--------|-------|------|-------|-------|-------|
|                                                  | Female |       | Male |       |       |       |
|                                                  | n      | %     | n    | %     | n     | %     |
| Implant                                          | 425    | 58.50 | 309  | 53.90 | 734   | 56.50 |
| Impacted tooth and impacted tooth with pathology | 130    | 17.90 | 87   | 15.18 | 217   | 16.70 |
| Lesion                                           | 112    | 15.42 | 110  | 19.20 | 222   | 17.09 |
| Maxillary sinus                                  | 20     | 2.75  | 28   | 4.89  | 48    | 3.70  |
| Other*                                           | 39     | 5.38  | 39   | 6.80  | 78    | 6.00  |
| Total                                            | 726    | 100   | 573  | 100   | 1299  | 100   |

\*: Other imaging indications include condylar and temporomandibular joint disorders, root fractures, root canal resorption, post-operative evaluation and complications, tooth and jaw morphology, trauma, foreign bodies, cleft lip and palate, and orthognathic surgery.

**Table 3.** Distribution of imaging indications by age groups (n/%)

| Indications                                      | Age groups – n (%) |              |              |              | Total – n (%) |
|--------------------------------------------------|--------------------|--------------|--------------|--------------|---------------|
|                                                  | 0–30               | 31–45        | 46–60        | 61+          |               |
| Implant                                          | 57 (15.12)         | 172 (63.70)  | 354 (77.80)  | 151 (76.60)  | 734 (56.50)   |
| Impacted tooth and impacted tooth with pathology | 172 (45.62)        | 25 (9.26)    | 16 (3.52)    | 4 (2.03)     | 217 (16.71)   |
| Lesion                                           | 91 (24.13)         | 46 (17.03)   | 55 (12.08)   | 30 (15.23)   | 222 (17.09)   |
| Maxillary sinus                                  | 9 (2.39)           | 17 (6.29)    | 16 (3.52)    | 6 (3.04)     | 48 (3.69)     |
| Other*                                           | 48 (12.73)         | 10 (3.70)    | 14 (3.07)    | 6 (3.04)     | 78 (6.00)     |
| Total                                            | 377 (100.00)       | 270 (100.00) | 455 (100.00) | 197 (100.00) | 1299 (100.00) |

\*: Other imaging indications include condylar and temporomandibular joint disorders, root fractures, root canal resorption, post-operative evaluation and complications, tooth and jaw morphology, trauma, foreign bodies, cleft lip and palate, and orthognathic surgery.

CBCT requests for lesion assessment were more evenly distributed between sexes but were higher among men (19.2%, n=110), compared to women (15.4%, n=112). These findings indicate that imaging for pathological conditions may be relatively more frequent in male patients.

Requests for maxillary sinus evaluation were also more common among men (4.9%, n=28) than women (2.8%, n=20), demonstrating a sex-related difference in sinus-related imaging indications.

Other request indications were similarly distributed between sexes (5.4% among women; and 6.8% among men).

Overall, the distribution of the 1299 CBCT requests by sex demonstrates that implant planning is the most prevalent imaging indication for both male and female patients. In contrast, indications such as lesion assessment and sinus evaluation appear more frequently among men. These findings suggest that clinical utilization patterns of CBCT may vary meaningfully by sex.

An examination of the distribution of CBCT request indications across age groups revealed that implant planning was the most frequent indication in all age categories (Table

3). Notably, implant-related CBCT requests reached particularly high proportions in the 46–60 age group (77.8%, n=354) and among individuals aged 61 years and older (76.6%, n=151). This pattern clearly reflects the markedly increased need for dental implants in older age groups. The 31–45 age groups also demonstrated a substantial proportion of implant requests (63.7%). In contrast, implant-related CBCT requests were considerably lower in the 0–30 age group (15.1%), which is consistent with the naturally lower demand for implant therapy in younger individuals.

CBCT requests for the assessment of impacted and pathologically impacted teeth showed pronounced variation across age groups. Such requests were highest in the 0–30 age group, accounting for 45.6% (n=172) of all indications, indicating that this developmental period is the most frequently associated with impacted-tooth-related pathologies. With increasing age, these requests declined sharply, reaching minimal levels in the 46–60 age groups (3.5%) and among those 61 years and older (2.0%).

Requests for lesion evaluation displayed a more balanced distribution across the age groups. The proportion of lesion-related CBCT requests was 24.1% (n=91) in the 0–30

**Table 4.** Analysis of differences in imaging indications by department

| Measure                      | Value   | df | Asymptotic significance (2-sided) | Monte carlo sig. (2-sided) |
|------------------------------|---------|----|-----------------------------------|----------------------------|
| Pearson Chi-square           | 822.397 | 16 | p<0.001                           | 0.001                      |
| Likelihood ratio             | 779.814 | 16 | p<0.001                           | 0.001                      |
| Fisher's exact test          | 764.500 | –  | –                                 | 0.001                      |
| Linear-by-Linear association | 158.414 | 1  | p<0.001                           | p<0.001                    |
| Phi                          | 0.796   | –  | p<0.001                           | p<0.001                    |
| Cramer's V                   | 0.398   | –  | p<0.001                           | p<0.001                    |

N of valid cases: 1299. Note: Four cells (16%) had expected counts <5 (minimum expected count=2.33); therefore, Monte Carlo simulation (10,000 samples, 99% confidence interval) was applied. p<0.001 are reported as p<0.001. df: Degrees of freedom.

**Table 5.** Analysis of differences in imaging indications by age group

| Measure                      | Value   | df | Asymptotic significance (2-sided) | Monte carlo sig. (2-sided) |
|------------------------------|---------|----|-----------------------------------|----------------------------|
| Pearson Chi-square           | 503.019 | 12 | p<0.001                           | p<0.001                    |
| Likelihood ratio             | 518.397 | 12 | p<0.001                           | p<0.001                    |
| Fisher's exact test          | 513.423 | –  | –                                 | p<0.001                    |
| Linear-by-Linear association | 141.563 | 1  | p<0.001                           | p<0.001                    |
| Phi                          | 0.707   | –  | p<0.001                           | p<0.001                    |
| Cramer's V                   | 0.320   | –  | –                                 | –                          |

N of Valid Cases: 1299. Note: Monte Carlo simulation (10,000 samples, 99% confidence interval) was applied due to low expected cell counts. p<0.001 are reported as p<0.001. df: Degrees of freedom.

age group, 17.0% in the 31–45 age group, 12.1% in the 46–60 age group, and 15.2% in those 61 years and older. This distribution suggests that lesions requiring imaging assessment are encountered with relatively similar frequency across different age groups.

CBCT requests for maxillary sinus evaluation were low in all age groups; however, the 31–45 age group exhibited a slightly higher proportion (6.3%) compared with other groups.

Requests classified under “other” indications remained low and relatively similar across all age categories.

In summary, distinct differences were observed in CBCT request indications across age groups. While implant planning predominated in middle-aged and older adults, impacted tooth evaluation emerged as the most common indication among younger individuals. These findings highlight how CBCT utilization patterns reflect age-dependent clinical needs.

The relationship between CBCT request indications and the clinical departments initiating these requests was analyzed (Table 4). The results indicate that CBCT request indications differ significantly across clinical departments and reflect variations in CBCT utilization according to specialty-specific diagnostic and treatment workflows.

The analyses revealed that the variation primarily stemmed from department-specific clinical practices. The OMFS department predominantly requested CBCT imaging for implant planning and impacted/pathologically impacted teeth. The periodontology department was almost exclusively focused on implant-related requests. OMFR department showed higher frequencies of lesions and maxillary sinus evaluations, while orthodontics was especially associated with impacted tooth assessments. Other departments demonstrated distinctive patterns in lesion-related and miscellaneous CBCT indications.

Collectively, these findings demonstrate that differences in CBCT request indications are driven by specialty-specific usage patterns and highlight distinct diagnostic priorities among clinical disciplines.

The association between CBCT request indications and age groups was evaluated (Table 5). The analyses revealed that requests for evaluation of impacted and pathologically impacted teeth were significantly more frequent in the 0–30 age group compared with all other age categories. In contrast, implant-related CBCT requests were predominant in the 31–45 and 46–60 age groups, and similarly represented the most frequent indication in individuals aged 61 years and older. Requests for maxillary

**Table 6.** Correlation table

| Correlations <sup>b</sup> |     |            |            |          |
|---------------------------|-----|------------|------------|----------|
| Spearman's rho            | Sex | Indication | Department | Age      |
| Sex                       |     |            |            |          |
| Correlation coefficient   | 1   | 0.042      | -0.031     | 0.023    |
| Sig. (two-tailed)         |     | 0.129      | 0.261      | 0.416    |
| Indication                |     |            |            |          |
| Correlation coefficient   |     |            | 0.247**    | -0.502** |
| Sig. (two-tailed)         |     |            | 0          | 0        |
| Department                |     |            |            |          |
| Correlation coefficient   |     |            | 1          | -0.187** |
| Sig. (two-tailed)         |     |            |            | 0        |
| Age                       |     |            |            |          |
| Correlation coefficient   |     |            |            | 1        |

Spearman's rho correlation coefficients are presented. Categorical variables were coded numerically for correlation analysis. Correlations marked with \*\*are significant at the 0.01 level (two-tailed). p<0.001 are reported as p<0.001. List-wise n=1299.

sinus evaluation and other indications exhibited relatively low frequencies across all age groups.

These findings demonstrate that the distribution of CBCT indications varies meaningfully by age and reflects age-related clinical priorities in diagnostic imaging.

A correlation analysis was conducted to evaluate the relationships among sex, age, requesting department, and CBCT request indications. The results of the Spearman's rho test are presented in Table 6.

Sex showed only very weak correlations with the other variables: A weak positive correlation with the reason for the request ( $r=0.042$ ,  $p>0.05$ ), a weak negative correlation with the requesting department ( $r=-0.031$ ,  $p>0.05$ ), and a weak positive correlation with age ( $r=0.023$ ,  $p>0.05$ ). These findings indicate that sex was not a determining factor in CBCT request patterns.

By contrast, significant associations were observed for age and department. The indication for CBCT was moderately and negatively correlated with patient age ( $r=-0.502$ ,  $p<0.01$ ), suggesting that younger patients were more frequently referred for non-implant-related reasons such as impacted teeth, whereas implant planning was predominant among older age groups. In addition, a weak but significant positive correlation was found between the request indication and the department ( $r=0.247$ ,  $p<0.01$ ), reflecting that certain clinical departments were more strongly associated with specific request reasons. A weak but significant negative correlation between department and age ( $r=-0.187$ ,  $p<0.01$ ) further supported the observation that referrals from some departments (e.g., orthodontics and pediatric dentistry) were concentrated in younger

age groups, while others (e.g., prosthodontics and periodontology) were associated with older patients.

Overall, these results indicate that while sex had little influence on referral patterns, both patient age and the requesting department played a substantial role in shaping the distribution of CBCT indications.

Discussion

At present, CBCT is commonly utilized for assessing the alveolar bone and adjacent anatomical structures before implant surgery. Specifically, in the posterior maxilla, factors including alveolar bone trabeculation, the positioning of the maxillary sinus, and sinus pneumatization can contribute to implant failure.<sup>[16]</sup>

This study provides a comprehensive evaluation of CBCT referral patterns in a university dental faculty, highlighting both similarities and differences compared with the existing literature.

According to Geduk and Haylaz,<sup>[17]</sup> requests for CBCT for pre-operative implant planning constituted 29.5% of all CBCT indications. Implant evaluation constitutes a prevalent rationale for requests for CBCT. The department of periodontology often requests CBCT to assess adjacent anatomical structures before implant surgery. Tarım Ertaş and Kalabalık<sup>[8]</sup> reported a rate of 25.19% for implant-related CBCT requests, whereas Menziletoğlu et al.<sup>[18]</sup> identified this rate as 43.12%. The findings underscore the importance of CBCT as an imaging modality in implant planning. In this study, requests for CBCT related to implants accounted for 54.3% of total requests. Warhekar et al.,<sup>[19]</sup> Türker and Göller Bulut,<sup>[20]</sup> and Akarslan

and Peker<sup>[21]</sup> documented comparable rates of 52.7%, 52.7%, and 42.04%, respectively. The department of OMFS was the most frequently requested, accounting for 43.3%, followed by periodontology at 30.5% and OMFR at 12.2%. The higher rate in our setting may be explained by the fact that implant procedures are performed extensively in OMFS and periodontology clinics at university hospitals, where costs are lower and multidisciplinary support is available.

Geduk and Haylaz<sup>[17]</sup> found that 20.6% of CBCT requests were for lesion assessment, ranking it as the second most prevalent indication, whereas Yalçın and Artaş<sup>[22]</sup> found that intraosseous lesions represented 23.07% of requests, predominantly initiated by the department of OMFS. Consistent with the existing literature, our study identified lesion evaluation as the second most common indication for CBCT utilization, occurring at a rate of 17.1%. These findings underscore the clinical reliance on CBCT for three-dimensional visualization of cysts, tumors, and bone pathologies. The application of CBCT to evaluate the position of impacted teeth and their relationship with adjacent structures is well established.<sup>[23]</sup> Yalçın and Artaş<sup>[22]</sup> reported a rate of 6.73%, whereas Tarım Ertaş and Kalabalık<sup>[8]</sup> found it to be 32.13%. These differences may arise from variations in the average age of the patient population or regional factors. In contrast, in a referral-based retrospective study, Vollan et al.<sup>[24]</sup> identified impacted teeth and endodontic issues as the predominant indications for CBCT examinations. In this study, requests for CBCT imaging of impacted teeth accounted for 13.4%, placing them in third position. Importantly, our age-stratified analysis showed that impacted tooth referrals were highly concentrated in younger patients (particularly 0–14 years), while implant requests dominated in older groups. This highlights how demographic distribution strongly shapes referral trends.

In a study conducted on children and young individuals, Ismayılov and Özgür<sup>[25]</sup> reported that malocclusion and dento-facial anomaly were the most common indications for CBCT imaging (28.7%), while our findings demonstrate that in the 0–30-year age group, CBCT was most frequently requested for impacted teeth and impacted teeth with pathology (45.62%), which may reflect differences in age grouping, referral patterns, and institutional clinical priorities.

Yalçın and Artaş<sup>[22]</sup> indicated that requests for CBCT in sinus evaluation represented 2.38% of total requests. In the current investigation, the observed rate was 3.7%, contrasting with the 0.8% reported by Warhekar et al.<sup>[19]</sup> in 2015. The observed discrepancy may be attributed to demographic factors, including ethnicity, or to advancements in dental imaging and implant procedures in the last decade.

Yalçın and Artaş<sup>[22]</sup> reported that CBCT requests for temporomandibular joint (TMJ) evaluation constituted 1.29% of total requests, while Warhekar et al.<sup>[19]</sup> indicated a figure of 12.4%. In contrast, in our study, this rate was identified only within the “other” category, accounting for 5.8%, likely attributable to the preference for magnetic resonance imaging, which offers superior soft-tissue contrast for TMJ evaluation.<sup>[26]</sup>

In endodontics, CBCT is utilized to evaluate root resorption, identify root canals, assess trauma, planning of endodontic surgery, and localization of fractured instruments<sup>[27]</sup> Matherne et al.<sup>[28]</sup> compared between CBCT and 2D digital imaging, revealing that a considerable number of root canals were overlooked with 2D techniques. In this study, the requests originating from the field of endodontics were inconsistent with the existing literature. This discrepancy may be attributed to a preference for two-dimensional alternative imaging techniques – such as angled radiographs or tube-shift methods – to minimize radiation exposure. These 2D approaches may allow clinicians to obtain the necessary diagnostic information without the need for CBCT.

## Conclusion

According to the results of this study, most CBCT requests at our faculty comply with SedentexCT guidelines. Nevertheless, implementing structured protocols and enhancing staff training may further reduce unnecessary radiation exposure and optimize the appropriate use of CBCT in dental practice.

**Ethics Committee Approval:** The Gülhane Scientific Research Ethics Committee of the University of Health Sciences granted approval for this study (date: 06.05.2025, number: 2025-242).

**Informed Consent:** Informed consent was not required due to the retrospective nature of the study.

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# The Relationship between Midwifery Students' Adverse Childhood Experiences, Fear of Childbirth, and Professional Interest: A Multicenter Cross-sectional Study

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## Abstract

**Introduction:** Very little is known about how midwifery students' own negative experiences affect their transition into their professional roles. This study aims to examine the relationship between adverse childhood events, fear of childbirth, and professional interest levels among final-year midwifery students.

**Methods:** This cross-sectional and descriptive study was conducted between September 1 and December 31, 2022, with final-year midwifery students selected using a multi-stage purposive sampling method aimed at representing different geographical regions of Türkiye. Data were collected through an online questionnaire, and the sample consisted of 567 students who agreed to participate. Data were analyzed using the Statistical Package for the Social Sciences. Independent samples t-test, analysis of variance, and Chi-square test were used for group comparisons; Pearson correlation and linear regression analyses were used to examine the relationships between variables.

**Results:** The mean age of the participants was 22.2±1.21, and the majority were single (96.6%, n=548). After graduation, 71.6% (n=406) of the students stated that they wanted to work as midwives in the public sector, 91.9% (n=521) stated that they were satisfied with their midwifery education, and 58.0% (n=329) stated that the midwifery profession was suitable for them. Participants' mean fear of childbirth score was 3.44 (±1.17), a high level of professional interest (3.97±0.71), and a low level of adverse childhood events (0.16±0.198). A significant positive correlation was found between the number of traumatic experiences and fear of childbirth ( $r=0.111$ ;  $p<0.01$ ), while no significant correlation was observed with professional interest. A moderate negative correlation was identified between fear of childbirth and professional interest ( $r=-0.330$ ;  $p<0.001$ ). Regression analysis revealed that adverse childhood events significantly increased fear of childbirth ( $\beta=0.144$ ;  $p<0.001$ ), but had no significant effect on professional interest.

**Discussion and Conclusion:** Past-traumatic experiences among midwifery students appear to increase their fear of childbirth, which may negatively impact their level of professional interest. These findings underscore the importance of trauma-informed approaches in midwifery education. It is recommended that midwifery curricula incorporate content aimed at enhancing psychosocial support, emotional awareness, and coping skills for trauma.

**Keywords:** Adverse childhood experiences, Cross-sectional study, Fear of childbirth, Professional interest, Trauma-informed care

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Adverse childhood experiences (ACEs) encompass a range of painful and distressing events that occur during childhood.<sup>[1]</sup> These include various forms of abuse, neglect, and household dysfunction, all of which are known to have long-term consequences for individuals' psychological, emotional, and social well-being.<sup>[2,3]</sup> An expanding body of research demonstrates that the effects of ACEs extend into adulthood, influencing not only mental health outcomes but also individuals' perceptions, coping mechanisms, and career trajectories.<sup>[2,4,5]</sup> Evidence further suggests that women exposed to ACEs are at increased risk of experiencing perinatal depression and anxiety, as well as other mental health issues during pregnancy and the postpartum period, including postpartum symptoms.<sup>[2]</sup>

One such manifestation is fear of childbirth (tokophobia), which may arise not only among women of childbearing age but also among health professionals who support them, such as midwives.<sup>[1]</sup> Midwives are healthcare professionals who provide autonomous and collaborative care to women throughout pregnancy, childbirth, and the postpartum period.<sup>[6,7]</sup> Final-year midwifery students preparing to enter a profession centered on pregnancy and childbirth may be particularly vulnerable to heightened emotional responses related to unresolved trauma histories. ACEs can increase their susceptibility to fear of childbirth, potentially undermining clinical confidence and diminishing motivation to pursue a career in midwifery.<sup>[8]</sup>

Among midwifery students, fear of childbirth can affect clinical decision-making and may contribute to inappropriate choices regarding vaginal birth and cesarean section. In some cases, students may inadvertently project their own fears of childbirth onto pregnant women, thereby contributing to increased cesarean section rates.<sup>[9]</sup> Furthermore, such fears can negatively influence the quality of care provided, shaping not only delivery mode but also the birth experience of the pregnant individual. Despite growing recognition of the importance of trauma-informed care in maternity services,<sup>[8]</sup> relatively little is known about how student midwives' adverse experiences may shape their transition into professional roles.<sup>[10]</sup>

Midwives, who play an important role in normal births, generally experience positive and happy birth experiences alongside women.<sup>[11]</sup> However, difficult births can cause intense emotional reactions in midwives.<sup>[12,13]</sup> Midwifery students inevitably encounter traumatic situations during their clinical training and, as students, are more vulnerable to trauma.<sup>[14–16]</sup> Witnessing traumatic births can affect midwifery students' perceptions, making it difficult for

them to provide professional care and support during childbirth.<sup>[17]</sup> Beyond its psychological impact, exposure to both personal and indirect trauma has been shown to affect professional interest, career commitment, and the intention to remain in healthcare professions. Studies on nursing and midwifery education suggest that unresolved trauma, increased emotional distress, and fear related to clinical practice may lead to decreased professional motivation, indecision about the profession, and even the intention to drop out of education programs or avoid certain clinical areas.<sup>[18,19]</sup> In this context, professional interest can be understood as a multidimensional structure comprising enthusiasm for the profession, commitment to clinical practice, and the intention to pursue a midwifery career.<sup>[20]</sup>

When considered together, these findings suggest a conceptual pathway whereby ACEs may increase vulnerability to fear of childbirth, which, in turn, may negatively affect midwifery students' professional interest and career-related attitudes. However, there are few empirical studies that simultaneously examine negative childhood experiences, fear of childbirth, and professional interest within a single model, particularly among final-year midwifery students approaching entry into the profession. The present study aims to examine the relationship between ACEs, fear of childbirth, and professional interest among final-year midwifery students. A deeper understanding of these relationships may inform the development of targeted support strategies within midwifery education, ultimately enhancing the quality of maternity care as well as the well-being of midwives themselves.

## Materials and Methods

This cross-sectional and descriptive study was conducted online with final-year students enrolled in the midwifery departments of seven universities in Türkiye between September 1 and December 31, 2022.

## Research Questions

1. What socio-demographic variables affect ACEs, fear of childbirth, and professional interest?
2. What are the ACEs and levels of fear of childbirth among midwifery students?
3. What are the ACEs and professional interest levels of midwifery students?
4. What is the relationship between ACEs and fear of childbirth among midwifery students?
5. What is the relationship between ACEs and professional interest among midwifery students?

## Population and Sample

The population of this study consisted of a total of 4,050 final-year midwifery students enrolled in 59 universities offering midwifery education in Türkiye as of 2022. The sample size was determined using the sample calculation formula for the known population, and it was calculated that a minimum of 478 students would be sufficient to include in the study at a 98% confidence level. In the sampling process, a multi-stage purposive sampling method was used to represent Türkiye's different geographical regions. Within this scope, the universities with the highest number of final-year midwifery students in each geographical region were identified (Marmara University, Medipol University, Üsküdar University, Ankara University, Çanakkale On Sekiz Mart University, Atatürk University, and Cumhuriyet University), and students studying at these universities were invited to participate in the study. This approach aimed to ensure that the sample reflected geographical diversity across the country. Therefore, the selection of universities was not random but based on a conscious choice to strengthen regional representation.

Students who were enrolled at the selected universities, met the research criteria, and voluntarily agreed to participate were included in the study. At the end of the data collection process, a total of 567 senior midwifery students were reached, exceeding the minimum sample size. Exceeding the calculated sample size was preferred in order to compensate for possible data losses, increase statistical power, and enable more reliable subgroup analyses. To assess the statistical power of the study, a post hoc power analysis was performed using the G\*Power 3.1 program based on the final sample size. The analysis, conducted with a medium effect size (effect size=0.30), a 5% significance level ( $\alpha=0.05$ ), and a sample size of 567, determined that the statistical power of the study was above 0.95. This result indicates that the current sample has sufficient power to reveal the relationships between the research variables. However, due to the purposeful nature of the sample, the findings cannot be generalized to all final-year midwifery students in Türkiye. While the results reflect the views of students from different regions, they do not claim to be fully generalizable.

## Data Collection

Data were collected using an electronic questionnaire. Participants were reached through student representatives at the selected universities, and the survey link was distributed through student WhatsApp groups. Students

were informed that participation was voluntary. To prevent duplication, participants were required to verify their email addresses before accessing the survey, and each email address could be used only once. After login, participants first viewed the informed consent form and proceeded to the survey only after providing consent. All questions were mandatory to ensure complete responses. On average, the survey took approximately fifteen minutes to complete.

## The Data Collection Instrument Consisted of Four Sections

### General Information Form

Developed by the researchers based on a literature review,<sup>[14–17]</sup> this 15-item form captured socio-demographic characteristics (e.g., age, marital status, income, and residence) and professional attitudes (e.g., reasons for choosing midwifery and perceptions of the value of the profession).

### ACEs–Turkish Form (ACE-TR)

Originally developed by Felitti et al.<sup>[21]</sup> and adapted into Turkish by Gündüz et al.<sup>[22]</sup> This 10-item instrument assesses adverse experiences before age 18. Responses are coded as “yes” or left blank. Scores range from 0 to 10, with higher scores indicating more ACEs. No cut-off value exists. The Turkish validation study reported Cronbach's  $\alpha=0.74$ ; in this study,  $\alpha=0.757$ . Although there is no universal cut-off point for the ACEs, a score of 4 or higher is widely used in the literature, including by the authors who developed the scale, as a cut-off value associated with a significant increase in risk for health and psychosocial outcomes.<sup>[21,23–25]</sup> In this context, scale scores in the analyses were considered under two categories: 0–3 (low exposure) and 4–10 (high exposure).

### Professional Interest Scale (PIS)

Developed by Kaysi (2021), this 19-item scale measures professional interest among university students and graduates. Factor analysis identified four subdimensions: Professional preparedness, self-development, professional choice awareness, and recommending the profession to others. Responses are scored on a 5-point Likert scale (1=strongly disagree to 5=strongly agree), with item 7 reverse coded. Scale interpretation: 1.00–1.80 very low; 1.81–2.60 low; 2.61–3.40 moderate; 3.41–4.20 high; and 4.21–5.00 very high. Cronbach's  $\alpha=0.923$  in the original study and  $\alpha=0.941$  in the present study.<sup>[26]</sup>

### **Childbirth Fear–prior to Pregnancy Scale (CF-PPS)**

Childbirth fear–prior to pregnancy scale (CF-PPS): This 10-item self-report scale, adapted into Turkish by Uçar and Taşhan,<sup>[27]</sup> assesses fear of childbirth in young women and men across domains such as pain, loss of control, coping, complications, and irreversible physical harm. Responses are scored on a 6-point Likert scale (1 = strongly disagree to 6 = strongly agree). Scores range from 10 to 60, with higher scores indicating greater fear. Cronbach's  $\alpha$  was 0.86 in the Turkish validation study and 0.915 in the current study.

### **Statistical Analysis**

Data were analyzed using IBM Statistical Package for the Social Sciences Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation and median, while categorical variables are presented as frequencies and percentages. Normality of distributions was assessed using the Shapiro-Wilk test. For comparisons between two independent groups, the independent samples t-test was used as appropriate; for comparisons involving more than two groups, one-way analysis of variance was applied. Relationships between categorical variables were analyzed with Chi-square tests. Correlations among the ACE-TR, PIS, and CF-PPS scores were examined using Pearson correlation coefficients. Linear regression analysis was conducted to explore predictive relationships between scales. Statistical significance was set at  $p < 0.05$ .

### **Ethical Considerations**

This study was approved by the Ethics Committee of the Faculty of Health Sciences at Marmara University (Date: January 27, 2022, Decision: 18). Online informed consent was obtained from each participant stating that they were volunteering. The study was conducted in accordance with the principles of the Declaration of Helsinki.

### **Results**

A total of 567 final-year midwifery students from seven universities across Türkiye participated in the study. The mean age of the participants was  $22.2 \pm 1.21$  years. The majority were single (96.6%,  $n=548$ ), and more than half (52.4%,  $n=297$ ) reported that their income was equal to their expenses. Of the students, 41.1% ( $n=233$ ) lived with their families, and 89.4% ( $n=507$ ) reported a nuclear family structure. The most frequently cited reason for choosing the midwifery department was "ease of finding a job" (49.0%,  $n=278$ ), while 39.9% ( $n=226$ ) stated that they had

chosen it of their own free will. After graduation, 71.6% ( $n=406$ ) expressed a desire to work as midwives in the public sector. In addition, 91.9% ( $n=521$ ) reported being satisfied with their midwifery education, and 58.0% ( $n=329$ ) considered the profession suitable for themselves. During their internships, students assisted in a mean of  $27.2 \pm 18.8$  births and performed an average of  $9.89 \pm 12.7$  births.

The mean score on the CF-PPS was  $3.44 \pm 1.17$ . The mean score on the PIS was  $3.97 \pm 0.713$ , reflecting a high level of professional interest. The mean score on the ACEs Questionnaire – Turkish Version (ACE-TR) was  $0.16 \pm 0.198$ , indicating a low level of reported ACEs. Based on the responses to the 10 items of the ACEs scale, 44.8% of the participants reported no history of childhood trauma. In contrast, 36.7% reported experiencing one to three ACEs, while 18.5% indicated exposure to four or more ACEs. These proportions were calculated based on the participants' affirmative ("yes") responses to the ACE scale items.

The reliability analysis showed high internal consistency for all scales, with Cronbach's alpha values as follows: CF-PPS=0.915, PIS=0.941, and ACE-TR=0.757. The results of the Shapiro–Wilk test for normality distribution were examined, and according to the test result, no deviation from normality was observed, and the variables showed a normal distribution ( $p > 0.05$ ).

### **Comparison of Fear of Childbirth with Sociodemographic Characteristics**

The relationship between students' sociodemographic characteristics and fear of childbirth is presented in Table 1. No statistically significant differences were found in fear of childbirth scores according to income status, place of residence, or family structure ( $p > 0.05$ ). However, a significant difference was observed based on the reason for choosing the department ( $p < 0.05$ ). Specifically, students who reported choosing the department "because my score was sufficient" had the highest fear of childbirth scores ( $4.23 \pm 0.67$ ).

Fear of childbirth also varied significantly by post-graduation work preference ( $p = 0.017$ ). Students who planned to work outside the field of midwifery had the highest scores ( $3.93 \pm 1.36$ ), whereas those intending to work as midwives in hospitals had lower scores ( $3.36 \pm 1.12$ ).

Students who considered the profession suitable for themselves had significantly lower fear of childbirth scores ( $p < 0.001$ ). The mean score was 2.97 among those who reported the profession as "very suitable," compared with  $4.11 \pm 1.28$  among those who considered it "not suitable." Similarly, students satisfied with their education reported

**Table 1.** Comparison of students' characteristics and fear of childbirth scores

|                                                 | n (%) | Childbirth fear-prior to pregnancy scale Mean±SD | p      |
|-------------------------------------------------|-------|--------------------------------------------------|--------|
| Income status                                   |       |                                                  |        |
| Less than expenses                              | 228   | 3.51±1.20                                        | 0.176  |
| Equal to expenses                               | 297   | 3.36±1.11                                        |        |
| More than expenses                              | 42    | 3.65±1.27                                        |        |
| Place of residence                              |       |                                                  |        |
| With family                                     | 233   | 3.39±1.24                                        | 0.858  |
| With relatives                                  | 25    | 3.32±1.08                                        |        |
| Student house/apartment                         | 79    | 3.48±1.14                                        |        |
| Dormitory                                       | 216   | 3.50±1.10                                        |        |
| Other                                           | 14    | 3.44±1.28                                        |        |
| Family structure                                |       |                                                  |        |
| Nuclear family                                  | 507   | 3.42±1.16                                        | 0.14   |
| Extended family                                 | 60    | 3.65±1.16                                        |        |
| Intended career path after graduation           |       |                                                  |        |
| Work as a midwife in a hospital                 | 406   | 3.36±1.12                                        | 0.017  |
| Become an academic                              | 75    | 3.71±1.19                                        |        |
| Practice as an independent midwife              | 49    | 3.38±1.15                                        |        |
| Work outside the field of midwifery/Other       | 37    | 3.93±1.36                                        |        |
| Perception of the profession's suitability      |       |                                                  |        |
| Very suitable                                   | 185   | 2.97±0.00                                        | <0.001 |
| Suitable                                        | 329   | 3.6±1.11                                         |        |
| Not suitable                                    | 53    | 4.11±1.28                                        |        |
| Satisfaction with midwifery education           |       |                                                  |        |
| Yes                                             | 521   | 3.38±1.14                                        | <0.001 |
| No                                              | 46    | 4.12±1.21                                        |        |
| Professional interest scale level               |       |                                                  |        |
| Very low                                        | 5     | 5.68±0.716                                       | <0.001 |
| Low                                             | 16    | 3.93±1.152                                       |        |
| Moderate                                        | 98    | 3.87±0.998                                       |        |
| High                                            | 299   | 3.47±1.093                                       |        |
| Very high                                       | 149   | 2.98±1.208                                       |        |
| Adverse childhood experiences – Turkish version |       |                                                  |        |
| No traumatic experiences                        | 254   | 3.34±1.116                                       | <0.001 |
| 1 traumatic experience                          | 90    | 3.42±1.10                                        |        |
| 2 traumatic experiences                         | 65    | 3.54±1.225                                       |        |
| 3 traumatic experiences                         | 53    | 3.19±1.224                                       |        |
| 4 traumatic experiences                         | 52    | 3.38±1.312                                       |        |
| 5 or more traumatic experiences                 | 53    | 4.15±0.97                                        |        |
| Adverse childhood experiences – Turkish version |       |                                                  |        |
| None                                            | 254   | 3.34±1.12                                        | <0.001 |
| Present                                         | 313   | 3.52±1.20                                        |        |

SD: Standard deviation.

**Table 2.** Correlation analysis between scale scores

|                                     | ACE-TR | Childbirth<br>fear-prior to<br>pregnancy scale | Professional<br>interest<br>scale |
|-------------------------------------|--------|------------------------------------------------|-----------------------------------|
| ACE-TR                              |        |                                                |                                   |
| r                                   | –      |                                                |                                   |
| p                                   |        |                                                |                                   |
| Pre-pregnancy fear<br>of childbirth |        |                                                |                                   |
| r                                   | 0.111  | –                                              |                                   |
| p                                   | **     |                                                |                                   |
| Professional interest<br>scale      |        |                                                |                                   |
| r                                   | -0.026 | -0.330                                         | –                                 |
| p                                   | 0.209  | ***                                            |                                   |

\*\*: <0.01; \*\*\*: <0.001; Pearson correlation analysis. ACE-TR: Adverse childhood experiences–Turkish version.

lower fear of childbirth scores ( $3.38 \pm 1.14$ ), while those dissatisfied had higher scores ( $4.12 \pm 1.21$ ) ( $p < 0.001$ ).

Professional interest levels were also significantly associated with fear of childbirth ( $p < 0.001$ ). Students with very low professional interest had the highest fear scores ( $5.68 \pm 0.71$ ), whereas those with very high interest had the lowest scores ( $2.98 \pm 1.20$ ). Furthermore, professional interest was significantly influenced by post-graduation goals, perceived suitability of the profession, and satisfaction with education (all  $p < 0.001$ ).

Of the participants, 44.8% ( $n=254$ ) reported no traumatic childhood experiences, while 55.2% ( $n=313$ ) reported at least one. Fear of childbirth scores increased with the number of traumatic experiences. Students reporting five or more traumas had a mean score of  $4.15 \pm 0.98$ , compared with  $3.34 \pm 1.12$  among those with no reported traumas ( $p < 0.001$ ). Each additional trauma was associated with a mean increase of 0.08 points in pre-pregnancy fear of childbirth. While ACEs were not significantly associated with professional interest, differences were observed according to the desired post-graduation work field ( $p=0.042$ ).

### Inter-scale Correlation

The Pearson correlation analysis revealed a weak but statistically significant positive correlation between ACEs scores and fear of childbirth scores ( $r=0.111$ ,  $p < 0.01$ ). A moderate negative correlation was found between professional interest and fear of childbirth ( $r=-0.330$ ,  $p < 0.001$ ). However, no significant correlation was observed between ACEs and professional interest ( $p=0.209$ ) (Table 2).

### Regression Analysis Findings

In the linear regression analysis conducted to examine the effect of ACEs on fear of childbirth, ACEs were found to have a statistically significant positive effect on fear of childbirth ( $\beta=0.144$ ,  $p < 0.001$ ). Although the explanatory power of the model was low ( $R^2=0.021$ ), the result was statistically significant. In contrast, no statistically significant effect of ACEs was observed on professional interest ( $\beta=-0.053$ ,  $p=0.209$ ).

### Scale Scores Based on Postgraduate Goals

Significant differences were observed across all scale scores according to students' intended post-graduation work areas. Students who planned to work outside the field of midwifery had higher fear of childbirth scores (mean [ $M$ ]=3.93, standard deviation [ $SD$ ]=1.36) and lower professional interest scores ( $M=3.29$ ,  $SD=0.95$ ) compared with other groups ( $p < 0.001$ ). The highest professional interest scores were found among students who intended to work as midwives in hospitals ( $M=4.03$ ,  $SD=0.67$ ) (Table 3).

### Scale Comparisons Based on Suitability for the Profession

Students who considered the profession "very suitable" reported the highest professional interest scores ( $M=4.43$ ,  $SD=0.49$ ) ( $p < 0.001$ ). Fear of childbirth scores were lowest in this group ( $M=2.97$ ,  $SD=1.04$ ). In contrast, students who regarded the profession as "not suitable" reported significantly lower professional interest scores ( $M=2.97$ ,  $SD=0.83$ ) and higher fear of childbirth scores ( $M=4.11$ ,  $SD=1.29$ ) ( $p < 0.001$ ) (Table 4).

### Scale Comparisons Based on Satisfaction with Education

Students who were satisfied with their education reported higher scores across all subdimensions of professional interest ( $p < 0.001$ ) and lower fear of childbirth scores ( $M=3.38$ ,  $SD=1.14$ ) ( $p < 0.001$ ). No significant differences were observed between satisfaction groups with respect to ACEs scores ( $p=0.913$ ; Table 5).

### Discussion

This study examined the relationships between midwifery students' ACEs, pre-pregnancy fear of childbirth, and levels of professional interest. The findings revealed that an increase in ACEs during childhood significantly elevated fear of childbirth. This result is consistent with the existing literature. Several studies have demonstrated

**Table 3.** Comparison of scale scores according to post-graduation goals

| Post-graduation career plans                  | n   | Mean | SD    | SE     | F    | p      |     |
|-----------------------------------------------|-----|------|-------|--------|------|--------|-----|
| Professional interest scale                   |     |      |       |        |      |        |     |
| Work as a midwife in a hospital               | 406 | 4.03 | 0.667 | 0.0331 | 7.69 | <0.001 | 1>4 |
| Pursue an academic career                     | 75  | 4    | 0.695 | 0.0802 |      |        | 2>4 |
| Practice as an independent midwife            | 49  | 3.87 | 0.632 | 0.0903 |      |        | 3>4 |
| Work outside the field of midwifery           | 37  | 3.29 | 0.957 | 0.1573 |      |        |     |
| Childbirth fear–prior to pregnancy scale      |     |      |       |        |      |        |     |
| Work as a midwife in a hospital               | 406 | 3.36 | 1.127 | 0.0559 | 3.55 | 0.017  | 4>1 |
| Pursue an academic career                     | 75  | 3.71 | 1.198 | 0.1384 |      |        |     |
| Practice as an independent midwife            | 49  | 3.38 | 1.156 | 0.1651 |      |        |     |
| Work outside the field of midwifery           | 37  | 3.93 | 1.363 | 0.224  |      |        |     |
| Adverse childhood experiences–Turkish version |     |      |       |        |      |        |     |
| Work as a midwife in a hospital               | 406 | 1.49 | 1.907 | 0.0947 | 2.85 | 0.042  | 3>1 |
| Pursue an academic career                     | 75  | 1.67 | 2.016 | 0.2328 |      |        | 3>4 |
| Practice as an independent midwife            | 49  | 2.53 | 2.45  | 0.3501 |      |        |     |
| Work outside the field of midwifery           | 37  | 1.41 | 1.817 | 0.2988 |      |        |     |
| Recommending your profession to others        |     |      |       |        |      |        |     |
| Work as a midwife in a hospital               | 406 | 4.11 | 0.881 | 0.0437 | 7.79 | <0.001 | 1>4 |
| Pursue an academic career                     | 75  | 3.98 | 0.898 | 0.1037 |      |        | 2>4 |
| Practice as an independent midwife            | 49  | 3.85 | 0.914 | 0.1306 |      |        | 3>4 |
| Work outside the field of midwifery           | 37  | 3.24 | 1.128 | 0.1855 |      |        |     |
| Professional preparedness                     |     |      |       |        |      |        |     |
| Work as a midwife in a hospital               | 406 | 3.99 | 0.691 | 0.0343 | 9.58 | <0.001 | 1>4 |
| Pursue an academic career                     | 75  | 3.91 | 0.741 | 0.0855 |      |        | 2>4 |
| Practice as an independent midwife            | 49  | 3.85 | 0.666 | 0.0951 |      |        | 3>4 |
| Work outside the field of midwifery           | 37  | 3.06 | 1.044 | 0.1716 |      |        |     |
| Professional choice awareness                 |     |      |       |        |      |        |     |
| Work as a midwife in a hospital               | 406 | 4.28 | 0.717 | 0.0356 | 5.58 | 0.001  | 1>4 |
| Pursue an academic career                     | 75  | 4.2  | 0.72  | 0.0831 |      |        | 2>4 |
| Practice as an independent midwife            | 49  | 4.09 | 0.721 | 0.103  |      |        | 3>4 |
| Work outside the field of midwifery           | 37  | 3.65 | 0.968 | 0.1591 |      |        |     |
| Self-development                              |     |      |       |        |      |        |     |
| Work as a midwife in a hospital               | 406 | 3.82 | 0.854 | 0.0424 | 3.99 | 0.01   | 1>4 |
| Pursue an academic career                     | 75  | 3.94 | 0.915 | 0.1056 |      |        | 2>4 |
| Practice as an independent midwife            | 49  | 3.68 | 0.719 | 0.1027 |      |        |     |
| Work outside the field of midwifery           | 37  | 3.26 | 1.097 | 0.1803 |      |        |     |

SD: Standard deviation; SE: Standard error.

that individuals with a history of ACEs report higher levels of childbirth-related anxiety, develop negative expectations regarding the birthing process, and are more prone to tokophobia.<sup>[28–30]</sup>

One of the striking findings of this study is that students who chose midwifery “because their grades were sufficient,” who did not perceive the profession as suitable

for themselves, or who wished to work in a field other than midwifery after graduation, exhibited significantly higher fear of childbirth scores. This suggests that fear of childbirth is not solely a consequence of professional training but may also function as an unconscious factor influencing, or even determining, career choice. For instance, a student may not wish to become a midwife due to an unconscious fear of

**Table 4.** Comparison of scale scores according to suitability for the profession

| Perception of the profession's suitability | n   | Mean | SD    | SE     | F       | p      |       |
|--------------------------------------------|-----|------|-------|--------|---------|--------|-------|
| Professional interest scale                |     |      |       |        |         |        |       |
| Very suitable                              | 185 | 4.43 | 0.497 | 0.0365 | 115.971 | <0.001 | 1>2>3 |
| Suitable                                   | 329 | 3.86 | 0.58  | 0.032  |         |        |       |
| Not suitable                               | 53  | 2.97 | 0.829 | 0.1138 |         |        |       |
| Childbirth fear–prior to pregnancy scale   |     |      |       |        |         |        |       |
| Very suitable                              | 185 | 2.97 | 1.049 | 0.0771 | 28.617  | <0.001 | 1<2<3 |
| Suitable                                   | 329 | 3.6  | 1.115 | 0.0615 |         |        |       |
| Not suitable                               | 53  | 4.11 | 1.288 | 0.1769 |         |        |       |
| Recommending the profession to others      |     |      |       |        |         |        |       |
| Very suitable                              | 185 | 4.48 | 0.727 | 0.0534 | 60.221  | <0.001 | 1>2>3 |
| Suitable                                   | 329 | 3.92 | 0.825 | 0.0455 |         |        |       |
| Not suitable                               | 53  | 2.96 | 1.117 | 0.1535 |         |        |       |
| Professional preparedness                  |     |      |       |        |         |        |       |
| Very suitable                              | 185 | 4.42 | 0.534 | 0.0392 | 128.884 | <0.001 | 1>2>3 |
| Suitable                                   | 329 | 3.79 | 0.6   | 0.0331 |         |        |       |
| Not suitable                               | 53  | 2.81 | 0.84  | 0.1154 |         |        |       |
| Recommending your profession to others     |     |      |       |        |         |        |       |
| Very suitable                              | 185 | 4.67 | 0.483 | 0.0355 | 99.976  | <0.001 | 1>2>3 |
| Suitable                                   | 329 | 4.12 | 0.646 | 0.0356 |         |        |       |
| Not suitable                               | 53  | 3.21 | 0.932 | 0.1281 |         |        |       |
| Self-development                           |     |      |       |        |         |        |       |
| Very suitable                              | 185 | 4.2  | 0.774 | 0.0569 | 45.535  | <0.001 | 1>2>3 |
| Suitable                                   | 329 | 3.69 | 0.786 | 0.0433 |         |        |       |
| Not suitable                               | 53  | 2.96 | 1.019 | 0.14   |         |        |       |

SD: Standard deviation; SE: Standard error.

childbirth but may select this department for economic reasons or due to limited alternatives. The literature notes that individuals who enter health professions without intrinsic motivation are more vulnerable to clinical stressors and constitute a group at higher risk for professional burnout.<sup>[31–33]</sup> Fear of childbirth is therefore not only an individual psychological problem but also a systemic factor influencing the quality of maternity care. Prior studies highlight that this fear may increase midwives' tendency to recommend cesarean sections and foster insensitive attitudes toward trauma when providing care to women. Combined with a weak professional identity, this may result in a decline in care quality, professional role conflicts, and negative implications for patient safety.

<sup>[34]</sup> For these reasons, midwifery students' professional orientations and psychological backgrounds should be assessed multidimensionally, and educational programs should incorporate structured content informed by a trauma-sensitive approach.

Previous research have shown that even a single adverse childhood experience can have long-lasting emotional and psychological consequences in adulthood, and that exposure to four or more ACEs before the age of 18 substantially increases the risk of mental health problems and behavioral disorders.<sup>[22–25,35]</sup> Consistent with these findings, our study demonstrated that each one-unit increase in trauma score was associated with an approximate 0.08-unit increase in pre-pregnancy fear of childbirth. This finding suggests that past traumas may trigger childbirth-related anxieties, influencing perceptions of future childbirth, women's health, and the clinical environment. Overlooking the trauma histories of midwifery students may therefore impair their professional attitudes toward the birthing process.

Another noteworthy finding is the negative correlation between fear of childbirth and professional interest. The decline in professional interest among students with high

**Table 5.** Comparison of scale scores according to satisfaction with professional education

| Group                                    | n   | Mean | Median | SD    | SE     | Statistic | p      |
|------------------------------------------|-----|------|--------|-------|--------|-----------|--------|
| Professional interest scale              |     |      |        |       |        |           |        |
| Yes                                      | 521 | 4.05 | 4.05   | 0.643 | 0.0282 | 10.961    | <0.001 |
| No                                       | 46  | 2.96 | 3.08   | 0.697 | 0.103  |           |        |
| Childbirth fear–prior to pregnancy scale |     |      |        |       |        |           |        |
| Yes                                      | 521 | 3.38 | 3.3    | 1.143 | 0.0501 | -4.181    | <0.001 |
| No                                       | 46  | 4.12 | 4.1    | 1.219 | 0.18   |           |        |
| Adverse childhood events Turkish form    |     |      |        |       |        |           |        |
| Yes                                      | 521 | 1.6  | 1      | 1.953 | 0.0856 | -0.11     | 0.913  |
| No                                       | 46  | 1.63 | 1      | 2.341 | 0.345  |           |        |
| Recommending your profession to others   |     |      |        |       |        |           |        |
| Yes                                      | 521 | 4.11 | 4      | 0.859 | 0.0376 | 9.179     | <0.001 |
| No                                       | 46  | 2.89 | 3      | 0.948 | 0.14   |           |        |
| Professional preparedness                |     |      |        |       |        |           |        |
| Yes                                      | 521 | 4    | 4      | 0.682 | 0.0299 | 10.913    | <0.001 |
| No                                       | 46  | 2.84 | 3.14   | 0.752 | 0.111  |           |        |
| Professional choice awareness            |     |      |        |       |        |           |        |
| Yes                                      | 521 | 4.29 | 4.4    | 0.685 | 0.03   | 9.402     | <0.001 |
| No                                       | 46  | 3.28 | 3.3    | 0.845 | 0.125  |           |        |
| Self-development                         |     |      |        |       |        |           |        |
| Yes                                      | 521 | 3.87 | 3.8    | 0.831 | 0.0364 | 8.051     | <0.001 |
| No                                       | 46  | 2.84 | 3      | 0.871 | 0.128  |           |        |

SD: Standard deviation; SE: Standard error.

levels of fear of childbirth suggests that such individuals may also experience reduced professional motivation. The literature indicates that fear of childbirth affects not only those giving birth but also the healthcare professionals supporting the process, potentially leading to variability in clinical decision-making.<sup>[9,13,14,16]</sup>

In line with the study's results, no significant direct effect of ACEs on professional interest was observed. This finding suggests that the impact of adverse experiences may be moderated by individual coping strategies, social support networks, and positive experiences during training (e.g., problem-focused and emotion-focused coping as mediators of ACE impacts on outcomes).<sup>[36,37]</sup> Indeed, studies has shown that individuals with a history of ACEs report that these experiences influenced their decision to enter helping professions and shaped their professional motivations, suggesting that ACEs may be integrated into professional growth and meaning in career choice.<sup>[38,39]</sup>

Although a statistically significant positive correlation was identified between ACEs and fear of childbirth, the strength of this relationship was weak ( $r=0.111$ ). This

indicates that while childhood trauma may contribute to fear of childbirth, it represents only a minor component of a broader set of influencing factors.

Finally, this study found that students' perceptions of the suitability of the midwifery profession for themselves significantly influenced both their fear of childbirth and their professional interest. This finding underscores the importance of self-efficacy beliefs in the development of professional identity among midwifery students.<sup>[40]</sup> Although the regression analysis demonstrated a statistically significant relationship between ACEs and fear of childbirth, the explanatory power of the model was relatively low ( $R^2=0.021$ ). This finding suggests that ACEs explain only a small proportion of the variance in fear of childbirth. Therefore, fear of childbirth among midwifery students is likely influenced by multiple psychosocial, educational, and experiential factors beyond childhood trauma. Consequently, the findings should be interpreted with caution, and future studies should consider incorporating additional predictors to better explain this complex phenomenon.

## Strengths and Limitations of the Study

One of the strengths of this study is that seven universities were randomly selected to represent the seven different geographical regions of Türkiye. This enhanced the representativeness of the sample and strengthened the generalizability of the findings. In addition, the internal consistency of the measurement tools used in the study was high (Cronbach's  $\alpha > 0.75$ ), supporting the reliability of the data obtained. The fact that all questions were answered during the online data collection process eliminated the possibility of missing data and ensured the integrity of the dataset.

However, several limitations should be noted. First, the cross-sectional design does not allow causal relationships between variables to be established. Second, the use of self-reported data introduces the potential for subjective bias, such as social desirability bias. Finally, the restriction of the sample to final-year midwifery students limits the generalizability of the findings to other health disciplines and student groups.

## Conclusions and Recommendations

This study demonstrated that ACEs significantly increased fear of childbirth among midwifery students before pregnancy, and that fear of childbirth negatively affected their level of professional interest. The findings underscore that midwifery education should not be confined to imparting clinical knowledge and skills but should also be supported with content that enhances students' psychological resilience, fosters emotional awareness, and facilitates coping with past traumas.

**Based on these findings, the following recommendations are proposed:**

- Integration of psychosocial content: Midwifery education programs should incorporate modules on emotional intelligence, stress management techniques, and trauma-informed care.
- Development of structured support systems: Psychosocial support mechanisms – including early identification, counseling, and tailored support services – should be established for students experiencing fear of childbirth and those with a history of traumatic experiences.
- Ongoing monitoring and mentoring: The professional development of students with trauma histories should be regularly monitored, and individualized mentoring and guidance systems should be implemented.
- Longitudinal research: Future studies should adopt longitudinal designs to provide clearer insights into the causal relationships between traumatic experiences, professional development, and psychological outcomes.
- Broader research scope: Conducting similar studies across different health disciplines and with more diverse demographic samples would enhance the generalizability of the findings to health education.

**Ethics Committee Approval:** The Marmara University Faculty of Health Sciences Ethics Committee granted approval for this study (date: 27.01.2022, number: 18).

**Informed Consent:** Online informed consent was obtained from each participant stating that they were volunteering.

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# Clinical and Laboratory Predictors of COVID-19 Severity and the Need for Intensive Care: A Retrospective Cohort Study

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## Abstract

**Introduction:** To identify demographic, clinical, imaging, and laboratory predictors of disease severity and intensive care unit (ICU) requirement in patients with coronavirus disease 2019 (COVID-19).

**Methods:** This retrospective cohort study was conducted between March and August 2020 in the Department of Infectious Diseases. The study included suspected or confirmed cases of COVID-19. Patients' data were retrieved from the hospital's electronic medical records and patient files.

**Results:** The study included 500 patients. Increasing age and elevated ferritin levels were independently associated with severe COVID-19. Although not statistically significant, delayed admission showed a trend toward increased disease severity. Patients requiring ICU care had significantly higher C-reactive protein (CRP), lactate dehydrogenase (LDH), ferritin, and aspartate aminotransferase (AST) levels, along with lower absolute lymphocyte counts at admission. The multivariable model demonstrated good calibration (Hosmer-Lemeshow  $p=0.978$ ) and acceptable discrimination (area under the curve=0.76).

**Discussion and Conclusion:** Advanced age and elevated ferritin levels were independent predictors of severe COVID-19. Higher CRP, LDH, ferritin, and AST levels, along with lower absolute lymphocyte counts, were associated with ICU requirement. Early assessment of these routinely available laboratory parameters may facilitate timely risk stratification and improve clinical management.

**Keywords:** COVID-19; Pandemic; Risk factors

The coronavirus pandemic, first identified in Wuhan, Hubei Province, China, on December 31, 2019, and later named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has become one of the most widespread and prolonged pandemics in modern history.<sup>[1,2]</sup> As of November 2, 2025, the number of confirmed COVID-19 cases worldwide has reached 778,900,250,

with 7,103,247 reported deaths.<sup>[3]</sup> The global burden of COVID-19 remains substantial.

SARS-CoV-2, like other RNA viruses, undergoes continuous genetic evolution, resulting in the emergence of viral variants over time. Although differences in transmissibility and immune escape have been described in later phases of the pandemic, this study was conducted during the early

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phase of COVID-19, when variant-level analyses were not feasible. Therefore, the findings of this study reflect the clinical characteristics and outcomes observed before the widespread emergence of variant-specific differences.

Epidemiological, clinical, radiological, and laboratory data collected throughout the pandemic have improved understanding of disease mechanisms and contributed to advances in diagnosis and treatment. Nevertheless, reliable prognostic markers remain essential to identify high-risk patients and support early, individualized clinical management.<sup>[4]</sup> Therefore, this study aimed to identify demographic, clinical, and laboratory predictors of disease severity and intensive care unit (ICU) requirement in patients with COVID-19.

## Materials and Methods

### Study Design and Setting

This retrospective cohort study was conducted between March and August 2020 in the Infectious Diseases and Clinical Microbiology Clinic of a tertiary care hospital. The study included adult patients with possible or confirmed COVID-19 who were managed either as outpatients or inpatients during the study. Patients were eligible if they had polymerase chain reaction (PCR) positivity and/or lung imaging findings compatible with COVID-19.

Age was categorized into three groups (18–45, 46–65, and >65 years) based on commonly used clinical and epidemiological classifications. Patients older than 65 years were considered the older-adult group, since advanced age is a well-established risk factor for severe COVID-19.

### Data Collection

Patient data were retrospectively retrieved from the hospital's electronic medical records and patient files. During the study, the Turkish Ministry of Health regularly updated its national COVID-19 Clinical Guidelines in response to the evolving pandemic and emerging scientific evidence. These guidelines defined the criteria for outpatient follow-up, hospital admission, and ICU referral.

Accordingly, all clinical management decisions, including outpatient follow-up, ward admission, and ICU referral, were based on the guideline version in effect at the time of patient presentation.<sup>[5]</sup> This approach ensured consistency with national standards despite ongoing revisions to case definitions and treatment algorithms during the early phase of the pandemic.

### Patient Classification

Patients were categorized into three groups according to their clinical status at initial hospital admission. The asymptomatic group included patients without symptoms. The severe group comprised patients with bilateral ground-glass opacities on lung computed tomography (CT) and an oxygen saturation of  $\leq 90\%$  at initial evaluation or at any time during hospitalization. The mild–moderate group included patients who did not meet the criteria for the asymptomatic or severe categories.

### Ethical Approval

Approval for the study was obtained from the Ministry of Health on May 27, 2020 (application date: May 06, 2020). This study was approved by the Dışkapı Yıldırım Beyazıt Training and Research Hospital Clinical Research Ethics Committee (Date: 21.09.2020, Decision no: 96/03). The study was conducted in accordance with the principles of the Declaration of Helsinki.

### Statistical Analysis

Statistical analyses were performed using IBM Statistical Package for the Social Sciences Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Kolmogorov–Smirnov test and homogeneity of variances was evaluated with Levene's test. Continuous variables were presented as mean  $\pm$  standard deviation if normally distributed and as median (interquartile range [IQR]) if non-normally distributed, whereas categorical variables were expressed as number and percentage.

Comparisons between groups were conducted using the chi-square test or Fisher's exact test for categorical variables. For continuous variables, Student's t-test was applied to normally distributed data, and the Mann–Whitney U test was used for non-normally distributed data. When comparing more than two groups, one-way analysis of variance was used for normally distributed variables, and the Kruskal–Wallis test was applied for non-normally distributed variables. For multiple comparisons, p-values were adjusted using the Holm–Bonferroni method.

To identify independent predictors of severe COVID-19, multivariable logistic regression analysis was performed. Variables with  $p < 0.10$  in univariate analyses were entered into the multivariable model. Model calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test, and discriminative ability was evaluated using the area under the receiver operating characteristic curve (AUC).

A  $p < 0.05$  was considered statistically significant. Values reported as  $p = 0.000$  were expressed as  $p < 0.001$ .

## Results

### Demographic and Epidemiological Characteristics

The study included 500 patients: 42 (8.4%) asymptomatic, 373 (74.6%) mild-moderate, and 85 (17%) severe. Of all cases, 269 (53.8%) were male. No statistically significant association was observed between disease severity and gender ( $p = 0.228$ ).

The median age of all patients was 48.0 (33.0–62.0) years. The median (IQR) ages of the asymptomatic, mild-moderate, and severe groups were 37.5 (26.3–47.8), 46.0 (32.0–60.0), and 62.0 (52.0–75.0) years, respectively, and age differed significantly across all disease severity groups (Kruskal–Wallis  $H(2) = 66.509$ ,  $p < 0.001$ ), with post hoc analyses confirming statistically significant differences between each pair of groups (all Holm-adjusted  $p < 0.05$ ).

Forty-five patients (9%) were healthcare professionals. Healthcare professional status was significantly associated with lower disease severity ( $p < 0.001$ ).

At least one chronic disease was present in 9 patients (29%) in the asymptomatic group, 168 (45.7%) in the mild-moderate group and 65 (76.5%) in the severe group. Disease severity was significantly higher among patients with comorbidities ( $p < 0.001$ ). Among chronic conditions, hypertension (HT) ( $p < 0.001$ ) and diabetes mellitus (DM) ( $p = 0.011$ ) were significantly associated with increased disease severity.

Smoking status differed significantly across disease severity groups ( $p = 0.009$ ). The prevalence of smoking was 33.3% in the asymptomatic group, 30.9% in the mild-moderate group, and 11.7% in the severe group.

The demographic and epidemiological characteristics and comorbidities of the study population are presented in Table 1.

### Clinical Characteristics

The median duration of symptoms at hospital admission was 3 (2–5) days in the mild-moderate group and 4 (2–7) days in the severe group. Patients in the severe group presented 1 day later than those in the mild-moderate group, but this difference was not statistically significant ( $p = 0.075$ ).

The most common symptom among all patients was cough (63.8%), followed by fever (44.2%), weakness/fatigue (36%), dyspnea (35%), and myalgia (29.4%) (Table

2). Sputum and dyspnea were significantly more frequent in the severe group ( $p = 0.019$  and  $p = 0.004$ , respectively). Among gastrointestinal symptoms, nausea and vomiting were significantly more frequent in the severe group ( $p = 0.048$  and  $p = 0.018$ , respectively).

### Laboratory and Imaging Features

The median lymphocyte count was 1700 (1400–2270) cells/ $\mu\text{L}$  in the asymptomatic group, 1565 (1120–2122) cells/ $\mu\text{L}$  in the mild-moderate group, and 1100 (790–1630) cells/ $\mu\text{L}$  in the severe group. Both lymphocyte count and lymphocyte percentage decreased significantly with increasing disease severity ( $p < 0.001$ ).

Aspartate aminotransferase (AST) levels differed significantly between the groups ( $p = 0.001$ ). Similarly, lactate dehydrogenase (LDH) levels were significantly higher in patients with severe disease ( $p < 0.001$ ).

Creatine kinase (CK), CK-myocardial band, and troponin-I levels did not differ significantly between the groups. Although not statistically significant, median CK levels were numerically higher in the severe group (99.5 [55.5–161.0]) than in the asymptomatic (88.0 [60.0–125.5]) and mild-moderate (86.0 [60.5–143.5]) groups.

Among acute-phase reactants, C-reactive protein (CRP) was significantly associated with disease severity ( $p < 0.001$ ), with higher levels observed in patients with more severe disease (Table 3).

Among the 500 patients, 433 (86.6%) underwent thoracic CT, and 41 (8.2%) underwent chest X-ray. Overall, 474 patients (94.8%) received pulmonary imaging. Pneumonia was identified in 286 patients (60.3%) overall.

### Multivariable Logistic Regression Analysis for Severe COVID-19

A multivariable logistic regression analysis was performed including age, comorbidity status, lymphocyte count at admission, and ferritin level at admission.

Increasing age (odds ratio [OR] 1.036, 95% confidence interval [CI] 1.011–1.063,  $p = 0.005$ ) and higher ferritin levels (OR 1.001, 95% CI 1.000–1.002,  $p = 0.029$ ) were independently associated with severe COVID-19. Lymphocyte count showed a non-significant trend ( $p = 0.071$ ), while comorbidity status was not independently associated with disease severity (OR 1.208, 95% CI 0.490–2.981,  $p = 0.682$ ). The model demonstrated good calibration (Hosmer–Lemeshow  $p = 0.978$ ) and acceptable discriminative ability (AUC = 0.76) (Table 4).

**Table 1.** Baseline demographic and clinical characteristics according to COVID-19 severity (n=500)

| Characteristics                                | Asymptomatic (n=42) (%) | Mild-moderate (n=373) (%) | Severe (n=85) (%) | p                                         |
|------------------------------------------------|-------------------------|---------------------------|-------------------|-------------------------------------------|
| Types of patient care                          |                         |                           |                   |                                           |
| Outpatient                                     | 25 (59.5)               | 79 (21.2)                 | –                 | $\chi^2(2)=60.587$ ,<br><b>p&lt;0.001</b> |
| Hospitalized                                   | 17 (40.5)               | 294 (78.8)                | 85 (100.0)        |                                           |
| Age, years median (IQR)                        | 37.5 (26.3–47.8)        | 46.0 (32.0–60.0)          | 62.0 (52.0–75.0)  | H(2)=66.509,<br><b>p&lt;0.001</b>         |
| Gender (Male)                                  | 18 (42.9)               | 208 (55.8)                | 43 (50.6)         | $\chi^2(2)=2.955$ ,<br>p=0.228            |
| Age                                            |                         |                           |                   |                                           |
| 18–45                                          | 29 (69.0)               | 182 (48.8)                | 13 (15.3)         | $\chi^2(4)=58.341$ ,<br><b>p&lt;0.001</b> |
| 46–65                                          | 13 (31.0)               | 137 (36.7)                | 33 (38.8)         |                                           |
| >65                                            | –                       | 54 (14.5)                 | 39 (45.9)         |                                           |
| Healthcare professional (Doctor, Nurse, Other) | 12 (28.6)               | 31 (8.3)                  | 2 (2.4)           | $\chi^2(2)=26.245$ ,<br><b>p&lt;0.001</b> |
| Any chronic disease                            | 9 (29.0)                | 168 (45.7)                | 65 (76.5)         | $\chi^2(2)=32.058$ ,<br><b>p&lt;0.001</b> |
| Diabetes mellitus                              | 2 (6.5)                 | 53 (14.4)                 | 22 (25.9)         | $\chi^2(2)=9.017$ ,<br><b>p=0.011</b>     |
| Hypertension                                   | 2 (6.5)                 | 76 (20.7)                 | 39 (45.9)         | $\chi^2(2)=29.655$ ,<br><b>p&lt;0.001</b> |
| Chronic kidney disease                         | –                       | 17 (4.6)                  | 7 (8.2)           | $\chi^2(2)=4.631$ ,<br>p=0.113            |
| Coronary artery disease                        | –                       | 32 (8.7)                  | 12 (14.1)         | $\chi^2(2)=5.768$ ,<br>p=0.056            |
| Asthma                                         | –                       | 26 (7.1)                  | 6 (7.1)           | $\chi^2(2)=2.345$ ,<br>p=0.310            |
| Chronic obstructive pulmonary disease          | –                       | 19 (5.2)                  | 8 (9.4)           | $\chi^2(2)=4.323$ ,<br>p=0.115            |
| Smoking                                        | 7 (33.3)                | 83 (30.9)                 | 7 (11.7)          | $\chi^2(2)=9.368$ ,<br><b>p=0.009</b>     |

Data are presented as n (%) or median (IQR). Pearson's Chi-square test was used for categorical variables. Kruskal–Wallis test; post hoc pairwise comparisons were performed using the Mann–Whitney U test with Holm correction. A two-sided p<0.05 was considered statistically significant. IQR: Interquartile range.

**Table 2.** Clinical characteristics of mild-moderate and severe COVID-19 patients at admission

| Characteristics                                       | Mild-moderate (n=373) | Severe (n=85) | p                                  |
|-------------------------------------------------------|-----------------------|---------------|------------------------------------|
| Symptom duration, days - Median (interquartile range) | 3 (2–5)               | 4 (2–7)       | U=10,756.000, p=0.075              |
| Symptoms (%)                                          |                       |               |                                    |
| Fever                                                 | 177 (47.5)            | 44 (51.8)     | $\chi^2(1)=0.667$ , p=0.414        |
| Cough                                                 | 259 (69.4)            | 60 (70.6)     | $\chi^2(1)=0.043$ , p=0.835        |
| Sputum                                                | 40 (10.7)             | 17 (20.0)     | $\chi^2(1)=5.466$ , <b>p=0.019</b> |
| Dyspnea                                               | 131 (35.1)            | 44 (51.8)     | $\chi^2(1)=8.122$ , <b>p=0.004</b> |
| Nausea                                                | 41 (11.0)             | 16 (18.8)     | $\chi^2(1)=3.896$ , <b>p=0.048</b> |
| Vomiting                                              | 24 (6.4)              | 12 (14.1)     | $\chi^2(1)=5.643$ , <b>p=0.018</b> |
| Myalgia                                               | 124 (33.2)            | 23 (27.1)     | $\chi^2(1)=1.125$ , p=0.270        |
| Weakness/Fatigue                                      | 146 (39.1)            | 34 (40.0)     | $\chi^2(1)=0.021$ , p=0.884        |

Continuous variables were compared using the Mann–Whitney U test; categorical variables were compared using Pearson's Chi-square test.

**Table 3.** Laboratory parameters at hospital admission according to disease severity

| Laboratory parameters              | Asymptomatic (n=42)       | Mild-moderate (n=373)     | Severe (n=85)             | p                              |
|------------------------------------|---------------------------|---------------------------|---------------------------|--------------------------------|
| Hemogram Median (IQR)              |                           |                           |                           |                                |
| WBC (/μL)                          | 6055 (4970–7985)          | 7025 (5282.5–9475)        | 7230 (5260–8970)          | H(2)=3.161, p=0.206            |
| Number of NEUs (/μL)               | 3550 (2535–4570)          | 4270 (2952.5–6627.5)      | 5170 (3500–6900)          | H(2)=10.082, <b>p=0.006</b>    |
| Number of LYMs (/μL)               | 1700 (1400–2270)          | 1565 (1120–2122.5)        | 1100 (790–1630)           | H(2)=28.593, <b>p&lt;0.001</b> |
| LYM%                               | 31.5 (23.0–36.75)         | 23.7 (15.0–32.0)          | 17.0 (10.5–22.5)          | H(2)=39.359, <b>p&lt;0.001</b> |
| PLT (/μL)                          | 225.500 (194.750–272.500) | 227.500 (188.250–281.000) | 209.000 (170.000–263.000) | H(2)=3.304, p=0.192            |
| Biochemistry median (IQR)          |                           |                           |                           |                                |
| Cr (mg/dL)                         | 0.725 (0.665–0.847)       | 0.800 (0.650–0.950)       | 0.880 (0.690–1.080)       | H(2)=8.990, <b>p=0.011</b>     |
| AST (U/L)                          | 18.0 (14.0–21.0)          | 19.0 (15.0–26.0)          | 22.5 (17.0–33.75)         | H(2)=13.508, <b>p=0.001</b>    |
| ALT (U/L)                          | 19.0 (14.0–22.0)          | 19.0 (13.0–30.25)         | 19.0 (12.0–28.0)          | H(2)=0.627, p=0.731            |
| LDH (U/L)                          | 162.5 (146.5–197.0)       | 191.0 (164.0–226.0)       | 240.0 (197.0–284.75)      | H(2)=31.959, <b>p&lt;0.001</b> |
| Cardiac markers median (IQR)       |                           |                           |                           |                                |
| CK (U/L)                           | 88.0 (60.0–125.5)         | 86.0 (60.5–143.5)         | 99.5 (55.5–161.0)         | H(2)=0.559, p=0.756            |
| CK-MB (U/L)                        | 17.0 (14.0–19.5)          | 16.0 (13.0–19.0)          | 16.0 (12.5–21.0)          | H(2)=0.928, p=0.629            |
| TROPONIN-I (ng/mL)                 | 0.10 (0.10–0.10)          | 0.10 (0.10–0.10)          | 0.10 (0.10–0.10)          | H(2)=2.698, p=0.259            |
| Acute phase reactants median (IQR) |                           |                           |                           |                                |
| CRP (mg/L)                         | 2.21 (1.02–3.74)          | 17.0 (2.94–69.0)          | 60.0 (27.0–131.0)         | H(2)=38.853, <b>p&lt;0.001</b> |
| Procalcitonin (μg/L)               | 0.04 (0.02–0.04)          | 0.06 (0.04–0.105)         | 0.13 (0.06–0.21)          | H(2)=22.799, <b>p&lt;0.001</b> |
| Ferritin (μg/L)                    | 125.0 (76.5–146.5)        | 108.0 (50.0–246.0)        | 229.0 (82.25–429.75)      | H(2)=11.049, <b>p=0.004</b>    |
| Coagulation median (IQR)           |                           |                           |                           |                                |
| Fibrinogen (mg/dL)                 | 310.0 (270.5–335.5)       | 371.0 (306.0–462.0)       | 430.0 (349.5–538.75)      | H(2)=27.684, <b>p&lt;0.001</b> |
| PRO-BNP (ng/L)                     | 21.0 (6.36–39.5)          | 36.5 (13.0–119.25)        | 123.5 (46.25–435.75)      | H(2)=27.313, <b>p&lt;0.001</b> |
| D-Dimer (μg/mL)                    | 0.20 (0.20–0.32)          | 0.26 (0.20–0.53)          | 0.47 (0.215–0.825)        | H(2)=14.389, <b>p=0.001</b>    |
| PT (sec)                           | 9.2 (9.05–9.60)           | 9.4 (8.93–10.0)           | 9.3 (9.06–10.0)           | H(2)=1.267, p=0.531            |
| INR                                | 1.03 (1.01–1.07)          | 1.05 (1.00–1.13)          | 1.04 (1.01–1.13)          | H(2)=1.590, p=0.452            |

Data are presented as median (IQR). Overall comparisons among three severity groups were performed using the Kruskal–Wallis test. p-values for multiple laboratory parameters were adjusted using the Holm–Bonferroni method. Post-hoc pairwise comparisons were conducted using the Mann–Whitney U test with Holm correction. WBC: White blood cells; NEU: Neutrophil; LYM: Lymphocyte; PLT: Platelet; Cr: Creatinine; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; LDH: Lactate dehydrogenase; CK: Creatine kinase; CK-MB: Creatine kinase-myocardial band; CRP: C-reactive protein; PRO-BNP: Pro-B type natriuretic peptide; D-dimer: Fibrin degradation product; PT: Prothrombin time; INR: International normalized ratio; IQR: Interquartile range.

## Evaluation of ICU Need

ICU care was required in 27 patients (5.4%) in the overall cohort, and all of these patients were in the severe disease group. Among the 85 patients categorized as severe, 31.8% required ICU admission. There was no statistically significant association between ICU admission and gender (p=0.759).

The median age was 68.0 (54.0–79.0) years in patients requiring ICU care and 62.0 (50.0–74.0) years in those managed in the ward (p=0.524).

The median time from symptom onset to hospital admission was 4.0 (3.0–7.8) days in ICU patients and 4.0 (2.0–6.0) days in non-ICU patients (p=0.159).

Regarding laboratory parameters, the median CRP level was significantly higher in ICU patients (102.0 mg/L

**Table 4.** Multivariable logistic regression analysis for severe COVID-19

| Variables   | Multivariate analysis |             |              |
|-------------|-----------------------|-------------|--------------|
|             | OR                    | 95% CI      | p            |
| Age (years) | 1.036                 | 1.011–1.063 | <b>0.005</b> |
| Comorbidity | 1.208                 | 0.490–2.981 | 0.682        |
| LYM         | 1.000                 | 0.999–1.000 | 0.071        |
| Ferritin    | 1.001                 | 1.000–1.002 | <b>0.029</b> |

The multivariable model showed good calibration (Hosmer–Lemeshow  $\chi^2=2.08$ , p=0.978) and acceptable discriminative ability for predicting severe COVID-19 (AUC=0.76). LYM: Lymphocyte; OR: Odds ratio; CI: Confidence interval.

[57.5–180.3 mg/L]) than in non-ICU patients (39.0 mg/L [12.0–107.0 mg/L]) (p=0.004). ICU patients also had significantly higher LDH levels (257.0 U/L [224.5–347.0

**Table 5.** Comparison of characteristics of patients requiring and not requiring intensive care

| Characteristics                                                   | Severe patients followed up in the ward (n=58) | Severe patients transferred to ICU (n=27) | p                                          |
|-------------------------------------------------------------------|------------------------------------------------|-------------------------------------------|--------------------------------------------|
| Gender (Male) (%)                                                 | 30 (51.7)                                      | 13 (48.1)                                 | $\chi^2(1)=0.094$ , $p=0.759$              |
| Age (years) median (IQR)                                          | 62.0 (50.0–74.0)                               | 68.0 (54.0–79.0)                          | $U=850.500$ , $p=0.524$                    |
| Number of chronic diseases (%)                                    |                                                |                                           |                                            |
| None                                                              | 16 (27.6)                                      | 4 (14.8)                                  | $\chi^2(2)=1.909$ , $p=0.385$              |
| 1                                                                 | 19 (32.8)                                      | 9 (33.3)                                  |                                            |
| 2 and above                                                       | 23 (39.6)                                      | 14 (51.9)                                 |                                            |
| Smoke (%)                                                         | 6 (14.6)                                       | 1 (5.3)                                   | Exact test, $p=0.414$                      |
| Duration of symptoms (Days) at the time of admission median (IQR) | 4.0 (2.0–6.0)                                  | 4.0 (3.0–7.75)                            | $U=732.500$ , $p=0.159$                    |
| Laboratory features median (IQR)                                  |                                                |                                           |                                            |
| D-dimer ( $\mu\text{g/mL}$ )                                      | 0.47 (0.228–0.818)                             | 0.43 (0.20–0.885)                         | $U=617.500$ , $p=0.946$                    |
| CRP (mg/L)                                                        | 39.0 (12.0–107.0)                              | 102.0 (57.5–180.25)                       | $U=770.500$ , <b><math>p=0.004</math></b>  |
| LDH (U/L)                                                         | 209.0 (179.0–261.5)                            | 257.0 (224.5–347.0)                       | $U=778.500$ , <b><math>p=0.003</math></b>  |
| Troponin (ng/mL)                                                  | 0.10 (0.10–0.10)                               | 0.10 (0.10–0.125)                         | $U=251.000$ , $p=0.111$                    |
| Ferritin ( $\mu\text{g/L}$ )                                      | 165.0 (73.75–304.5)                            | 474.5 (248.5–791.5)                       | $U=390.000$ , <b><math>p=0.001</math></b>  |
| Number of LYMs ( $/\mu\text{L}$ )                                 | 1205.0 (845.0–1680.0)                          | 960.0 (575.0–1355.0)                      | $U=539.500$ , <b><math>p=0.022</math></b>  |
| Number of NEUs ( $/\mu\text{L}$ )                                 | 5650.0 (3862.5–7690.0)                         | 4560.0 (3130.0–5645.0)                    | $U=578.500$ , $p=0.054$                    |
| CK (U/L)                                                          | 96.0 (56.5–160.5)                              | 137.0 (52.0–159.0)                        | $U=627.000$ , $p=0.645$                    |
| AST (U/L)                                                         | 21.0 (15.0–31.0)                               | 26.0 (20.5–40.5)                          | $U=1044.000$ , <b><math>p=0.009</math></b> |
| ALT (U/L)                                                         | 17.0 (12.0–27.0)                               | 20.0 (14.5–28.5)                          | $U=886.000$ , $p=0.333$                    |
| Procalcitonin ( $\mu\text{g/L}$ )                                 | 0.12 (0.05–0.218)                              | 0.14 (0.09–0.185)                         | $U=354.500$ , $p=0.565$                    |

Continuous variables were compared using Mann–Whitney U test; categorical variables using Pearson's Chi-square test. D-dimer: Fibrin degradation product; CRP: C-reactive protein; LDH: Lactate dehydrogenase; NEU: Neutrophil; LYM: Lymphocyte; CK: Creatine Kinase; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase.

U/L]) and ferritin levels (474.5  $\mu\text{g/L}$  [248.5–791.5]) than those managed in the ward ( $p=0.003$  and  $p=0.001$ , respectively).

The median lymphocyte count was significantly lower in ICU patients (960 [575–1355] cells/ $\mu\text{L}$ ) than in non-ICU patients ( $p=0.022$ ). In addition, the median AST level was higher in the ICU group (26 U/L [20.5–40.5 U/L]), and this difference was statistically significant ( $p=0.009$ ).

A comparison of clinical and laboratory characteristics between patients who required ICU care and those managed in the ward is presented in Table 5.

Among severe patients, 14 (16.5%) required high-flow oxygen therapy, 13 (15.3%) required non-invasive mechanical ventilation, and 11 (12.9%) underwent endotracheal intubation (all  $p<0.001$ ). Among intubated patients, the median time from symptom onset to intubation was 4.0 (3.5–7.0) days. Oxygen therapy modalities and ventilatory support requirements according to disease severity are presented in Table 6.

## Discussion

In this retrospective cohort, disease severity increased significantly with age. The median age rose progressively from the asymptomatic to the severe group, and increasing age remained an independent predictor of severe COVID-19 in multivariable analysis. This finding is consistent with previous reports demonstrating poorer outcomes among older adults.<sup>[6–8]</sup> Male patients constituted a slightly higher proportion of the cohort (53.8%), consistent with previous reports describing a male predominance in COVID-19 cohorts;<sup>[7,9–11]</sup> however, disease severity did not differ significantly by sex in our study ( $p=0.228$ ). The mild-moderate group represented the largest subgroup in our cohort.

According to national data, 29,865 healthcare professionals, representing 10.9% of all COVID-19 cases in Türkiye, had been infected, and 52 had died as of September 02, 2020.<sup>[12]</sup> In our cohort, healthcare professionals accounted for 9% of cases and were more frequently represented in the

**Table 6.** Oxygen therapy and ventilatory support according to disease severity

| Characteristics                     | Mild-moderate (n=373) (%) | Severe (n=85) (%) | p                                       |
|-------------------------------------|---------------------------|-------------------|-----------------------------------------|
| Patient receiving oxygen therapy    | 69 (20.7)                 | 85 (100.0)        | $\chi^2(1)=183.490$ , <b>p&lt;0.001</b> |
| Amount of oxygen supplied*          |                           |                   |                                         |
| Between 0 and 2 L                   | 50 (15.0)                 | 28 (32.9)         | $\chi^2(1)=23.820$ , <b>p&lt;0.001</b>  |
| >2 L                                | 19 (5.7)                  | 57 (67.1)         |                                         |
| Oxygen therapy in ICU               |                           |                   |                                         |
| High-flow oxygen therapy            | -                         | 14 (16.5)         | Exact test, <b>p&lt;0.001</b>           |
| Non-invasive mechanical ventilation | -                         | 13 (15.3)         | Exact test, <b>p&lt;0.001</b>           |
| Intubated patient                   | 1 (0.3)                   | 11 (12.9)         | Exact test, <b>p&lt;0.001</b>           |

P-values were adjusted for multiple comparisons using the Holm–Bonferroni method; all associations remained statistically significant after correction.  
ICU: Intensive care unit.

asymptomatic group ( $p<0.001$ ). No mortality was observed among healthcare professionals in our study. This finding may reflect routine occupational health screening and earlier detection within this population.

According to data from the Turkish Statistical Institute's 2022 Türkiye Health Survey, HT is the most prevalent chronic condition among adults (16.1%), followed by diabetes mellitus (11.4%).<sup>[13]</sup> Consistent with these national data and previous reports,<sup>[14–16]</sup> HT was the most common comorbidity in our cohort, followed by diabetes mellitus. Although comorbidity was associated with greater disease severity in univariate analyses, it did not remain an independent predictor in the multivariable model.

The association between smoking and COVID-19 severity has been reported inconsistently. Some meta-analyses suggest that smoking increases the risk of severe disease and mortality,<sup>[17]</sup> whereas others have found no significant association between active smoking and severe COVID-19.<sup>[18]</sup> In our cohort, smoking was less frequent among patients with severe disease, and a statistically significant inverse association was observed between smoking status and disease severity ( $p=0.009$ ). However, this finding should be interpreted cautiously, as it may be influenced by confounding factors such as age distribution, comorbidity burden, and healthcare access. Overall, the conflicting evidence underscores the need for larger, well-designed prospective studies to clarify this relationship.

Consistent with previous reports,<sup>[9,11,15]</sup> cough and fever were the most common presenting symptoms in our cohort; however, their frequencies did not differ significantly between severity groups. In contrast, sputum, dyspnea, nausea, and vomiting were significantly associated with disease severity. The median time from symptom onset to hospital admission was 3.0 (2.0–5.0) days, comparable

to earlier findings.<sup>[10,19]</sup> Although the difference was not statistically significant, patients with severe disease presented slightly later than those in the mild–moderate group. This trend may indicate a potential association between delayed presentation and greater disease severity. CRP and ferritin levels were significantly higher in patients with severe disease, consistent with previous reports demonstrating the association between acute-phase reactants and COVID-19 severity.<sup>[20–22]</sup> Similarly, fibrinogen, Pro-B type natriuretic peptide, and D-dimer levels were elevated in the severe group, supporting the role of systemic inflammation and coagulopathy in disease progression. Also at initial admission, patients with severe disease exhibited higher absolute neutrophil counts, AST, and LDH,<sup>[23]</sup> whereas absolute lymphocyte counts and lymphocyte percentages were lower.

While several of these parameters were associated with disease severity in univariate analyses, multivariable modeling identified age and ferritin level as independent predictors of severe disease. These findings suggest that inflammatory and hematological markers may reflect disease severity, although not all retain independent prognostic significance.

Procalcitonin levels were significantly lower in the asymptomatic group ( $p<0.001$ ). However, the prognostic value of procalcitonin in COVID-19 remains uncertain, and its elevation may reflect secondary bacterial infection rather than direct viral severity.

ICU requirement occurred exclusively among patients in the severe disease group. Among these patients, 31.8% required intensive care support.

Patients transferred to the ICU demonstrated significantly higher CRP, LDH, ferritin, and AST levels at admission, while absolute lymphocyte counts were significantly lower.

Elevated inflammatory markers, particularly CRP, along with reduced absolute lymphocyte counts, were associated with both increased disease severity and ICU requirement. These findings are consistent with previous reports highlighting the role of systemic inflammation and comorbidity burden in identifying high-risk COVID-19 patients, including the study by Aryal et al.<sup>[24]</sup>

Taken together, selected inflammatory and hematological markers at presentation may reflect a more severe in-hospital clinical trajectory among patients already classified as having severe disease.

Intubation was required in 2.4% of patients in our cohort. Of the 12 intubated patients, 11 belonged to the severe disease group and one to the mild–moderate group. Within the severe subgroup, the intubation rate reached 12.9%.

Among patients with severe disease, the median time from symptom onset to intubation was 4.0 (3.5–7.0) days, suggesting that respiratory deterioration may occur early in the disease course. This observation is consistent with findings reported by Argenziano et al.,<sup>[25]</sup> who described a bimodal distribution in intubation timing, with peaks at 3–4 days and 9 days after symptom onset.

The concordance of our results with the earlier peak indicates that a subset of patients may experience clinical worsening within the 1<sup>st</sup> week of illness. These findings underscore the importance of close monitoring during the early phase of hospitalization, particularly in patients with markers of heightened systemic inflammation.

Taken together, our findings indicate that advanced age and heightened systemic inflammatory response are closely associated with greater disease severity and increased likelihood of intensive care requirement. Among laboratory parameters, ferritin remained independently associated with severe disease in multivariable analysis, while other inflammatory markers and reduced absolute lymphocyte counts reflected more advanced clinical presentation.

These routinely available clinical and laboratory parameters may assist in early identification of high-risk hospitalized COVID-19 patients, although their independent prognostic value warrants further investigation.

## Limitations

Our study has certain limitations. The COVID-19 Pandemic Guidelines of the Turkish Ministry of Health, which formed the basis for patient management during the study period, were updated frequently in response to rising case numbers and newly emerging information.

Consequently, outpatient and inpatient follow-up criteria evolved, and the distribution of cases in our cohort may not fully reflect current clinical practice. In addition, the lack of standardization in reverse transcription-PCR testing during the early phase of the pandemic and limited experience with this novel infection may have influenced diagnostic accuracy.

Furthermore, this was a retrospective, single-center study, which may limit the generalizability of the findings. Although multivariable logistic regression analysis was performed to identify independent associations, residual confounding cannot be excluded. Finally, the relatively small number of ICU patients limits the statistical power of subgroup analyses and may have reduced the ability to detect independent predictors of intensive care requirement.

## Conclusion

This retrospective cohort study demonstrates that advanced age and heightened systemic inflammatory response are closely associated with increased COVID-19 severity. Among laboratory parameters, ferritin remained independently associated with severe disease, while elevated inflammatory markers and reduced absolute lymphocyte counts reflected more advanced clinical presentation and greater likelihood of intensive care requirement.

These routinely available clinical and laboratory indicators may assist in the early identification of high-risk hospitalized patients. Although not all markers retained independent prognostic significance, their combined assessment may support clinical decision-making and risk stratification during COVID-19 and future respiratory viral outbreaks.

**Ethics Committee Approval:** The Dışkapı Yıldırım Beyazıt Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 21.09.2020, number: 96/03).

**Informed Consent:** Retrospective study.

**Conflict of Interest:** None declared.

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# Clinical Assessment of Spiritual Care Needs: A Cross-sectional Study Focusing on Patient Experiences

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## Abstract

**Introduction:** Spirituality encompasses a person's interaction with themselves and others, their place in the universe, and their efforts to understand the meaning of life. This study aims to identify the spiritual care needs of patients receiving professional healthcare services.

**Methods:** This cross-sectional study was conducted with 273 patients treated at a research hospital in İstanbul between April 2025 and May 2025. Data were collected using an Information Form and the Patient Spiritual Needs Assessment Scale (PSNAS). Mann–Whitney U test, Kruskal–Wallis test, and Dunn–Bonferroni tests were used to analyze the data.

**Results:** There were 49.4% (n=134) female and 51.6% (139) male, with a mean age of 48.29±12.95. The mean PSNAS score was 64.16±16.10. The mean PSNAS scores were as follows: “Divine” subdimension 11.24±3.86, “Appreciation of Art and Beauty” subdimension 8.24±2.86, “Meaning and Purpose” subdimension 7.30±2.48 the “Love and Belonging” subscale was 14.67±3.97, the “Death and Resolve” subscale was 10.09±3.25, and the “Positivity/Gratitude/Hope/Peace” subscale was 12.52±3.52 points. Spiritual needs levels differed according to gender, chronic illness, and expectations of spiritual support from nurses.

**Discussion and Conclusion:** Hospitalized patients have high spiritual care needs. Participants who were female, participants with chronic illnesses, and expected spiritual support from nurses had significantly higher spiritual care needs. These research findings will guide the development of spiritual care practices and spiritual care training content for healthcare professionals.

**Keywords:** Needs assessment; Nursing care; Patient beliefs; Spirituality

Spirituality in healthcare services is an important component of a holistic care approach that addresses not only an individual's physical symptoms but also their social, psychological, and existential needs. It also focuses on faith, rituals, culture, values, perceptions, traditions, intrinsic motivation, well-being, security, experiences,

expectations, and ways of resolving internal conflicts. Therefore, spirituality is characterized as the process of understanding the meaning of life.<sup>[1–4]</sup> The spiritual dimension must also be considered in healthcare, and individuals' spiritual needs must be identified and incorporated into healthcare.<sup>[1,5]</sup>

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Spiritual needs express the desire to understand the importance of life. They also aim to comprehend the relationship between oneself and other people, the Creator, or nature. Spiritual care needs vary for each patient and family. Descriptive studies planned for the spiritual needs of patients will enable healthcare professionals to select personalized spiritual care interventions based on individuals' spiritual needs and cultural backgrounds. Furthermore, they will provide important evidence for public health policies and clinical care practices by yielding significant results regarding the quantitative aspects of spiritual needs.<sup>[3,6,7]</sup>

Most studies on patient-centered spiritual care need to focus on palliative care and oncology patients.<sup>[7-9]</sup> A Taiwan-based study argued that spiritual care practices are an effective component in controlling post-traumatic stress disorder in cancer patients.<sup>[4]</sup> Another Nigeria-based study determined that cancer patients have high levels of spiritual care needs. It was also recommended that healthcare workers meet the spiritual needs of cancer patients to improve their quality of life.<sup>[10]</sup>

The fact that this study did not differentiate between types of illness is important in terms of the heterogeneity of the study results. Therefore, understanding the spiritual care needs of patients and the factors that influence them will help support their physical and mental health.<sup>[11]</sup> This study, which aims to determine the spiritual care needs of patients, seeks to answer the following research questions.

1. Is the level of spiritual care needs of sick individuals high?
2. Which sociodemographic variables affect the spiritual care needs of sick individuals?

## Materials and Methods

### Study Design

This study was designed as a descriptive cross-sectional study. The STROBE checklist was used in reporting this study.

### Place and Time of the Study

The study was conducted in the inpatient clinics of a research hospital in Istanbul between April 2025 and May 2025.

### Sample

A power analysis was performed using a purposive sampling method to determine the number of participants

to include in the study. The study population consists of patients receiving treatment in relevant clinics who meet the inclusion criteria. Since the population size is not precisely known, a sample size calculation method for an unknown population was used. The total sample size was calculated as  $n=132$  using G\*Power 3.1.3 (Heinrich-Heine Universität Düsseldorf, Düsseldorf, Germany) with an effect size of 0.5, 80% power, and a 0.5% margin of error based on the percentage measurement values for the methods to be studied.<sup>[10,12]</sup> The study was completed with 273 patients who met the inclusion criteria and agreed to participate in the study. After the study was completed, a post-hoc power analysis was performed using G\*Power 3.1 software. The results obtained indicate that the current sample size is sufficient to detect a statistically significant difference.

### Inclusion Criteria

Individuals who agreed to participate in the study by signing the informed consent form, who did not have visual or hearing impairment, who were literate, who were over 18 years of age, and who were treated in the inpatient clinics of the research hospital, was obtained between April 2025 and May 2025, were included in the study.

### Ethical Approval

This study was approved by the University of Health Sciences Hamidiye Scientific Research Ethics Committee (Date: 14.11.2024, Decision no: 13/4). The ethical rules in the Declaration of Helsinki were followed at all stages of the study. The purpose, duration, plan, how and where the data would be used, and what was expected from them were explained to the individuals included in the study through the Informed consent form prepared in accordance with the Declaration of Helsinki. Their written consent was obtained for their inclusion in the study in accordance with the principle of voluntarism.

### Data Collection

The research data were collected using the "Introductory Information Form" and the "Patient Spiritual Needs Assessment Scale." Data collection tools were administered by researchers to patients face-to-face in the patient room. The data collection process took approximately 4–5 min.

### Introductory Information Form

It consists of a total of 16 questions created by the researcher in line with the literature and aims to examine the sociodemographic characteristics of the participants.

### Patients' Spiritual Needs Assessment Scale (PSNAS)

Developed by Galek in 2005.<sup>[13]</sup> Dedeli et al.<sup>[14]</sup> adapted it to Turkish society by conducting validity and reliability studies.<sup>[14]</sup> The Turkish version of the scale consists of 23 items and 6 subscales. The subscales are: "Appreciation of art and beauty" (1), "Meaning and purpose" (2), "Love and belonging" (3), "Death/resolve" (4), "Positivity/gratitude/hope/peace" (5), and "Divine" (6). The questions on the scale can be answered with "yes" or "no." To determine the extent to which those who answer "yes" need this requirement, they are asked to rate their level of need by selecting "Never," "Rarely," "Often," or "Very often." Responses are scored between 0 and 3. The lowest possible score on the scale is "0," and the highest is "69." Needs are evaluated according to descriptive statistical analysis showing numbers and percentages. In this study, the total and sub-dimension mean scores of the scale were also calculated. The factor loadings of the items on the scale range from 0.41 to 0.78, and the Cronbach's Alpha internal consistency coefficient is 0.89. In this study, the Cronbach's Alpha value of the scale was determined to be 0.93. When we examined the Cronbach's alpha of the scale's sub-dimensions, we determined that the "Divine" sub-dimension had a value of 0.91, the "Appreciation of art and beauty" sub-dimension had a value of 0.80, the "Meaning and purpose" sub-dimension had a value of 0.60, the "Love and belonging" sub-dimension had a value of 0.81, the "Death/resolve" sub-dimension had a value of 0.77, and the "Positivity/gratitude/hope/peace" sub-dimension had a value of 0.90.

### Analysis of Data

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) Statistics 25 (Published 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Descriptive statistics included mean±standard deviation, median (min-max), frequency, and percentage values. The internal consistency of the scale and its sub-dimensions was evaluated using the Cronbach's Alpha coefficient. For intergroup comparisons, the assumption of normal distribution was assessed using the Shapiro–Wilk test. When the normality assumption was not met, appropriate nonparametric tests were applied; the Mann–Whitney U test was used for comparisons between two groups. The Kruskal–Wallis test was used for comparisons involving three or more groups. For variables with statistically significant differences following the Kruskal–Wallis test, Dunn–Bonferroni correction was applied for multiple comparisons. The confidence level

**Table 1.** Findings related to socio-demographic and disease characteristics of individuals (n=273)

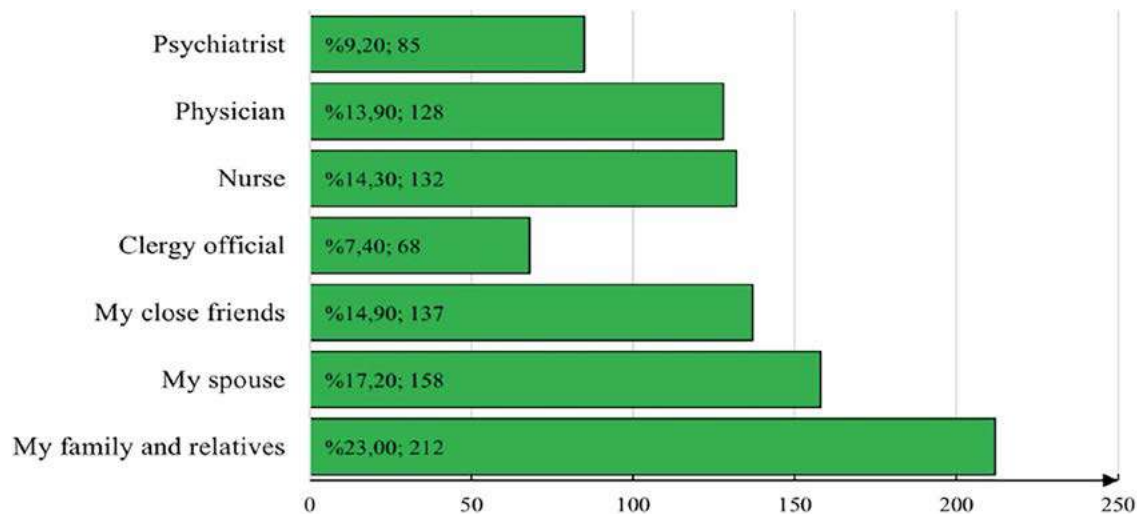
| Variable                                   | n          | %     |
|--------------------------------------------|------------|-------|
| Gender                                     |            |       |
| Female                                     | 134        | 49.4  |
| Male                                       | 139        | 50.6  |
| Marital status                             |            |       |
| Married                                    | 188        | 69.4  |
| Single                                     | 95         | 30.6  |
| Educational background                     |            |       |
| Illiterate                                 | 32         | 11.5  |
| Primary school graduate                    | 118        | 43.7  |
| High school graduate                       | 77         | 28.5  |
| University graduate                        | 46         | 16.3  |
| Chronic disease                            |            |       |
| No                                         | 140        | 50.9  |
| Yes                                        | 133        | 49.1  |
| Clinic where treatment is given            |            |       |
| Internal medicine clinics                  | 165        | 62.4  |
| Surgical clinics                           | 108        | 37.6  |
| Hospitalization experience                 |            |       |
| Yes                                        | 171        | 63.1  |
| No                                         | 102        | 36.9  |
| Expectation of moral support from nurses   |            |       |
| No                                         | 94         | 33.9  |
| Yes                                        | 179        | 66.1  |
| Relaxation methods*                        |            |       |
| Praying, reading the Quran                 | 177        | 21.40 |
| Praying                                    | 187        | 22.60 |
| Watching television and listening to music | 73         | 8.90  |
| Working on the computer                    | 39         | 4.70  |
| Reading books, newspapers, magazines, etc. | 55         | 6.70  |
| Traveling, picnicking, etc.                | 122        | 14.80 |
| Chatting with loved ones                   | 153        | 18.60 |
| Illiterate                                 | 18         | 2.30  |
| Age, median (min-max)                      | 48 (19–80) |       |

\*: Multiple options were selected. SD: Standard deviation.

in the analyses was set at 95%. The significance level was determined as  $p < 0.05$  in pairwise comparisons.

### Results

The findings regarding the socio-demographic and disease characteristics of the individuals included in the study are given in Table 1. The mean age of the participants was  $48.29 \pm 12.95$ ; 139 (50.6%) were male, 188 (69.4%) were



**Figure 1.** Expectations for spiritual support providers (n=273\*).

\*: Multiple options were selected.

married, and 118 (43.7%) were primary school graduates. When the disease characteristics of the participants were examined, it was determined that 133 (49.1%) had a chronic disease, 165 (62.4%) received treatment and care services in the internal clinic, and 171 (63.1%) had previous hospitalization experience. In this study, 179 (66.1%) of the patients expected moral support from nurses.

The findings of the patients regarding their expectations from spiritual support providers are given in Figure 1. Accordingly, 212 (23%) of the participants expected spiritual support from family and relatives, 137 (14.90%) from close friends, 132 (14.30%) from nurses, 128 (13.90%) from physicians, and 68 (7.40%) from religious officials.

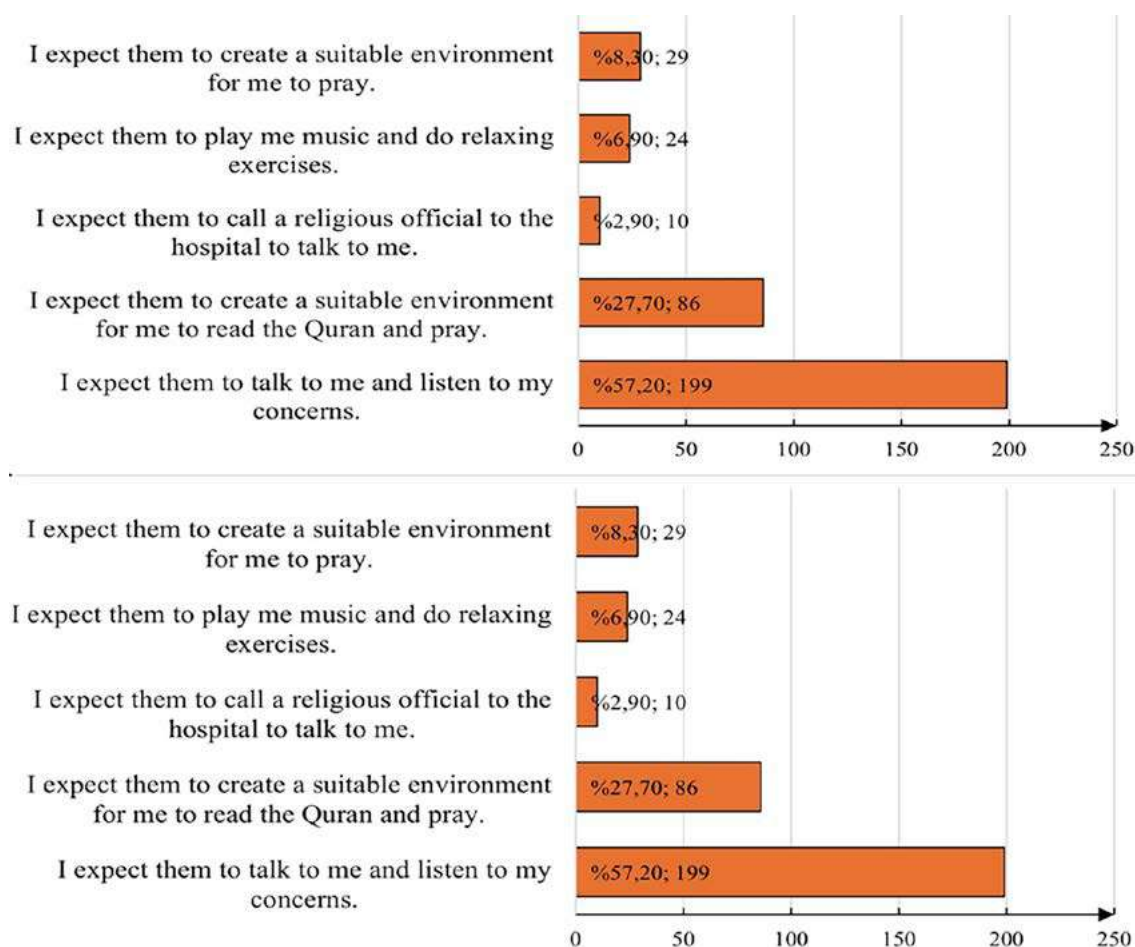
The findings of the participants regarding the spiritual support practices they expect from nurses are given in Figure 2. 199 (57.20%) of the participants expected nurses to talk to them and listen to their problems, 86 (27.70%) expected them to prepare a suitable environment for them to worship, 24 (6.90%) expected them to listen to music and do relaxing exercises, and 10 (2.90%) expected them to call a religious official to chat.

The mean scores of the PSNAS total and sub-dimensions of the participants are given in Figure 3. The mean total score of PSNAS was  $64.16 \pm 16.10$ . The mean score of the "Godly" sub-dimension of the scale was  $11.24 \pm 3.86$ , the "Appreciation of Art and Beauty" sub-dimension was  $8.24 \pm 2.86$ , the "Meaning and Purpose" sub-dimension was  $7.30 \pm 2.48$ , the "Love and Belonging" sub-dimension was  $14.67 \pm 3.97$ , the "Death and Determination" sub-dimension was  $10.09 \pm 3.25$ , and the "Positivity/Gratitude/Hope/Peace" sub-dimension was  $12.52 \pm 3.52$ .

The answers of the patients regarding the propositions of spiritual needs are analyzed in detail in Table 2. When the spiritual needs of the patients in the "Godly" dimension were analyzed, 29.2% (n=79) of patients needed to be able to participate in religious or spiritual services, 32.8% (n=89) needed to read religious or spiritual materials, 50.9% (n=139) needed to pray with someone or have someone pray for them and 40.2% (n=110) needed guidance from a higher power.

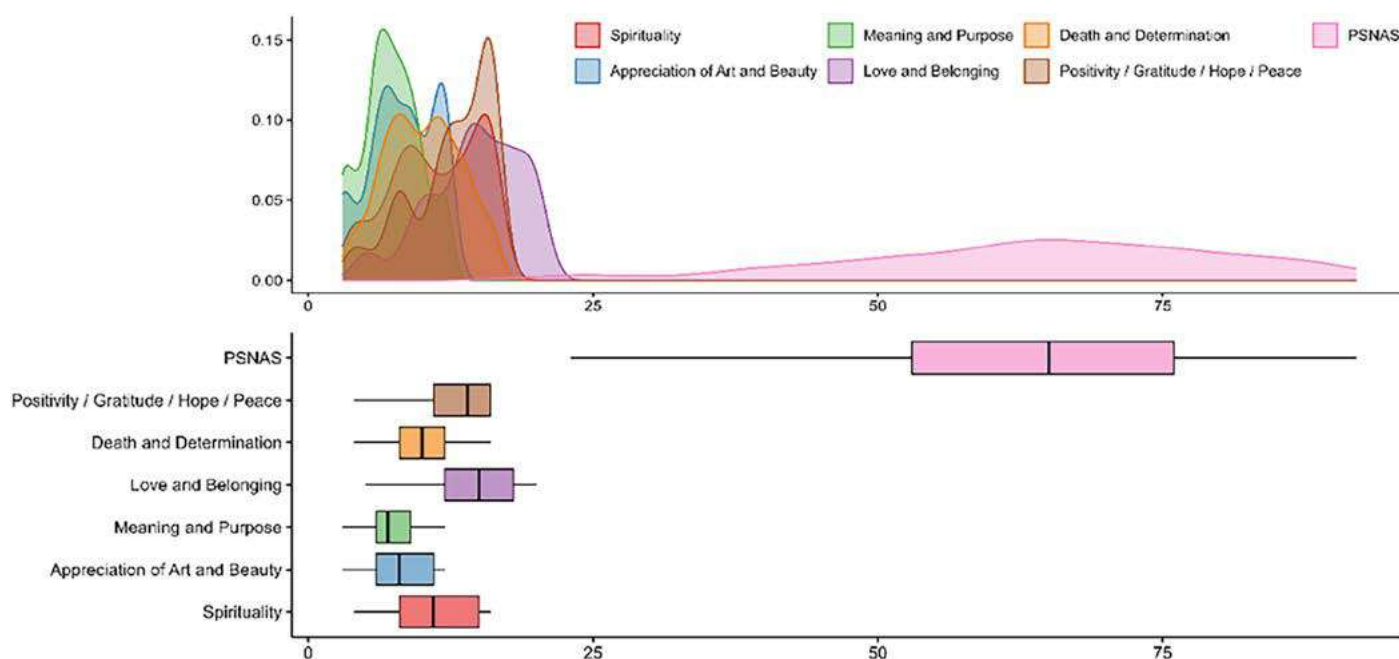
When the spiritual needs of the patients in the dimension of "Knowing the Value of Art and Beauty" were analyzed, 39.5% (n=108) of patients had a strong need to experience or value beauty. However, 37.3% (n=102) of the patients rarely needed to experience or appreciate nature, and 31% (n=85) of the patients never needed to enjoy or experience music.

According to "Meaning and Purpose" dimension, 32.5% (n=88) of patients rarely needed to find the meaning and purpose of life, 37.6% (n=102) never needed to find the meaning in suffering, and 41.3% (n=113) needed a lot to understand why this disease/medical condition occurred. The dimension of "Love and Belonging" was also evaluated. 47.6% (n=130) of patients needed to love and be loved, 36.9% (n=101) needed to be accepted as an individual, 42.1% (n=115) needed friendship, 46.5% (n=127) needed compassion and kindness very much, and 32.5% (n=88) rarely needed to feel a meaningful connection with the world. In terms of "Death and Determination," 33.6% (n=91) of patients rarely needed to talk about unresolved problems before death, and 35.8% (n=97) rarely needed to express their concerns about life after death. It was determined that 31.4% (n=86) of the participants needed



**Figure 2.** Spiritual support practices expected from nurses (n=273\*).

\*: Multiple options were selected.



**Figure 3.** Patient spiritual needs assessment scale total and sub-dimension score averages (n=273).

**Table 2.** Spiritual care needs of patients (n=273)

| Dimension                       | Item                                                               | Never (%)  | Rarely (%) | Much (%)  | Too much (%) | Total (%) |
|---------------------------------|--------------------------------------------------------------------|------------|------------|-----------|--------------|-----------|
| Spirituality                    | Attending religious or spiritual services                          | 55 (19.9)  | 73 (26.6)  | 66 (24.4) | 79 (29.2)    | 273 (100) |
|                                 | Storing religious or spiritual materials                           | 57 (20.7)  | 65 (23.6)  | 62 (22.9) | 89 (32.8)    | 273 (100) |
|                                 | Praying with someone or having someone pray for you                | 30 (11.1)  | 49 (18.1)  | 55 (19.9) | 139 (50.9)   | 273 (100) |
|                                 | Receiving guidance from a higher power                             | 44 (16.2)  | 69 (25.5)  | 50 (18.1) | 110 (40.2)   | 273 (100) |
| Appreciation of art and beauty  | Experiencing beauty or practicing values                           | 36 (13.3)  | 41 (15.1)  | 88 (32.1) | 108 (39.5)   | 273 (100) |
|                                 | Experiencing or appreciating nature                                | 48 (17.7)  | 51 (18.8)  | 72 (26.2) | 102 (37.3)   | 273 (100) |
|                                 | Enjoying or experiencing music                                     | 85 (31)    | 69 (25.5)  | 36 (12.9) | 83 (30.6)    | 273 (100) |
| Meaning and purpose             | Keeping the meaning and purpose of life                            | 78 (28.8)  | 88 (32.5)  | 46 (16.6) | 61 (22.1)    | 273 (100) |
|                                 | Meaning in suffering                                               | 102 (37.6) | 78 (28.8)  | 44 (15.9) | 49 (17.7)    | 273 (100) |
|                                 | Understanding the full manifestation of this illness/medical event | 51 (18.8)  | 52 (19.2)  | 57 (20.7) | 113 (41.3)   | 273 (100) |
| Love and belonging              | Loving and being loved                                             | 27 (10)    | 39 (14.4)  | 77 (28)   | 130 (47.6)   | 273 (100) |
|                                 | Being accepted as an individual                                    | 47 (17.3)  | 57 (21)    | 68 (24.7) | 101 (36.9)   | 273 (100) |
|                                 | Friendship                                                         | 35 (12.9)  | 57 (21)    | 66 (24)   | 115 (42.1)   | 273 (100) |
|                                 | Compassion and kindness                                            | 31 (11.4)  | 41 (15.1)  | 74 (26.9) | 127 (46.5)   | 273 (100) |
|                                 | Feeling a meaningful connection to the world                       | 38 (14)    | 88 (32.5)  | 65 (23.6) | 82 (29.9)    | 273 (100) |
| Death and determination         | Recognizing unresolved issues before death                         | 72 (26.6)  | 91 (33.6)  | 66 (24)   | 44 (15.9)    | 273 (100) |
|                                 | Not expressing concerns about the afterlife                        | 84 (31)    | 97 (35.8)  | 46 (16.6) | 46 (16.6)    | 273 (100) |
|                                 | Reviewing your life                                                | 45 (16.6)  | 76 (28)    | 66 (24)   | 86 (31.4)    | 273 (100) |
|                                 | Influencing yourself and others                                    | 41 (15.1)  | 58 (21.4)  | 56 (20.3) | 118 (43.2)   | 273 (100) |
| Positivity/gratitude/hope/peace | Expressing gratitude and appreciation                              | 23 (8.5)   | 52 (19.2)  | 61 (22.1) | 137 (50.2)   | 273 (100) |
|                                 | Feeling hopeful                                                    | 25 (9.2)   | 45 (16.6)  | 68 (24.7) | 135 (49.4)   | 273 (100) |
|                                 | A mutual perspective                                               | 21 (7.7)   | 48 (17.7)  | 63 (22.9) | 141 (51.7)   | 273 (100) |
|                                 | Feeling a sense of peace and relief                                | 19 (7)     | 53 (19.6)  | 66 (24)   | 135 (49.4)   | 273 (100) |

Response variations are given as frequencies (%).

to review their lives and 43.2% (n=118) needed to forgive themselves and others a lot. "Positivity/Gratitude/Hope/Peace" evaluation showed 50.2% (n=137) of the patients participating in the study needed to feel gratitude, 49.4% (n=135) needed to feel hopeful, 51.7% (n=141) needed to provide a positive perspective, and 49.4% (n=135) needed to feel a sense of peace and refreshment.

The comparison of participants' PSNAS total and subscale mean scores according to certain sociodemographic characteristics is presented in Table 3. Statistically significant differences were found in the PSNAS total mean score with respect to the variables "gender," "chronic illness", and "expectation of spiritual support from nurses." In the subgroup analysis, it was determined that female participants, participants with chronic illness, and participants expecting spiritual support from nurses had higher PSNAS total score averages ( $p<0.05$ ). The pairwise

comparison results of the sub-dimensions that differ according to gender and education are given in Table 4.

## Discussion

The findings regarding the socio-demographic and disease characteristics of the individuals included in this study, in which the spiritual care needs of sick individuals and the factors affecting them were examined, are given in Table 1. Accordingly, it was determined that more than half of the participants were male, married, and had graduated from primary school. These results are associated with the fact that the participants are predominantly middle-aged and older adults. Some studies examining the need for spiritual care are similar to the findings of this study in terms of sociodemographic characteristics.<sup>[9,11,13]</sup>

The findings regarding the participants' expectations for spiritual support providers are given in Figure 1.

**Table 3.** Comparison of PSNAS total and sub-dimension score averages according to some sociodemographic characteristics (n=273)

|                                          | Divine       | Appreciation of art and beauty | Meaning and purpose | Love and belonging          | Death and resolve | Positivity/gratitude/hope/peace | PSNAS        |
|------------------------------------------|--------------|--------------------------------|---------------------|-----------------------------|-------------------|---------------------------------|--------------|
| Gender                                   |              |                                |                     |                             |                   |                                 |              |
| Male                                     | 9 (4-16)     | 7 (3-12)                       | 7 (3-12)            | 14 (5-20)                   | 9 (4-16)          | 13 (4-16)                       | 60 (23-89)   |
| Female                                   | 12 (4-16)    | 9 (3-12)                       | 8 (3-12)            | 16 (5-20)                   | 11 (4-16)         | 14 (4-16)                       | 67 (23-92)   |
| p <sup>†</sup>                           | 0.004*       | 0.069                          | 0.020*              | <0.001*                     | 0.045*            | 0.110                           | 0.010*       |
| Marital status                           |              |                                |                     |                             |                   |                                 |              |
| Married                                  | 12 (4-16)    | 8 (3-12) <sup>a</sup>          | 7 (3-12)            | 14 (5-20) <sup>a</sup>      | 10 (4-16)         | 14 (4-16)                       | 63 (23-89)   |
| Single                                   | 11 (4-16)    | 9 (3-12) <sup>b</sup>          | 7 (3-12)            | 17 (5-20) <sup>b</sup>      | 10 (4-16)         | 15 (4-16)                       | 66 (23-92)   |
| Divorced                                 | 11.5 (10-16) | 10 (6-12) <sup>b</sup>         | 7.5 (6-10)          | 15.5 (12-19) <sup>a,b</sup> | 11.5 (7-12)       | 12.5 (12-14)                    | 69 (54-77)   |
| p <sup>†</sup>                           | 0.667        | 0.001*                         | 0.588               | 0.007*                      | 0.672             | 0.147                           | 0.08         |
| Educational background                   |              |                                |                     |                             |                   |                                 |              |
| Illiterate                               | 10 (4-16)    | 8 (3-11)                       | 7 (3-11)            | 15 (5-20) <sup>a,b</sup>    | 10 (4-16)         | 13 (4-16)                       | 63 (23-89)   |
| Primary school graduate                  | 11.5 (4-16)  | 7 (3-12)                       | 7 (3-12)            | 14 (5-20) <sup>a</sup>      | 10 (4-16)         | 13 (4-16)                       | 63 (23-89)   |
| High school graduate                     | 12 (4-16)    | 9 (3-12)                       | 7 (3-12)            | 16 (10-20) <sup>b</sup>     | 10 (4-16)         | 14 (5-16)                       | 67 (44-92)   |
| University graduate                      | 11 (4-16)    | 9 (3-12)                       | 8 (3-12)            | 15.5 (5-20) <sup>a,b</sup>  | 11 (4-16)         | 13 (4-16)                       | 66 (23-92)   |
| p <sup>†</sup>                           | 0.331        | 0.148                          | 0.162               | 0.006*                      | 0.830             | 0.628                           | 0.259        |
| Hospitalization experience               |              |                                |                     |                             |                   |                                 |              |
| Yes                                      | 12 (4-16)    | 9 (3-12)                       | 7 (3-12)            | 15 (5-20)                   | 10 (4-16)         | 13 (4-16)                       | 66 (23-92)   |
| No                                       | 10 (4-16)    | 8 (3-12)                       | 7 (3-12)            | 15 (5-20)                   | 9 (4-16)          | 14 (4-16)                       | 63 (23-92)   |
| p <sup>†</sup>                           | 0.147        | 0.316                          | 0.016*              | 0.771                       | 0.151             | 0.9                             | 0.214        |
| Chronic disease                          |              |                                |                     |                             |                   |                                 |              |
| Yes                                      | 13 (4-16)    | 9 (3-12)                       | 8 (3-12)            | 15 (5-20)                   | 11 (4-16)         | 14 (4-16)                       | 67 (23-89)   |
| No                                       | 10 (4-16)    | 8 (3-12)                       | 7 (3-12)            | 15 (5-20)                   | 9 (4-16)          | 13 (4-16)                       | 63 (23-92)   |
| p <sup>†</sup>                           | 0            | 0.169                          | 0.112               | 0.040*                      | 0.008*            | 0.043*                          | 0.008*       |
| Expectation of moral support from nurses |              |                                |                     |                             |                   |                                 |              |
| Yes                                      | 13 (4-16)    | 9 (3-12)                       | 8 (3-12)            | 16 (8-20)                   | 11 (4-16)         | 14 (4-16)                       | 71 (35-92)   |
| No                                       | 8.5 (4-16)   | 6 (3-12)                       | 6 (3-10)            | 13 (5-20)                   | 8 (4-15)          | 12 (4-16)                       | 58.5 (23-82) |
| p <sup>†</sup>                           | 0            | <0.001*                        | <0.001*             | <0.001*                     | <0.001*           | <0.001*                         | <0.001*      |

†: Mann Whitney U; #: Kruskal Wallis H; a-b: a-b represent group memberships in Bonferroni results; Statistic are presented as median (minimum maximum); \*: p<0.05. PSNAS: Patient spiritual needs assessment scale.

**Table 4.** Post hoc pairwise comparisons of appreciation of art and beauty and love and belonging according to marital status and educational background

| Pairwise                                            | Test statistic | P <sub>Adj</sub> |
|-----------------------------------------------------|----------------|------------------|
| MaritalStatus (Appreciation of Art and Beauty)      |                |                  |
| Married versus Single                               | -36.485        | 0.004            |
| Married versus Divorce                              | -43.923        | 0.049            |
| Single versus Divorce                               | -7.438         | 1.000            |
| Marital Status (Love and Belonging)                 |                |                  |
| Married versus Single                               | -35.109        | 0.006            |
| Married versus Divorce                              | -18.961        | 0.905            |
| Divorce versus Single                               | 16.148         | 1.000            |
| Educational background (Love and Belonging)         |                |                  |
| Primary school graduate versus Illiterate           | 17.967         | 1.000            |
| Primary school graduate versus University graduate  | -27.581        | 0.267            |
| Primary school graduate versus High school graduate | -38.934        | 0.004            |
| Illiterate versus University graduate               | -9.614         | 1.000            |
| Illiterate versus High school graduate              | -20.966        | 1.000            |
| University graduate versus High school graduate     | 11.352         | 1.000            |

P<sub>Adj</sub>: Adjusted p-values were calculated using the Bonferroni correction.

Accordingly, the participants expected the most spiritual support from family and relatives, followed by close friends, nurses, physicians, and religious officials, respectively. This result, as supported by the literature, shows that individuals tend to meet their spiritual support needs primarily from their close social environment.<sup>[9,15]</sup>

Figure 2 presents the findings regarding the emotional support practices that participants expected from nurses. Accordingly, it was determined that the participants mostly expected nurses to talk to them and listen to their problems. This was followed by preparing a suitable environment for worship, listening to music and relaxing exercises, and calling a religious official for a chat. In a study examining the spiritual care needs of caregivers, it was reported that the participants requested regular priest visits and prayer support. In addition, the importance of efforts to strengthen the trust and connection that support the communication of religious officials with patients and caregivers was emphasized.<sup>[7,15]</sup> The results obtained prove that health care services should be handled with a holistic approach that includes not only physiological but also psychological and spiritual aspects. As supported by the literature, it is understood that nurses' ability to provide emotional support is an important element of the care process.<sup>[10,16]</sup>

The mean scores of PSNAS total and sub-dimensions of the participants are given in Figure 3. The findings obtained show that the spiritual care needs of the patients are at a

high level. When the PSNAS sub-dimensions were analyzed, it was found that the highest mean score belonged to the sub-dimension of "Love and Belonging," followed by the sub-dimension of "Positivity/Gratitude/Hope/Peace," "Godly," "Death and Determination," "Appreciation of Art and Beauty" and "Meaning and Purpose." The higher level of spiritual care needs for the "Love and Belonging" sub-dimension shows that the needs for love, bonding and feeling of belonging come to the forefront in coping with feelings of loneliness, uncertainty and fear during periods of illness. In a study that assessed the spiritual care needs of oncology patients from a multicultural perspective, the vast majority of participants stated that they had high levels of unmet spiritual needs, particularly 6 months after diagnosis, and requested assistance in this regard. It was noted that the spiritual care needs expressed by more than half of the participants were related to "sharing thoughts or feelings," "finding hope", and "concerns about family".<sup>[9,17]</sup> The literature indicates that regularly assessing spiritual health and integrating spiritual care into clinical care reduces post-traumatic stress levels in cancer patients.<sup>[4]</sup> Furthermore, patients who discuss their spiritual concerns while hospitalized report higher levels of satisfaction with treatment and care services, and it has been recommended that an early intervention plan for spiritual care needs be developed and clinical guidelines be established.<sup>[7,17]</sup> A study conducted in Denmark also indicated that the vast majority of participants had very strong spiritual care needs,

with these needs most frequently related to inner peace, productivity, existential, and religious needs, respectively.

<sup>[12]</sup> The results obtained from all these studies prove that spiritual care services are in high demand among patients.

Patients' responses to the propositions in the Spiritual Needs Scale are analysed in detail in Table 2. When the spiritual needs of the patients in the "Godly" dimension were analyzed, it was found that the patients most needed to be able to participate in religious or spiritual services, followed by reading religious or spiritual materials, praying with someone or having someone pray for them, and needing guidance from a higher power. This suggests that patients' spiritual orientations function as a supportive coping mechanism in the process of health care services, but these needs are often ignored in clinical practice. In a study examining the level of spiritual care needs of oncology patients, similar to the results of this study, it was determined that the participants most needed "personal meditation or prayer practices," followed by "visit from clergy" and "visit from hospital chaplain."<sup>[9]</sup> In the literature, it has been reported that practices such as reading the Bible, praying, and other religion-specific practices are practical non-pharmacological spiritual care interventions. These interventions have positive physiological and psychological effects on the health outcomes of patients and improve the quality of life.<sup>[6,18]</sup>

In studies, it has been stated that alpha waves in the brain increase significantly after reading or listening to the Holy Qur'an, which provides calmness, relaxation, and hemodynamic stability.<sup>[18,19]</sup> In addition, it was determined that reading the Holy Qur'an decreased blood pressure, heart and respiratory rate, increased oxygen saturation, increased level of consciousness, and improved pain control. The results obtained support that spiritual care practices improve mental and emotional processes and increase the satisfaction levels of patients and their families with care.<sup>[18,20]</sup> The fact that the results obtained from this study are similar to the findings of the literature shows that spiritual needs in the disease experience are a universal need regardless of cultural and religious structure.<sup>[21,22]</sup>

When the spiritual needs of the patients in the dimension of "Knowing the Value of Art and Beauty" were analyzed, it was determined that most participants had a strong need to experience or value beauty; it was found that they had a limited need to experience nature, appreciate its value, and enjoy music or engage in musical activities. The literature indicates that practices such as art therapy, music therapy, and dance are drug-free, practical spiritual care interventions.<sup>[6,23]</sup> Nevertheless, some studies indicate

that the artistic and esthetic dimensions of spiritual needs in disease and care processes are often secondary, and individuals tend to turn to more concrete sources of spiritual support.<sup>[24]</sup> This result, which supports the findings of the current study, draws attention to the importance of using music, art, and nature-based approaches more effectively in spiritual care practices.

This study shows that patients' spiritual needs related to the "Meaning and Purpose" dimension are perceived at different levels. The findings suggest that some patients attach limited importance to questions about the meaning and purpose of life and the reasons for their suffering, whereas for many patients, the search for an explanation for the cause of their illness or medical condition emerges as a distinct spiritual need. This situation shows that a significant portion of the participants are not seeking the general meaning of life or the meaning of suffering, but rather have a strong search for meaning regarding the cause of their illness. It suggests that individuals' spiritual inquiries focus on cause-and-effect relationships directly related to the illness experience rather than abstract existential themes. In the literature, studies conclude that spiritual needs in the "Meaning and Purpose" dimension are at a lower level compared to other dimensions.<sup>[9,25]</sup> In a study of oncology patients, unlike the results of this study, it was reported that more than half of the participants needed spiritual care practices in the "Meaning and Purpose" dimension.<sup>[26]</sup>

When examining participants' spiritual needs in the dimension of "Love and Belonging," it is evident that needs related to human contact, such as loving and being loved, acceptance, friendship, compassion, and kindness, are paramount for many patients. In contrast, the need to establish a meaningful connection with the world, a more abstract concept, is felt to a more limited extent by some patients. This indicates that individuals may tend to turn primarily to close and concrete sources of social support primarily during the illness process.

The analysis of participants' spiritual needs in the "Love and Belonging" dimension revealed that needs related to human contact, such as loving and being loved, acceptance, friendship, compassion, and kindness, are highly significant for many patients. In contrast, the need to establish a meaningful connection with the world, a more abstract concept, appears less prominent for some individuals. These findings suggest that, during the illness process, patients tend to rely primarily on close and tangible sources of social support rather than on more abstract forms of connection. In similar studies conducted in the literature, it was reported that the spiritual needs

of the patients in the dimension of "Love and Belonging" were higher than the other dimensions, and this need emphasized the importance of emotional bonding especially in care relationships.<sup>[26,27]</sup>

In the "Death and Resolve" dimension, some patients report a limited need to discuss issues related to death and the afterlife, whereas needs related to evaluating life and forgiving oneself or others are more pronounced. These results are consistent with the literature, suggesting that during the illness process, individuals may tend to focus on making sense of life, confronting the past, and achieving inner peace rather than death. This suggests that individuals approach the phenomenon of death indirectly through emotional acceptance and the search for inner peace, rather than directly.<sup>[26,28]</sup>

The analysis of participants' spiritual needs in the "Death and Resolve" dimension revealed that some patients report a limited need to discuss issues related to death and the afterlife, whereas needs related to evaluating life and forgiving oneself or others are more pronounced. These results are consistent with the literature, suggesting that during the illness process, individuals may tend to focus on making sense of life, confronting the past, and achieving inner peace rather than death. This suggests that individuals approach the phenomenon of death indirectly through emotional acceptance and the search for inner peace, rather than directly.<sup>[26,28]</sup>

When examining participants' spiritual needs in terms of "Positivity/Gratitude/Hope/Peace," patients have a strong need to feel grateful, to feel hopeful, to maintain a positive outlook, and to feel a sense of peace and serenity. The high level of need for the dimension of "Positivity/Gratitude/Hope/Peace" shows that patients tend to find meaning in life, provide inner peace, and maintain a sense of hope despite difficulties. In studies conducted with patients diagnosed with chronic disease, pain, and cancer, it was determined that the "Positivity/Gratitude/Hope/Peace" dimension was the highest spiritual need dimension.<sup>[26,29]</sup> The results obtained emphasise the importance of approaches that strengthen the positive emotional resources of individuals in spiritual care practices.

The comparison of participants' PSNAS total and subscale mean scores according to certain sociodemographic characteristics is presented in Table 3. According to this, statistically significant differences were found in the PSNAS total mean score with respect to the variables "gender," "chronic illness," and "expectation of spiritual support from nurses." In the advanced analysis, female participants, participants with chronic diseases, and participants

expecting spiritual support from nurses had higher PSNAS total score averages. The higher level of spiritual care needs among female participants can be explained by women's more pronounced tendencies toward empathy, emotional awareness, and forming meaningful bonds with others. This finding, supported by the literature, suggests that spiritual needs are closely related not only to religious beliefs but also to forms of emotional expression, gender, and social roles. Studies examining spiritual needs in patients with terminal cancer have also reported that, as in this study, spiritual care needs are stronger in female patients than in male patients.<sup>[13,30]</sup>

The high level of spiritual care needs among individuals with chronic illnesses suggests that chronic illness may increase individuals' need for support in areas such as meaning of life, spiritual resilience, and death awareness. Although spiritual care practices are more frequently requested by individuals with chronic illnesses, these needs are often not addressed within the scope of healthcare services.<sup>[12,31]</sup>

The literature reports a strong relationship between spiritual support received from healthcare professionals, primarily nurses, and the fulfillment of individuals' spiritual care needs. This study found that patients expect spiritual support more from nurses.<sup>[32,33]</sup> These results emphasize the importance of nurses' role in spiritual care services and highlight the necessity of nurses' active participation in the planning of spiritual care.

One of the strengths of the study is that the results provide a multifaceted perspective on patient expectations regarding spiritual care practices, which are described as unmet care in the literature. The results obtained due to limited sample representation cannot be generalized to the whole society.

## Conclusion

Participants mostly expected spiritual support from relatives and nurses to listen to their concerns. Patients' spiritual care needs were high, and their spiritual care needs related to the "Love and Belonging" sub-dimension were greater. Female participants, participants with chronic illnesses, and participants who expected spiritual support from nurses had higher levels of spiritual care needs. The findings will shed light on how the identified spiritual care needs can be met in accordance with individuals' cultural and religious beliefs, as well as on the clinical effectiveness of such spiritual care interventions, informing future research and public policy. Future research should focus on the link between the needs reported by patients and test spiritual care practices.

**Ethics Committee Approval:** The University of Health Sciences Hamidiye Scientific Research Ethics Committee granted approval for this study (date: 14.11.2024, number: 13/4).

**Informed Consent:** Written informed consent was obtained.

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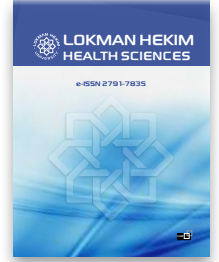
**Authorship Contributions:** Concept: NŞ, RG; Design: NŞ, RG; Supervision: NŞ, RG; Resource: NŞ, RG; Materials: NŞ, RG; Data Collection or Processing: NŞ, RG; Analysis or Interpretation: NŞ, RG; Literature Search: NŞ, RG; Writing: NŞ, RG; Critical Review: NŞ, RG.

**Peer-review:** Double blind peer-reviewed.

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# Neuroprotective Potential of Boric Acid in a Rotenone-induced *in Vitro* Parkinson's Disease Model

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## Abstract

**Introduction:** Parkinson's disease (PD) is characterized by progressive dopaminergic neurodegeneration and pathological  $\alpha$ -synuclein aggregation. Mitochondrial dysfunction and oxidative stress are central to PD pathogenesis, and mitochondrial complex I inhibitors such as rotenone are widely used to model PD-related neurotoxicity *in vitro*. Boric acid (BA), a boron-containing compound with reported antioxidant and neuroprotective properties, has not been fully explored in PD-related apoptotic mechanisms. Therefore, this study aimed to investigate the neuroprotective and anti-apoptotic effects of BA in a rotenone-induced *in vitro* PD model using SH-SY5Y human neuroblastoma cells.

**Methods:** SH-SY5Y cells were exposed to 50  $\mu$ M rotenone to induce PD-like neurotoxicity and co-treated with BA at concentrations ranging from 100 to 800  $\mu$ M. Cell viability was assessed using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide assay. Apoptosis-related molecular changes were evaluated by real-time quantitative polymerase chain reaction and Western blot analyses, focusing on key regulators of mitochondrial apoptosis, including BAX (B-cell lymphoma 2 [BCL-2]-associated X protein), BCL-2, and cleaved caspase-3.

**Results:** Rotenone treatment significantly reduced cell viability compared to control cells. Co-treatment with 200  $\mu$ M BA markedly restored cell viability (\*\* $p < 0.01$ ), indicating a strong neuroprotective effect. Molecular analyses demonstrated that BA treatment significantly decreased the BAX/BCL-2 ratio in rotenone-treated cells ( $p = 0.0295$ ), suggesting an attenuation of mitochondria-mediated apoptotic signaling.

**Discussion and Conclusion:** These findings demonstrate that BA exerts a significant neuroprotective effect against rotenone-induced cytotoxicity by enhancing cell survival and modulating apoptosis-related pathways. BA may represent a promising candidate for mitigating PD-associated neuronal damage, warranting further mechanistic and *in vivo* investigations.

**Keywords:** Cancer molecular biology; Cell biology; Drug analysis; Molecular biology; neurodegenerative diseases

Parkinson's disease (PD) is one of the most common neurodegenerative conditions, characterized by motor symptoms such as tremors, stiffness, and bradykinesia.<sup>[1]</sup>

The development of dopaminergic neuronal death in PD is a complex process involving oxidative stress, mitochondrial dysfunction, and impairment of mitochondrial complex I

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activity. Mitochondrial malfunction, arising from genetic susceptibility or environmental exposure, leads to excessive production of reactive oxygen species (ROS), thereby promoting programmed cell death in dopaminergic neurons.<sup>[2,3]</sup> The defining pathological features of PD include progressive degeneration of dopamine-producing neurons and intracellular accumulation of Lewy bodies, primarily composed of  $\alpha$ -synuclein, which is closely associated with mitochondrial dysfunction and increased neuronal vulnerability.<sup>[4]</sup> Collectively, these pathological alterations converge on the activation of apoptotic signaling pathways, ultimately promoting dopaminergic neuronal loss.<sup>[5]</sup>

Rotenone, a naturally generated chemical found in different plant species, successfully inhibits the activity of mitochondrial complex I, resulting in an accumulation of ROS and neuroinflammation.<sup>[6]</sup> Prolonged exposure to rotenone can result in neurodegeneration and the development of PD-like symptoms by impairing the OXPHOS system and causing mitochondrial dysfunction.<sup>[7]</sup> Rotenone, 1-methyl-4-phenylpyridinium, isoquinoline, and tetrahydroisoquinoline, which are complex I inhibitors, have been reported to induce apoptosis in SH-SY5Y cell lines.<sup>[8–10]</sup> The neurotoxic effect of rotenone in PD is largely attributed to excessive free radical production and oxidative stress.

BA, generally referred to as orthoboric acid ( $H_3BO_3$ ), is a boron compound with distinctive characteristics and versatile applications in diverse domains. It is widely used in chemistry and medicine due to its versatile characteristics.<sup>[11]</sup> Boron is crucial for maintaining optimal bodily health and facilitating several biological functions. Boric acid (BA) has demonstrated encouraging neuroprotective properties in numerous trials.<sup>[12]</sup> Research has demonstrated that BA can inhibit lipid peroxidation and oxidative stress induced by traumatic brain injury, leading to improved catalase (CAT) activity and reduced malondialdehyde levels.<sup>[13]</sup> Furthermore, BA has shown promising effects in PD research. Studies have demonstrated that BA exhibits dose-dependent antioxidant activity, protecting the dopaminergic system in experimental PD models.<sup>[14]</sup>

Since some antioxidants can reduce rotenone-induced toxicity, scavenging and preventing the formation of free radicals may be useful as a therapeutic target in PD.<sup>[15]</sup> Recent evidence indicates that BA exerts neuroprotective effects through several complementary mechanisms. BA forms complexes with hydroxyl-containing biomolecules, influencing membrane stability, calcium signaling, and redox balance.<sup>[16,17]</sup> It has been shown to act as an antioxidant by reducing ROS generation and enhancing

endogenous antioxidant defenses, such as CAT activity.<sup>[18,19]</sup> In addition, BA supports calcium homeostasis and stabilizes mitochondrial function, preventing excessive ROS formation and apoptosis mechanisms critically impaired during PD pathology.<sup>[20,21]</sup> Therefore, BA may counteract rotenone-induced mitochondrial dysfunction, oxidative stress, and apoptosis, indicating its potential as a neuroprotective compound in PD models.

Considering the potential therapeutic benefits of BA, this study involved the development of a PD model by treating SH-SY5Y cells with rotenone. Our objective was to mitigate the resultant toxicity using BA and to explore the underlying apoptotic mechanisms responsible for this reduction.

## Materials and Methods

This study was carried out in the Cell Culture and Molecular Biology Laboratory of the Department of Medical Biology, Dokuz Eylül University Faculty of Medicine. SH-SY5Y cells were cultured and treated with 50  $\mu$ M rotenone to establish an *in vitro* PD model, followed by co-treatment with 200  $\mu$ M BA to evaluate its neuroprotective potential. Cell viability was assessed using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay, and apoptosis-related gene and protein expression levels (BAX, B-cell lymphoma 2 [BCL-2], cleaved caspase-3) were analysed using real-time quantitative polymerase chain reaction (RT-qPCR) and Western blot techniques.

The study was designed to investigate the neuroprotective effects of BA on an *in vitro* rotenone-induced PD model using the SH-SY5Y cell line.

## Cell Culture and Reagents

In this experiment, SH-SY5Y cells of human neuroblastoma origin were cultured in DMEM/ F12 medium containing 10% fetal bovine serum, 1% Penicillin/Streptomycin, and L-Glutamine. The cultures were maintained at 37°C with 5% CO<sub>2</sub> in a controlled humidified incubator. Cells were seeded at a density of 5×10<sup>6</sup> cells per T-25 flask and incubated at 37°C in a humidified atmosphere containing 5% CO<sub>2</sub>.

## Cytotoxicity Assay

To evaluate cellular cytotoxicity, the MTT assay was performed utilizing the Cell Proliferation Kit I supplied by Roche (catalog number 11465007001), in accordance with standardized procedures. Cells from the SH-SY5Y line were distributed into 96-well plates at a concentration of 1×10<sup>4</sup> cells per well, followed by overnight incubation to facilitate adherence and stabilization.

Rotenone was freshly dissolved in dimethyl sulfoxide (DMSO), and the final concentration of DMSO was adjusted to 0.5% (v/v) in all groups, including the control. BA was dissolved in serum-free medium and applied to the cells at final concentrations of 800  $\mu$ M, 400  $\mu$ M, 200  $\mu$ M, and 100  $\mu$ M. Subsequently, the cells were treated with these concentrations of BA in combination with 50  $\mu$ M rotenone to evaluate its potential in mitigating the induced toxicity. After 24 h of treatment, 10  $\mu$ L of MTT solution was added and incubated for 4 h at 37°C in a 5% CO<sub>2</sub> incubator. Following this, 200  $\mu$ L of solubilization solution was added to each well, and the plates were incubated overnight at 37°C in an incubator with 5% CO<sub>2</sub>. The absorbance values at 570 nm were measured for each well using a microplate reader (Thermo Scientific Multiskan Go).<sup>[22]</sup>

### RNA Isolation and cDNA Synthesis

SH-SY5Y cells were cultured in T25 flasks and incubated overnight at 37°C with 5% CO<sub>2</sub>. After incubation, the cells were treated with 50  $\mu$ M rotenone, 200  $\mu$ M BA, or a combination of 50  $\mu$ M rotenone + 200  $\mu$ M BA. After 24 h of treatment, total RNA was extracted using TRIzol™ reagent (Thermo Fisher Scientific, catalog number 15596018) following the manufacturer's recommended protocol. RNA concentration was measured with a microplate reader (Thermo Scientific Multiskan Go). cDNA was synthesized from the isolated RNA using a High-Capacity cDNA Reverse Transcription Kit (New England Biolabs, Inc., catalog number 6300L), in accordance with the supplier's instructions.

### RT-qPCR Analysis

Amplifications were performed using iTaq™ Universal SYBR® Green Supermix (Bio-Rad, cat. no. 1725121) on the LightCycler® 480 real-time PCR system (Roche) with primers listed in Table 1.

The amplification was initiated at 95°C for 30 s, followed by 40 cycles of denaturation at 95°C for 15 s and annealing/extension at 60°C for 60 s. Transcription levels were normalized to GAPDH Ct values. Relative gene expression levels were calculated using the  $2^{-\Delta\Delta C_t}$  method as previously described.<sup>[23]</sup>

### Western Blot

SH-SY5Y cells were cultured in T25 flasks and maintained overnight in a humidified incubator at 37°C with 5% CO<sub>2</sub>. The cultured cells were then treated with 50  $\mu$ M rotenone, 200  $\mu$ M BA, or a combination of 50  $\mu$ M rotenone + 200  $\mu$ M BA and incubated for 24 h. After incubation, the cells were harvested, and the pellets were lysed using RIPA

**Table 1.** Designed primer sequences

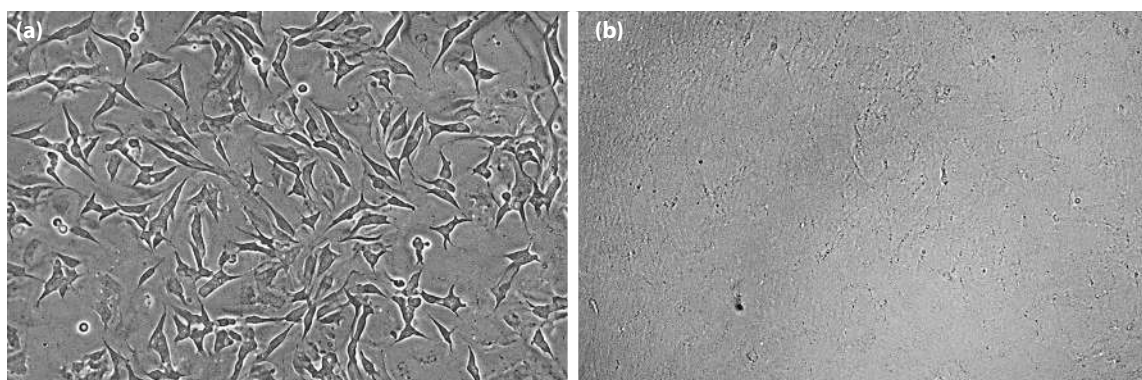
|       |         |                               |
|-------|---------|-------------------------------|
| GAPDH | Forward | 5'-GTCTCCTCTGACTTCAACAGCG-3'  |
|       | Reverse | 5'-ACCACCCTGTTGCTGTAGCCAA-3'  |
| BAX   | Forward | 5'-AAGAAGCTGAGCGAGT-3'        |
|       | Reverse | 5'-GCCCCATGATGGTTCTG-3'       |
| BCL-2 | Forward | 5'-TCAGGCTGCTTGGGATAAAGATG-3' |
|       | Reverse | 5'-GGCTTCTGGAGGACATTTGGA-3'   |
| CYC-C | Forward | 5'-TGGGTGATGTTGAGA AAG G -3'  |
|       | Reverse | 5'-TTTGTCCAGGGATGTAC T -3'    |

CYC-C: Cytochrome c; BCL-2: B-cell lymphoma 2.

lysis buffer supplemented with protease inhibitor. Protein concentration was quantified using the BCA Protein Assay Kit (Thermo Scientific, A55864), and absorbance was measured with a Multiskan Go microplate reader (Thermo Scientific). Approximately 20  $\mu$ g of protein was loaded onto a 10–12% SDS-PAGE gel, electrophoresed, and transferred to a polyvinylidene fluoride membrane. Membranes were blocked with 5% non-fat milk prepared in PBST (1  $\times$  PBS with 0.05% Tween-20) for 1 h at room temperature and incubated overnight at 4°C with primary antibodies against BAX, BCL-2, cleaved caspase-3, and  $\beta$ -actin (Proteintech), diluted in 3% non-fat milk in PBST. After washing, membranes were incubated with HRP-conjugated secondary antibodies diluted 1:2000 in PBST for 1 h at room temperature. Protein bands were visualized using an Enhanced Chemiluminescence detection kit (Thermo Fisher Scientific) and imaged using the FUSION Solo X Chemi Imaging System (VILBER).<sup>[24]</sup>

### Statistical Analysis

Normality of the data was assessed using the Shapiro–Wilk test, and the data were found to be normally distributed. Accordingly, parametric statistical tests were applied where appropriate. Two-group comparisons, including control versus rotenone comparisons performed to validate the *in vitro* PD model, were analysed using the independent samples t-test. For experiments involving more than two groups or multiple concentrations, statistical analysis was performed using the Kruskal–Wallis test followed by non-parametric post hoc multiple comparisons (Dunn's test) with correction for multiple testing. MTT assay analyses were conducted using GraphPad Prism 9 (GraphPad Software, San Diego, CA, USA). A  $p < 0.05$  was considered statistically significant. In all figures, statistical significance is indicated as follows: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ , and \*\*\*\*  $p < 0.0001$ . All experiments were performed in triplicate ( $n=3$ ).



**Figure 1.** Microscopic images of SH-SY5Y cells. **(a)** Untreated control cells showing normal morphology and proliferation. **(b)** Cells after treatment with 50 µM rotenone (× 5 magnification).

## Results

### MTT Assay Results Indicating the Neuroprotective Effect of BA on Rotenone-Induced Toxicity in SH-SY5Y Cells

We performed an MTT assay on the SH-SY5Y cell line to evaluate the neuroprotective effects of BA in a rotenone-induced PD model. Representative microscopic images of untreated control and 50 µM rotenone-treated SH-SY5Y cells are shown in Figure 1.

The effects of BA alone on cell viability were evaluated using the MTT assay. Kruskal–Wallis analysis revealed a significant overall difference among the control and BA-treated groups (\*\*\*\* $p < 0.0001$ ). However, Dunn's multiple comparisons test showed that none of the tested BA concentrations (100–800 µM) resulted in a statistically significant change in cell viability compared with the control group (Fig. 2a). Although this increase did not reach statistical significance after correction for multiple comparisons, treatment with 200 µM BA was associated with a marked increase in mean cell viability, reaching 125.308% relative to the control group.

Cell viability decreased dramatically to 58.867% compared to the control group (\*\*\*\* $p < 0.0001$ ) when 50 µM rotenone was used to induce Parkinson's-like toxicity in SH-SY5Y cells. However, co-treatment with BA attenuated this toxic effect and improved cell viability. The combination of 200 µM BA with rotenone significantly increased cell viability to 137.79%, demonstrating a strong neuroprotective effect compared to the rotenone group (\*\* $p < 0.01$ ). In addition, BA doses of 100 µM, 400 µM, and 800 µM also exhibited a protective effect by increasing cell viability in comparison to rotenone alone, whereas the greatest protective effect was observed with 200 µM BA (Fig. 2b).

### RT-qPCR Results Indicating Boric Acid's Neuroprotective Effect

In this study, the selected dose for further analysis was determined to be 50 µM rotenone combined with 200 µM BA. The RT-qPCR results revealed significant findings in the mRNA expression levels related to apoptotic pathways.

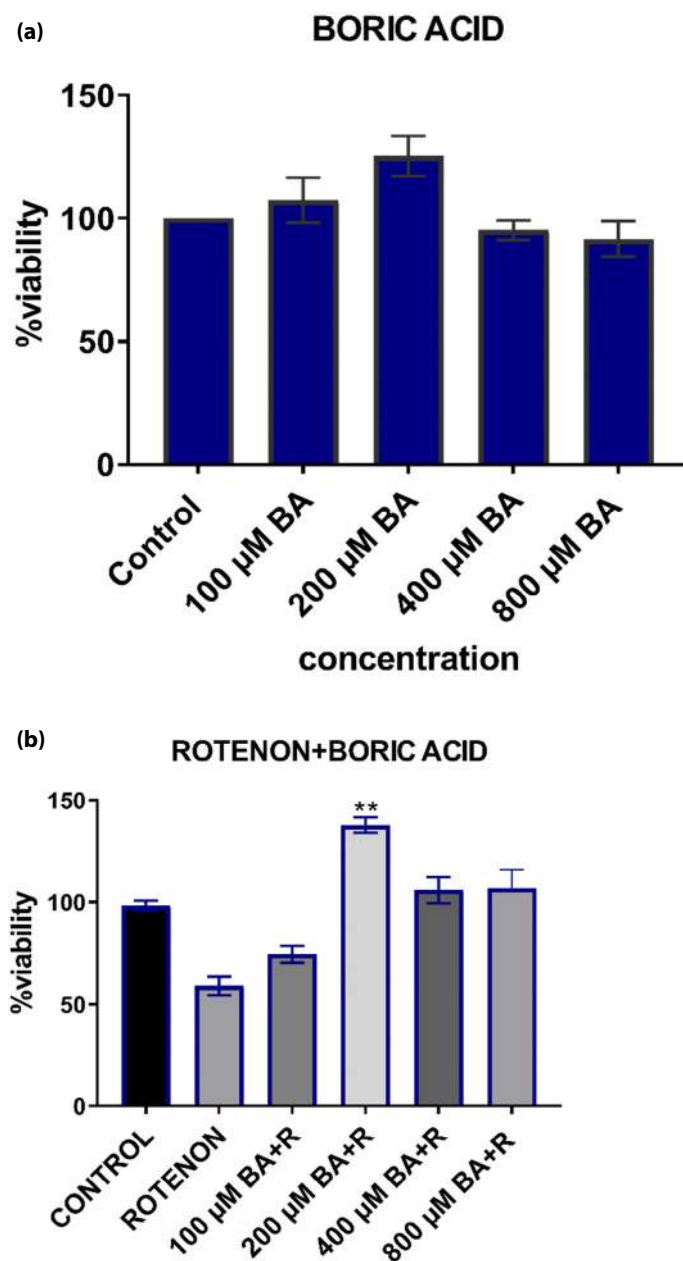
The combination of 50 µM rotenone and 200 µM BA reduced the BAX/BCL-2 ratio by 0.54-fold compared with rotenone alone ( $p = 0.0287$ ), indicating reduced apoptosis. This reduction in the BAX/BCL-2 ratio indicates a protective effect against apoptosis (Fig. 3a).

The levels of cytochrome c (CYC-C) expression exhibited distinct differences across the various treatment groups. Treatment with BA alone resulted in a marked decrease in CYC-C expression when compared to the rotenone group ( $p = 0.0018$ ). Moreover, treatment of rotenone alone led to a significant upregulation of CYC-C expression compared to the control group ( $p = 0.0006$ ). The combination of BA and rotenone resulted in a further increase in CYC-C expression compared with rotenone alone; however, this difference was not statistically significant ( $p = 0.1458$ ) (Fig. 3b).

### Western Blot Results Indicating Apoptotic Modulation by Boric Acid

Western blot analysis showed that BA modulated the BAX/BCL-2 ratio in rotenone-treated cells. In the co-treatment group, the BAX/BCL-2 ratio was significantly decreased compared with the rotenone group ( $p = 0.0295$ ), supporting an anti-apoptotic and neuroprotective effect of BA (Fig. 4a).

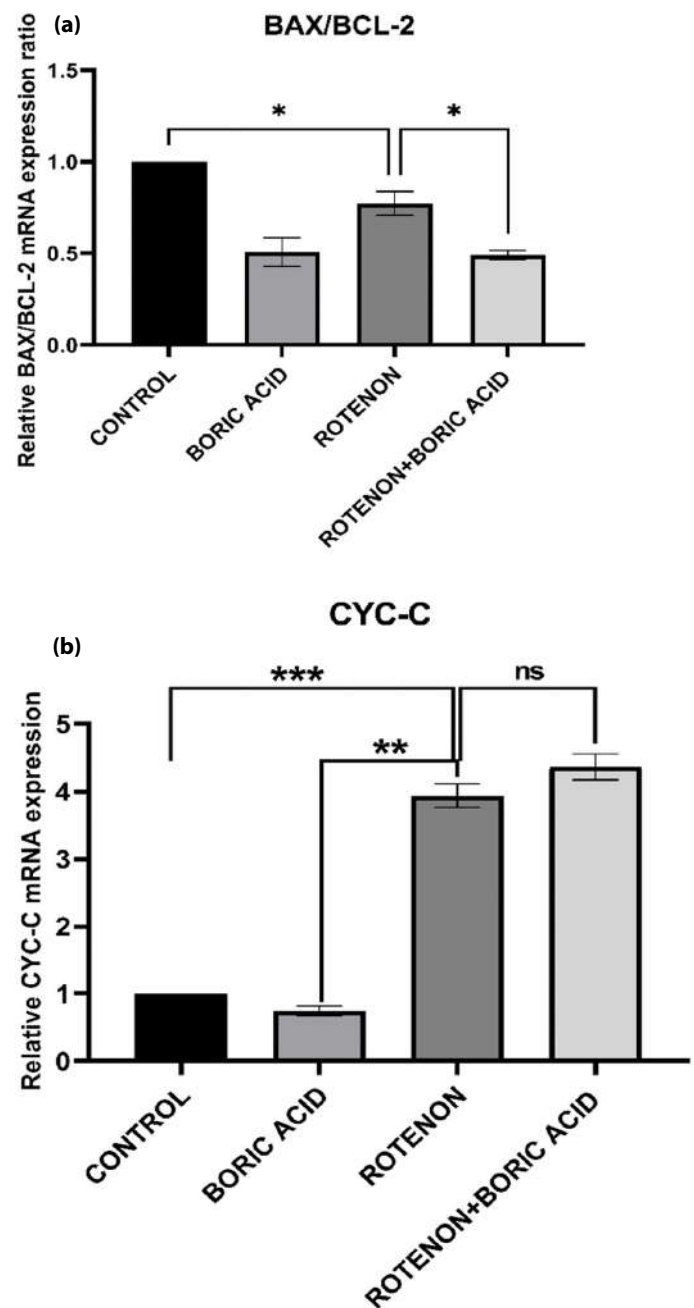
Cleaved caspase-3 levels decreased to 0.8 in the BA alone-treated group compared with the rotenone group ( $p = 0.0030$ ), indicating reduced apoptotic activity. In the BA + rotenone group, cleaved caspase-3 levels



**Figure 2.** Cytotoxic effects of boric acid in rotenone-induced SH-SY5Y cells. **(a)** MTT assay results of boric acid (100, 200, 400, and 800 µM) on SH-SY5Y cells after 24 h of treatment. **(b)** MTT assay results of 50 µM rotenone and boric acid combinations. Statistical analysis was performed using the Kruskal-Wallis test followed by Dunn's non-parametric post hoc multiple comparisons with correction for multiple testing. In panel **(a)**, comparisons were made with the control group, whereas in panel **(b)**, comparisons were made with the rotenone-treated group. Data are presented as a percentage of the control group. Experiments were repeated 3 times.

\*:  $p < 0.05$  versus control; \*\*:  $p < 0.01$  versus rotenone.

were lower than in the rotenone group; however, this reduction did not reach statistical significance ( $p = 0.1084$ ) (Fig. 4b), suggesting only a partial attenuation of rotenone-induced apoptosis.

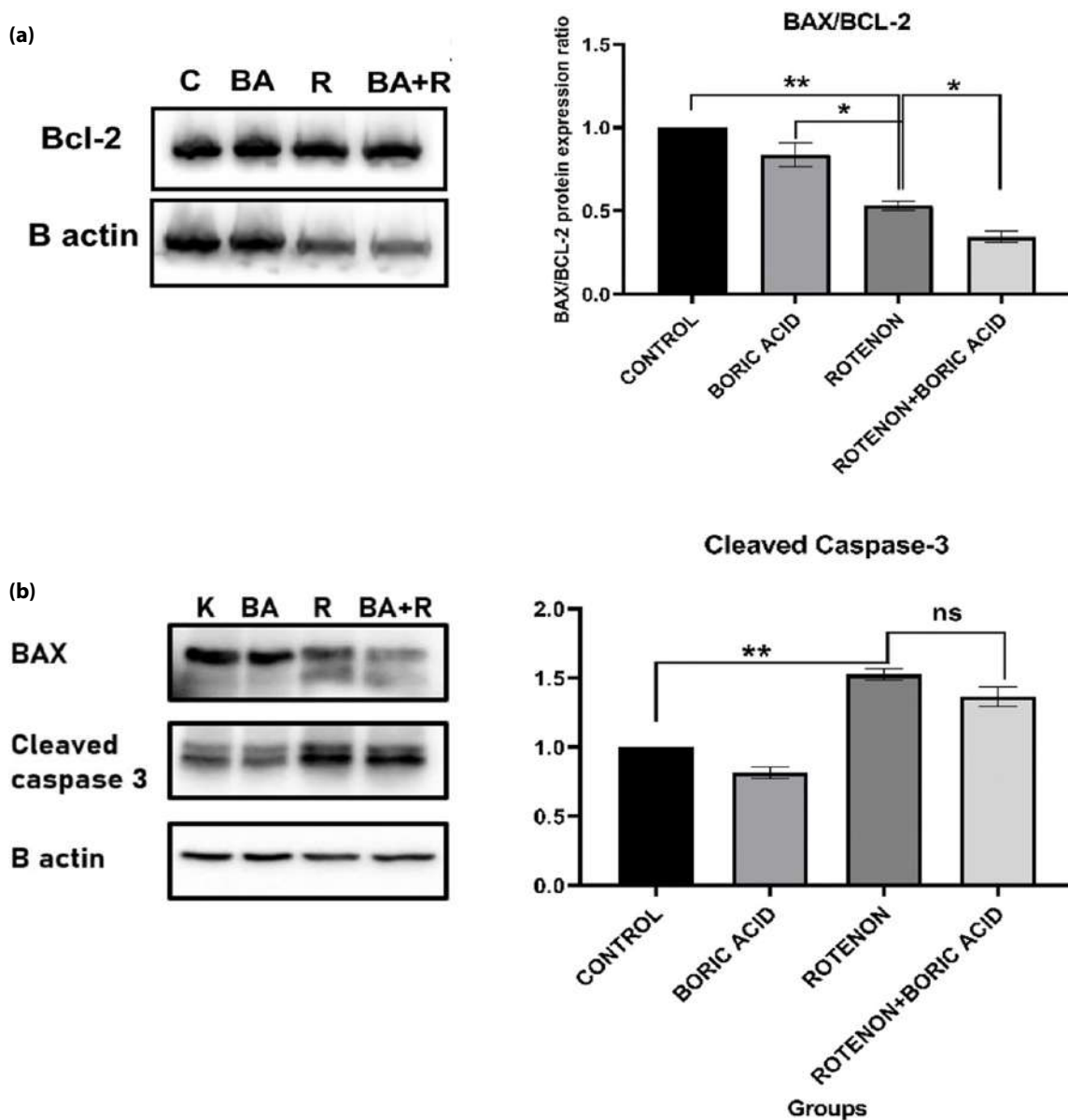


**Figure 3.** Effects of boric acid on apoptotic gene expression in rotenone-induced SH-SY5Y cells. Relative mRNA expression levels of BAX and B-cell lymphoma 2 (BCL-2), along with the corresponding **(a)** BAX/BCL-2 ratio and **(b)** cytochrome c expression levels. Gene expression levels were determined by real-time quantitative polymerase chain reaction and calculated using the  $2^{-\Delta\Delta C_t}$  method after normalization to GAPDH. Experiments were repeated 3 times.

Statistical significance is indicated as follows: \*:  $p < 0.05$  versus control; and \*\*:  $p < 0.01$ ; \*\*\*:  $p < 0.001$  versus rotenone-treated group.

## Discussion

The present study demonstrates that BA exerts a significant neuroprotective effect against rotenone-induced toxicity in SH-SY5Y cells, primarily through modulation of oxidative



**Figure 4.** Effects of boric acid on apoptotic protein expression in rotenone-induced SH-SY5Y cells. Relative protein expression levels of BAX and B-cell lymphoma 2 (BCL-2), along with the corresponding (a) BAX/BCL-2 ratio, and (b) cleaved caspase-3 in SH-SY5Y cells. The intensity of BCL-2 and BAX bands was quantified and shown as relative expression levels after normalization by  $\beta$ -actin. Densitometry tracing was used to illustrate the quantitative differences, positioned next to the figure for the SH-SY5Y cell line.

Statistical significance is indicated as follows: \*\*:  $p < 0.01$  versus control; and \*:  $p < 0.05$ ; \*\*:  $p < 0.01$  versus rotenone-treated group.

stress and mitochondrial apoptotic pathways. Given that mitochondrial dysfunction and excessive ROS generation are central drivers of PD pathogenesis, the ability of BA to enhance cellular antioxidant capacity represents a mechanistically relevant protective strategy. Previous studies have shown that BA increases the activity of key antioxidant enzymes, including superoxide dismutase, CAT, and glutathione peroxidase, thereby limiting oxidative damage and preserving mitochondrial integrity.<sup>[12–14]</sup> In line with these reports, our findings demonstrate a marked

improvement in cell viability following BA treatment, supporting its role in maintaining redox homeostasis under neurotoxic conditions.<sup>[12–14]</sup>

The MTT cytotoxicity assay demonstrated that 50  $\mu$ M rotenone significantly reduced cell viability in SH-SY5Y cells (58.87%), confirming its well-established neurotoxic effect. Co-treatment with BA significantly improved cell viability and attenuated rotenone-induced cytotoxicity, with the most pronounced protective effect observed at the 200  $\mu$ M BA concentration (Fig. 2b). These findings

are consistent with previous studies investigating antioxidant-based neuroprotection in similar *in vitro* PD models. For example, Polyphyllin VI (PPVI) has been reported to increase cell viability from 49.91% under 20  $\mu$ M rotenone exposure to 81.75% following treatment.<sup>[25]</sup> Similarly, rosmarinic acid has been shown to restore cell viability by approximately 80% in SH-SY5Y cells treated with 50  $\mu$ M rotenone, where this concentration induced nearly a 50% reduction in viability, closely aligning with our observations.<sup>[26]</sup> Notably, in our study, BA treatment increased cell viability to 137.79% relative to the control, indicating a comparatively stronger protective effect than those reported for other antioxidant compounds. This suggests that BA may exert a more pronounced cytoprotective effect in rotenone-induced neurotoxicity, potentially through more effective modulation of oxidative stress and mitochondrial dysfunction.

At the molecular level, apoptosis regulation through the BAX/BCL-2 axis represents a central mechanism governing mitochondria-dependent cell death. The balance between pro-apoptotic BAX and anti-apoptotic BCL-2 is widely recognized as a critical determinant of neuronal survival.<sup>[27]</sup> In the present study, treatment with 200  $\mu$ M BA in combination with 50  $\mu$ M rotenone significantly reduced the BAX/BCL-2 ratio at both mRNA and protein levels, with RT-qPCR analysis demonstrating a 0.54-fold decrease compared to the rotenone-only group (Fig. 3a). This reduction was further confirmed at the protein level by Western blot analysis (Fig. 4a). Notably, analysis of individual protein expression revealed that this effect was driven by both downregulation of BAX and upregulation of BCL-2, indicating a coordinated shift toward an anti-apoptotic state. These findings are consistent with previous studies reporting that neuroprotective agents mitigate mitochondrial apoptosis by modulating the BAX/BCL-2 equilibrium in favor of cell survival. In addition to upstream apoptotic regulators, activation of caspases represents a key hallmark of apoptosis, with cleaved caspase-3 acting as a critical executioner of programmed cell death.<sup>[28]</sup> In our study, Western blot analysis of cleaved caspase-3 provided further insight into the apoptotic mechanisms. BA treatment alone reduced cleaved caspase-3 levels to 0.8 relative to the rotenone group, indicating a decrease in apoptotic activity ( $p=0.0030$ ). When BA was applied in combination with rotenone, the rotenone-induced elevation in cleaved caspase-3 levels was attenuated; however, this reduction did not reach statistical significance ( $p=0.1084$ ) (Fig. 4b). This partial modulation suggests that BA predominantly affects early-stage mitochondrial apoptotic signaling

rather than completely inhibiting downstream caspase activation. Similar observations have been reported in studies where antioxidant or neuroprotective interventions attenuated upstream apoptotic pathways without fully suppressing execution-phase markers, indicating a staged regulation of apoptosis.<sup>[25,26,29]</sup>

In addition to cytotoxicity and apoptotic markers, validation of the PD model in this study is supported by molecular features consistent with PD pathology. Rotenone is well known to induce  $\alpha$ -synuclein phosphorylation and aggregation through mitochondrial complex I inhibition and increased oxidative stress.<sup>[6]</sup> Although  $\alpha$ -synuclein expression was not directly quantified, the observed decrease in cell viability together with increased BAX/BCL-2 ratio and cleaved caspase-3 levels indicates activation of mitochondrial-dependent apoptosis, a hallmark of PD. These findings are in line with previous studies demonstrating that rotenone exposure induces mitochondrial dysfunction, ROS accumulation, and  $\alpha$ -synuclein-related pathology in SH-SY5Y cells,<sup>[25–29]</sup> thereby supporting the validity of our *in vitro* PD model.

Previous studies have shown that various compounds can modulate rotenone-induced toxicity through distinct molecular pathways.<sup>[25,28,29]</sup> For instance, PPVI has been reported to exert neuroprotective effects through signaling pathways involving FOXO3a, CREB1, and DJ-1,<sup>[25]</sup> while rosmarinic acid significantly reduced apoptosis in rotenone-treated SH-SY5Y cells as demonstrated by Annexin V analysis.<sup>[26]</sup> Similarly, Growth Differentiation Factor 15 has been shown to protect against rotenone-induced neurotoxicity by suppressing mitochondrial-mediated apoptotic pathways.<sup>[29]</sup> In this context, our findings extend the current literature by demonstrating that BA also exerts neuroprotective effects in a rotenone-induced PD model, particularly through modulation of apoptosis-related pathways.

Consistent with previous studies investigating antioxidant-based interventions in PD models, BA demonstrated dose-dependent neuroprotective effects, protecting dopaminergic neurons and reducing oxidative damage in experimental systems.<sup>[30]</sup> These findings support the broader concept that antioxidants can mitigate rotenone-induced neurotoxicity by targeting oxidative stress and mitochondrial dysfunction. In agreement with this, our results indicate that BA enhances cell viability and modulates apoptotic signaling, suggesting that its neuroprotective effect is mediated through regulation of the oxidant-antioxidant balance and mitochondrial integrity.

Overall, the findings of this study support the growing body of evidence that antioxidant compounds can provide neuroprotection in PD models. However, while BA demonstrated significant neuroprotective effects by modulating apoptotic signaling, these findings require further validation *in vivo* systems. Moreover, since apoptosis is regulated by multiple interconnected pathways, the use of a limited panel of apoptosis-related markers may restrict the mechanistic interpretation of the findings. Future studies incorporating additional apoptotic and mitochondrial markers are necessary to more comprehensively elucidate the molecular mechanisms underlying the neuroprotective effects of BA and to confirm its translational potential.

## Conclusion

This study provides evidence that BA can mitigate rotenone-induced neurotoxicity in SH-SY5Y cells by reducing apoptotic activity and enhancing cell viability. While BA demonstrates significant potential as a neuroprotective agent, further research is needed to fully understand its mechanisms of action and to optimize its therapeutic application in PD.

**Ethics Committee Approval:** The SH-SY5Y human neuroblastoma cell line used in this study is commercially available and does not involve human subjects or animal experiments; therefore, no ethical approval was required.

**Informed Consent:** Commercial materials were used in the study, not require inform consent.

**Conflict of Interest:** None declared.

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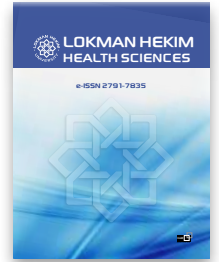
**Authorship Contributions:** Concept: ES; Design: DEK, SK; Supervision: SK; Resource: SK; Materials: ES, SK; Data Collection or Processing: DEK, BB, BBitmez; Analysis or Interpretation: ES, DEK, BB, BBitmez, SK; Literature Search: DEK; Writing: ES, DEK, BB, BBitmez, SK; Critical Review: ES, DEK.

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# The Relationship between Caregivers' Contribution to Self-Care and Symptom Intensity in Patients with Heart Failure and Influencing Factors: A Descriptive Study

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## Abstract

**Introduction:** Caregivers play a crucial role in facilitating engagement in self-care practices and improving symptom experiences among individuals with heart failure (HF). This study aimed to examine the relationship between caregiver contributions to HF self-care and symptom intensity experienced by patients, as well as patient- and caregiver-related sociodemographic factors influencing this relationship.

**Methods:** This descriptive and correlational study was conducted in a public hospital between January and May 2023. The sample consisted of patients diagnosed with HF classified as New York Heart Association class II or higher (n=192) and their primary caregivers (n=192) who provided at least six hours of care per day. Data were collected using a Personal Information Form, the Symptom Status Questionnaire–HF (SSQ-HF), and the caregiver contribution to self-care of HF index (CCSCHFI).

**Results:** The mean SSQ-HF score was 48.63±17.56, indicating symptom intensity above a moderate level. Weak but statistically significant positive correlations were identified between SSQ-HF scores and the CCSCHFI total score and its subscales: Caregiver contribution to self-care maintenance (r=0.147, p=0.042), self-care management (r=0.245, p=0.001), and confidence in contributing to self-care (r=0.241, p=0.001). Overall, caregiver contributions to patient self-care were found to be at a moderate level.

**Discussion and Conclusion:** Despite moderate caregiver contribution, patients experienced relatively high symptom intensity, suggesting that characteristics of the patient–caregiver dyad and disease-related self-efficacy may significantly influence symptom outcomes. Interventions targeting caregivers' knowledge gaps, enhancing self-efficacy, and strengthening caregiver–patient communication may help reduce symptom intensity in patients with HF.

**Keywords:** Caregivers; Heart failure; Nursing; Self-care; Symptom burden

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Clinically, heart failure (HF) is a condition that results from a structural or functional disorder of the heart in which patients experience typical symptoms and findings.

<sup>[1]</sup> HF is among the most commonly seen chronic diseases around the world as a result of factors including the aging of the global population, increases in other comorbidities, and individuals' adoption of lifestyle habits that may pose a risk to cardiovascular health.<sup>[2]</sup> It was reported that there were approximately 56.5 million patients with HF in the world in 2021. Therefore, HF is accepted as a global public health problem.<sup>[3]</sup> Similar to the global situation in Türkiye the estimated prevalence of HF was 2.114% at the end of 2022.<sup>[4]</sup> However, according to the Turkish Cardiology Association, the average age of patients with HF in Türkiye is 60, and HF is seen approximately 10 years earlier in Türkiye compared to Western societies.<sup>[5]</sup> This data indicate the need for a more comprehensive approach for HF.

Patients with HF commonly experience many disturbing symptoms related to decreased cardiac functions.<sup>[6]</sup> Studies in the literature have reported that the total symptom intensity is quite high among patients diagnosed with HF.<sup>[7,8]</sup> An increase in the frequency and severity of these symptoms is linked to recurrent hospital admissions and life-threatening adverse clinical outcomes.<sup>[9,10]</sup> Patients with HF who practice better self-care are more likely to reach their treatment goals than those with poor self-care.<sup>[11]</sup> However, patients may have difficulty in performing effective self-care as a result of multiple factors, such as aging, ineffective coping with treatments, cognitive impairment, comorbidities, depression, and complex medical regimens that are challenging to follow. In addition, the self-care behaviors of patients living with HF, such as medical visits, medication treatment management, recognition and control of key symptoms, and the adoption of a lifestyle in accordance with recommended diet and physical activity styles, are activities that may be difficult to perform independently.<sup>[12,13]</sup> Therefore, most patients living with HF need support from family members, friends, or relatives.

<sup>[3]</sup> Caregivers, therefore, play a crucial role in supporting the self-management of individuals with HF. Caregiver's contribution to the self-care of individuals with HF can be defined as the process of supporting the maintenance of self-care, recognizing symptoms, and facilitating behaviors that help respond when symptoms of an HF exacerbation emerge. This can involve suggesting appropriate actions or acting on behalf of the patient.<sup>[14]</sup> The situation-specific theory of caregiver contributions to HF self-care, developed by Vellone et al.,<sup>[14]</sup> provides a conceptual framework that enables a detailed understanding of how caregivers' active

contributions to the self-care process of individuals with HF influence patient outcomes. According to this theory, caregivers assume roles such as monitoring symptoms, supporting self-care decision-making, and assisting in the maintenance of self-care behaviors. Many of the activities performed by caregivers to contribute to patient care are not merely forms of social support but are directly related to the provision of self-care. The theory proposes that active caregiver involvement in the self-care process can facilitate early recognition of symptoms and timely intervention, thereby improving patient outcomes and reducing hospital visits and symptom burden. At the same time, the theory suggests that the effect of caregiver contribution on self-care is directly influenced by certain characteristics related to the caregiver, the patient, and the caregiver-patient relationship.<sup>[14]</sup> In this context, examining the impact of caregiver contributions on patients' experiences of symptom intensity is theoretically meaningful and clinically important.

Recent evidence indicates that greater caregiver contribution to the maintenance of HF self-care is associated with better patient self-care and lower symptom burden, and that patient self-care may mediate this relationship.<sup>[15]</sup> Although the importance of caregiver support is widely recognized, most previous HF research has focused on caregiver burden, psychological outcomes, or general support variables, rather than on how caregiver involvement specifically contributes to patients' self-care behaviors and symptom experiences. An updated systematic review demonstrates that caregivers are involved in multiple HF self-care activities, including care provision, monitoring, and management; however, it also highlights significant gaps in clearly defining these activities and their effects on clinical outcomes.<sup>[16]</sup>

Based on this evidence and the situation-specific theory of HF self-care, we hypothesized that higher caregiver contributions to HF self-care would be associated with lower patient-reported symptom intensity, mediated through improved patient self-care behaviors. By integrating caregiver contributions within a specific theoretical framework and directly examining their relationship with symptom outcomes in HF, this hypothesis extends the existing literature.

## Materials and Methods

### Study Design and Participants

A descriptive cross-sectional study design was employed to examine the relationship between symptom intensity and caregiver contributions in patients with HF, as well

as patient- and caregiver-related sociodemographic characteristics influencing this relationship. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology checklist.

The study was conducted between January and May 2023 in the cardiology outpatient clinic and inpatient cardiology service of a public hospital in Adana, Türkiye. The necessary sample size was calculated to be a minimum of 139 pairs of patients and caregivers through power analysis using the G\*Power 3.1.9.4 program with an alpha value of 0.05, beta value of 0.95, and effect size (Cohen's  $g$ ) of 0.14.<sup>[8,17,18]</sup> As the data collection period allowed for the recruitment of a greater number of eligible participants, the study was finalized with a total of 192 dyads consisting of patients and their caregivers.

The inclusion criteria for patients were as follows: (1) being over 18 years of age, (2) not having any physical or cognitive disabilities that would make it difficult to respond to the data collection tools, and (3) having been diagnosed with HF of Class II or above according to the classification of the New York Heart Association (NYHA). The inclusion criteria for caregivers were: (1) being over 18 years of age and (2) being the primary caregiver who assists the patient in self-care for at least 6 h daily. Caregivers were excluded if they had any cognitive disabilities interfering with the ability to participate in the study. Patients were excluded if they were diagnosed with any other disease during the data collection period or if they had to leave the study because of the worsening of their current health status or diagnosis with an additional disease, and had to receive treatment in another clinic.

### Data Collection Tools

The symptom status questionnaire-HF (SSQ-HF) and the Caregiver Contribution to Self-care of HF Index (CCSCHFI) were used. The personal information form was developed by the researchers. It addressed the characteristics of the patient and caregiver, such as age, gender, marital status, education level, and employment status. The form also included the HF classification, time of diagnosis, and with whom the individual lived as patient-specific questions. Questions addressing the level of kinship with the patient (spouse, child, relative, or friend), duration of care responsibility, and daily caring time were included in the form as caregiver-specific questions.

### SSQ-HF

The SSQ-HF was developed by Heo et al.<sup>[19]</sup> and adapted to Turkish by Gök Metin and Gülbahar.<sup>[20]</sup> The Cronbach's

alpha value of the scale is 0.86,<sup>[20]</sup> while in our study it was found to be 0.937. The SSQ-HF consists of seven questions that assess the presence, frequency, severity, and distress of common physical symptoms of HF, including daytime dyspnea, dyspnea while lying down, fatigue, chest pain, edema, difficulty in sleeping, and dizziness or loss of balance. If the symptom is present, the patient is asked to report the frequency of the symptom on a scale of 1 ("less than once per week") to 4 ("nearly daily"). Severity responses range from 1 ("slight") to 4 ("very much"), while distress responses range from 0 ("not at all") to 4 ("very much"). Higher scores indicate more severe symptoms. A score of 0 signifies the absence of the respective symptom.<sup>[20]</sup>

### CCSCHFI

The CCSCHF was developed by Vellone et al.<sup>[21]</sup> who adapted it from the self-care of HF index (SCHFI) to assess the psychometric characteristics of the scale in evaluating caregiver contributions. Their scale was subsequently converted to Turkish by Akbiyık and Enç.<sup>[22]</sup> Akbiyık and Enç reported the Cronbach's alpha coefficients of the scale as 0.66 for the caregiver contribution self-care maintenance subscales, 0.81 for the caregiver contribution to self-care management subscale, and 0.80 for the caregiver confidence in contributing to self-care.<sup>[22]</sup> In our study, the Cronbach's alpha coefficients were 0.788, 0.662, and 0.904 for the respective subscales, while the overall Cronbach's alpha of the SCHFI was 0.878. The index consists of 22 items within three subscales: "caregiver contribution to self-care maintenance," "caregiver contribution to self-care management," and "caregiver confidence in contributing to self-care." The first subscale comprises four factors: Symptom monitoring, physical activity, medical treatment adherence, and sodium intake control. The second comprises two factors: autonomous management and directive-dependent management. The third also consists of two factors: Advanced confidence and basic confidence. Each of the three subscales uses a 4-point Likert-type scale for responses. The total possible score that can be obtained from the first subscale is 40. The highest scores that can be obtained from the second and third subscales are 24 in both cases. Higher scores reflect greater contributions to self-care.<sup>[22]</sup>

### Implementation of Data Collection Tools

The data were collected by the researchers through face-to-face interviews. The purposes of the survey forms used in the study were first explained to the patients and caregivers by the researchers. For each participant who met the inclusion criteria, an explanation of how to answer

the questions within the scope of the survey was provided in a face-to-face discussion in the outpatient clinics or the patient's own room in the inpatient services. Care was taken to ensure that no one other than the patient or caregiver was present in these places where face-to-face interviews were held for informational purposes. Afterward, the patients answered the SSQ-HF questionnaire, and the caregivers answered the CCSCHF questionnaire. It took 30 min in total. The interviews were performed first with the patient and then with the caregiver in the cardiology outpatient clinics and units.

### Statistical Analysis

IBM Statistical Package for the Social Sciences Statistics 26.0 for Windows (IBM Corp., Armonk, NY, USA) was used to analyze the data. The normality of the dataset was examined both visually, using histogram and probability graphs, and with the Shapiro–Wilk test. Sociodemographic variables were analyzed using descriptive statistics and provided as mean values, percentages, and ranges. For group comparisons, Student's t-test was used for two independent groups, and one-way analysis of variance (ANOVA) was used for more than two independent groups. Relationships between the sociodemographic features of the caregivers and the total mean SSQ-HF and CCSCHF scores were analyzed with Student's t-test and one-way ANOVA, and the differences between the groups were determined through post hoc analysis with Bonferroni correction. Correlations between variables were assessed using Pearson correlation analysis, as the data were normally distributed. Statistical significance was accepted at  $p < 0.05$  within a 95% confidence interval (CI).

A multivariable linear regression analysis was performed to identify independent factors associated with SSQ-HF total scores. Variables with a  $p < 0.10$  in univariate analyses were included in the model.

### Ethical Considerations and Data Collection

The study was conducted with the approval of Osmaniye Korkut Ata University Non-Interventional Clinical Research Ethics Committee granted approval for this study (date: August 05, 2022, number: E.79002).

Written permission was obtained from the selected hospital. Oral and written informed consent were obtained from all voluntary participants. To ensure reliability, it was explained to patients and caregivers that their answers should not be shared with each other or anyone else. This research adhered to the principles of the 2008 Declaration of Helsinki.

**Table 1.** The mean score of SSQ-HF by sociodemographic characteristics of patients (n=192)

| Sociodemographic features  | n   | %    | Mean±SD     | p*               |
|----------------------------|-----|------|-------------|------------------|
| Sex                        |     |      |             | <b>0.011*</b>    |
| Male                       | 102 | 53.1 | 45.63±17.24 |                  |
| Female                     | 90  | 46.9 | 52.06±17.39 |                  |
| Age                        |     |      |             | <b>0.031**</b>   |
| 41–54                      | 23  | 12.0 | 39.95±20.08 |                  |
| 55–65                      | 53  | 27.6 | 49.58±17.74 |                  |
| 66–75                      | 70  | 36.5 | 51.98±14.81 |                  |
| 76–94                      | 46  | 24.0 | 46.84±18.71 |                  |
| Education                  |     |      |             | 0.647*           |
| Primary education          | 143 | 75.0 | 48.97±17.40 |                  |
| High school and University | 48  | 25.0 | 47.62±18.19 |                  |
| Current working status     |     |      |             | 0.157*           |
| Employed                   | 22  | 11.5 | 43.63±18.33 |                  |
| Unemployed                 | 170 | 88.5 | 49.28±17.41 |                  |
| Job                        |     |      |             | 0.106**          |
| Retired                    | 93  | 48.4 | 47.75±17.32 |                  |
| Housewife                  | 76  | 39.6 | 51.44±17.11 |                  |
| Worker                     | 22  | 11.5 | 43.63±18.33 |                  |
| Marital status             |     |      |             | <b>0.002*</b>    |
| Married                    | 142 | 74.0 | 55.14±16.31 |                  |
| Single                     | 50  | 26.0 | 46.32±17.46 |                  |
| NYHA classes               |     |      |             | <b>&lt;0.001</b> |
| Class 2                    | 94  | 49.5 | 40.91±17.77 |                  |
| Class 3                    | 75  | 39.1 | 57.45±12.86 |                  |
| Class 4                    | 22  | 11.5 | 51.55±15.99 |                  |
| Diagnosis time (month)     |     |      |             | <b>0.001</b>     |
| 2–6                        | 44  | 22.9 | 40.11±19.50 |                  |
| 7–24                       | 45  | 23.4 | 49.50±16.80 |                  |
| 25≥                        | 103 | 53.6 | 51.90±16.17 |                  |

\*: Independent-samples t-test; \*\*: One-way analysis of variance (Bonferroni).  
%: Percentage; SD: Standard deviation; SSQ-HF: Symptom status questionnaire - heart failure; NYHA class: New York Heart Association's classification.

### Results

A total of 192 patients with HF and 192 informal caregivers took place in the study. Table 1 presents the characteristics of patients, and Table 2 presents the sociodemographic characteristics of caregivers.

Table 3 presents the mean scores of the SSQ-HF and CCSCHF subscales (n=192; n=192, respectively). The mean score of SSQ-HF of patients was 48.63±17.56, indicating that they experienced symptoms characterized by an intensity that

**Table 2.** Comparison of CCSCHF-I and subscale scores across caregivers' sociodemographic characteristics (n=192)

| Socio-demographic features  | n (%)      | CCSCHFI subscale scores |                  |            |            |                      |           |            |                      |            |            |
|-----------------------------|------------|-------------------------|------------------|------------|------------|----------------------|-----------|------------|----------------------|------------|------------|
|                             |            | CCSCHFI-A<br>Mean±SD    |                  |            |            | CCSCHFI-B<br>Mean±SD |           |            | CCSCHFI-C<br>Mean±SD |            |            |
|                             |            | SM                      | PA               | MTA and NI | Total      | AM                   | D/DM      | Total      | AC                   | BC         | Total      |
| Age                         |            |                         |                  |            |            |                      |           |            |                      |            |            |
| 20–40                       | 62 (32.3)  | 5.41±1.45               | 4.01±1.82        | 18.22±4.68 | 27.66±6.44 | 11.67±2.87           | 6.09±1.82 | 17.77±4.01 | 9.80±1.81            | 10.24±1.56 | 20.04±3.09 |
| 41–60                       | 99 (51.6)  | 5.39±1.57               | 3.95±1.91        | 18.04±4.29 | 27.39±5.94 | 12.19±3.16           | 5.84±1.79 | 18.04±4.27 | 9.78±2.47            | 10.06±2.30 | 19.84±4.55 |
| 61–81                       | 31 (16.1)  | 6.00±1.59               | 3.29±1.67        | 18.74±4.07 | 28.03±5.45 | 12.25±2.94           | 5.90±1.75 | 18.16±4.09 | 10.09±2.31           | 10.22±2.14 | 20.32±4.29 |
| p**                         |            | 0.144                   | 0.163            | 0.740      | 0.870      | 0.526                | 0.691     | 0.891      | 0.792                | 0.840      | 0.846      |
| Sex                         |            |                         |                  |            |            |                      |           |            |                      |            |            |
| Male                        | 50 (26.0)  | 5.36±1.42               | 3.98±1.85        | 18.68±4.09 | 28.02±5.84 | 11.30±2.92           | 5.76±1.54 | 17.06±3.80 | 9.56±2.01            | 9.74±1.93  | 19.30±3.73 |
| Female                      | 142 (74.0) | 5.54±1.58               | 3.83±1.86        | 18.04±4.47 | 27.42±6.07 | 12.29±3.03           | 6.00±1.87 | 18.29±4.22 | 9.94±2.32            | 10.28±2.08 | 20.23±4.17 |
| p*                          |            | 0.458*                  | 0.627            | 0.382      | 0.551      | <b>0.046</b>         | 0.417     | 0.070      | 0.300                | 0.105      | 0.165      |
| Education                   |            |                         |                  |            |            |                      |           |            |                      |            |            |
| Primary education           | 104 (54.2) | 5.57±1.69               | 3.43±1.74        | 18.13±4.35 | 27.14±6.06 | 12.30±2.97           | 5.79±1.87 | 18.10±4.20 | 9.90±2.39            | 10.01±2.20 | 19.92±4.47 |
| High school                 | 88 (45.8)  | 5.40±1.35               | 4.38±1.86        | 18.30±4.42 | 28.10±5.93 | 11.71±3.08           | 6.10±1.68 | 17.81±4.09 | 9.77±2.06            | 10.29±1.87 | 20.06±3.58 |
| p*                          |            | 0.455                   | <b>&lt;0.001</b> | 0.787      | 0.272      | 0.179                | 0.242     | 0.633      | 0.688                | 0.355      | 0.807      |
| Working status              |            |                         |                  |            |            |                      |           |            |                      |            |            |
| Employed                    | 56 (29.2)  | 5.37±1.31               | 4.41±1.88        | 18.82±4.22 | 28.60±5.63 | 11.58±3.09           | 5.82±1.64 | 17.41±3.88 | 9.57±2.13            | 10.25±1.88 | 19.82±3.62 |
| Unemployed                  | 136 (70.8) | 5.55±1.63               | 3.64±1.80        | 17.96±4.27 | 27.16±6.12 | 12.22±3.00           | 5.98±1.85 | 18.20±4.24 | 9.95±2.28            | 10.10±2.13 | 20.05±4.26 |
| p*                          |            | 0.473                   | <b>0.009</b>     | 0.218      | 0.130      | 0.191                | 0.566     | 0.228      | 0.282                | 0.614      | 0.715      |
| Marital status              |            |                         |                  |            |            |                      |           |            |                      |            |            |
| Married                     | 142 (74.0) | 5.44±1.49               | 3.84±1.84        | 18.24±4.73 | 27.53±5.52 | 12.09±2.96           | 5.80±1.71 | 18.20±4.65 | 9.83±2.17            | 10.14±1.99 | 19.97±3.92 |
| Single                      | 50 (26.0)  | 5.66±1.68               | 3.94±1.91        | 18.12±4.79 | 27.72±7.26 | 11.88±3.25           | 6.32±1.95 | 17.89±3.96 | 9.88±2.45            | 10.14±2.24 | 20.02±4.53 |
| p*                          |            | 0.396                   | 0.757            | 0.861      | 0.852      | 0.673                | 0.079     | 0.655      | 0.895                | 0.981      | 0.951      |
| Family member cared for     |            |                         |                  |            |            |                      |           |            |                      |            |            |
| Spouse                      | 53 (27.6)  | 5.58±1.65               | 3.66±1.92        | 18.07±4.05 | 27.32±5.43 | 11.86±2.67           | 5.73±1.53 | 17.60±3.45 | 9.94±2.34            | 9.90±2.22  | 19.84±4.41 |
| Children                    | 107 (55.7) | 5.42±1.52               | 3.97±1.87        | 18.28±4.70 | 27.67±5.54 | 12.10±3.17           | 6.04±1.90 | 18.14±4.47 | 9.83±2.30            | 10.23±2.10 | 20.06±4.17 |
| Other relatives             | 32 (16.7)  | 5.62±1.43               | 3.87±1.73        | 18.21±3.84 | 27.71±5.11 | 12.09±3.16           | 5.90±1.82 | 18.00±4.00 | 9.71±1.98            | 10.25±1.56 | 19.96±3.18 |
| p**                         |            | 0.724                   | 0.610            | 0.962      | 0.932      | 0.894                | 0.586     | 0.737      | 0.903                | 0.609      | 0.951      |
| Length of time as caregiver |            |                         |                  |            |            |                      |           |            |                      |            |            |
| 2–6 months                  | 68 (35.4)  | 5.35±1.56               | 3.82±1.62        | 17.76±4.45 | 26.94±5.89 | 11.82±3.22           | 5.58±1.83 | 17.71±4.47 | 9.76±2.12            | 9.91±1.81  | 19.67±3.69 |
| 7–24 months                 | 40 (20.8)  | 5.67±1.28               | 4.12±2.04        | 18.57±4.30 | 28.37±5.14 | 11.55±2.63           | 5.92±1.47 | 17.47±3.16 | 9.97±2.01            | 10.45±1.90 | 20.42±3.65 |
| 1 year ≥                    | 84 (43.8)  | 5.53±1.64               | 3.78±1.95        | 18.40±4.36 | 27.72±6.27 | 12.41±3.03           | 6.25±1.84 | 18.86±4.21 | 9.84±2.45            | 10.19±2.29 | 20.03±4.56 |
| p**                         |            | 0.558                   | 0.619            | 0.566      | 0.470      | 0.274                | 0.060     | 0.124      | 0.896                | 0.410      | 0.651      |

**Table 2 (cont.).** Comparison of CCSCHFI and subscale scores across caregivers' sociodemographic characteristics (n=192)

| Socio-demographic features | n (%)      | CCSCHFI subscale scores |           |            |            |              |              |              |
|----------------------------|------------|-------------------------|-----------|------------|------------|--------------|--------------|--------------|
|                            |            | CCSCHFI-A               |           |            | CCSCHFI-B  |              |              | CCSCHFI-C    |
|                            |            | SM                      | PA        | MTA and NI | Total      | AM           | D/DM         | Mean±SD      |
| Daily caregiving hours     |            |                         |           |            |            |              |              |              |
| 6-12                       | 56 (29.2)  | 5.35±1.41               | 4.16±1.81 | 18.39±4.33 | 27.91±6.35 | 11.17±2.97   | 5.42±1.72    | 16.60±3.80   |
| >12                        | 136 (70.8) | 5.55±1.59               | 3.75±1.86 | 18.13±4.40 | 27.44±5.88 | 12.38±2.99   | 6.14±1.78    | 18.53±4.54   |
| p*                         |            | 0.412                   | 0.165     | 0.717      | 0.629      | <b>0.012</b> | <b>0.011</b> | <b>0.003</b> |
|                            |            |                         |           |            |            |              |              | 9.33±2.10    |
|                            |            |                         |           |            |            |              |              | 10.01±1.81   |
|                            |            |                         |           |            |            |              |              | 10.19±2.15   |
|                            |            |                         |           |            |            |              |              | 10.05±2.27   |
|                            |            |                         |           |            |            |              |              | <b>0.046</b> |
|                            |            |                         |           |            |            |              |              | 0.581        |
|                            |            |                         |           |            |            |              |              | 0.169        |

\*: Independent-samples t-test; \*\*: One-way analysis of variance (Bonferroni). CCSCHFI: Caregiver contribution to self-care of heart failure index; CCSCHFI-A: Caregiver contribution to self-care maintenance; CCSCHFI-B: Caregiver contribution to self-care management; CCSCHFI-C: Caregiver confidence in contributing to self-care; SM: Symptom monitoring; PA: Physical activity; MTA&NI: Medical treatment adherence and sodium intake control; AM: Autonomous management; D/DM: Directive-dependent management; AC: Advanced confidence; BC: Basic confidence.

**Table 3.** SSQ-HF and CCSCHFI subscale's points averages

| SSQ-HF and CCSCHFI Subscale's points averages |       |       |     |
|-----------------------------------------------|-------|-------|-----|
| Min-Max                                       | Mean  | SD    | n   |
| SSQ-HF total 9-84                             | 48.63 | 17.56 | 192 |
| CCSCHFI -A total 10-40                        | 27.58 | 6.00  | 192 |
| CCSCHFI -B total 8-25                         | 17.97 | 4.15  | 192 |
| CCSCHFI -C total 6-24                         | 19.99 | 4.08  | 192 |

CCSCHFI-A: Caregiver contribution to self-care maintenance; CCSCHFI-B: Caregiver contribution to self-care management; CCSCHFI-C: Caregiver confidence in contributing to self-care; SD: Standard deviation.

surpassed the moderate threshold. The average score of the CCSCHFI "caregiver contribution to self-care maintenance" subscale was  $27.58 \pm 6.1$ , for the "caregiver contribution to self-care management" subscale was  $17.97 \pm 4.1$ , and for the "confidence in contributing to the self-care" subscale was  $19.98 \pm 4.1$ . These results indicated that the caregivers contributed moderately to the patients' self-care (Table 3).

The mean score of SSQ-HF by characteristics of patients (n=192) is presented in Table 1. Married patients had significantly higher mean SSQ-HF score than the single ones ( $p=0.002$ ). Symptom severity score of female patients was statistically higher than that of male patients ( $p=0.011$ ). The difference between the NYHA Classes of patients was found to be statistically significant in terms of symptom severity ( $p<0.001$ ). When post hoc tests were performed, patients with NYHA Class III had the highest symptom severity, and it was determined that the difference between classes in terms of symptom severity resulted from Class II - III and Class II and IV ( $p<0.001$ ;  $p=0.015$ , respectively). The difference between the diagnosis times was found to be statistically significant ( $p=0.001$ ). Post hoc tests suggested that symptom severity gradually increased up to  $\leq 25$  months. It was determined that the difference between months in terms of diagnosis time was due to 2-6 months/7-24 months and 2-6 months and  $\geq 25$  months ( $p=0.031$ ;  $p<0.001$ , respectively).

Multivariable linear regression analysis demonstrated that sex ( $\beta=5.187$ , 95% CI: 0.493-9.882,  $p=0.031$ ) and NYHA stage ( $\beta=8.510$ , 95% CI: 5.284-11.736,  $p<0.001$ ) were independent predictors of higher SSQ-HF total scores. Age ( $\beta=-0.053$ , 95% CI: -0.262-0.155,  $p=0.613$ ), marital status ( $\beta=-4.925$ , 95% CI: -10.392-0.542,  $p=0.077$ ), and diagnosis time ( $\beta=0.563$ , 95% CI: -1.610-2.736,  $p=0.610$ ) were not significantly associated with SSQ-HF total scores.

Table 2 shows the comparison between CCSCHFI subscale scores and sociodemographic characteristics of caregivers (n=192). Female caregivers had a significantly higher

**Table 4.** The relationships between SSQ-HF and CCSCHFI subscale scores ("R" values of the correlation analysis)

|        | CCSCHFI subscale scores |           |           |
|--------|-------------------------|-----------|-----------|
|        | CCSCHFI-A               | CCSCHFI-B | CCSCHFI-C |
| SSQ-HF |                         |           |           |
| r      | 0.147                   | 0.245     | 0.241     |
| p      | 0.042                   | 0.001     | 0.001     |

SSQ-HF: Symptom status questionnaire - heart failure; CCSCHFI: Caregiver contribution to self-care of heart failure index; CCSCHFI-A: Caregiver contribution to self-care maintenance; CCSCHFI-B: Caregiver contribution to self-care management; CCSCHFI-C: Caregiver confidence in contributing to self-care.

mean CCSCHFI "autonomous management" score than male caregivers ( $p=0.046$ ). Those who graduated from high school and university and employed caregivers had significantly higher mean CCSCHFI "physical activity" scores ( $p<0.001$ ;  $p=0.009$ , respectively). Caregivers who provided care for more than 11 h daily had significantly higher mean CCSCHFI "autonomous management", "directive-dependent management", "caregiver contribution to self-care management", and "advanced confidence" scores than those who provided care for less than 11 hours daily ( $p=0.012$ ;  $p=0.011$ ;  $p=0.003$ ;  $p=0.046$ , respectively).

There was a weak positive correlation between SSQ-HF scores and CCSCHFI "caregiver contribution to self-care maintenance" ( $r=0.147$ ,  $p=0.042$ ), "caregiver contribution to self-care management" ( $r=0.245$ ,  $p=0.001$ ), and "confidence in contributing to the self-care" subscale scores ( $r=0.241$ ,  $p=0.001$ ) (Table 4).

## Discussion

The aim of this study was to investigate the relationship between caregiver involvement in HF self-care and patient symptom intensity, as well as the factors influencing this relationship. A weak but statistically significant association was found between caregiver contribution and symptom intensity; notably, symptom burden remained high despite a moderate level of caregiver involvement. Although the correlation coefficients were relatively weak, they may still reflect meaningful associations; therefore, the findings should be interpreted in a balanced and cautious manner.

In the present study, sex and NYHA functional class were identified as independent predictors of symptom severity in patients with HF. The strong association with NYHA class is expected, as it directly reflects disease severity and symptom burden.<sup>[23]</sup> The effect of sex is also consistent with recent evidence indicating that women tend to report higher symptom burden and poorer quality of life compared to men.

<sup>[24–26]</sup> In contrast, age, marital status, and duration of diagnosis were not significant, suggesting that clinical severity may play a more dominant role than sociodemographic factors in determining symptom burden.<sup>[25]</sup>

An important finding is the weak positive association between caregiver contribution and symptom intensity, which appears to contradict the expectation that greater caregiver involvement would reduce symptom burden. This may be explained by a reactive relationship, whereby caregiver involvement increases in response to worsening symptoms rather than leading to their reduction. In this context, higher symptom intensity may trigger greater caregiver involvement, particularly among patients with advanced disease or higher care needs. Therefore, caregiver contribution may reflect increased care demand rather than effective symptom control. However, due to the cross-sectional study design, the results show association only, not causation.

The situation-specific theory of HF self-care supports this interpretation by emphasizing that outcomes are shaped by the interaction among patient, caregiver, and dyadic factors.<sup>[15]</sup> Although previous studies have shown that caregiver contribution can improve self-care and quality of life,<sup>[15,27]</sup> other findings suggest that such contributions may be insufficient and do not consistently lead to improved outcomes.<sup>[17,28]</sup>

In our sample, patients' low educational levels, advanced age, comorbidities, and functional limitations may have reduced the effectiveness of caregiver support. Limited self-care awareness and skills may have further hindered the translation of caregiver involvement into improved symptom management.

Caregiver-related factors such as education, experience, perceived control, and confidence in caregiving were found to influence contribution.<sup>[14,29]</sup> Consistent with the literature, higher education, longer cohabitation, and extended caregiving duration were associated with greater confidence in symptom management in our study. Spending more time with the patient may facilitate closer observation and greater disease-related knowledge, thereby enhancing care management skills. However, findings regarding caregiving duration remain inconsistent.<sup>[30]</sup>

Female caregivers demonstrated more effective recognition and management of symptoms. This may reflect sociocultural norms in Türkiye, where caregiving roles are predominantly assumed by women.<sup>[31,32]</sup> Previous studies also highlight the positive impact of female caregivers on patient outcomes.<sup>[17,27]</sup>

Finally, patient–caregiver communication may play a critical role in determining outcomes. Patients' reluctance

to share symptoms and caregivers' limited self-efficacy may reduce the effectiveness of caregiver contributions. Consistent with Lyons et al.,<sup>[33]</sup> inadequate communication and insufficient help-seeking behaviors may contribute to higher symptom intensity.

Overall, these findings suggest that caregiver involvement alone is not sufficient; its effectiveness depends on patient capacity, caregiver competence, and the quality of dyadic interaction. Therefore, interventions should focus not only on increasing caregiver involvement but also on improving caregiver education, self-efficacy, and patient-caregiver communication.

## Limitations

This study has several limitations. First, due to the descriptive cross-sectional design, the findings can only be interpreted as associations rather than causal relationships. The study was conducted in a single hospital, which may limit the representativeness of the sample and restrict the generalizability of the findings to broader populations of patients with HF and their caregivers. Furthermore, psychosocial variables that may influence caregiver contributions and symptom intensity, such as caregiver burden, psychological distress, quality of the patient-caregiver relationship, and social support, were not assessed. The absence of these variables may have limited a more comprehensive interpretation of the observed associations. Finally, no structured intervention targeting caregivers was implemented; therefore, caregiver contributions were evaluated only within the context of existing care practices.

## Conclusion

This study emphasizes that while caregivers' contributions to patients' self-care are at an acceptable level, it is crucial to consider the characteristics of patient-caregiver dyads that influence the care process, the appropriateness of their interaction and communication, and the caregiver's self-efficacy in caregiving when addressing symptom intensity in HF. Interventions aimed at addressing caregivers' knowledge gaps regarding HF self-care, supporting their self-efficacy behaviors, and strengthening caregiver-patient communication may help reduce symptom severity in patients. In line with these results, it is recommended to carry out studies to improve the characteristics of patient-caregiver pairs that affect the care process, the appropriateness of interactions and communication between them, and the caregiver's self-efficacy level in care, to reduce symptom intensity through the care provided.

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## ORIGINAL ARTICLE

# Glymphatic System Research in Neurosurgery: A Bibliometric and Co-Word Network Analysis (2015–2026)

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## Abstract

**Introduction:** This study characterized the intellectual structure and emerging clinical themes at the intersection of glymphatic research and neurosurgery, with particular attention to the field's movement from a predominantly macroscopic cerebrospinal-fluid framework toward perivascular and parenchymal transport concepts.

**Methods:** Bibliographic metadata for 317 documents indexed in the Web of Science Core Collection from 2015 through the first quarter of 2026 were analyzed with the R-based bibliometrix package. Co-word analysis used Author Keywords after lower-case conversion, whitespace trimming, and exact-string deduplication; semantic, plural, spacing, and hyphen variants were not consolidated. Network centrality and community detection identified influential lexical nodes and thematic clusters. Results involving 2026 were interpreted descriptively because the year was incomplete.

**Results:** The dataset included 317 documents from 171 sources, 2,199 authors, and 10,694 cited references. Three thematic clusters were identified: acute neurosurgical insults and aquaporin-4-related clearance impairment; clinical translation and neuroimaging, including magnetic resonance imaging and diffusion tensor image analysis along the perivascular space (DTI-ALPS); and chronic hydrocephalus-neurodegeneration research linking idiopathic normal pressure hydrocephalus, dementia, and shunt-related management. Because 2026 was incomplete, no complete-period annual growth rate was reported.

**Discussion and Conclusion:** The network maps a research field increasingly integrating perivascular transport with established pressure-volume concepts. DTI-ALPS should be interpreted as a localized, structure-dependent diffusion biomarker rather than a direct measure of whole-brain glymphatic clearance. Proposed applications in surgical selection and outcome prediction require prospective clinical validation.

**Keywords:** Aquaporin 4; Bibliometrics; Diffusion tensor imaging; Glymphatic system; Hydrocephalus, normal pressure; Neurosurgery

Three concepts frame this analysis. The Monro-Kellie doctrine states that, within the rigid cranium, the combined volume of brain parenchyma, cerebrospinal fluid (CSF), and blood is essentially constant; expansion of one component must therefore be offset by reduction

of another until compensatory reserve is exhausted and intracranial pressure rises.<sup>[1]</sup> The glymphatic system describes a perivascular fluid-transport framework in which CSF enters along periarterial spaces, exchanges with interstitial fluid, and drains through perivenous,

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meningeal-lymphatic, and deep cervical-lymphatic pathways, thereby contributing to solute clearance.<sup>[2–4]</sup> Aquaporin-4 (AQP4) is a water channel concentrated at astrocytic end-feet that supports CSF-interstitial fluid exchange; altered AQP4 polarization has been associated with traumatic brain injury (TBI), subarachnoid hemorrhage, edema, and neurodegeneration.<sup>[3,5]</sup>

Clinical neurosurgery and neurocritical care traditionally conceptualize intracranial fluid kinetics and pressure-volume compliance through the Monro-Kellie doctrine.<sup>[1]</sup> In the classical bulk-flow model, CSF is produced by the choroid plexus, circulates through the ventricular system, and is absorbed through arachnoid granulations. Traumatic brain injury (TBI), subarachnoid hemorrhage (SAH), and hydrocephalus are therefore commonly approached as disorders of pressure, obstruction, or macroscopic CSF circulation.<sup>[1]</sup> This framework remains clinically fundamental, but it does not by itself explain persistent parenchymal edema, delayed neuroinflammation, or progressive cognitive decline after intracranial pressure or ventricular size has been corrected.<sup>[6]</sup>

The glymphatic framework adds a parenchymal dimension to intracranial fluid transport. Experimental studies describe CSF entry along periaxonal spaces, AQP4-facilitated exchange with interstitial fluid, and movement of solutes toward perivenous and lymphatic drainage pathways.<sup>[2,3]</sup> This pathway has been linked to the clearance of amyloid-beta, hyperphosphorylated tau, and other extracellular metabolites. The model is still evolving, and the relative contributions of diffusion, convection, vascular pulsatility, sleep, and white-matter microstructure remain under investigation.

In acute neurosurgical insults, secondary injury may extend beyond mass effect or vasospasm. TBI and SAH have been associated with loss of perivascular AQP4 polarization, obstruction of perivascular spaces by blood products, and impaired CSF-interstitial fluid exchange.<sup>[5,7]</sup> In idiopathic normal pressure hydrocephalus (iNPH), gait disturbance, urinary symptoms, and cognitive decline have also been studied in relation to altered perivascular transport.<sup>[8]</sup> Non-invasive imaging approaches, particularly the diffusion tensor image analysis along the perivascular space (DTI-ALPS) index and enlarged perivascular-space assessment, have consequently emerged as candidate markers of the local tissue environment.<sup>[9,10]</sup>

The Monro-Kellie and glymphatic frameworks address different levels of the same intracranial system. The former provides an established clinical model of compartmental volume and pressure, whereas the latter focuses on fluid exchange within and around the parenchyma. Current

evidence does not justify replacing one model with the other. A more useful translational question is whether perivascular transport helps explain outcomes that are incompletely predicted by intracranial pressure, ventricular size, or conventional structural imaging. This distinction is important because conceptual novelty should not be mistaken for clinical validation.

Glymphatic concepts have expanded rapidly across neurology, neuroradiology, and neurosurgery since 2015. Descriptive reviews have summarized mechanisms and clinical applications, but the conceptual organization of the neurosurgical literature has not been quantitatively mapped. This study, therefore, used bibliometric and co-word network methods to characterize publication dynamics, influential sources and documents, and the thematic architecture of glymphatic research relevant to neurosurgical practice.

## Materials and Methods

### Data Source and Search Strategy

Bibliographic metadata were retrieved from the Web of Science (WoS) Core Collection (Clarivate Analytics, Philadelphia, PA, USA) during the first quarter of 2026. The analysis covered publications from 2015 through the retrieval period in 2026. The search was treated as a partial-year snapshot, and all analyses involving 2026 were interpreted descriptively. The Topic field was searched using the following Boolean expression:

TS= ([“glymphatic system” OR “glymphatic pathway” OR “perivascular space\*”] AND [“neurosurg\*” OR “subarachnoid hemorrhage” OR “intracranial hemorrhage” OR “traumatic brain injury” OR “hydrocephalus” OR “increased intracranial pressure”]).

### Inclusion and Exclusion Criteria

Records published from 2015 through the first quarter of 2026 were screened for relevance to the intersection of glymphatic pathways and neurosurgical disease. Eligible records included full-length research articles, review articles, early-access records, and other scholarly documents with complete bibliographic metadata and cited-reference information. Letters, editorials, meeting abstracts without complete reference mapping, records labeled as retracted, and incomplete records were excluded. WoS document labels may overlap (for example, an article may also be designated Early Access); therefore, document-type categories were not treated as mutually exclusive, and exact subtype totals are not reported. No language restriction was applied. The 2026 publication count and the

**Table 1.** Baseline bibliometric characteristics of glymphatic system and neurosurgery literature (2015–2026)

| Category            | Indicator                        | Value                              |
|---------------------|----------------------------------|------------------------------------|
| Temporal scale      | Analyzed timespan                | 2015 through first quarter of 2026 |
| Source dynamics     | Total sources                    | 171                                |
| Source dynamics     | Total documents                  | 317                                |
| Document age        | Mean document age                | 3.68 years                         |
| Citation impact     | Mean citations per document      | 31.00                              |
| Citation impact     | Total cited references           | 10,694                             |
| Conceptual metadata | Keywords Plus                    | 759                                |
| Conceptual metadata | Author Keywords                  | 770                                |
| Collaboration       | Total authors                    | 2,199                              |
| Collaboration       | Single-authored documents        | 5                                  |
| Collaboration       | Mean co-authors per document     | 8.55                               |
| Collaboration       | International co-authorship rate | 26.18%                             |

Metadata were extracted from the Web of Science Core Collection and analyzed using bibliometrix/biblioshiny. The 2026 observation period was incomplete; therefore, no complete-period annual growth rate is reported.

2024–2026 thematic interval were interpreted descriptively because the final year was incomplete.

## Data Analysis and Visualization

Full records and cited references were exported from WoS in plain-text format. Bibliometric processing and visualization were performed with the R-based bibliometrix package (version 4.0) through the biblioshiny interface within RStudio (version 0.7.5). Descriptive analyses included source distribution according to Bradford's Law, author productivity according to Lotka's Law, global citations, fractionalized authorship, and international collaboration. Annual publication output was inspected descriptively, but a single annual scientific growth rate was not retained in the revised report because the 2026 observation period was incomplete.

Conceptual-structure analysis was based exclusively on Author Keywords (DE). Keywords Plus (ID) were not entered into the co-word matrix; their count is reported descriptively in Table 1. In the original analysis, Author Keywords were converted to lower case, leading and trailing spaces were removed, and exact duplicate strings were standardized. No semantic synonym merging, singular-plural consolidation, spacing harmonization, or hyphen-variant consolidation was applied. Consequently, source variants such as "normal-pressure hydrocephalus" and "normal pressure hydrocephalus" remain separate lexical nodes. A post hoc merge was not undertaken during revision because it would alter the reported network topology without a prespecified thesaurus. The complete Author Keyword preprocessing rules, retained lexical variants, and representative examples are provided in Appendix 1.

A co-occurrence matrix was constructed from the minimally standardized Author Keywords. Betweenness centrality, closeness centrality, and PageRank were calculated to characterize node position, and the Walktrap algorithm was used for community detection. The thematic map categorized clusters by centrality and density. The thematic-evolution analysis compared 2015–2023 with 2024 through the first quarter of 2026; the latter interval is descriptive because it includes an incomplete year.

Betweenness centrality was used to identify keywords that connect otherwise distinct parts of the network, closeness centrality described the relative distance of a node from other nodes, and PageRank estimated prestige according to the importance of connected terms. These metrics were interpreted as properties of the literature network, not as measures of biological importance. Analyses were descriptive; no patient-level data, hypothesis tests, or clinical-effect estimates were generated.

## Results

### Macro-Level Bibliometric Profile

The search yielded 317 documents published across 171 sources, with 10,694 cited references. The dataset included 2,199 authors, a mean of 8.55 authors/document, and an international co-authorship rate of 26.18%. The mean document age was 3.68 years and the mean citation count was 31.00/document. Because the retrieval included only the first quarter of 2026, a complete-period annual scientific growth rate was not reported. Baseline characteristics are presented in Table 1.

**Table 2.** Top 10 globally cited landmark documents

| Rank | Seminal study                               | DOI                            | Total citations | Normalized citation score |
|------|---------------------------------------------|--------------------------------|-----------------|---------------------------|
| 1    | Jessen, 2015, <i>Neurochem Res</i>          | 10.1007/s11064-015-1581-6      | 1,552           | 7.34                      |
| 2    | Ringstad, 2017, <i>Brain</i>                | 10.1093/brain/awx191           | 566             | 4.28                      |
| 3    | Plog, 2015, <i>J Neurosci</i>               | 10.1523/JNEUROSCI.3742-14.2015 | 421             | 1.99                      |
| 4    | Dichgans, 2017, <i>Circ Res</i>             | 10.1161/CIRCRESAHA.116.308426  | 410             | 3.10                      |
| 5    | Ringstad, 2018, <i>JCI Insight</i>          | 10.1172/jci.insight.121537     | 400             | 6.34                      |
| 6    | Lee, 2015, <i>J Neurosci</i>                | 10.1523/JNEUROSCI.1625-15.2015 | 329             | 1.55                      |
| 7    | Simon, 2016, <i>BBA-Mol Basis Dis</i>       | 10.1016/j.bbadis.2015.10.014   | 261             | 3.69                      |
| 8    | Mortensen, 2019, <i>J Neurosci</i>          | 10.1523/JNEUROSCI.1974-18.2019 | 209             | 3.55                      |
| 9    | Schain, 2017, <i>J Neurosci</i>             | 10.1523/JNEUROSCI.3390-16.2017 | 195             | 1.47                      |
| 10   | Eide, 2019, <i>J Cereb Blood Flow Metab</i> | 10.1177/0271678X18760974       | 185             | 3.14                      |

Citation metrics were derived from Web of Science. Normalized citation score is interpreted relative to publication year and disciplinary cohort.

Only five documents were single-authored, indicating that the field is predominantly collaborative. The combination of a relatively young mean document age and a high mean citation count suggests rapid uptake of foundational work, although citation accumulation is uneven and favors early mechanistic and imaging studies. The international co-authorship rate of 26.18% also indicates that most documents were produced within national or institutional networks rather than large cross-border consortia.

**Bradford’s Law and Productive Sources**

Bradford’s Law identified a core zone of 10 journals containing 85 documents (26.81% of the dataset). *Frontiers in Neurology* (n=13), *Fluids and Barriers of the central nervous system* (n=12), and *Neurology* (n=11) were the most productive sources. *Journal of Neurotrauma* (n=10) and *World Neurosurgery* (n=7) demonstrate the presence of glymphatic research within clinically oriented neurosurgical literature. The complete distribution of the 10 most productive sources is presented in Appendix 2.

The core zone spans neurology, neurotrauma, vascular neurology, neuroscience, and neurosurgery rather than a single specialty. This dispersion is consistent with the interdisciplinary character of glymphatic research and may also explain why clinically relevant evidence is distributed across journals with different methodological traditions and readerships.

**Productive Authors and Fractionalized Contributions**

Eide PK (13 documents) and Ringstad G (12 documents) had the highest publication counts, followed by Li J and Nedergaard M (8 documents each). Fractionalized

publication scores were 4.15 for Eide PK and 3.15 for Ringstad G, indicating substantial individual contribution within their publication networks. In contrast, Li J had a fractionalized score of 0.91 despite eight documents, reflecting participation in larger collaborative teams. Detailed productivity and fractionalized authorship indicators for the 10 most productive authors are presented in Appendix 3.

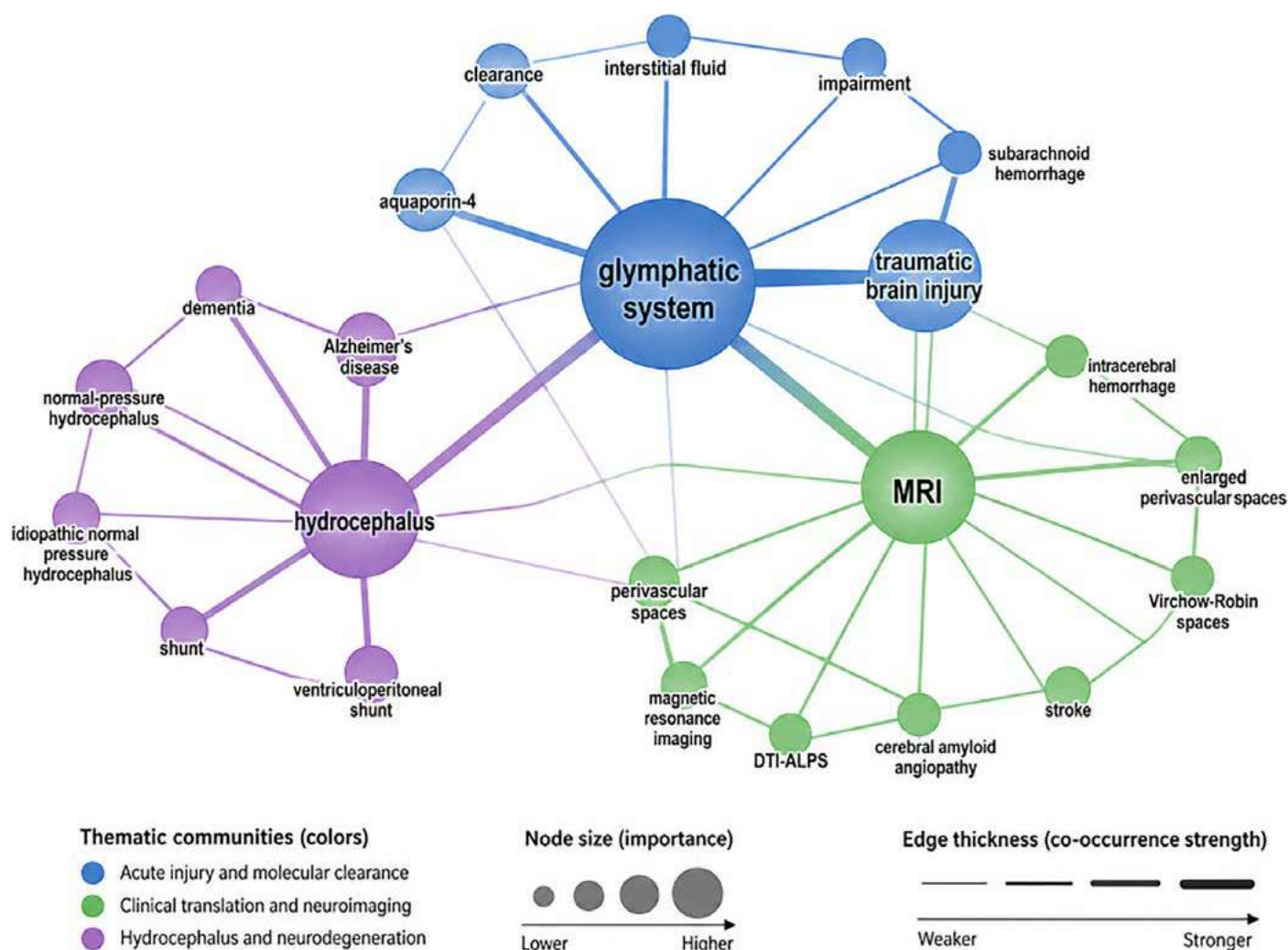
**Global Citation Structure**

Jessen et al.<sup>[11]</sup> was the most globally cited document, with 1,552 citations and an annual average of 129.30. Clinical magnetic resonance imaging (MRI) studies by Ringstad et al.<sup>[12]</sup> in *Brain* and *JCI Insight*<sup>[13]</sup> received 566 and 400 citations, respectively; the latter had the highest normalized citation score (6.34). Other highly cited documents included experimental work on post-traumatic transport impairment by Plog et al.<sup>[14]</sup> and vascular cognitive impairment by Dichgans and Leys.<sup>[15]</sup> The top-10 cited documents are listed in Table 2.

The citation structure was dominated by a small group of foundational mechanistic reviews and human tracer-imaging studies. This pattern indicates that the intellectual backbone of the field continues to depend on early descriptions of the pathway and on a limited number of translational MRI cohorts. Citation rank should nevertheless be interpreted cautiously because older publications have had more time to accumulate citations and may receive attention for controversy as well as confirmation.

**Co-Word Network and Thematic Structure**

The Author Keyword co-occurrence network is separated into three thematic communities (Fig. 1). Betweenness



**Figure 1.** Author-keyword co-occurrence network of glymphatic research relevant to neurosurgery from 2015 through the first quarter of 2026. Node size represents PageRank, edge thickness indicates co-occurrence strength, and node colors denote communities identified using the Walktrap algorithm. The network comprises three principal thematic communities: acute injury and molecular clearance; clinical translation, neuroimaging, and perivascular spaces; and chronic hydrocephalus and neurodegeneration. Only lower-case conversion, whitespace trimming, and exact-string deduplication were applied. Consequently, semantically related spelling, spacing, singular-plural, and hyphenation variants remain represented as separate lexical nodes.

centrality, closeness centrality, and PageRank values for the principal nodes are presented in Table 3. Node distance represents relative conceptual proximity, whereas edges indicate keyword co-occurrence. Because only exact-string standardization was applied, centrality values represent the displayed lexical nodes rather than fully harmonized clinical concepts.

The central position of the glymphatic system node shows that it connects acute injury, imaging, and chronic disease vocabularies. MRI also acts as an important bridge, whereas the chronic hydrocephalus and dementia nodes form a more clinically focused community. The strategic map complements these node-level measures by distinguishing highly developed themes from broadly connected foundational themes.

### Cluster 1: Acute Injury and Molecular Clearance

The “glymphatic system” node had the highest betweenness centrality (255.13) and PageRank (0.0935), functioning as the principal bridge in the network. Acute neurosurgical conditions were represented by “traumatic brain injury” (betweenness 44.09; PageRank 0.0390) and “subarachnoid hemorrhage” (betweenness 9.57). Molecular and transport-related nodes included “aquaporin-4,” “interstitial fluid,” “clearance,” and “impairment,” linking acute injury with perivascular transport research.<sup>[16,17]</sup>

### Cluster 2: Clinical Translation and Neuroimaging

The second cluster was anchored by “MRI” (betweenness 71.84; PageRank 0.0418) and “perivascular spaces”

**Table 3.** Co-word thematic clusters and representative centrality structure

| Cluster   | Representative high-centrality terms                                                                                                                                    | Dominant research axis                                          | Interpretation                                                                                                                                  |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Cluster 1 | Glymphatic system; traumatic brain injury; impairment; interstitial fluid; clearance; cerebrospinal fluid; subarachnoid hemorrhage; aquaporin-4                         | Acute injury, neurotrauma, AQP4, and molecular clearance        | Research linking acute neurosurgical insults with perivascular transport, astrocytic dysfunction, and clearance impairment.                     |
| Cluster 2 | MRI; perivascular spaces; magnetic resonance imaging; cerebral amyloid angiopathy; stroke; Virchow-Robin spaces; enlarged perivascular spaces; intracerebral hemorrhage | Clinical translation and advanced neuroimaging                  | Imaging-based translation, including DTI-ALPS and enlarged perivascular spaces as indirect markers of local tissue and small-vessel properties. |
| Cluster 3 | Alzheimer's disease; brain; dementia; normal pressure hydrocephalus; idiopathic normal pressure hydrocephalus; shunt                                                    | Chronic hydrocephalus, neurodegeneration, and cognitive decline | Conceptual overlap between chronic clearance-related hypotheses, CSF dynamic disorders, neurodegeneration, and shunt-related research.          |

Centrality metrics indicate bibliometric network position, not biological importance or clinical causality. Key reported node values include glymphatic system (betweenness 255.13; PageRank 0.0935), MRI (betweenness 71.84; PageRank 0.0418), traumatic brain injury (betweenness 44.09; PageRank 0.0390), perivascular spaces (betweenness 24.73), and subarachnoid hemorrhage (betweenness 9.57). CSF: Cerebrospinal fluid; DTI-ALPS: Diffusion tensor image analysis along the perivascular space; MRI: Magnetic resonance imaging.

(betweenness 24.73). Additional nodes included “magnetic resonance imaging,” “cerebral amyloid angiopathy,” “stroke,” “Virchow-Robin spaces,” “enlarged perivascular spaces,” and “intracerebral hemorrhage.” DTI-ALPS appeared within this translational imaging axis, reflecting the effort to derive non-invasive markers of perivascular and interstitial fluid-related tissue properties.<sup>[9,10,18–20]</sup>

**Cluster 3: Chronic Neurodegeneration and Hydrocephalus**

The third cluster connected “Alzheimer’s disease,” “dementia,” “normal-pressure hydrocephalus,” “normal pressure hydrocephalus,” and “idiopathic normal pressure hydrocephalus” with treatment-related terms such as “shunt” and “ventriculoperitoneal shunt.”<sup>[12,21]</sup> The strategic thematic map positioned acute injury terms within the motor-theme quadrant, MRI and perivascular-space terms near the niche-motor boundary, and the glymphatic-system and CSF cluster within the basic-theme quadrant (Fig. 2).

**Discussion**

**Acute Neurosurgical Insults**

The network demonstrates that acute neurotrauma, hemorrhage, AQP4, and clearance concepts form a closely connected research domain. This bibliometric association does not itself establish a biological mechanism; rather, it identifies the concepts that recur together in the literature. Experimental studies provide the mechanistic basis for interpreting these links. TBI has been associated with loss of perivascular AQP4 polarization and impaired transport of injury-related biomarkers.<sup>[14,22]</sup> Such changes may reduce CSF-interstitial fluid exchange and contribute

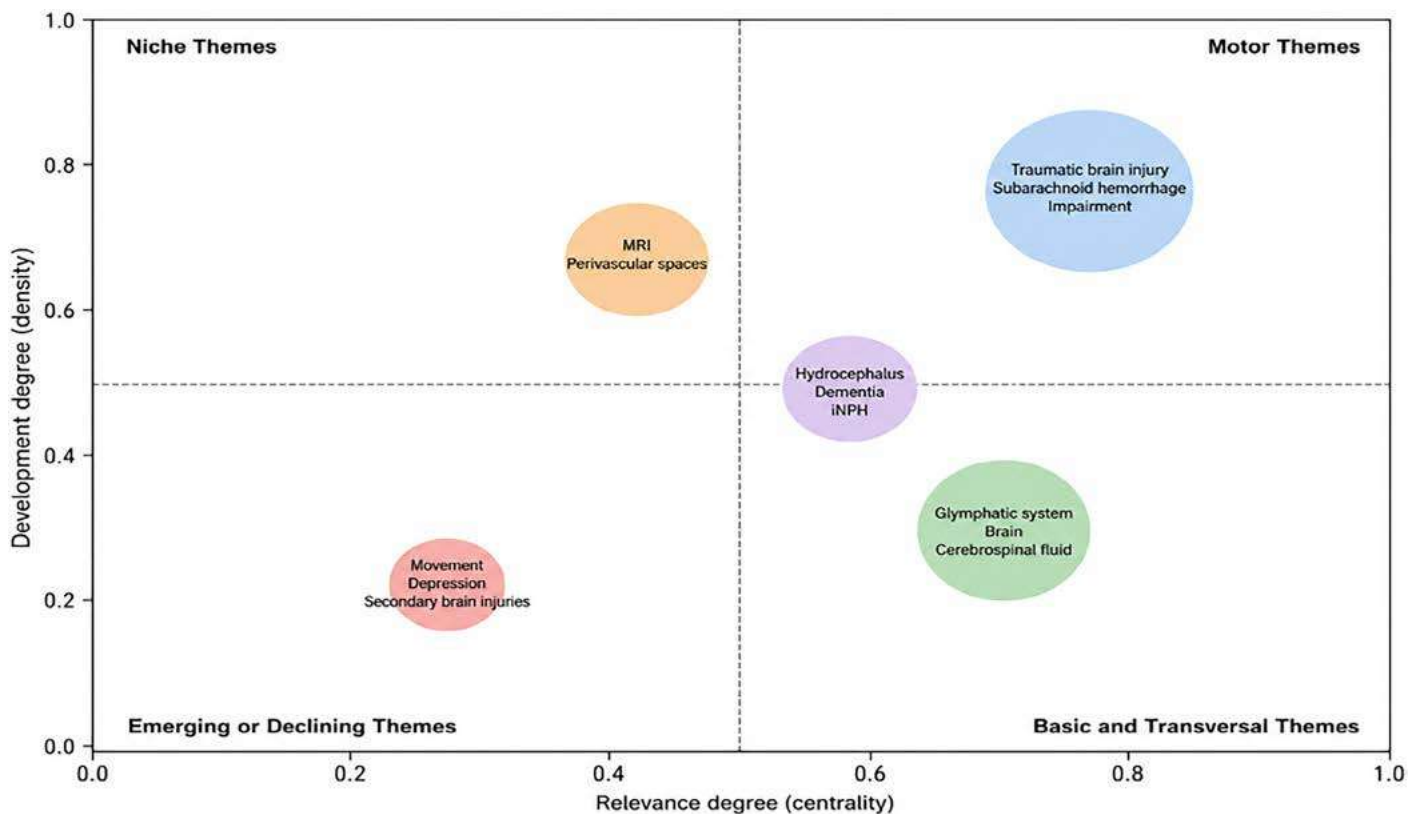
to retention of cellular debris, extracellular hemoglobin, and inflammatory mediators.

A related pattern has been described after SAH. Blood and degradation products may enter or obstruct cortical perivascular spaces, limiting CSF movement through the parenchyma.<sup>[23]</sup> Inflammation and altered ependymal or perivascular transport have also been implicated in acquired hydrocephalus.<sup>[24,25]</sup> These observations broaden the pathophysiological discussion beyond macroscopic CSF obstruction, but they do not displace the Monro-Kellie doctrine or established pressure-management principles. The clinical value of glymphatic-directed monitoring or treatment remains investigational.

For neurosurgical research, the main implication is that pressure control and parenchymal transport may represent complementary targets rather than competing explanations. Experimental models suggest that the timing of AQP4 depolarization, sleep-wake state, vascular pulsatility, anesthesia, and blood-product clearance can modify transport after injury. These factors are rarely measured together in clinical cohorts. Future neurotrauma and SAH studies should therefore align imaging time points with intracranial pressure, edema, perfusion, neurological outcome, and treatment exposure before proposing glymphatic-specific interventions.

**Neuroimaging and DTI-ALPS**

The prominence of MRI-related nodes reflects the field’s transition from experimental tracer studies toward clinically applicable imaging. Intrathecal contrast-enhanced MRI has demonstrated delayed tracer clearance in iNPH, but its invasive nature limits routine application.<sup>[12,21]</sup> DTI-ALPS



**Figure 2.** Strategic thematic map of glymphatic research relevant to neurosurgery from 2015 through the first quarter of 2026. Author-keyword clusters are positioned according to centrality, representing thematic relevance, and density, representing thematic development. Traumatic brain injury, subarachnoid hemorrhage, and impairment constitute a motor theme. Magnetic resonance imaging and perivascular-space research form a relatively developed but less central niche theme. Glymphatic-system, brain, and cerebrospinal-fluid terms constitute a basic and transversal theme, whereas movement, depression, and secondary brain-injury terms appear as emerging or declining themes. The hydrocephalus, dementia, and idiopathic normal pressure hydrocephalus cluster occupies an intermediate position near the centrality-density boundary, reflecting its transitional role between established clinical relevance and thematic development.

was developed as a non-invasive diffusion-based approach and is calculated as a dimensionless ratio of directional diffusivity components in projection- and association-fiber regions at the level of the lateral ventricular body.<sup>[9,18]</sup>

$DTI-ALPSindex = \frac{\text{mean}(D_{xx,proj}, D_{xx,assoc})}{\text{mean}(D_{yy,proj}, D_{zz,assoc})}$

DTI-ALPS does not directly measure fluid flow or whole-brain glymphatic clearance. It reflects localized directional Brownian motion and is influenced by white-matter architecture, fiber orientation, crossing fibers, extracellular geometry, age, acquisition protocol, and the relative behavior of numerator and denominator diffusivity terms.<sup>[9,26,27]</sup> It is therefore more appropriately interpreted as a structure-dependent, spatially fixed-point diffusion biomarker of the local tissue environment. A lower index should be reported as a lower DTI-ALPS value rather than automatically labeled as glymphatic failure.

Longitudinal studies have reported changes in DTI-ALPS after tap testing or shunt surgery in iNPH.<sup>[10,19]</sup> These observations

are clinically promising, but they remain associations and do not prove that shunting restores glymphatic flow. Multimodal imaging, standardized acquisition, prespecified clinical outcomes, and prospective validation are required before DTI-ALPS can contribute to surgical indication or outcome prediction. Enlarged perivascular spaces likewise represent a morphological marker associated with small-vessel disease and cerebral amyloid angiopathy, but their meaning is heterogeneous and should not be reduced to a single clearance mechanism.<sup>[20]</sup>

The ratio structure of DTI-ALPS creates an additional interpretive challenge: an identical index may arise from different combinations of numerator and denominator diffusivity. Between-study comparisons can also be affected by scanner platform, acquisition plane, diffusion directions, echo time, head position, region-of-interest placement, and white-matter lesions. These sources of variation support reporting the constituent diffusivity values and technical protocol alongside the summary index. In multicenter

research, harmonization and test-retest assessment should precede the use of pooled thresholds.

DTI-ALPS may still be valuable when used as one component of a multimodal framework. Convergent assessment could include structural perivascular-space burden, free-water imaging, phase-contrast CSF measures, intrathecal tracer MRI in selected research settings, sleep and vascular variables, and longitudinal clinical outcomes. The key question is not whether a single index represents the entire glymphatic system, but whether a reproducible imaging panel provides incremental information beyond established clinical and radiological predictors.

### Hydrocephalus and Neurodegeneration

The chronic cluster links iNPH, Alzheimer's disease, dementia, and shunt-related management. This pattern reflects an active literature examining whether impaired perivascular transport contributes to overlapping cognitive and gait phenotypes. Tracer MRI studies have demonstrated delayed clearance in iNPH,<sup>[12,21]</sup> while mechanistic reviews describe possible convergence between hydrocephalus-related hydrodynamic disturbance and neurodegenerative protein accumulation.<sup>[25,28,29]</sup>

It has been hypothesized that CSF diversion may improve the pressure environment supporting perivascular exchange, and post-operative increases in DTI-ALPS have been reported.<sup>[10]</sup> However, the present co-word analysis cannot determine whether such imaging changes represent restored glymphatic transport, altered white-matter diffusivity, or both. DTI-ALPS and related measures may eventually complement clinical assessment, tap testing, and established imaging markers, but they should not currently be used as stand-alone criteria for shunt selection or for differentiating iNPH from primary neurodegeneration.

The overlap between iNPH and neurodegenerative disease is clinically important because both may present with cognitive impairment, gait dysfunction, ventriculomegaly, and white-matter change. A biomarker that merely correlates with disease severity may not distinguish reversible hydrodynamic dysfunction from irreversible neurodegeneration. Studies evaluating neurofluid markers should therefore include appropriate disease controls, standardized tap-test or infusion-test protocols, post-operative follow-up, and outcomes that separate gait, cognition, continence, and quality of life.

### Clinical and Research Implications

The network identifies three priorities for the next phase of the field. First, mechanistic studies should connect

molecular and perivascular observations to clinically measurable endpoints rather than relying on pathway terminology alone. Second, neuroimaging studies should prioritize reproducibility, transparent preprocessing, and external validation. Third, neurosurgical cohorts should test whether neurofluid markers improve decisions beyond established variables such as symptoms, ventricular morphology, intracranial pressure, CSF drainage response, age, comorbidity, and conventional MRI findings.

For clinical practice, the present results support awareness rather than immediate protocol change. Glymphatic concepts may offer plausible explanations for delayed injury, cognitive decline, and variable response to CSF diversion, but the evidence base is not yet sufficient to define treatment thresholds. The most defensible near-term application is the design of prospective studies in which imaging and biological markers are collected alongside standard neurosurgical assessments. This approach can determine incremental predictive value and reduce the risk of adopting a mechanistically attractive but insufficiently validated biomarker.

For bibliometric research, future analyses should integrate multiple databases, publish a prespecified thesaurus and complete preprocessing log, distinguish Author Keywords from database-generated terms, and conduct sensitivity analyses comparing unmerged and harmonized networks. Dynamic analyses should use complete calendar years or explicitly model partial-year data. These steps would improve reproducibility and clarify whether apparent thematic shifts reflect genuine scientific development or changes in indexing and terminology.

### Limitations and Future Directions

Several limitations require emphasis. First, this study used a single bibliographic database. This improves metadata consistency but may omit relevant records indexed elsewhere. Second, the co-word analysis was based on Author Keywords, which depend on authors' terminology and may underrepresent concepts that appear only in titles or abstracts. Keywords Plus were reported descriptively but were not included in the network. Third, only lower-case conversion, whitespace trimming, and exact-string deduplication were applied; semantic synonyms, plural forms, spacing variants, and hyphen variants were not merged. This preserves the original source vocabulary but fragments concept weight across related lexical nodes and may affect centrality estimates. Fourth, citation indicators favor older publications and do not fully capture the influence of recent studies.

Fifth, the 2026 records covered only the first quarter; therefore, the 2024–2026 thematic-evolution interval is descriptive, and no complete-period annual growth rate is reported. Finally, co-word networks quantify lexical association and the organization of a literature; they do not establish biological causality, diagnostic accuracy, treatment mechanisms, or clinical effectiveness. Mechanistic interpretations in this discussion are derived from cited experimental and clinical studies, not from network centrality itself.

Future research should use prospectively registered, multicenter imaging protocols; harmonized DTI acquisition and region-of-interest placement; multimodal measures of CSF and interstitial-fluid dynamics; and clinically meaningful endpoints. Such studies are necessary to determine whether DTI-ALPS, perivascular-space burden, or other neurofluid markers add value beyond established neurosurgical assessment.

## Conclusion

This bibliometric and co-word analysis maps the intellectual structure of glymphatic research relevant to neurosurgery. The literature is organized around acute injury and AQP4-related transport, clinical translation through MRI-based measures, and chronic hydrocephalus-neurodegeneration research. The findings document a growing research emphasis on perivascular and parenchymal transport that complements, rather than replaces, the Monroe-Kellie pressure-volume framework.

DTI-ALPS should be interpreted as a localized, structure-dependent diffusion biomarker, not as a direct measure of whole-brain glymphatic clearance. Its proposed roles in shunt selection, differential diagnosis, and outcome prediction remain hypotheses requiring prospective validation. The network is therefore best understood as a map of research priorities and conceptual relationships, not as evidence of causal mechanisms or established clinical protocols.

**Ethics Committee Approval:** This bibliometric study used published bibliographic metadata and did not involve human participants, animals, or identifiable private information; ethics committee approval was not required. This bibliometric and science-mapping study was based exclusively on published bibliographic metadata retrieved from the Web of Science Core Collection. It did not involve human participants, animals, clinical interventions, biological materials, identifiable personal data, patient records, or sensitive private information. Therefore, ethics committee approval and informed consent were not required.

**Informed Consent:** Not applicable. This study is a bibliometric analysis based on publicly available secondary data and did not involve human participants.

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**Data Availability:** The complete search strategy and analytical procedures are reported in the manuscript. The bibliographic dataset may be shared by the corresponding author subject to Clarivate licensing conditions. The bibliographic metadata analyzed in this study were retrieved from the Web of Science Core Collection. Derived bibliometric outputs and analytical matrices are available from the corresponding author upon reasonable request, subject to Clarivate licensing conditions.

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**Appendix 1.** Author keyword preprocessing rules, standardization procedures, retained lexical variants, and representative examples

| Processing domain        | Rule                                 | Implementation/implication                                                           |
|--------------------------|--------------------------------------|--------------------------------------------------------------------------------------|
| Source field             | Author keywords (DE) only            | Keywords plus (ID) were excluded from the co-word matrix.                            |
| Case normalization       | Converted to lower case              | Applied before network construction.                                                 |
| Whitespace               | Leading and trailing spaces removed  | Internal spacing variants were not harmonized.                                       |
| Exact duplicates         | Exact duplicate strings standardized | Only identical post-normalization strings were consolidated.                         |
| Semantic synonyms        | Not merged                           | A prespecified semantic thesaurus was not used.                                      |
| Singular/plural variants | Not merged                           | Variants remained separate lexical nodes.                                            |
| Hyphen variants          | Not merged                           | Example: normal-pressure hydrocephalus vs normal pressure hydrocephalus.             |
| Post hoc harmonization   | Not undertaken                       | Avoided alteration of reported topology after analysis.                              |
| Interpretation           | Lexical-node level                   | Centrality values represent displayed terms, not fully harmonized clinical concepts. |

**Appendix 2.** The 10 most productive sources in glymphatic research relevant to neurosurgery, including publication counts and Bradford core-zone classification

| Rank | Source journal                 | Article count | Cumulative count | Bradford zone |
|------|--------------------------------|---------------|------------------|---------------|
| 1    | Frontiers in Neurology         | 13            | 13               | Zone 1        |
| 2    | Fluids and barriers of the CNS | 12            | 25               | Zone 1        |
| 3    | Neurology                      | 11            | 36               | Zone 1        |
| 4    | Journal of Neurotrauma         | 10            | 46               | Zone 1        |
| 5    | Experimental Neurology         | 7             | 53               | Zone 1        |
| 6    | Scientific Reports             | 7             | 60               | Zone 1        |
| 7    | Stroke                         | 7             | 67               | Zone 1        |
| 8    | World Neurosurgery             | 7             | 74               | Zone 1        |
| 9    | Frontiers in Neuroscience      | 6             | 80               | Zone 1        |
| 10   | Brain Communications           | 5             | 85               | Zone 1        |

The top 10 sources accounted for 85 records (26.81% of the dataset). CNS: Central nervous system

**Appendix 3.** The 10 most productive authors, including total publications and fractionalized authorship scores

| Rank | Author     | Total articles | Fractionalized articles |
|------|------------|----------------|-------------------------|
| 1    | Eide       | 13             | 4.15                    |
| 2    | Ringstad   | 12             | 3.15                    |
| 3    | Li         | 8              | 0.91                    |
| 4    | Nedergaard | 8              | 1.54                    |
| 5    | Jiang      | 6              | 0.46                    |
| 6    | Werring    | 6              | 0.6                     |
| 7    | Xia        | 6              | 0.79                    |
| 8    | Zhang      | 6              | 0.54                    |
| 9    | Dong       | 5              | 0.37                    |
| 10   | Greenberg  | 5              | 0.43                    |

Fractionalized article counts account for the number of co-authors per document.

**Appendices note:** The supplementary tables contain descriptive bibliometric outputs and preprocessing documentation. They do not introduce additional patient-level data, inferential analyses, or clinical-effect estimates beyond those reported in the main manuscript.

## INVITED REVIEW

# Sarcopenia: The Emerging Geriatric Syndrome of the 21<sup>st</sup> Century

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## Abstract

Sarcopenia is a progressive generalized disorder of skeletal muscle defined by declines in muscle mass, strength, and function, resulting in increased risk of falls, fractures, disability, dependency, reduced quality of life, and mortality. It primarily affects older adults, with prevalence rising with age, but can also develop secondary to chronic diseases, prolonged immobilization, malnutrition, or systemic inflammatory conditions. Early identification is crucial, as sarcopenia is a preventable and potentially reversible condition when appropriate interventions are implemented. Diagnosis involves sequential assessment of muscle strength, quantity, and physical performance, with the European Working Group on Sarcopenia in Older People<sup>2</sup> recommending the find–assess–confirm–severity approach to ensure standardized evaluation across clinical and research settings. Lifestyle-based interventions remain the cornerstone of management, including resistance and aerobic exercise, adequate protein intake, Vitamin D supplementation, and high-quality dietary patterns. Nutritional supplements, including leucine,  $\beta$ -hydroxy- $\beta$ -methylbutyric acid, and omega-3 fatty acids, provide additional support. Pharmacological options are limited, with testosterone demonstrating benefits in deficiency states, and emerging agents such as a mas receptor agonist, BIO101, showing potential as future therapeutic interventions. Given its multifactorial pathophysiology – including hormonal changes, chronic inflammation, neuromuscular decline, and lifestyle-related factors – effective sarcopenia management requires a comprehensive, multi-targeted approach addressing both lifestyle and underlying mechanisms.

**Keywords:** Geriatrics; Muscle strength; Older adults; Sarcopenia

The human body contains over 600 skeletal muscles, which constitute a major proportion (45–55%) of total body mass, and the majority of them are located in the lower extremities. With advancing age, both the size and function of these muscles undergo substantial changes.

<sup>[1]</sup> Sarcopenia is a generalized skeletal muscle disorder defined by progressive decline in muscle mass and function and related to increased risk of negative outcomes such as falls, fractures, functional loss, and mortality.<sup>[2]</sup> Sarcopenia

is predominantly associated with aging but may also develop secondary to chronic conditions such as prolonged immobilization or systemic inflammatory diseases.<sup>[3,4]</sup>

## Why it is Important

Sarcopenia imposes substantial individual, social, and financial burdens if left untreated. Clinically, it increases the risk of falls, bone fractures, mobility disorders, and disability in activities of daily living, and is associated with

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cardiovascular, respiratory, and cognitive impairments. These consequences lead to reduced quality of life, dependency, institutionalization, and increased mortality. Sarcopenia leads to significantly higher healthcare expenditures, as affected individuals experience higher rates of hospitalization and markedly greater inpatient costs. Early recognition is crucial, as sarcopenia is a preventable and potentially reversible condition when appropriate intervention strategies are implemented.<sup>[2]</sup>

## Sarcopenia is a Geriatric Syndrome

Geriatric syndromes are characterized by complex, multifactorial conditions that arise from interactions between genetic, environmental, and physiological factors, and do not fit neatly into traditional disease categories. They are frequent in older adults and are associated with multiple comorbidities, disability, and diminished quality of life.

Sarcopenia meets the main criteria of a geriatric syndrome:

- It is highly prevalent, affecting about 30% of individuals over 65 and more than 50% over 80 years of age
- It results from multiple contributing factors, including aging, genetics, lifestyle, environmental influences, and chronic diseases
- It is related to functional decline, disability, poor life quality, and death
- Managing individual risk factors alone does not reverse its clinical manifestations.

Therefore, sarcopenia represents a multifactorial condition reflecting vulnerability due to impairments in multiple systems, fitting the definition of a geriatric syndrome rather than a single disease entity. Considering sarcopenia as a geriatric syndrome facilitates its recognition and the assessment of associated risk factors.<sup>[1]</sup>

This review aims to provide a comprehensive and up-to-date overview of sarcopenia as an emerging geriatric syndrome, focusing on its definition, epidemiology, pathophysiology, diagnostic approaches, management strategies, and preventive interventions, based on current evidence from the literature.

The literature search was conducted using the PubMed database. Articles were identified using the keywords "sarcopenia," "older," and "elderly," along with related terms such as "grip strength," "gait speed," "frailty," and "geriatric syndrome." In addition, reference lists of relevant articles were manually screened to identify further eligible studies. The search included studies published between 1997 and 2025. Original articles and review papers addressing

the definition, epidemiology, pathophysiology, diagnosis, management, and prevention of sarcopenia in older adults were considered. Only studies published in English and involving human subjects were included. Articles not directly related to the topic or based on animal models were excluded.

## Definition

Sarcopenia was initially used to describe low muscle mass. "Sarx" means muscle, and "penia" means loss in Greek.<sup>[5]</sup> The concept of sarcopenia has evolved over time, first with the inclusion of muscle function – shown to better predict clinical outcomes than muscle mass – and later with its formal recognition as an independent disease through the assignment of an International Classification of Diseases, Tenth Revision, Clinical Modification code (M62.84) in 2016.<sup>[6]</sup> Moreover, with the implementation of the 11<sup>th</sup> revision of the ICD in 2022, the diagnostic code for sarcopenia was updated to FB32.Y.<sup>[3]</sup>

The European Union Geriatric Medicine Society (EUGMS) established a Sarcopenia Working Group in 2009 with the aim of developing standardized definitions and diagnostic criteria applicable to both clinical and research.<sup>[7]</sup> In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) offered a definition of sarcopenia that gained global acceptance and significantly contributed to progress in the recognition and management of individuals at risk for, or affected by, the condition.<sup>[7]</sup> The EWGSOP advised that sarcopenia should be diagnosed by the concurrent presence of reduced muscle mass and impaired muscle function, either in terms of strength or physical performance.<sup>[7]</sup>

The EWGSOP was most recently updated in 2019 and identified reduced muscle strength as the principal criterion for sarcopenia,<sup>[2]</sup> as declines in strength were reported to precede reductions in mass and serve as stronger predictors of adverse outcomes.<sup>[8]</sup> Nevertheless, reduced muscle mass remains an essential criterion that supports the diagnosis of sarcopenia. A further revision was made in which the concept of muscle mass was refined and replaced by muscle quantity or quality to better capture the multifaceted nature of sarcopenia. Recent evidence indicates that, beyond alterations in muscle mass, various factors contributing to muscle quality – such as composition, fatty or fibrotic changes, metabolism, and aerobic performance – may also play a critical role in the reduction of muscle function. Notably, deterioration in muscle quality may occur before the decline in muscle

**Table 1.** 2019 EWGSOP2 definition of sarcopenia<sup>[2]</sup>

|                                                               |
|---------------------------------------------------------------|
| 1. Reduced muscle strength                                    |
| 2. Reduced muscle quantity or quality                         |
| 3. Reduced physical performance                               |
| (1)=probable sarcopenia                                       |
| (1)+(2) = confirmed sarcopenia                                |
| (1)+(2)+(3) = severe sarcopenia                               |
| EWGSOP: European Working Group on Sarcopenia in Older People. |

mass. For this reason, early detection of muscle quality is important, particularly among middle-aged adults who may benefit from timely interventions aimed at preserving or enhancing muscle function.<sup>[9]</sup> With ongoing advancements in the assessment of muscle quality, this measure is expected to assume a more prominent role in defining sarcopenia.<sup>[2]</sup>

According to the EWGSOP2 criteria, reduced muscle strength represents “probable sarcopenia” (Table 1). A definite diagnosis requires confirmation of reduced muscle quantity or quality with various methods. When both of these criteria are present, the condition is defined as “confirmed sarcopenia.” With the additional presence of reduced physical performance, it is classified as “severe sarcopenia.”<sup>[2]</sup> In the 2010 EWGSOP criteria, physical performance was considered a defining component of sarcopenia.<sup>[7]</sup> After the 2019 revision, it was reclassified as a marker of the disease’s severity.

Because of the lack of a universally accepted definition of sarcopenia, an international initiative called global leadership initiative in sarcopenia (GLIS) was established to standardize the terminology commonly used in sarcopenia, for both clinical practice and research purposes. The initiative brings together leading investigators in the field to develop a single, globally applicable definition of sarcopenia. As a first step, GLIS aims to create a common glossary of terms that will provide consensus on the universal definition and support consistent interpretation of clinical and research findings.<sup>[4,10]</sup>

According to the GLIS committee, sarcopenia is recognized as a generalized disorder of skeletal muscle, and its prevalence increases progressively with advancing age. Experts largely agree that the conceptual definition of sarcopenia should remain consistent across different healthcare settings, such as inpatient and outpatient environments, and should not differ based on age or comorbid conditions. Moreover, it is widely accepted that the definition should be unified for both clinical practice and research purposes. Importantly, sarcopenia

is viewed as a condition that holds the potential to be reversible with appropriate interventions. There is strong consensus that muscle strength, muscle mass, and muscle-specific strength – such as the ratio of muscle strength to muscle size – are the key components of sarcopenia. Finally, sarcopenia leads to multiple adverse outcomes, such as poor physical performance, mobility limitations, falls, fractures, loss of independence in daily activities, increased hospitalizations, new admissions to long-term or nursing care facilities, poorer quality of life, and higher mortality risk. Impaired physical performance is considered an outcome of sarcopenia rather than a defining component.<sup>[11]</sup>

Epidemiology

Sarcopenia affects 10–27% of adults over 60 years<sup>[12]</sup> and nearly 30% of those over 80 years.<sup>[13]</sup> Severe sarcopenia was reported in 2–9% of individuals. Based on EWGSOP2, men had a higher prevalence of sarcopenia (11% vs. 2%).<sup>[12]</sup> Prevalence is expected to rise in Europe due to increased life expectancy.<sup>[13]</sup> Obesity and decreased physical activity exacerbate this trend, leading to sarcopenic obesity (SO). Sarcopenia may also develop before age 60 in patients with cancer, metabolic disorders, renal or liver disease, or rheumatologic conditions, and serves as a prognostic marker. Reducing the prevalence of sarcopenia may substantially lower healthcare expenditures. Exact estimation of the prevalence is challenging due to differences in diagnostic criteria, age of study population, clinical settings, and assessment methods.<sup>[13]</sup>

Pathophysiology

The pathophysiology underlying sarcopenia is incompletely understood. Both intrinsic and systemic factors contribute to the structural and functional decline of muscle tissue.<sup>[3]</sup> In affected individuals, multiple pathways may act concurrently, and their contributions can vary throughout the disease course. Identifying these mechanisms is crucial for the development of targeted intervention strategies.<sup>[7]</sup> Primary alterations underlying sarcopenia involve an imbalance in muscle protein synthesis and breakdown, fatty infiltration, impaired neuromuscular function, changes in the satellite cells, mitochondrial dysfunction, chronic systemic low-grade inflammation, hormonal changes (decrease in sex hormones, growth hormone, and insulin-like growth factor-1 [IGF-1]), activation of the classical renin-angiotensin system (RAS) pathway, microRNAs, dysbiosis, anorexia of aging, and physical inactivity.<sup>[3]</sup>

## Case Finding and Diagnosis

### Case Finding

As current screening tools lack sufficient accuracy, universal screening is not recommended for sarcopenia.<sup>[14]</sup> EWGSOP2 recommends a case finding strategy rather than screening. Sarcopenia should be considered when patients exhibit symptoms suggestive of sarcopenia, such as falls, generalized weakness, slowness, or unintentional weight/muscle loss. In these situations, further diagnostic evaluation for sarcopenia is advised.<sup>[2]</sup>

The application of the SARC-F questionnaire as a patient-reported screening instrument is recommended to recognize individuals susceptible to sarcopenia. It has been validated in multiple populations, demonstrating reliability and consistency for identifying individuals at risk of sarcopenia-related adverse outcomes. SARC-F exhibits low-to-moderate sensitivity but very high specificity, primarily detecting more severe cases. It is inexpensive, convenient, and suitable for use in community and clinical settings, reflecting patient-perceived limitations that are meaningful for care.<sup>[2]</sup> SARC-F is an acronym that stands for five components whose first letters are highlighted in the following way – strength, need for walking assistance, ability to rise from a chair, stair climbing, and falls – selected to reflect functional decline associated with sarcopenia. Scores range from 0 to 10 (0–2 per item), with higher scores indicating greater impairment, and are commonly categorized into symptomatic ( $\geq 4$ ) versus non-symptomatic (0–3) status. The scores  $\geq 4$  were associated with more instrumental activities of daily living deficits, lower grip strength, slower chair-stand times, reduced physical performance, slower gait, higher hospitalization risk, and higher mortality.<sup>[15]</sup>

### Diagnosis

The assessment of sarcopenia typically involves measuring muscle strength, mass, and physical function. Although definitions generally include two or more of these indicators, variability in threshold values complicates standardization and clinical application. The EWGSOP2 proposes a structured, sequential approach to improve diagnosis.<sup>[2,14]</sup>

### Measurement of Muscle Strength

Measurement of handgrip strength is recommended as a practical, quick, and cost-effective method for evaluating muscle function. It is validated and reliable in older adults.<sup>[16]</sup> Reduced grip strength has been consistently shown to predict adverse clinical outcomes, including prolonged hospitalization, functional decline, diminished quality of

**Table 2.** Sarcopenia cut-off values according to EWGSOP2<sup>[2]</sup>

|                            | Men                    | Women                  |
|----------------------------|------------------------|------------------------|
| Muscle strength            |                        |                        |
| Grip strength (kg)         | <27                    | <16                    |
| Chair stand                | >15 s for five rises   |                        |
| Muscle quantity (DXA, BIA) |                        |                        |
| ASM                        | <20 kg                 | <15 kg                 |
| ASM/height <sup>2</sup>    | <7.0 kg/m <sup>2</sup> | <5.5 kg/m <sup>2</sup> |
| Physical performance       |                        |                        |
| 4-m walking speed          | $\leq 0.8$ m/s         |                        |
| TUG test                   | $\geq 20$ s            |                        |

EWGSOP: European Working Group on Sarcopenia in Older People; DXA: Dual-energy X-ray absorptiometry; BIA: Bioelectrical impedance analysis; ASM: Appendicular skeletal muscle mass; TUG: Timed-up and go.

life, and increased mortality. Accurate assessment requires a calibrated handheld dynamometer and standardized testing procedures, along with reference values derived from appropriate populations. According to the EWGSOP2 criteria, cut-off values for grip strength are <27 kg for men and <16 kg for women (Table 2).<sup>[2]</sup> If grip strength is under the reference thresholds for sex or those defined by consensus guidelines, sarcopenia should be considered as a potential diagnosis. Early recognition of diminished grip strength is clinically important, as it serves as a strong predictor of multiple adverse health outcomes.<sup>[8,14,17]</sup>

Grip strength demonstrates a moderate correlation with strength in other muscle groups and thus serves as a useful proxy for overall muscle strength. In cases where grip assessment is not feasible due to hand impairments (e.g., severe arthritis, neurologic conditions), isometric torque measurements of the lower limbs can be applied as substitutes. The chair stand test – also referred to as the chair rise test – provides an indirect estimate of lower-limb muscle strength, particularly of the quadriceps. It involves measuring the time taken to rise from a seated position five consecutive times without arm support, or alternatively, counting repetitions within a 30-s interval.<sup>[2,18]</sup> According to EWGSOP2, a time >15 s for five chair rises indicates low muscle strength (Table 2).

### Measurement of Muscle Quantity

After detecting reduced muscle strength, the second step is evaluation of the muscle quantity to confirm the diagnosis of sarcopenia. Various methods have been employed to assess muscle mass; however, each presents significant limitations, such as variability in measurements, inconsistency in the application of cut-off values, and a weak correlation between muscle mass and adverse clinical outcomes.<sup>[14]</sup>

## Magnetic Resonance Imaging (MRI) and Computed Tomography (CT)

MRI and CT are regarded as the gold-standard modalities for the non-invasive evaluation of muscle quantity. Nevertheless, their application in primary care settings is limited due to factors such as higher costs, restricted portability, and the need for specialized personnel to operate the devices. In addition, standardized threshold values for defining reduced muscle mass using the mentioned imaging modalities have not yet been clearly established.<sup>[2]</sup> MRI and CT are primarily reserved for research purposes or for the monitoring of other medical conditions, such as in patients undergoing cancer evaluation or treatment.<sup>[14]</sup> Lumbar L3 cross-sectional area, mid-thigh muscle area, and psoas muscle measurements are commonly used as imaging-based proxies to estimate total body muscle composition.<sup>[2]</sup>

## Dual-energy X-ray Absorptiometry (DXA)

Among the available approaches, DXA remains the most reliable modality for estimating lean body mass.<sup>[14]</sup> It is an extensively used, non-invasive technique for assessing muscle quantity, reported as either total body lean tissue mass or appendicular skeletal muscle mass (ASM). On the other hand, measurements may vary across different DXA device brands. A notable limitation of DXA is its lack of portability for community-based use, and its measurements can be influenced by the individual's hydration level. Despite these limitations, DXA remains a preferred method among clinicians and researchers due to its ability to provide rapid and reproducible estimates of ASM when the same instrument and cut-off values are applied.<sup>[2]</sup>

## Bioelectrical Impedance Analysis (BIA)

BIA provides an indirect estimation of muscle mass by assessing total body electrical conductivity and applying population-specific prediction equations calibrated against DXA-measured lean mass. Although BIA is affordable, portable, and widely available, its accuracy varies across devices, reference populations, and hydration states. While BIA offers practical advantages over DXA, its precision is restricted by the population- and device-specific nature of predictive equations and cut-off thresholds, as well as the absence of standardization. Further validation of prediction models in diverse populations is required.<sup>[2,14]</sup>

## Ultrasound

Since 2018, ultrasound has been suggested as a practical and accessible method for assessing muscle mass in clinical

settings. However, the technique remains non-standardized and currently lacks validated cut-off points.<sup>[14]</sup> It allows bedside evaluation of muscle morphology by trained clinicians, demonstrating high intra- and inter-observer reliability. Measurements of muscle thickness and cross-sectional area, particularly in pennate muscles, for example, quadriceps femoris, can identify early changes in muscle mass, supporting its clinical applicability.<sup>[2]</sup> The EuGMS sarcopenia group<sup>[19]</sup> has recommended a consensus protocol standardizing ultrasound parameters, including muscle thickness, cross-sectional area, fascicle length, pennation angle, and echogenicity. Ultrasound is a valid technique and comparable to DXA, MRI, and CT for estimating muscle mass. However, further research is required to refine prediction equations across diverse clinical and functional populations.<sup>[20]</sup>

The widespread implementation of sarcopenia assessment is constrained by limited access to DXA, BIA, and ultrasound, as these techniques are not available in all healthcare centers. Cost, infrastructure requirements, and the need for trained personnel further limit their routine use, particularly in primary care settings. Consequently, simpler and more widely applicable screening tools, such as handgrip strength and calf circumference measurements, are often preferred in routine clinical practice.

Because muscle mass is correlated with body size, skeletal muscle mass (SMM) or ASM is often adjusted using indices such as weight (ASM/weight), height<sup>2</sup> (ASM/height<sup>2</sup>), or body mass index (ASM/BMI). Although no universal recommendation exists regarding which adjustment should be applied, normalization may be appropriate when reference data from relevant populations are available. Height-adjusted values (ASM/height<sup>2</sup>) are most commonly used to establish diagnostic cut-offs. However, variability among studies in defining these cut-off points has resulted in inconsistent thresholds and challenges in standardizing sarcopenia diagnosis. Therefore, in its updated definition, the EWGSOP chose a practical strategy by selecting straightforward and easily applicable cut-off values based on the best available evidence (Table 2).<sup>[2,14]</sup>

## Anthropometry

Anthropometric measures are not good indicators of muscle mass. Nevertheless, calf circumference has been identified as an indicator of physical performance and survival in this population, with a proposed cut-off value of <31 cm.<sup>[21]</sup> Different cut-off values are present according to sex and ethnicity. In clinical settings where direct assessment of muscle mass is not feasible, calf

circumference may serve as a practical surrogate marker for sarcopenia screening in older adults.<sup>[2]</sup>

### **Creatine Dilution**

It is possible to estimate total body muscle mass using creatinine excretion rate. In the creatine dilution test, a fasting individual ingests a deuterium-labeled creatine (D3-creatine) tracer, and subsequent measurements of labeled and unlabeled creatine/creatinine in urine allow calculation of total body creatine and muscle mass. This method correlates well with MRI and moderately with BIA and DXA. Currently, the test is primarily used in research, and further development is needed for routine clinical application.<sup>[2]</sup>

### **Muscle Quality Measurement**

Muscle quality may be a more clinically relevant indicator of sarcopenia than muscle mass; however, it has not yet been adequately defined for routine use in clinical settings.<sup>[14]</sup> Ultrasound echogenicity is used as an indicator of muscle quality due to its correlation with myosteatosis. In research settings, advanced imaging modalities such as MRI and CT have been employed to evaluate muscle quality, for example, by assessing intramuscular fat infiltration. Other approaches include calculating the ratio of muscle strength to ASM or muscle volume and using BIA-derived phase angle measurements. Currently, no standardized method exists for routine practice, yet muscle quality evaluation is expected to become a standard part of treatment decision-making and follow-up.<sup>[2]</sup>

### **Assessment of Physical Performance**

Physical performance in older adults can be evaluated using various tests, including gait speed, the short physical performance battery (SPPB), the timed-up-and-go (TUG) test, and the 400-m walk test. Among these, gait speed (mostly 4-m walking speed) is a quick, safe, and reliable measure. EWGSOP2 recommends a gait speed cut-off of  $\leq 0.8$  m/s to indicate severe sarcopenia.<sup>[2]</sup> Gait speed is preferred for routine sarcopenia assessment due to its convenience and predictive value for adverse outcomes such as disability, falls, cognitive decline, institutionalization, and mortality.<sup>[22]</sup> The SPPB, TUG, and 400-m walk tests also predict adverse outcomes but are more often used in research or specialized settings due to longer administration time or space requirements.

<sup>[2]</sup> Limitations can be faced in patients with cognitive impairment, gait disorders, or balance problems. Cut-off values of commonly used parameters are listed in Table 2.

## **Ethnic Variability and Population-based Cut-off Values for Sarcopenia in the Turkish Population**

Ethnic variability is an important consideration in the interpretation of sarcopenia-related cut-off values, as muscle strength, muscle mass, and physical performance are influenced by anthropometric characteristics, genetic background, lifestyle, and environmental factors. Cut-off values derived from Western populations may not be directly applicable to Asian or Middle Eastern populations, leading to potential misclassification. The higher cut-off values proposed by AWGS 2019 compared with EWGSOP2 emphasize the role of ethnic variability in defining diagnostic criteria. According to the AWGS 2019 criteria, low muscle strength is defined as handgrip strength  $< 28$  kg in men and  $< 18$  kg in women, while low physical performance is identified by a 6-m gait speed  $< 1.0$  m/s, an SPPB score  $\leq 9$ , or a 5-time chair stand test  $\geq 12$  s. ASM/height<sup>2</sup> cut-offs  $< 7.0$  kg/m<sup>2</sup> in men and  $< 5.4$  kg/m<sup>2</sup> in women by DXA;  $< 7.0$  kg/m<sup>2</sup> in men and  $< 5.7$  kg/m<sup>2</sup> in women by BIA, and calf circumference  $< 34$  cm in men and  $< 33$  cm in women.<sup>[23]</sup>

At present, there are no nationally established consensus cut-off values for the diagnosis of sarcopenia in the Turkish population, and population-based studies have reported varying threshold values. In a community-dwelling older population, the cut-off thresholds for SMM index (SMMI) were 9.2 kg/m<sup>2</sup> for men and 7.4 kg/m<sup>2</sup> for women by BIA. Corresponding handgrip strength cut-off values were 32 kg for men and 22 kg for women, while a calf circumference threshold of 33 cm was applied for both sexes.<sup>[24]</sup> In another population-based study including 1,150 older adults, the SMMI cut-off values were defined as 8.33 kg/m<sup>2</sup> for men and 5.70 kg/m<sup>2</sup> for women by BIA. In the same study, handgrip strength thresholds were determined as 28 kg for men and 14 kg for women, based on measurements obtained from a healthy young adult reference population.<sup>[25]</sup>

The EWGSOP2 proposes a practical diagnostic pathway for sarcopenia, known as the find–assess–confirm–severity strategy.<sup>[2]</sup> It is recommended for use in both clinical practice and research.

- 1) Find: Identify individuals susceptible to sarcopenia according to the SARC-F questionnaire or according to clinical suspicion
- 2) Assess: Evaluate muscle strength using the grip strength or chair stand test
- 3) Confirm: Confirm the diagnosis by measuring low muscle quantity and quality using DXA, BIA, CT, and MRI

**Table 3.** Classification of sarcopenia<sup>[2,7,14]</sup>

|                                                                   |
|-------------------------------------------------------------------|
| Primary=Age-related                                               |
| Secondary                                                         |
| Nutritional                                                       |
| Low protein or energy intake                                      |
| Micronutrient deficiency                                          |
| Malabsorption                                                     |
| Drug-related anorexia or anorexia of aging                        |
| Obesity                                                           |
| Inactivity                                                        |
| Bed rest or immobility                                            |
| Sedentary lifestyle                                               |
| Disease-associated                                                |
| Inflammatory conditions (e.g. malignancy, advanced organ failure) |
| Endocrine diseases (androgen deficiency)                          |
| Neurological disorders                                            |
| Bone and joint diseases                                           |

4) Severity: Determine the severity of sarcopenia by assessing physical performance (e.g., gait speed or the TUG test).

**Classification of Sarcopenia**

After diagnosis of sarcopenia, it is crucial to identify the mechanism underlying the condition. Common causes of sarcopenia are listed in Table 3.

**Sarcopenia-Like Conditions**

**SO**

SO refers to the coexistence of sarcopenia and obesity.<sup>[26]</sup> SO is predominantly observed in older adults. The presence of obesity accelerates the progression of sarcopenia, promotes intramuscular fat infiltration, impairs physical function, and increases the risk of mortality.<sup>[2]</sup> The risk of mortality and functional decline may increase with the loss of SMM in individuals with obesity, particularly during periods of weight loss.<sup>[14]</sup>

Evaluation of SO involves two main levels: screening and diagnosis, followed by staging to determine disease severity. SO screening is based on the simultaneous presence of increased BMI or waist circumference and risk of sarcopenia. A confirmed diagnosis requires abnormalities in both skeletal muscle function and body composition. After diagnosis, two stages of SO are defined. Stage I: No complications linked to altered muscle or fat composition. Stage II: Existence of one or more complications, such as

metabolic disorders, functional disability, or cardiovascular/respiratory diseases. SO is thus a multifactorial condition requiring combined functional and compositional assessment for correct diagnosis and management.<sup>[26]</sup>

**Dynapenia**

Dynapenia is defined as the age-related decline in muscle strength.<sup>[27]</sup> It is measured with handgrip strength, and a value <16 kg for women, <27 kg for men indicates dynapenia.

**Frailty**

Frailty is a clinical condition characterized by heightened vulnerability to increased dependency and/or mortality when an individual faces stressors. It may develop as a consequence of various diseases or medical conditions.<sup>[28]</sup> According to Fried et al.,<sup>[29]</sup> is a clinical syndrome defined by the presence of ≥3 of the following five criteria: unintentional weight loss, exhaustion, reduced physical activity, slowness, and weakness. Its physical phenotype overlaps with sarcopenia, sharing features such as reduced handgrip strength, slower walking, and weight loss, which also contribute to sarcopenia. Treatment strategies for both conditions, including optimal protein intake, vitamin D supplementation, and physical exercise, are similar. Nevertheless, frailty represents a broader concept encompassing multiple physiological systems, whereas sarcopenia is a specific skeletal muscle disease.<sup>[2]</sup>

**Treatment of Sarcopenia**

The management of sarcopenia is mainly based on non-pharmacologic strategies. There is no known pharmacologic therapy specifically approved for sarcopenia. Due to the complex underlying pathophysiology, developing an effective treatment for sarcopenia remains challenging. Multiple therapeutic modalities have been investigated for the treatment of sarcopenia. Among them, the only treatment options shown to be beneficial are Vitamin D supplementation, exercise, and adequate nutrition.<sup>[3]</sup> In addition, testosterone supplementation has been shown to have potential benefits on muscle tissue in men with testosterone deficiency.<sup>[30]</sup>

Nutritional approaches, including adequate calorie, protein, and micronutrient intake, are important for optimal muscle function. European Society for Clinical Nutrition and Metabolism guidelines recommend a daily protein consumption of 1.0–1.2 g/kg body weight (BW) to preserve muscle health in older adults. Protein requirements increase to 1.2–1.5 g/kg BW during the state of acute or chronic illness and may reach up to 2.0 g/kg BW critical

illness or malnutrition states.<sup>[31]</sup> If combined with resistance exercise, whey protein, particularly doses above 20 g per meal, effectively stimulates muscle protein synthesis.<sup>[13]</sup>

Leucine, one of the essential amino acids, is fundamental for the triggering of muscle protein synthesis. Leucine-rich protein supplements support lean body mass, but supplementation alone without exercise is insufficient.  $\beta$ -hydroxy- $\beta$ -methylbutyric acid (HMB) is a metabolite of leucine, and HMB supplementation (3 g/day) has been demonstrated to improve muscle strength and body composition in older adults, particularly in untrained or immobilized individuals.<sup>[32]</sup>

Evidence suggests that Vitamin D supplementation improves muscle strength and physical performance, particularly in women with vitamin D deficiency (<25 nmol/l).<sup>[30]</sup> Vitamin D supplementation is also associated with decreased mortality in older adults.<sup>[33]</sup> Omega-3 (n3-PUFA) supplementation may also improve muscle mass, volume, strength, and physical performance, particularly at higher doses (>2 g/day).

Other nutrients, including selenium, magnesium, inorganic nitrate, Vitamin C and E, calcium, probiotics, collagen, and polyphenols, have been investigated for their potential effects on muscle performance and physical activity in older adults.<sup>[3,32]</sup> In a cross-sectional study, low magnesium levels were found to be associated with dynapenia in malnourished older women even after adjusting for nutritional status.<sup>[34]</sup>

Physical exercise, particularly resistance training, is a highly effective approach to improve muscle mass and function. Aerobic exercise is beneficial not only for muscle mass and function but also for endurance and cardiovascular health,<sup>[3]</sup> with an additional protective role against mitochondrial dysfunction.<sup>[35]</sup> Beyond stimulating muscle protein synthesis, exercise also enhances the effects of nutritional interventions.<sup>[13]</sup> A combined exercise program, including resistance and aerobic training, is the best strategy to counteract sarcopenia.<sup>[35]</sup>

High-quality dietary patterns, for example, the Mediterranean and Nordic diets, have been shown to improve muscle strength and reduce sarcopenia risk, likely due to their antioxidant and anti-inflammatory properties. Nutrient timing is crucial for optimizing dietary effects in sarcopenia. The circadian clock regulates metabolic processes, and an early breakfast modulates peripheral clock genes that enhance glucose metabolism and muscle protein synthesis. Disruptions in clock-gene expression increase the risk of obesity and sarcopenia. Similarly, late-afternoon resistance exercise influences the circadian rhythm of anabolic and

catabolic hormones. It alternates the testosterone to cortisol balance and promotes skeletal muscle protein synthesis.<sup>[13]</sup>

Various pharmacological agents have been investigated for treatment of sarcopenia, including testosterone, selective androgen receptor modulators, selective estrogen receptor modulators, dehydroepiandrosterone, growth hormone, IGF-1, insulin, anti-diabetic drugs, ghrelin and ghrelin receptor agonists, myostatin and activin II receptor inhibitors, RAS inhibitors, mas receptor agonists, mechanistic target of rapamycin inhibitors, espendolol, indoxyl sulfate, fast skeletal muscle troponin activators, elamipretide, and anti-tumor necrosis factor drugs. Among these agents, none have demonstrated efficacy in sarcopenia, except for testosterone in patients with testosterone deficiency. In addition, a mas receptor agonist, BIO101, is considered a leading candidate with the potential to become the first approved therapeutic agent for the treatment of sarcopenia.<sup>[3]</sup>

Despite continued research on sarcopenia management, the most effective strategies for prevention and treatment remain lifestyle interventions. Due to the complex and multifactorial nature of the disease, focusing on a single causative mechanism is unlikely to be effective, and multi-targeted interventions may be required.<sup>[3]</sup>

In routine clinical practice, adherence to exercise programs and difficulties in accessing adequate amounts of high-quality dietary protein represent major barriers to the implementation of sarcopenia prevention and management strategies. Older age, comorbidities, functional limitations, lack of motivation, and limited access to supervised exercise facilities have been shown to negatively affect long-term compliance with exercise interventions.<sup>[2,36,37]</sup> Socioeconomic constraints, food insecurity, and limited availability of protein-rich foods may prevent older adults from meeting recommended protein intake levels, particularly in community-dwelling and resource-limited settings.<sup>[2,38]</sup> These barriers may compromise the effectiveness of combined exercise and nutritional interventions and should be considered when translating evidence-based recommendations into routine clinical practice.

## Conclusion

Sarcopenia is a multifactorial geriatric syndrome with significant clinical, social, and economic consequences. Early identification and intervention are essential to prevent adverse outcomes, including functional decline, institutionalization, and mortality. Current evidence supports lifestyle-based strategies, particularly exercise combined with adequate

nutrition, as the cornerstone of sarcopenia management. While pharmacological therapies remain limited, emerging agents such as a mas receptor agonist BIO101 offer potential for future treatment. A comprehensive, multi-dimensional approach addressing muscle strength, mass, quality, and physical performance is critical for effective prevention and management of sarcopenia in aging populations.

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## REVIEW

# A Comparative Review of Bloom's and Fink's Taxonomies in Nursing Education: Bridging Theory and Practice

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## Abstract

Bloom's revised taxonomy provides a theoretical framework that enables the systematic structuring of educational program objectives by classifying cognitive learning into six stages. This model, consisting of the stages of knowledge, comprehension, application, analysis, evaluation, and creation, serves as a guide in planning students' cognitive development processes. Case analysis, problem-based learning, clinical skill stations, and scenario-based applications, which are widely used in nursing education, are consistent with Bloom's approach that supports higher-order thinking skills. These activities contribute to the development of students' critical thinking, problem-solving, and clinical decision-making skills. Fink's Meaningful Learning Taxonomy, on the other hand, approaches learning from six dimensions, offering a holistic perspective that goes beyond cognitive skills. This model, which includes the elements of basic knowledge, application, integrated learning, human dimension, change of perspective, and learning to learn, aims to support both the academic and personal development of students. Assessments based on Fink's taxonomy in nursing education contribute to strengthening ethical sensitivity, empathy, self-management, professional identity development, and interdisciplinary connection skills. This study demonstrates the application of Bloom and Fink taxonomies in nursing education programs through examples of case-based teaching, clinical simulations, rubric development, and digital learning environments. The use of taxonomy-based assessment tools enables the objective and systematic monitoring of students' development in cognitive, affective, and psychomotor domains. Therefore, when Bloom's constructivist approach and Fink's student-centered and meaning-focused model are evaluated together, it is possible to develop a nursing education design that is appropriate for the needs of the digital age, ethically grounded, and holistic.

**Keywords:** Bloom's taxonomy; Fink's taxonomy; Nursing education

The dynamic and rapidly evolving nature of health services requires nursing education to cultivate professionals who can adapt to contemporary needs and demonstrate strong critical-thinking skills.<sup>[1]</sup> Therefore, nursing education should extend beyond the transmission of theoretical knowledge and incorporate

active, student-centered, and experience-based learning approaches that promote holistic development across cognitive, affective, and psychomotor domains.<sup>[1]</sup>

Learning taxonomies play an essential role in guiding educators as they design and evaluate effective teaching processes.<sup>[2]</sup> Bloom's Taxonomy, long used for

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the classification of educational objectives, provides a structured framework that organizes learning within the cognitive, affective, and psychomotor domains.

<sup>[3]</sup> Addressing these domains separately is particularly valuable in nursing, where theoretical instruction is closely intertwined with clinical practice.<sup>[4]</sup>

Fink's taxonomy of significant learning, in contrast, offers a multidimensional and student-centered perspective. Rather than focusing solely on knowledge acquisition, it emphasizes the integration of knowledge into real-life contexts, the development of personal and professional values, and the cultivation of self-directed learning skills.<sup>[5]</sup> This broader approach is especially beneficial in applied disciplines such as nursing, where meaningful and lasting learning experiences are essential for professional competence.<sup>[6]</sup> In this study, the contributions of Bloom and Fink taxonomies to nursing education are discussed comparatively; their effects on the basic stages of instructional design, such as determining teaching objectives, structuring learning processes, and assessment and evaluation practices, are evaluated together with theoretical approaches and application examples. In addition, the integration of both taxonomies with digital educational environments, simulation-based learning, and interdisciplinary practices is discussed, and strategic recommendations for improving the quality of nursing education are provided. This comparison under six main headings aims to help educators understand which model is more functional in which context and contributes to the development of instructional designs that support meaningful and lasting learning. In this context, the study aims to comparatively examine the reflections of Bloom and Fink taxonomies on the establishment of teaching objectives in nursing education, planning of learning processes and evaluation practices, and to develop recommendations for teaching designs appropriate to the field of nursing.

Following this aim, a targeted literature review was conducted to identify studies examining the role of Bloom's and Fink's taxonomies in nursing education. The review focused on literature addressing the use of learning taxonomies in defining instructional objectives, structuring active and student-centered learning processes, and developing assessment and evaluation strategies within nursing curricula. Articles were searched using keywords such as "Bloom's Taxonomy," "Fink's Taxonomy," "nursing education," "learning outcomes," "instructional design," and "simulation-based learning."

The search was carried out in international databases including PubMed, Scopus, and Web of Science, covering studies published between January 2024 and April 2025 to ensure the inclusion of contemporary evidence relevant to current educational practices. Priority was given to peer-reviewed research that explored cognitive, affective, and psychomotor dimensions of nursing education and examined how taxonomy-based planning supports meaningful and lasting learning. Studies unrelated to nursing or lacking direct relevance to educational taxonomies were excluded. The selected articles were synthesized to comparatively evaluate the theoretical foundations and practical applications of Bloom's and Fink's models in modern nursing education.

## Nursing Education in the Context of Bloom's Taxonomy

Bloom's Taxonomy allows structuring the teaching process by classifying learning objectives in three basic areas: Cognitive, affective, and psychomotor.<sup>[7]</sup> In disciplines such as nursing education, which includes both theoretical knowledge and practical skills, structured teaching through these areas directly affects student success and professional competence (Table 1).<sup>[4]</sup>

**Table 1.** Learning areas and applications in nursing education based on Bloom's taxonomy<sup>[4]</sup>

| Learning area      | Definition                                                                                                  | Application examples in nursing education                           | Intended learning outcome                                                           |
|--------------------|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Cognitive domain   | Mental processes at the levels of knowledge, comprehension, application, analysis, synthesis and evaluation | Clinical scenarios, case analysis, problem-based learning           | Clinical decision making, critical thinking, evidence-based practice                |
| Affective domain   | Attitudes, values, empathy, ethical sensitivity and emotional responses                                     | Simulation, role-play, reflective diaries                           | Ethical sensitivity, empathic communication, internalization of professional values |
| Psychomotor domain | Acquisition and practice of physical skills                                                                 | Skills laboratories, simulation environments, clinical applications | Safe and effective nursing interventions, application competence                    |

**Table 2.** Dimensions of meaningful learning in nursing education based on Fink's taxonomy

| Learning dimension    | Definition                                             | Application examples in nursing education      | Intended learning outcome                     |
|-----------------------|--------------------------------------------------------|------------------------------------------------|-----------------------------------------------|
| Basic information     | Acquisition and recall of basic theoretical knowledge  | Anatomy, physiology, pharmacology courses      | Scientifically based clinical decision making |
| Application           | Use of knowledge and skills in the clinical setting    | Simulation, problem-based learning             | Application competence, clinical thinking     |
| Integrated learning   | Establishing interdisciplinary knowledge relationships | Integration of anatomy-ethics-communication    | Holistic professional perspective             |
| Human dimension       | Understanding yourself and others                      | Ethical debates, empathy studies               | Patient-centered approach and empathy         |
| Change of perspective | Change in the individual's value and belief system     | Public health and inequality cases             | Social sensitivity, ethical awareness         |
| Learning to learn     | Awareness of the learning process                      | Reflective journal, portfolio, self-assessment | Lifelong learning, self-regulation            |

Selecting appropriate methods and measurement tools for each learning area plays a critical role in increasing the professional competencies of student nurses.<sup>[7]</sup>

### Nursing Education with Fink's Meaningful Learning Taxonomy

Fink's taxonomy of meaningful learning defines learning with a holistic approach that is not limited to the acquisition of knowledge but also includes the student's personal development, competence in practice, value system, and awareness of the learning process.<sup>[5]</sup> It is emphasized that this model is especially effective in disciplines such as nursing, which are based on human relations, practice-oriented, and require continuous development.<sup>[6]</sup> Fink considers learning in six basic dimensions and aims to create "meaningful" and permanent learning in students by supporting each other.

This 6-dimensional taxonomy provides the basis for nursing students to understand and remember basic theoretical knowledge, such as human anatomy, physiology, pharmacology, and other learning dimensions.<sup>[5]</sup> This knowledge enables science-based thinking in clinical decision-making and patient care (Table 2).<sup>[8]</sup>

### Fink Applications with Clinical Simulation and Case-Based Learning

Fink's learning dimensions can be embodied through interactive methods, especially simulation and case-based learning. While clinical simulation allows students to develop skills in areas such as practice, integrated learning, and human dimension, case-based learning encourages analytical thinking, perspective taking, and empathy.<sup>[8,9]</sup> Students' exposure to realistic clinical situations enables

them to transform theoretical knowledge into practice and, at the same time, develop decision-making skills based on ethical values.<sup>[10]</sup>

### The Role of Fink's Taxonomy in Student-centered Planning

Another important contribution of Fink's model is that it allows for student-centered planning of instructional design. In this approach, teaching objectives focus not only on content transfer but also on the student's personal development, value system, and active participation in learning.<sup>[5]</sup> Nursing educators' lesson planning using this model enables individualization of education and increases intrinsic motivation in students.<sup>[6]</sup> Thus, nursing students are trained not only as knowledgeable but also as individuals who are sensitive, inquisitive, and open to learning. Learning taxonomies provide an effective structure for planning instructional design and assessment processes. Taxonomies developed by theorists such as Bloom and Fink provide educators with a systematic framework ranging from the formulation of instructional objectives to the development of assessment tools, and in disciplines such as nursing, where cognitive, affective, and psychomotor domains are integrated, taxonomy-based planning contributes to the clearer definition of learning outcomes and the establishment of more objective evaluation processes.<sup>[2,5,8]</sup>

### Determination of Training Objectives According to Taxonomic Level

Educational objectives, as one of the basic building blocks of the teaching process, explicitly set out the cognitive, affective, and psychomotor levels that students

**Table 3.** Goal structuring according to Bloom's revised taxonomy<sup>[22]</sup>

| Learning dimension | Definition                                                       | Application examples in nursing education                    |
|--------------------|------------------------------------------------------------------|--------------------------------------------------------------|
| Remembering        | Remembering, listing, recognizing information                    | "List the basic life support steps."                         |
| Understanding      | Interpreting, explaining and classifying information             | "Explains the clinical significance of vital signs."         |
| Application        | Using knowledge in new situations                                | "Applies injection techniques in a simulation environment."  |
| Analysis           | Breaking down information into parts, establishing relationships | "Determines clinical priorities based on patient case."      |
| Evaluation         | Making decisions, comparing arguments                            | "Compares treatment alternatives in light of clinical data." |
| Creation           | Creating a new structure or plan                                 | "Develops and individualizes patient care plan."             |

are expected to achieve. Structuring these objectives at the taxonomic level provides a systematic road map for both planning the teaching process and developing assessment tools.<sup>[2]</sup> Especially in disciplines such as nursing education, where cognitive competence, ethical sensitivity, and practical skills are developed together, taxonomy-based determination of educational objectives is of great importance in terms of clarity, measurability, and evaluability of learning outcomes.

### Goal Configuration According to Bloom's Revised Taxonomy

While Bloom's original taxonomy divides the cognitive domain into knowledge, comprehension, application, analysis, synthesis, and evaluation levels, the revised model developed by Anderson and Krathwohl (2001) restructured these levels as knowledge, comprehension, application, analysis, evaluation, and creation. This revision brought a more dynamic and process-oriented approach to learning processes. In nursing education, these levels can be concretized, for example, as follows (Table 3).

These levels give a strong direction to instructional design in terms of representing both the complexity of learning outcomes and higher-order cognitive processes.<sup>[4]</sup>

### Goal Setting According to Fink's Taxonomy of Meaningful Learning

Fink's taxonomy focuses not only on cognitive learning but also on the personal, ethical and practical development of the learner, defining learning goals in six dimensions: basic knowledge, application, integrated learning, human dimension, perspective change and learning to learn.<sup>[5]</sup>

This approach is of great advantage in areas such as nursing education that aim at holistic development. For example, within the scope of a course, the objectives according to Fink's dimensions can be determined as follows: (Fig. 1).

These dimensions are structured in such a way that students not only acquire knowledge but also gain a deeper understanding of themselves, society, and their professional roles.<sup>[6]</sup>

### Contribution of Taxonomy-based Objectives to the Educational Process

Objectives structured according to taxonomic levels contribute to making the educational process transparent and measurable. Thanks to these objectives, educators can adapt their teaching materials and assessment methods to the students' learning level. At the same time, it becomes easier for students to understand what and why they learn, and their intrinsic motivation increases.<sup>[5,7]</sup>

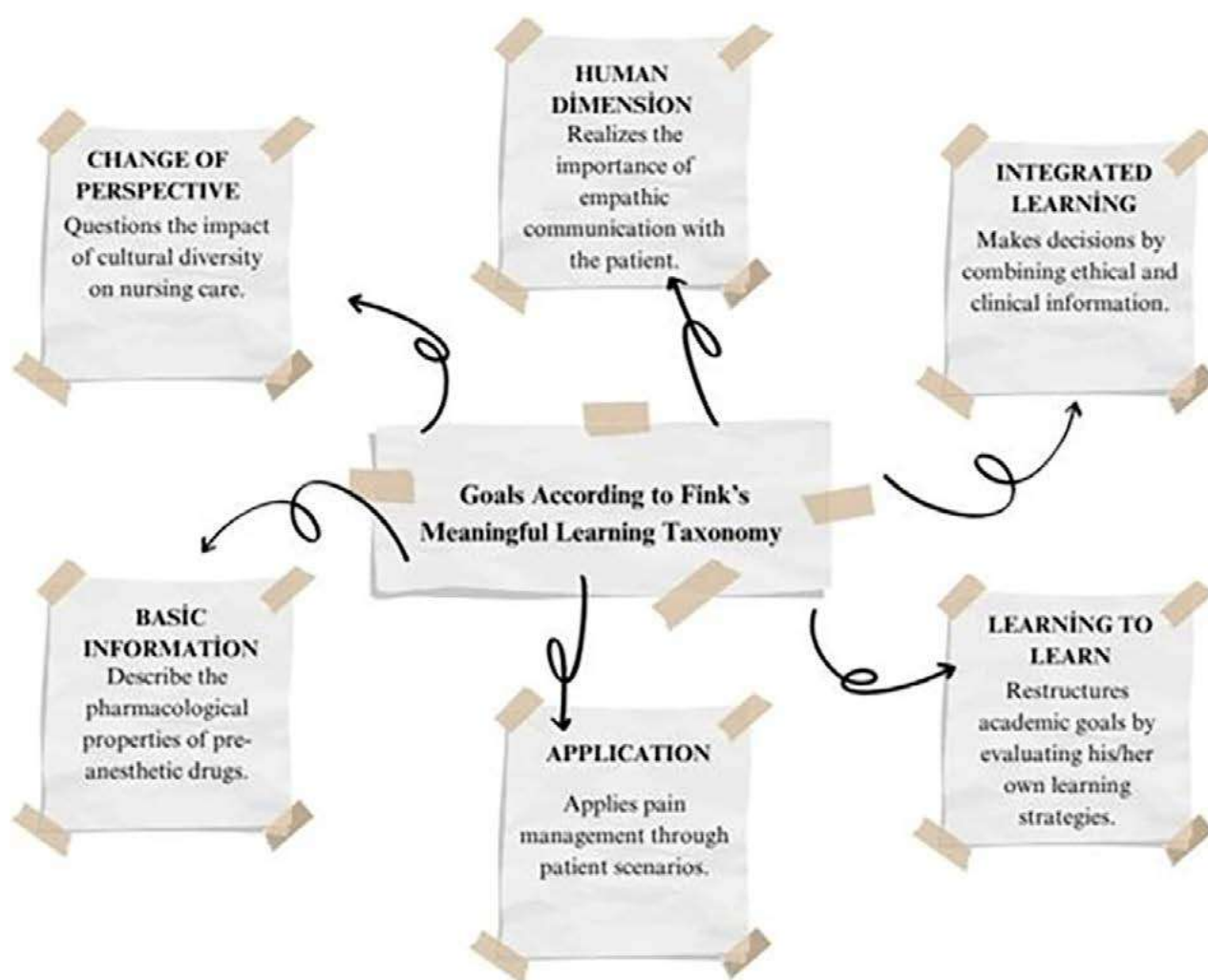
As a result, structuring educational objectives in line with Bloom and Fink taxonomies is a fundamental approach that improves the quality of teaching in nursing education, makes the assessment process objective, and supports the holistic development of the student.

### Examples of Taxonomic Alignment of Assessment Tools

Assessing the learning outcomes targeted in the teaching process is one of the most important ways of determining the effectiveness of education. However, this process cannot reflect the multidimensional nature of learning when it is limited to examinations at the knowledge level. Therefore, designing assessment tools in accordance with the specified taxonomic levels ensures the structural integrity between the learning process and assessment.<sup>[2,7]</sup>

### Assessment Approaches for Bloom's and Fink's Learning Taxonomies

According to Bloom's revised cognitive taxonomy, each level is associated with different types of assessment methods. Below are some examples for nursing education (Table 4).



**Figure 1.** Goals according to Fink's meaningful learning taxonomy.<sup>[5,6]</sup>

Thanks to this structure, it is possible for students to reach high-level cognitive processes based on application and critical evaluation, not just rote knowledge.<sup>[4]</sup>

Fink's taxonomy requires assessment to focus not only on the level of knowledge but also on the student's experiences, value system, and self-awareness. In this framework, assessment tools specific to each dimension are given below (Table 5).<sup>[5]</sup>

These tools encourage student-centered learning and allow multidimensional assessment of the learning process. Especially in a profession that touches people, such as nursing, the inclusion of elements such as empathy, ethical awareness, and continuous learning in the assessment directly affects professional development.<sup>[6]</sup>

### Using Rubrics in the Evaluation Process

Rubrics provide a transparent and structured method for assessing student performance and are especially effective when learning outcomes are shaped by Bloom's or Fink's

taxonomies. In nursing education, where cognitive reasoning, psychomotor skills, and affective competencies must all be evaluated, rubrics allow instructors to assess complex performance indicators consistently and objectively.<sup>[11]</sup>

By breaking down multifaceted skills into observable criteria, rubrics ensure alignment between instructional objectives and assessment practices. For example, a clinical skills rubric may include indicators related to procedural accuracy, patient communication, ethical decision-making, and reflective insight. This structure supports both technical proficiency and humanistic elements of nursing practice, resulting in a more comprehensive evaluation strategy.

### Rubric Development Based on Bloom's and Fink's Taxonomies

Rubrics informed by Bloom's taxonomy typically reflect a hierarchical structure, assessing whether students can recall essential knowledge, demonstrate understanding, apply

**Table 4.** Clinical assessment examples according to Bloom's taxonomy

| Grade         | Measurement and evaluation methods                                                             | Sample learning outcome/question                                                                            |
|---------------|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Information   | Multiple choice tests, true-false questions, short answer knowledge tests                      | "List the injection types."                                                                                 |
| Understanding | Open-ended questions, concept maps, summary writing                                            | "Explain the difference between sterile technique and aseptic technique."                                   |
| Application   | Practice exams, case studies, OSCE (Structured Clinical Exams)                                 | "Calculate the appropriate drug dose according to the patient scenario and prepare an administration plan." |
| Analysis      | Clinical decision-making simulations, problem-solving focused case scenarios                   | "Analyze possible causes in a hypotensive patient."                                                         |
| Evaluation    | Critical writing, comparison of care plans, reflective reports                                 | "Compare two different treatment approaches with evidence-based data and choose the most appropriate one."  |
| Creation      | Project presentations, preparation of patient education materials, innovative plan development | "Design culturally sensitive educational materials for individuals diagnosed with diabetes mellitus."       |

**Table 5.** Multidimensional clinical assessment according to Fink's meaningful learning taxonomy

| Learning type       | Evaluation methods                                         | Sample application/question                                                                                       |
|---------------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Basic information   | Conceptual exams, quizzes, knowledge tests                 | "A multiple choice exam on anatomy knowledge."                                                                    |
| Application         | Simulation assessments, skills checklists                  | "Error analysis form in intravenous intervention application."                                                    |
| Integrated learning | Case-based reports, interdisciplinary projects             | "Group presentation integrating ethics, pharmacology, and communication skills."                                  |
| Human dimension     | Reflective journals, self-assessment forms                 | "Written report containing personal analysis of difficulties experienced in communicating with the patient."      |
| Perspective change  | Pre-test-post-test comparisons, interview-based evaluation | "Attitude change regarding health inequalities before and after a community health course."                       |
| Learning to learn   | Portfolio assessment, personal learning plans              | "A portfolio that documents the learning strategies and resources developed over the course of an academic term." |

concepts in clinical scenarios, analyze case details, evaluate clinical decisions, or generate original care plans.<sup>[11]</sup> This format allows educators to measure progression from basic comprehension to higher-order thinking. Rubrics developed according to Fink's taxonomy extend beyond cognitive performance and include dimensions such as integration, the human dimension, ethical awareness, and self-directed learning.<sup>[5]</sup> These rubrics are particularly suitable for evaluating reflective journals, simulation debriefings, interprofessional collaborations, and portfolio assignments. Criteria may assess students' ability to connect knowledge across contexts, demonstrate empathy, engage in ethical reasoning, and articulate their own learning strategies.<sup>[12]</sup>

Collectively, taxonomy-informed rubrics reinforce the goals of nursing education by promoting critical thinking, reflective practice, and professional identity formation.

## Taxonomic Approaches in Nursing Education Program Design

Curriculum design is a multi-layered educational process that includes not only content planning, but also the structuring

of teaching objectives, the selection of teaching methods, and the design of evaluation processes. In disciplines such as nursing education that aim to develop cognitive, affective, and psychomotor domains simultaneously, it is of great importance to carry out this process in a systematic structure. At this point, taxonomy models such as Bloom and Fink contribute to the design of the education program in a balanced and holistic manner in terms of both teaching objectives and learning outcomes.<sup>[2,5]</sup>

## Education Program Structuring Based on Bloom's Taxonomy

Bloom's taxonomy provides a systematic framework for the teaching process by classifying educational objectives under cognitive, affective, and psychomotor domains.<sup>[3]</sup> In the nursing education program, each of these domains represents a different aspect of professional competence. The cognitive domain aims to improve students' acquisition of theoretical knowledge and critical thinking skills. In this context, various learning objectives ranging from knowledge to analysis and synthesis are set in courses such

as anatomy, physiology, and pharmacology. The affective domain covers students' emotional learning, such as professional ethics, empathy, and effective communication skills with patients. At this level, it is aimed to develop cultural sensitivity, professional attitude, and ethical decision-making competencies. In the psychomotor domain, students' acquisition of basic nursing skills is supported through laboratory environments and simulation applications. The development of these three areas in a balanced manner enables nursing students to achieve holistic professional competence. Skills such as injection practices, measurement of vital signs, and wound care are evaluated in this area.<sup>[13]</sup>

Bloom's taxonomy facilitates the structuring of the education program in nursing education without separating these areas from each other, but by making each of them separate objectives. Thus, course contents can be planned in a way that aims not only to enable students to acquire knowledge but also to use this knowledge critically and transfer it to practice.<sup>[4,7]</sup>

### **Curriculum Approach Integrated with Fink's Taxonomy of Meaningful Learning**

The taxonomy of meaningful learning developed by Fink (2013) brings a more holistic approach to curriculum design. In this model, learning is considered not only as a cognitive process, but also with multidimensional gains such as practical skills, individual development, ethical awareness, social responsibility, and learning to learn. In a field like nursing, which is based on practice and human relations, Fink's six learning dimensions can be integrated into the education program as follows: In these programs, the basic level of knowledge is provided to students through theoretical courses on medical sciences, pathophysiology, and health law. The practical dimension is reinforced through clinical internships, laboratory studies, and simulation-based training. Integrated learning aims to develop students' clinical decision-making skills by bringing together the knowledge gained in different courses through case studies. The human dimension aims to provide students with empathy and professional values through ethical discussions, analysis of patient stories, and cultural competency training. It increases students' social sensitivity by supporting them with interactive training modules on topics such as changing perspectives, health inequalities, and living with chronic diseases.

Finally, the learning to learn dimension encourages students to develop individual learning strategies, engage in self-assessment, and structure their academic goals.

This multi-layered structure supports nursing students to grow not only as knowledgeable but also as caring and competent professionals. This model increases the student's active participation in the learning process, especially by forming the basis of student-centered instructional designs. Structuring the education program in this way contributes to the development of not only professional skills but also professional identity.<sup>[5,6]</sup>

### **Advantages of Taxonomy-based Training Program**

Taxonomy-based curriculum design enables the creation of transparent, measurable, and student-centered learning objectives. This approach allows for clarity of expectations for both lecturers and students and more coherent planning of the learning process. At the same time, students are better prepared for the complex nature of the healthcare system through modules enriched by interdisciplinary collaborations.<sup>[14,15]</sup>

Designing the curriculum based on Bloom and Fink taxonomies deepens the learning outcomes and enables students to develop holistically in academic, ethical, and practical dimensions. In this way, nursing education becomes a structure that not only conveys knowledge but also aims to think, practice, and internalize human values.

### **Multidisciplinary and Digital Adaptations of Taxonomy-based Instructional Design**

In multidisciplinary health education, it is important for students from different disciplines to learn together in order to develop communication, collaboration, and mutual understanding (World Health Organization, 2010). In this context, taxonomically structuring common educational goals facilitates students from different disciplines to interact at similar cognitive and affective levels.<sup>[14]</sup>

For example, nursing and medical students working together in Fink's "practice" and "human dimension" areas in joint case scenarios support not only knowledge sharing but also empathy and professional role awareness.<sup>[16]</sup> Bloom's taxonomy also allows for the gradual structuring of objectives in such programs, enabling interdisciplinary learning to take place systematically.<sup>[2]</sup>

The proliferation of digital learning environments has necessitated the adaptation of taxonomy-based instructional designs to online systems. Learning management systems, virtual simulations, and interactive content offer powerful tools for designing learning activities in line with Bloom and Fink's taxonomic structures.

For example, Bloom's knowledge and application levels can be easily supported by video lectures and digital quizzes, while case studies, discussion forums, and digital project presentations can be effective for the analysis, evaluation, and creation levels.<sup>[17]</sup> According to Fink's model, digital environments can be structured with reflective blog posts, e-portfolios, and interactive scenario-based learning modules that reinforce the "learning to learn" and "integrated learning" dimensions.<sup>[17]</sup>

Taxonomy-based digital instructional designs provide great advantages in terms of maintaining learning depth and increasing student engagement, especially in distance education.<sup>[18]</sup> In addition, this approach facilitates nursing students to continue their professional development by supporting individualized and self-regulated learning processes.<sup>[19,20]</sup>

## Conclusion and Recommendations

Nursing education is constantly transforming with rapidly developing health technologies, digital learning tools, and approaches that prioritize interdisciplinary collaboration.<sup>[1]</sup> This transformation necessitates teaching strategies to become more flexible, student-centered, and result-oriented. In this context, Bloom and Fink taxonomies provide a theoretical basis not only for current teaching practices but also for research that will shape the future of nursing education.<sup>[2,5]</sup>

Bloom's revised taxonomy helps educators structure learning goals by preserving the hierarchical structure of cognitive processes and provides a structure suitable for integration with digital learning environments.<sup>[1,16]</sup> Future research should focus on how to optimize these cognitive levels, especially in virtual simulations, AI-supported instructional systems, and personalized learning environments.<sup>[4,8,17,18]</sup>

Fink's taxonomy provides a powerful theoretical framework for research that aims to strengthen nursing students' self-awareness, value system, and lifelong learning capacities, as it offers the opportunity to evaluate student experiences in a multidimensional way.<sup>[5,6]</sup> Future studies should particularly focus on how to measure and support more holistic learning outcomes such as learning to learn, ethical sensitivity, and social responsibility.

In addition, in-depth studies on how Bloom's and Fink's taxonomies are adapted to hybrid or digital learning environments are important for measuring effectiveness in instructional design.<sup>[20]</sup> In addition, how complex learning objectives such as interprofessional education, cultural

competence, and patient safety can be structured at the taxonomic level are interesting topics for new research.<sup>[14,16,19,21]</sup>

In conclusion, the theoretical and practical contributions of Bloom and Fink taxonomies to nursing education were examined comparatively. It was determined that both models provide a theoretical basis for student-centered, digital, and flexible instructional designs. Bloom's structured cognitive level approach facilitates the systematic identification of learning objectives, while Fink's holistic structure contributes to the support of meaningful and permanent learning. The future of nursing education should be based on multidimensional learning models that blend the strengths of these two taxonomies. In this context, the most effective approach for educators is to develop hybrid instructional designs that integrate Bloom and Fink taxonomies.

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## REVIEW

# Local and Systemic Factors Affecting the Eruption of Primary and Permanent Teeth in Children

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## Abstract

Tooth eruption is a biological process influenced by local and systemic factors. These factors impact the development and eruption timing of primary and permanent teeth, potentially leading to early or delayed eruption. While local factors generally affect the eruption of a single primary or permanent tooth, systemic factors can influence primary dentition, permanent dentition, or all eruption periods, causing eruption problems in both dentitions. Consequently, various clinical and radiographic findings may arise. Dentists can diagnose and assess these influencing factors through clinical and radiographic evaluations, enabling them to identify existing conditions or diseases. This review aims to compile the local and systemic factors affecting the eruption of primary and permanent teeth.

**Keywords:** Local factors; Systemic factors; Tooth eruption

**T**ooth eruption is defined as the movement of a tooth from its position within the alveolar bone to its functional position in the oral cavity. This process continues until contact is made with the opposing arch's tooth. It comprises five stages: Pre-eruptive, intraosseous, mucosal penetration, pre-occlusal, and post-occlusal.<sup>[1]</sup> The eruption movement of teeth begins with the initiation of root formation.<sup>[2]</sup> Experimental studies indicate that the coronal follicle, periodontal traction, root elongation, pulpal growth, bone development, periodontal ligament pressure, pulpal pressure, and vasculature all play a role in tooth eruption. The mechanism of tooth eruption and the regulation of this process are primarily determined by systemic and local factors.<sup>[1]</sup>

Tooth eruption is controlled by biological mechanisms that depend on coordinated signaling between the dental

follicle, alveolar bone, and adjacent tissues. The dental follicle plays a central role by secreting cytokines such as colony-stimulating factor-1 and regulating the receptor activator of nuclear factor kappa-B ligand/osteoprotegerin balance, which control osteoclast differentiation and bone resorption required for the eruptive pathway. Disruption of these regulatory mechanisms can delay or prevent normal eruption, highlighting the biological complexity of this process.<sup>[1,3]</sup>

## Literature Search Strategy

To provide a comprehensive review of these contributing factors, this review was prepared by selecting relevant literature through searches of PubMed, Google Scholar, and Scopus using the keywords “tooth eruption,” “eruption disorders,” “local factors,” “systemic factors,” “primary teeth,”

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and “permanent teeth.” Studies published in English between 2010 and 2024 were included if they provided clinical, radiographic, or etiological data related to local or systemic factors affecting tooth eruption. The exclusion criteria of this review were as follows: Studies that did not directly address the tooth eruption process, those focusing solely on treatment procedures or surgical interventions, animal model and *in vitro* experimental studies, and publications published before 2010 were excluded. These criteria were applied to ensure that only studies providing relevant, evidence-based, and up-to-date information related to the etiological factors influencing the eruption of primary and permanent teeth in children were included in the review.

Local and systemic factors affecting the tooth eruption process are summarized collectively in Figure 1. These factors are discussed in the text under their respective subheadings.

## Local Factors Affecting the Eruption of Primary Teeth

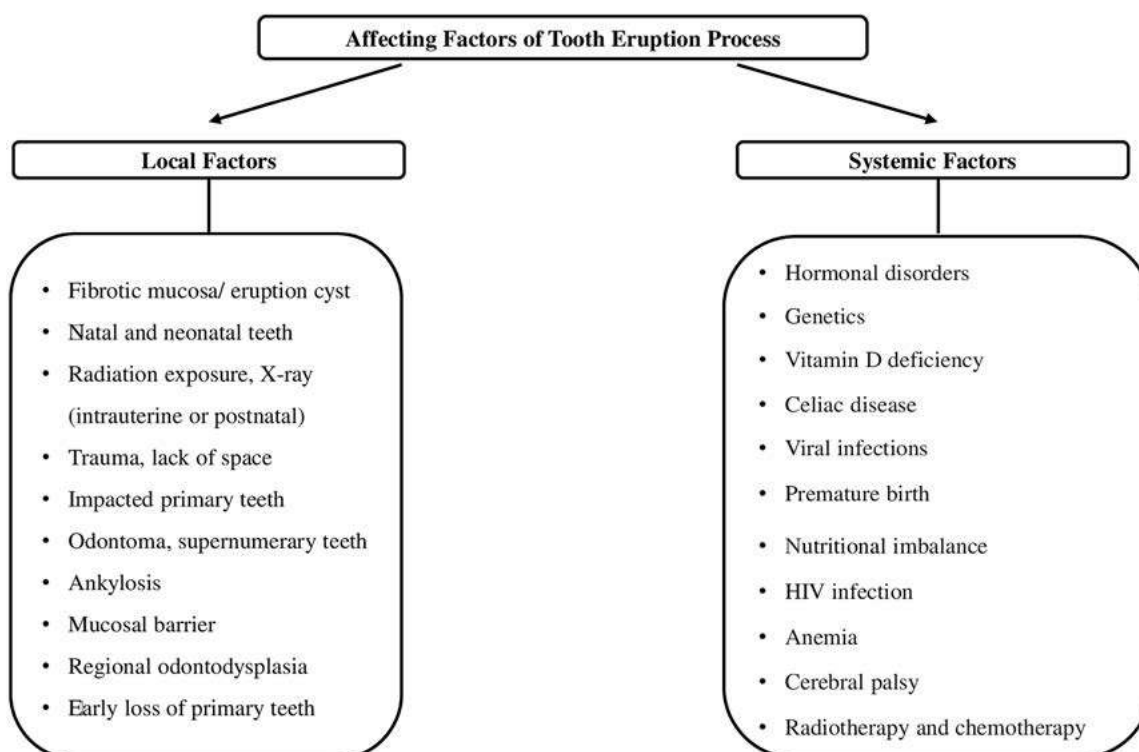
### Fibrotic Mucosa and Eruption Cyst

Changes in the oral mucosa overlying an erupting tooth may delay eruption in children. In particular, habitual chewing on hard objects can increase mucosal fibrosis,

further contributing to eruption delay.<sup>[1]</sup> An eruption cyst is a type of developmental cyst considered the soft-tissue counterpart of a dentigerous cyst. Evidence indicates that it occurs in both primary and permanent teeth, most commonly in the permanent first molars and maxillary permanent incisors. Although its exact etiology is unknown, factors such as trauma, infection, and limited space are thought to contribute to its development.<sup>[4]</sup> Typically asymptomatic, eruption cysts do not cause pain or sensitivity in children unless secondary infection occurs. They do not present any radiographic findings. However, in cases where there is a delay in tooth eruption or an increase in lesion size, enucleation or marsupialization of the cyst may be necessary.<sup>[5]</sup>

### Natal and Neonatal Teeth

Teeth present in the mouth at birth are called natal teeth, while those that erupt within the first 30 days after birth are referred to as neonatal teeth.<sup>[3,6]</sup> Natal teeth resemble primary teeth in shape and size but are generally smaller and have a yellowish color.<sup>[7]</sup> Natal teeth are most commonly found in the region of the mandibular primary central incisors, but they can also occur in the maxillary primary incisors and the regions of both mandibular and maxillary primary molars.<sup>[8]</sup> Although the exact etiology is



**Figure 1.** Local and systemic factors affecting the tooth eruption process.

not fully understood, factors such as infection, high fever, trauma, malnutrition, endocrine disorders, and kidney infections during pregnancy are believed to contribute to the formation of natal and neonatal teeth.<sup>[6,7]</sup> In addition, natal and neonatal teeth can occur in association with 50 different syndromes.<sup>[1]</sup> Some of these syndromes include Ellis-Van Creveld syndrome, Hallermann-Streiff syndrome, Jadassohn-Lewandowsky syndrome, Rubinstein-Taybi syndrome, Pierre-Robin syndrome, Craniofacial dysostosis, Steatocystoma multiplex, Sotos syndrome, Wiedemann-Rautenstrauch syndrome, Meckel-Gruber syndrome, Down syndrome, Walker-Warburg syndrome, and Ectodermal dysplasia.<sup>[1,7,8]</sup>

### **X-rays**

Animal studies have shown that exposure of the fetus to radiation during intrauterine life can lead to various disturbances in the development and eruption of both primary and permanent teeth. The potential damage to the fetus from radiation exposure during pregnancy varies based on the dose, duration, and the stage of development of the fetus. Exposure to radiation in the early stages of pregnancy can result in the complete absence of enamel and dentin, enamel defects, and a reduction in dentin apposition in certain areas of the tooth. Additionally, it can lead to the formation of short, curved, and dilacerated tooth roots. While low doses of radiation exposure in the fetus during intrauterine life may cause delays in tooth eruption in children, the same dose applied postnatally can accelerate tooth eruption. However, high doses of radiation administered during postnatal life can delay tooth eruption and may even cause pauses in the eruption mechanism.<sup>[1,9]</sup>

## **Systemic Factors Affecting the Eruption of Primary Teeth**

### **Hormonal Disorders**

#### **Hypothyroidism**

Hypothyroidism affects the functions of all organs, primarily the cardiovascular, gastrointestinal, and nervous systems. In addition, thyroid hormone plays a crucial role in growth and development in children.<sup>[10]</sup> Congenital hypothyroidism is referred to as cretinism and is characterized by abnormal dwarfism.<sup>[11]</sup> Cretinism is characterized by thick lips, macroglossia, malocclusion, a flat nose, a narrow forehead, and delayed tooth eruption. Thick lips and macroglossia develop due to subcutaneous mucopolysaccharide accumulation, while the impact of hypothyroidism on craniofacial and dental tissues can result

in the impaction of the mandibular permanent second molars.<sup>[12]</sup> In children with cretinism, primary dentition may begin around the ages of 3–4, while permanent dentition may start between the ages of 12–20.<sup>[11]</sup>

#### **Hypopituitarism**

Hypopituitarism refers to the hypofunction of the pituitary gland, typically caused by a pathological formation in or around the gland. Its most prominent feature is a delay in the growth of all tissues. Hypopituitarism during childhood leads to pituitary dwarfism. In pituitary dwarfism, due to developmental delays in the skeletal and genital systems, bone age lags significantly behind chronological age, and sexual development is halted. In these patients, delays in the formation and eruption of primary teeth are observed.<sup>[11]</sup>

#### **Hypoparathyroidism**

In hypoparathyroidism, teeth may exhibit cemental dysplasia, hypoplastic enamel, short and rounded roots, hypodontia, delays in tooth eruption or failure of eruption, and widening of the periodontal ligament.<sup>[13]</sup>

### **Genetics**

Several genetic syndromes have been reported to affect the eruption of primary teeth, leading to alterations in the timing, sequence, or pattern of eruption during early childhood. These conditions often involve developmental disturbances that influence both craniofacial and dental structures. Syndromes such as Down syndrome, Ellis-Van Creveld syndrome, Hallermann-Streiff syndrome, and Goltz syndrome are among the most frequently associated with delayed or abnormal eruption of primary dentition, mainly due to their systemic and skeletal manifestations. To provide a clearer understanding, the features related to these syndromes are summarized in Table 1.<sup>[3,14–17]</sup>

#### **Vitamin D Deficiency**

Vitamin D deficiency causes rickets in children and osteomalacia in adults. Rickets is described as a pediatric condition characterized by skeletal deformities and dwarfism due to a deficiency in mineralization of bone and cartilage tissue. The clinical signs of rickets include pale skin, sweating, hair loss, bone deformities, and muscle hypertrophy. In these patients, the gonial angle is increased, and the palate becomes deeper. Changes in teeth associated with rickets include delays in the eruption and shedding of primary teeth, alterations during the eruption process, systemic hypoplasia, and anomalies in the shape and size of teeth.<sup>[18]</sup>

**Table 1.** Syndromes associated with eruption disorders in the primary dentition.<sup>[3,14–17]</sup>

| Condition                  | Features                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Down syndrome              | Congenital heart defects, as well as eye and external ear anomalies associated with Down syndrome, begin to develop during the 6 <sup>th</sup> to 8 <sup>th</sup> weeks of intrauterine life. <sup>[5]</sup> Delays in the eruption of primary teeth and changes during the eruption process can be observed, particularly in the maxillary and mandibular primary anterior teeth and primary first molars. While in a normally developing healthy child, the primary central incisors erupt first and the primary second molars erupt last, children with Down syndrome may exhibit variations in this eruption sequence. The eruption of the first tooth typically occurs between 12 to 14 months; however, this timeline can extend up to 2 years, and the complete eruption of primary teeth in children with Down syndrome may not be achieved until they are 4 to 5 years old. <sup>[3,14]</sup> It has also been reported that some primary teeth in these children may persist in the mouth until the age of 14 to 15. <sup>[3]</sup> |
| Elis-van Creveld syndrome  | Ellis-Van Creveld syndrome is a genetic disorder inherited in an autosomal recessive manner, with its exact prevalence not fully known. The characteristic features of the syndrome include short ribs, polydactyly, growth retardation, ectodermal anomalies, and congenital heart defects. The most commonly observed oral manifestations are hypodontia and delayed eruption. In some patients, natal teeth and early erupting primary teeth observed within the first two months after birth may be present. Additionally, dental transpositions, enamel hypoplasia, taurodontism, multiple frenula, or frenulum anomalies are among the other oral findings that can be seen. <sup>[15]</sup>                                                                                                                                                                                                                                                                                                                                            |
| Goltz syndrome             | Goltz syndrome, also known as focal dermal hypoplasia, is an X-linked dominant disorder that affects multiple systems and can progress to be fatal. It is inherited genetically. The symptoms of Goltz syndrome can affect multiple systems, primarily involving the skin, bone tissue, eyes, and teeth. The manifestations associated with the syndrome can be of a severity that poses a threat to life. <sup>[16]</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Hallermann-striff syndrome | Hallermann-Streiff syndrome is a very rare congenital disorder. Its characteristic findings include craniofacial abnormalities, ocular malformations that contribute to a disease-specific facial phenotype, hair thinning, skin atrophy, short stature, skeletal anomalies, and developmental delays. Dental anomalies observed in patients include tooth agenesis, persistent primary teeth, malocclusion, open bite, malformed teeth, severe dental caries, early eruption of primary teeth, supernumerary teeth, and natal-neonatal teeth. <sup>[17]</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

**Celiac Disease**

Celiac disease is defined as an immune system disorder that causes hypersensitivity to gluten found in grains and grain products, often accompanied by malabsorption. Studies have indicated that children with this condition frequently present with oral manifestations such as enamel hypomineralization, poor oral hygiene, an increased risk of caries, and recurrent aphthous ulcers.<sup>[19]</sup> Moreover, children with celiac disease have been reported to experience delayed tooth eruption and maturation in both primary and permanent dentitions compared to healthy peers. This delay is thought to be associated with nutritional deficiencies and developmental disturbances related to the disease.<sup>[20]</sup>

**Viral Diseases**

Among viral diseases, the Rubella virus, which belongs to the Togaviridae family, is transmitted from the mother to the fetus and may result in congenital rubella syndrome.<sup>[21]</sup> Infants born with congenital rubella syndrome may present with various conditions and anomalies, including cataracts, cardiac anomalies, sensorineural hearing loss, microcephaly, speech and behavioral disorders, diabetes, bone lesions, thrombocytopenic purpura, hepatitis, and pneumonia.<sup>[21]</sup> In addition, a study conducted on children who have had this disease reported oral symptoms such

as enamel hypoplasia, hypoplastic enamel defects, and delays in the eruption of primary teeth.<sup>[22]</sup>

**Premature Birth**

Births occurring before 37 weeks of gestation are termed premature births. Premature infants typically have birth weights that are below the general average. Babies born prematurely or with low birth weight are predisposed to numerous medical issues during the neonatal development period, which can adversely affect the eruption of teeth in both primary and permanent teeth.<sup>[23]</sup>

**Local Factors Affecting the Eruption of Permanent Teeth**

**Impacted Primary Teeth**

The failure of a tooth to take its position in the occlusion when the time for eruption has arrived, often due to a mechanical obstruction, is referred to as tooth impaction. Impacted teeth are commonly found in the permanent dentition, particularly with the third molars (wisdom teeth), while impaction of primary teeth is quite rare.<sup>[24]</sup> This refers to the failure in the eruption process of teeth and can obstruct the eruption of permanent teeth. The most commonly impacted primary teeth, in order, are the primary second molars,

maxillary and mandibular primary central incisors, primary canines, and primary lateral incisors. The least frequently impacted primary teeth are the primary first molars. In terms of treatment, the primary tooth may be surgically extracted depending on the clinical situation, or managed through periodic monitoring without intervention.<sup>[25]</sup>

### Ectopic Eruption

Ectopic tooth eruption is defined as the abnormal positioning of a tooth during its emergence into the oral cavity. The teeth most commonly affected by ectopic eruption are, in order of frequency: Permanent molars and canines in the maxilla, permanent second premolars and canines in the mandible, and permanent lateral incisors in the maxilla.<sup>[26]</sup>

### Supernumerary Teeth and Odontoma

Supernumerary teeth, including mesiodens and odontomas, are among the primary issues causing tooth eruption disorders in children. If these formations are located around the permanent teeth follicles, they can lead to the permanent tooth remaining impacted and failing to erupt.<sup>[1]</sup>

Odontomas are typically asymptomatic and are often discovered incidentally during routine radiographic examinations. The primary problems caused by odontomas include dental malformations, retention of primary teeth, delayed eruption of permanent teeth, pain, cortical bone expansion, malposition, cyst formation, displacement of adjacent teeth, and resorption. The most commonly affected teeth due to odontomas are the permanent canines, maxillary central incisors, and third molars. To prevent odontomas from causing eruption issues in neighboring permanent teeth, surgical removal is recommended when one-third of the root development of the adjacent permanent teeth is completed.<sup>[27]</sup>

### Mucosal Barrier

The mucosal barrier is one of the etiological factors that can lead to delayed eruption of permanent teeth. Delays in the degradation of the mucosa may occur as a result of the inability of the dental follicle to integrate with the mucosa during the eruption process, thereby obstructing the eruption of the tooth.<sup>[28]</sup>

### Ankylosis

The etiology of ankylosis is not fully understood; however, it is believed that genetic factors, metabolic conditions, congenital absence of premolars, dental traumas, avulsion, and luxation injuries may contribute to its development. Ankylosis can lead to various complications, including the

cessation of alveolar process growth, resulting in open bite formation, an unesthetic smile, infraocclusion of the ankylosed tooth, tilting of adjacent teeth, elongation of antagonist teeth, and malocclusion. Conditions associated with ankylosis include cleidocranial dysplasia, ectodermal dysplasia, osteopetrosis, hypopituitarism, hypothyroidism, Fanconi syndrome, Down syndrome, epidermolysis bullosa, and deficiencies of vitamins A and D.<sup>[29]</sup>

### Dental Trauma

The close relationship between the apex of the primary tooth and the germ of the permanent teeth can lead to eruption problems in the permanent teeth following trauma to the primary teeth. The severity of the trauma is dependent on the patient's age, the developmental stage of the permanent teeth germs, the type and size of the trauma, and the extent of root resorption. According to research, the injuries that most adversely affect the permanent teeth germs are reported to be intrusive and avulsive injuries. Problems observed in permanent teeth as a result of trauma to primary teeth include changes in enamel color, enamel hypoplasia, coronal laceration, root lacerations, odontoma-like malformations, and eruption problems.<sup>[30]</sup>

### Regional Odontodysplasia

Regional odontodysplasia is defined as a rare developmental anomaly characterized by hypoplasia and hypocalcification of dental hard tissues, including enamel and dentin. Evidence indicates that it may affect both primary and permanent teeth, with a predilection for the maxilla, particularly the left segment.<sup>[31]</sup>

### Lack of Space

Lack of space is an important etiological factor for dental misalignment and the impaction of teeth. Research has indicated that a reduced arch length delays the eruption of maxillary permanent second molars, although it does not have any effect on tooth development. Moreover, it has been emphasized that crowding not only leads to delayed eruption but also often results in ectopic eruptions.<sup>[28]</sup>

### Early Loss of Primary Teeth

The primary causes of early loss of primary teeth are reported to be dental caries and trauma. Table 2 presents the systemic diseases that can lead to early loss of primary teeth.<sup>[32]</sup> Early loss of primary teeth can result in elongation of antagonist teeth, migration and inclination of adjacent teeth, impaction of permanent teeth, or eruption problems (either delayed or premature), leading to a shift in the midline.<sup>[33]</sup>

**Table 2.** Systemic diseases that cause early loss of primary teeth<sup>[32]</sup>

| Systemic disease                     | Causes of early loss of primary teeth                                          |
|--------------------------------------|--------------------------------------------------------------------------------|
| Papillon–Lefevre syndrome            | Periodontitis due to insufficient cortisol production                          |
| Erythromelalgia                      | Periodontitis associated with the accumulation of Langerhans cells             |
| Congenital adrenal hyperplasia       | Periodontitis related to metabolic absorption disorders                        |
| Langerhans cell histiocytosis        | Periodontitis due to accelerated cellular aging                                |
| Short bowel syndrome                 | Periodontitis resulting from abnormalities in osteoblast and osteoid functions |
| Dyskeratosis congenita               | Periodontitis due to osteoclastic degeneration in the jaws                     |
| Hajdu–Cheney syndrome                | Insufficient development of acellular cementum                                 |
| Cherubism                            | Insufficient development of acellular cementum                                 |
| Hypophosphatasia                     | Decreased production and release of neutrophils                                |
| Coffin–Lowry syndrome                | Phagocytic dysfunction                                                         |
| Cyclic neutropenia                   | Phagocytic dysfunction                                                         |
| Leukocyte adhesion deficiency type I | Reduced leukocyte chemotaxis and phagocytic dysfunction                        |
| Down syndrome                        | Deficiency of the catalase enzyme                                              |
| Chediak–Higashi syndrome             | Periodontitis due to insufficient cortisol production                          |
| Acatalasemia                         | Periodontitis associated with the accumulation of Langerhans cells             |

**Table 3.** Syndromes associated with delayed eruption and disturbances<sup>[34]</sup>

| Amelogenesis imperfecta | Goltz syndrome                                     | Osteogenesis imperfecta                               |
|-------------------------|----------------------------------------------------|-------------------------------------------------------|
| Apert syndrome          | Hallermann-striff syndrome                         | Osteopetrosis                                         |
| Carpenter syndrome      | Hereditary gingival fibromatosis                   | Otodental syndrome                                    |
| Cherubism               | Hyper IgE syndrome (Buckley syndrome)              | Parry-Romberg syndrome (PRS)                          |
| Dentin dysplasia        | Incontinentia Pigmenti (Bloch-Sulzberger syndrome) | Progeria (Hutchinson–Gilford syndrome)                |
| Down syndrome           | Cleidocranial Dysplasia                            | Rothmund-Thomson syndrome                             |
| Ectodermal dysplasia    | Ellis-van Creveld syndrome                         | SHORT syndrome                                        |
| GAPO syndrome           | Mucopolipidosis Type II (I-Cell) disease           | Singleton–Merten syndrome                             |
| Gaucher syndrome        | Mucopolysaccharidosis                              | Von Recklinghausen disease (Neurofibromatosis Type I) |

## Systemic Factors Affecting the Eruption of Permanent Teeth

### Genetics

Certain genetic disorders have been reported to affect tooth eruption as amelogenesis imperfecta, osteogenesis imperfecta, cleidocranial dysplasia, etc. Table 3 presents a list of genetic conditions that are associated with delayed eruption and related disturbances.<sup>[34]</sup>

### Gender

Research on tooth eruption has indicated that permanent teeth generally erupt earlier in girls than in boys, with an average difference in eruption timing ranging from 4 to 6 months. Teeth that exhibit significant differences in eruption timing based on gender include the maxillary permanent lateral incisors and canines, as well as the mandibular permanent canines. It is believed that this

difference arises because girls typically begin pubertal development earlier than boys, leading to the earlier eruption of permanent teeth. In addition, variations in eruption order can also be observed based on gender. In girls, the maxillary permanent canines are expected to erupt before the second premolars, while the mandibular second premolars are anticipated to erupt before the permanent second molars. Conversely, in boys, the order of eruption is reported to be the reverse.<sup>[34]</sup>

### Vitamin and Mineral Deficiency

The deficiency or excess of vitamins and minerals significantly impacts the development of oral and dental structures. In particular, deficiencies in calcium, phosphorus, and Vitamins A, B, C, and D can lead to hypomineralization, delayed eruption of teeth, gingival bleeding, disrupted alveolar bone patterns, and periodontal diseases. Among the oral effects, the literature contains the most studies on Vitamin D.

Vitamin D is essential for the absorption of elements such as calcium, magnesium, and phosphorus from the intestines, which are necessary for the calcification of bones and teeth. Long-term Vitamin D deficiency can lead to delayed tooth eruption associated with hypoparathyroidism, while hyperparathyroidism, which occurs in the opposite situation, increases the rate of the calcification process.<sup>[35]</sup>

### **Nutrition**

Childhood obesity is becoming one of the significant health issues worldwide, with an increasing prevalence. Obesity refers to an abnormal or excessive accumulation of body fat that poses a risk to health. A study has indicated that obesity affects the eruption of permanent teeth, noting that obese children aged 10–11 years tend to have a greater number of erupted permanent teeth compared to their non-obese counterparts.<sup>[36]</sup> In addition, because obese children tend to enter puberty earlier, they are likely to erupt their teeth approximately 1.2–1.5 years earlier.<sup>[34]</sup>

### **Human Immunodeficiency Virus (HIV) Infection**

HIV is one of the factors that can affect tooth eruption in children. Children with HIV infection commonly experience periodontal problems; however, delayed tooth eruption has also been reported in these individuals.<sup>[1]</sup> Research on the relationship between HIV infection and delayed tooth eruption has indicated that children infected with HIV may face health and nutritional problems due to their low socioeconomic status. Consequently, these issues can contribute to delays in tooth eruption among these children.<sup>[6]</sup>

### **Anemia**

The most common oral findings in patients with anemia include pallor of the gums, tongue, mucosa, and lips. Specifically, in individuals with sickle cell anemia, literature has noted issues related to dental eruption, with observed oral findings including mucosal pallor, jaundice, especially on the soft palate and floor of the mouth due to hemolysis, delayed eruption of teeth, enamel hypoplasia, symptomatic pulp necrosis, pulp stones, trabecular changes in the bone, and osteomyelitis. In addition, it has been reported that these patients are predisposed to dental infections. Therefore, it is crucial for dental practitioners to implement preventive measures for these individuals.<sup>[37]</sup>

### **Cerebral Palsy**

Cerebral palsy is a condition that arises from brain lesions that can occur during a child's development, leading to perceptual or sensory issues and resulting in motor dysfunction. Patients with cerebral palsy often struggle with

maintaining oral hygiene, making them more susceptible to oral problems. The oral issues commonly observed in these patients include musculoskeletal anomalies, early dental eruption, mouth breathing, and increased overjet and overbite due to inadequate lip closure.<sup>[38]</sup>

### **Radiotherapy and Chemotherapy**

Cancer is one of the most common causes of death in childhood, following accidents. In children undergoing oncological treatment, the side effects of chemotherapy are generally shorter in duration and temporary, whereas the effects of radiotherapy tend to be more long-lasting and permanent. These treatments can lead to changes in the quantity and composition of saliva. In addition, they can result in anomalies related to tooth size (often microdontia), number (commonly agenesis), crown-root structure, crown-root relationship, and hard tissue calcification. Delays in tooth eruption and an increased risk of caries and periodontal diseases may also be observed. The most serious complications in dental development occur as a result of radiation exposure during the formative and differentiation stages of tooth development. Complications seen in primary teeth can lead to severe malocclusions and deficiencies in facial development.<sup>[39]</sup>

### **Drug Use**

The use of long-term chemotherapy agents, medications that inhibit the prostaglandin pathway (such as aspirin, acetaminophen, ibuprofen, indomethacin, and clodronate), as well as bisphosphonate-containing drugs, can reduce osteoclastic activity in periodontal tissues. This reduction may slow the rate of tooth eruption and lead to delays in the eruption process.<sup>[40]</sup>

### **Socioeconomic Factors**

Some studies have found that children from higher socioeconomic backgrounds tend to experience earlier eruption of teeth compared to those from lower socioeconomic backgrounds. It is suggested that this phenomenon may be attributed to the healthier and better nutritional status of children with higher socioeconomic status, which triggers earlier tooth eruption.<sup>[34]</sup>

### **Evaluation of the Literature and Clinical Considerations**

A comparative analysis of the literature suggests that systemic factors – particularly hormonal and nutritional disorders – have stronger and more consistent effects on eruption timing than local mechanical factors. While endocrine disorders

such as hypothyroidism and hypopituitarism are commonly associated with delayed eruption, nutritional excesses or deficiencies (e.g., vitamin D imbalance, obesity) may accelerate or decelerate eruption depending on the context. However, the available evidence remains heterogeneous due to differences in study design, population characteristics, and diagnostic criteria. These inconsistencies highlight the need for standardized assessment protocols and longitudinal clinical research to clarify the relative impact of systemic and local influences on tooth eruption.

In clinical practice, early recognition of deviations in tooth eruption patterns is essential for timely diagnosis and management. Pediatric dentists should evaluate whether an eruption disturbance has a local or systemic origin and act accordingly – implementing interceptive measures for local causes and initiating multidisciplinary consultation when systemic involvement is suspected. Regular monitoring, preventive guidance, and early intervention help minimize complications such as malocclusion and ensure proper development of the dentition.

## Conclusion

Tooth eruption is an important biological process influenced by numerous mechanisms and factors. The eruption process is influenced by two major groups of factors: systemic and local factors. These factors can either slow down the eruption process, leading to delays, or accelerate it, resulting in early tooth eruption. Changes observed during this process may indicate the presence of a disease, syndrome, genetic condition, or environmental factor, all of which fall within the scope of pediatric dentistry. The pediatric dentist should identify the underlying cause of the eruption problem through clinical and radiological examinations and evaluations, subsequently developing a treatment plan tailored to this factor. Local factors can typically be managed through treatments implemented in dental clinics. However, since the effects of systemic factors extend beyond the oral cavity and may also cause other systemic manifestations, their management may require a multidisciplinary approach involving collaboration among physicians from various specialties, including a pediatric dentist. Therefore, pediatric dentists must possess a thorough understanding of both local and systemic factors that may be associated with eruption problems and should be able to provide appropriate referrals as necessary.

Despite advances in understanding the biological and clinical aspects of tooth eruption, many mechanisms underlying eruption disturbances remain unclear. Future research should focus on identifying molecular and genetic pathways

that regulate eruption timing and tooth movement, as well as the interaction between systemic diseases and dental development. Moreover, longitudinal and population-based studies are needed to establish standardized diagnostic criteria and evidence-based clinical guidelines for managing eruption disturbances in pediatric patients.

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## REVIEW

# Injection Molding Approach in Minimal Invasive Restorations: A Review Based on Current Literature and Clinical Application

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## Abstract

This narrative review aims to summarize and critically discuss the current level of knowledge regarding the injection molding technique, an approach increasingly utilized in minimally invasive restorative dentistry. In addition to synthesizing existing evidence, a clinical case is presented to illustrate its application in daily clinical practice and to highlight potential implications for future research. A narrative review was conducted using a focused search of the PubMed (MEDLINE) and Scopus databases for English-language articles published between 2015 and 2025, applying predefined keywords and, where applicable, Medical Subject Headings terms related to flowable composite resins and injection molding techniques. Relevant clinical and experimental studies were included, while non-relevant publications were excluded. The literature was narratively synthesized, and clinical relevance was illustrated through a representative anterior case. The search was last updated in January 2026. The available literature suggests that the injection molding technique may be associated with favorable esthetic and functional outcomes while potentially supporting a conservative restorative approach. The presented clinical case illustrates how this technique can be applied in anterior restorations and may contribute to acceptable functional integration and esthetic outcomes in a clinical setting. From a clinical perspective, the injection molding technique, when used with contemporary high-filler-content flowable composite resins, may represent a viable option within minimally invasive restorative dentistry. However, considering the current level of evidence, further well-designed clinical and laboratory studies are needed to clarify its long-term performance and to guide future research and clinical protocols.

**Keywords:** Direct composite veneer; Esthetic restoration; Flowable composite; Injection molding; Minimally invasive dentistry

Dental esthetics is widely regarded as an important factor influencing social interactions and self-perception.<sup>[1]</sup> The increasing demand for esthetic dental procedures appears to have contributed to a growing number of patients seeking esthetic treatments in daily clinical practice.<sup>[2]</sup> Given the prominent role of anterior teeth

in overall facial appearance, preserving or restoring their natural and harmonious morphology may be considered a key objective in contemporary restorative dentistry. Within this context, direct composite resin restorations have become one of the commonly preferred treatment options for esthetic rehabilitation of anterior teeth.<sup>[3]</sup>

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Composite resin materials are extensively utilized in esthetic dentistry due to their ability to reproduce the optical characteristics of natural tooth structures.<sup>[4]</sup> However, the handling challenges and limited adaptability associated with conventional packable composites have prompted clinicians to explore alternative restorative materials that may offer improved clinical manageability. As a result, flowable composite resins have been used in clinical practice for many years.<sup>[5]</sup>

Early-generation flowable composite resins were associated with relatively low filler content and, consequently, reduced mechanical strength, which restricted their indications mainly to low-stress restorative situations.<sup>[6]</sup> Advances in material science, however, have led to notable improvements in the physical and mechanical properties of these materials.<sup>[7]</sup> Contemporary high-filler-content flowable composite resins have been reported to demonstrate mechanical properties that may approach those of conventional packable composites in various clinical applications.<sup>[8]</sup>

These material advancements have facilitated the development of novel direct restorative techniques based on flowable composite resins. One such approach is the injection molding technique, which involves the controlled application of highly filled flowable composite resins onto tooth surfaces using pre-fabricated transparent silicone indices. The use of high-filler-content flowable composites in this technique may allow clinicians to obtain favorable esthetic outcomes while potentially maintaining adequate mechanical performance.<sup>[9]</sup> In addition, the relatively high elastic modulus of transparent index materials can enable the fabrication of thinner yet sufficiently rigid matrices, which may facilitate effective light transmission during polymerization while reducing excess material extrusion at the restoration margins.<sup>[10]</sup>

## Search Strategy

This narrative review was based on a focused and structured literature search conducted in the PubMed (MEDLINE) and Scopus databases. The literature search was conducted in December 2025 and updated in January 2026, and included articles published between January 2015 and December 2025.

The search strategy combined free-text keywords and, where applicable, Medical Subject Headings. The following terms were used alone and in combination using Boolean operators (AND/OR): "injection molding technique," "injectable composite," "injection composite technique," "flowable composite," and "resin injection technique."

Inclusion criteria comprised English-language publications addressing the injection molding technique and injectable flowable composites in restorative dentistry, including clinical studies, randomized clinical trials, *in vitro* studies, technical reports, book chapters, and relevant narrative or systematic reviews with clear methodological or clinical relevance.

Exclusion criteria included studies unrelated to restorative dental applications, conference abstracts without full-text availability, opinion articles lacking clinical or experimental support, and publications with insufficient methodological detail.

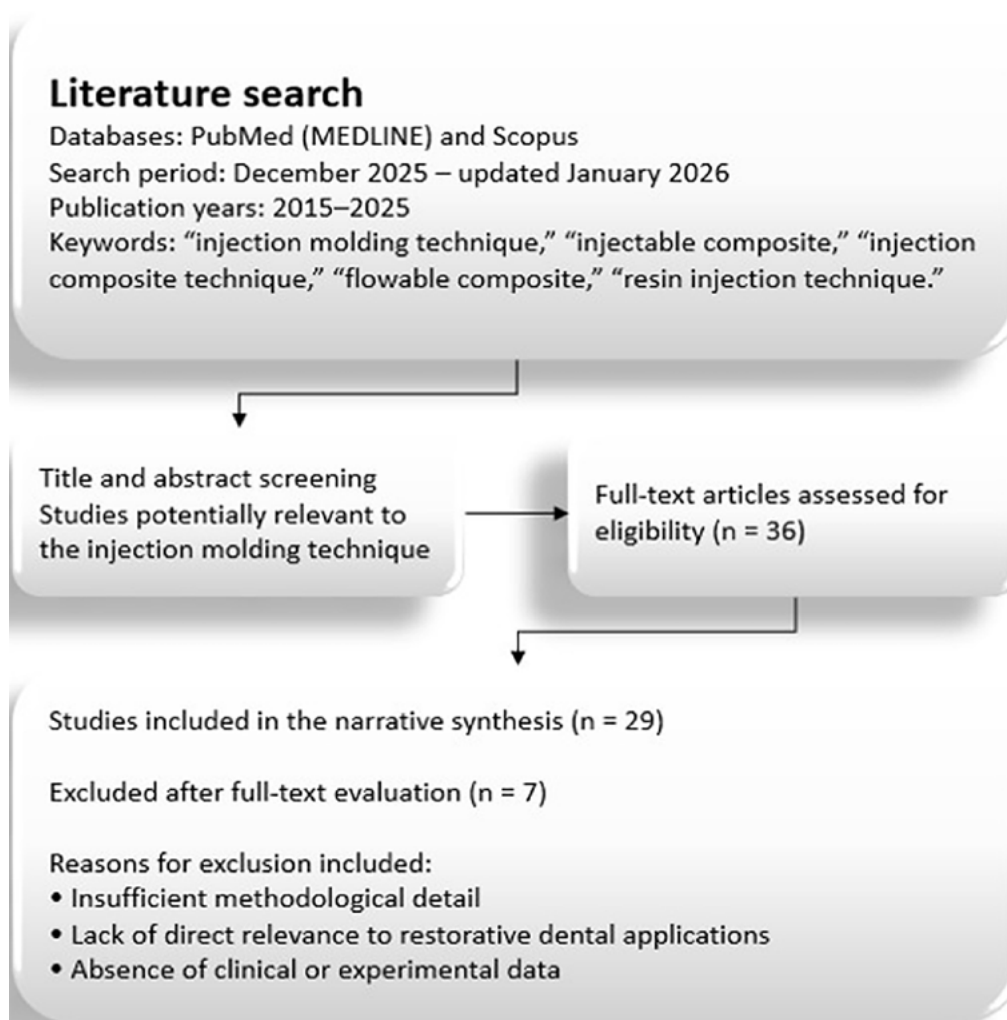
Following title and abstract screening, 36 articles were assessed for full-text eligibility, and 29 publications were ultimately included in the narrative synthesis based on their relevance to clinical practice and contribution to the understanding of the injection molding technique. The study selection process is illustrated in Figure 1.

## Indications, Advantages, and Disadvantages of Flowable Composites

Flowable composite resins have been reported to exhibit a broad range of clinical applications in restorative dentistry. Commonly cited indications may include:

- Preventive resin restorations in minimally invasive Class I cavities,<sup>[11]</sup>
- Pit and fissure sealants,<sup>[12]</sup>
- Use as cavity liner materials,<sup>[13]</sup>
- Minimally invasive Class III restorations,<sup>[14]</sup>
- Restoration of non-carious cervical lesions,<sup>[15]</sup>
- Repair of prosthetic restorations,<sup>[16]</sup>
- Cementation of indirect restorations,<sup>[17]</sup>
- Cementation of fiber posts in endodontics,<sup>[18]</sup>
- Bonding of orthodontic brackets,<sup>[19]</sup>
- Splinting of teeth following traumatic injuries.<sup>[20]</sup>

Compared with conventional packable composite resins, flowable composites may present certain advantages as well as limitations. Their lower viscosity can enhance adaptation to the cavity walls and tooth surfaces when compared to packable composites.<sup>[6]</sup> This property may facilitate easier handling with reduced need for instrument manipulation, potentially improving operator efficiency during clinical application.<sup>[21]</sup> In addition, the reduced viscosity has been associated with a lower risk of air bubble entrapment during placement.<sup>[6]</sup> Collectively, these characteristics have contributed to the development of restorative techniques such as the injection molding technique.<sup>[22]</sup>



**Figure 1.** Flow diagram illustrating the study selection process used for the narrative review.

Despite these advantages, flowable composite resins have traditionally been associated with higher polymerization shrinkage and lower filler content, which may result in inferior mechanical properties when compared to packable composites.<sup>[6]</sup> However, recent advancements in material formulation have been reported to improve the physical and mechanical properties of flowable composites, enabling certain high-filler-content materials to achieve mechanical performance that may be comparable to that of conventional packable composites in selected clinical applications.<sup>[8]</sup>

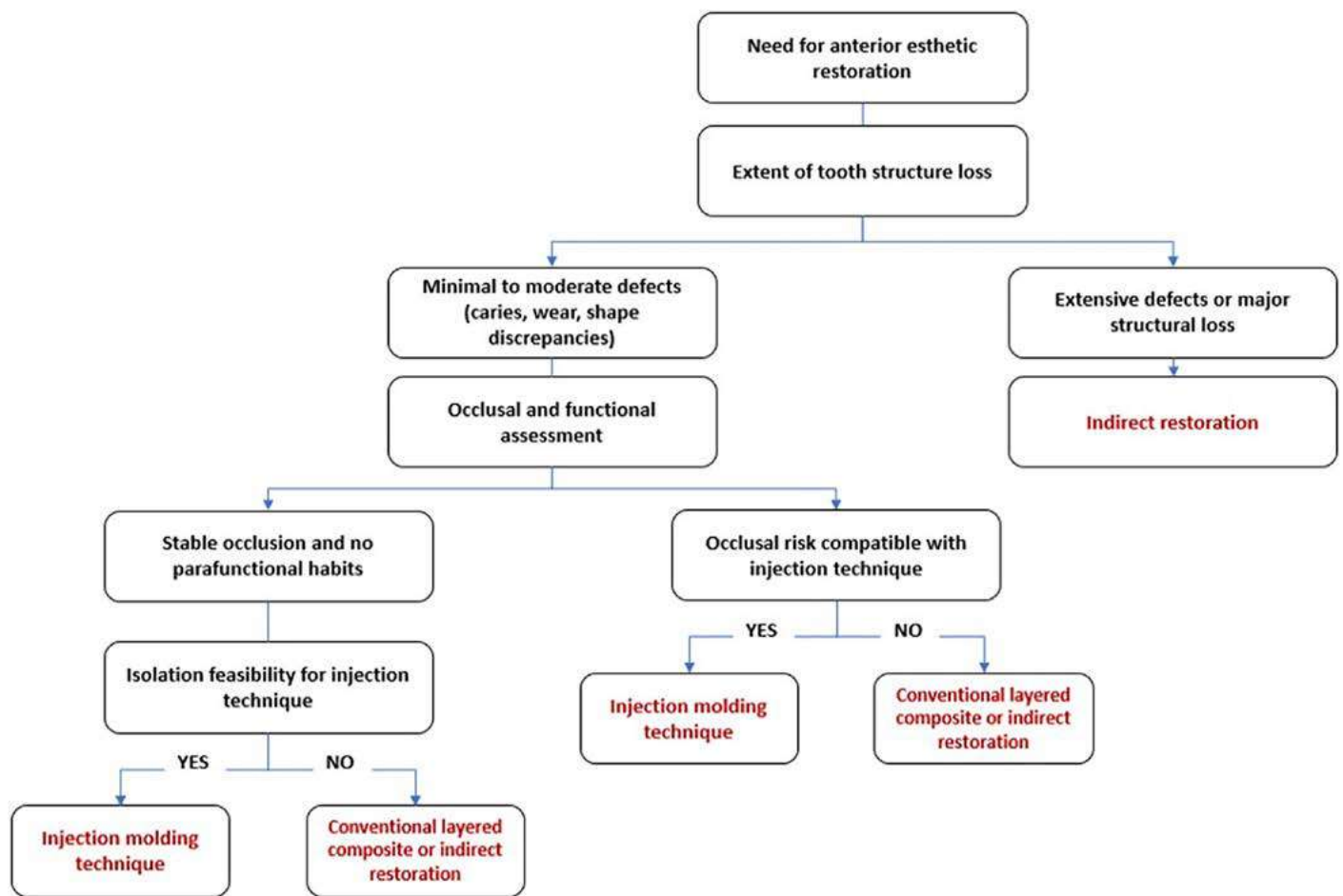
### Advantages and Limitations of the Injection Molding Technique

The injection molding technique has been described as a relatively predictable and controllable restorative approach that may allow clinicians to better anticipate esthetic and functional outcomes.<sup>[23]</sup> The technique can be considered minimally invasive and may offer several clinical

advantages, including cost-effectiveness and the potential to fabricate both provisional and definitive restorations using the same workflow.<sup>[24]</sup> In addition, it may contribute to reduced chair time and can facilitate restorations that are amenable to repair, thereby potentially enhancing overall clinical efficiency.<sup>[25]</sup>

Nevertheless, despite its reported clinical benefits, several limitations of the injection molding technique have been highlighted in the literature. The technique may not be recommended for stress-bearing areas<sup>[26]</sup> or for the closure of wide diastemas,<sup>[27]</sup> and its application can be considered contraindicated under conditions of inadequate isolation.<sup>[3]</sup> Furthermore, the composite materials used in this technique may exhibit color instability over time, as suggested by limited clinical and laboratory evidence, which could potentially compromise long-term esthetic outcomes.<sup>[28]</sup>

Another reported limitation of the injection molding technique is the inability to apply multiple composite



**Figure 2.** Simplified clinical decision-making flowchart for the injection molding technique in anterior esthetic restorations.

shades simultaneously during a single injection procedure. In clinical situations requiring complex layering or shade stratification, the injection process may need to be repeated, potentially increasing procedural complexity and chair time.<sup>[29]</sup> Moreover, despite the growing clinical interest in the injection molding technique, it should be emphasized that the current body of evidence is predominantly composed of case reports, technique descriptions, and short- to medium-term observational studies. High-level comparative clinical trials directly evaluating long-term outcomes such as wear resistance, color stability, and marginal integrity remain limited. Therefore, while reported outcomes appear promising, the available evidence should be interpreted with caution, and definitive conclusions regarding long-term clinical performance cannot yet be drawn.

Based on the aforementioned indications and limitations, a simplified clinical decision-making flowchart is presented in Figure 2 to support clinical case selection and treatment planning.

## General Clinical Steps in the Application of the Injection Molding Technique

The clinical workflow of the injection molding technique may be summarized through a series of sequential steps. It should be noted that minor modifications can be required depending on the clinical scenario and the restorative objectives.

1. Taking intraoral impressions: Impressions are obtained either by conventional methods or using digital scanners
2. Smile design: Based on the obtained impressions, the smile design is created. In conventional workflows, wax-up models are prepared, whereas in digital workflows, computer-aided design software is used for design and the models are produced using computer-aided manufacturing systems
3. Fabrication of the transparent matrix: A transparent polyvinyl siloxane (PVS) matrix is fabricated on the designed model. Small injection holes are then created

in the incisal areas of the matrix to allow the application of the flowable composite resin

4. Tooth preparation: In some cases, minimal tooth preparation may be required to ensure proper adaptation of the silicone matrix to the teeth. This step may also assist in minor repositioning of the teeth when necessary
5. Isolation: The teeth that will not be restored are isolated with Teflon tape. Typically, adjacent teeth are isolated (for example, when restoring teeth 13–11–22, the adjacent teeth 12–21–23 are isolated)
6. Etching: The tooth surfaces to be restored are etched with 37% phosphoric acid for 30 s and then thoroughly rinsed with water
7. Adhesive application: A bonding agent is applied to the etched surfaces, air-thinned, and light-cured
8. Placement of the transparent matrix: The previously fabricated transparent matrix is carefully seated on the teeth. It is crucial to ensure complete seating of the matrix, as improper adaptation may lead to an inaccurate final form
9. Composite injection: The flowable composite resin is injected through the pre-made holes in the matrix, filling the cavity space
10. Polymerization: The injected composite is light-cured from multiple directions for adequate polymerization
11. Matrix removal and finishing: The transparent matrix is carefully removed, and any excess composite material is trimmed and finished
12. Restoration of remaining teeth: The same procedure is repeated for the remaining teeth that were not initially restored
13. Polishing: After completing all restorations, the surfaces are polished with appropriate polishing systems to achieve optimal smoothness and gloss.

### Clinical Steps of the Technique: A Case with Complicated Carious Lesions

A 40-year-old female patient presented to our clinic for esthetic treatment due to wear on the incisal edges and multiple carious lesions in the anterior region (Fig. 3a). The patient requested esthetic treatment for the anterior teeth only and declined treatment of the posterior dentition. Because the patient also desired reshaping of the anterior tooth forms, it was decided to restore the six maxillary anterior teeth (FDI 13–23) using the injection molding technique to meet her esthetic expectations.

Clinical examination revealed no signs of parafunctional habits, and occlusal evaluation indicated no excessive anterior guidance or abnormal occlusal loading. The patient reported high satisfaction with the immediate esthetic outcome at the follow-up visit.

The anterior carious lesions were excavated under rubber-dam isolation. Enamel surfaces were etched with 37% phosphoric acid for 30 s and dentin surfaces for 15 s (Panora 200, Imicryl Dental, Konya, Turkey), then thoroughly rinsed with water. A universal adhesive (Nova Compo B Plus, Imicryl Dental, Konya, Turkey) was applied, air-thinned, and light-cured for 20 s using an LED curing unit (Valo Cordless, Ultradent, South Jordan, UT). The teeth were then restored with a composite resin (Essentia, MD shade, GC Corporation, Tokyo, Japan) (Fig. 3b).

Following the restorations, conventional impressions were taken using a C-type silicone impression material, and a dental cast was fabricated. Wax-up modeling was performed on this model for smile design purposes (Fig. 3c). This step may alternatively be performed using a fully digital workflow. Once the design was finalized, a transparent silicone matrix was fabricated from the model using an elastomeric PVS material (Exaclear, GC Corporation, Tokyo, Japan).

Minimally invasive veneer (laminare) preparations were then performed (Fig. 3d).

The adjacent teeth of those to be restored were isolated with PTFE (Teflon) tape (Fig. 3e). The surfaces were etched with 37% phosphoric acid for 30 s (Panora 200, Imicryl Dental, Konya, Turkey) and rinsed with water. A universal adhesive (Nova Compo B Plus, Imicryl Dental, Konya, Turkey) was applied, air-thinned, and light-cured from both buccal and lingual aspects for 10 s each using an LED curing unit (Valo Cordless, Ultradent, South Jordan, UT).

The transparent silicone matrix was then seated intraorally (Fig. 3e), and a highly filled flowable composite (G-aenial Universal Injectable, A2 shade, GC Corporation, Tokyo, Japan) was injected through the preformed access holes. The material was light-cured from buccal and lingual directions for 20 s each (Valo Cordless, Ultradent, South Jordan, UT). The same procedure was repeated for the remaining teeth that were not restored in the first sequence.

After removal of the silicone matrix, minor composite excesses around the restorations were removed with finishing/polishing discs (Sof-Lex, 3M ESPE, St. Paul, MN). The patient was scheduled for a follow-up appointment 1 week later. Intraoral images taken at the control visit are shown in Figure 3f.



**Figure 3.** Clinical workflow of the injection molding technique in the presented case. **(a)** Preoperative intraoral photographs of the patient. **(b)** Caries excavation under isolation and restoration with composite resin. **(c)** Wax-up models prepared on the cast. **(d)** Intraoral view after veneer preparations. **(e)** Tooth isolation and intraoral placement of the transparent silicone matrix. **(f)** Intraoral images at the 1-week follow-up.

The short-term clinical outcome was considered satisfactory. At the control visit, marginal adaptation and surface integrity of the restorations were judged to be acceptable. The patient was informed of the need for treatment of the posterior carious lesions and was given appropriate recommendations and referrals.

It should be noted that the 1-week follow-up period limits interpretation to short-term clinical observations, and no conclusions regarding long-term performance, color stability, or wear can be drawn from this illustrative case.

### Clinical and Research Consequences

The injection molding technique may provide clinicians with a structured and minimally invasive approach for achieving esthetic and functional anterior restorations.

When applied in carefully selected cases, this method may facilitate enhanced control over restoration morphology and surface adaptation, potentially minimizing extensive intraoral adjustments and chair time. The integration of both conventional and digital planning workflows, including wax-up and silicone index fabrication, can contribute to improved predictability of clinical outcomes and patient communication.

Clinically, this technique may be particularly relevant for practitioners seeking conservative alternatives to indirect restorations, especially in situations where preservation of sound tooth structure is prioritized. However, the successful clinical implementation of the injection molding technique appears to be linked to factors such as meticulous isolation, accurate matrix fabrication, and

appropriate material selection. Operator experience and case complexity may also influence outcomes, suggesting that clinicians should consider these factors when determining the suitability of the technique.

From a research perspective, the current evidence base is largely composed of short- and medium-term observations with limited high-level comparative data. Available data regarding mechanisms of long-term failure, including discoloration, wear, and marginal degradation, remain heterogeneous and are largely derived from indirect evidence extrapolated from studies on flowable composite materials rather than the injection molding technique itself. Future studies may benefit from standardized clinical protocols, randomized controlled trials, and long-term follow-up evaluations to assess outcomes such as color stability, wear resistance, marginal integrity, and patient-reported esthetic satisfaction. Comparative research examining different injectable materials and workflow variants could further clarify optimal clinical indications and limitations, ultimately supporting evidence-based decision-making in restorative dentistry.

Therefore, when interpreting the available literature, it should be considered that findings obtained under controlled laboratory conditions may not always directly correspond to clinical performance in the complex intraoral environment. While *in vitro* investigations provide valuable insights into material properties, degradation mechanisms, and potential failure patterns, the translation of these observations to long-term clinical outcomes may be limited. Accordingly, interpretations regarding the durability, esthetic stability, and long-term behavior of restorations performed using the injection molding technique should therefore be made with appropriate consideration of these contextual differences until supported by further clinical evidence.

## Conclusion

Within the limitations of this narrative review and the illustrative clinical case, the injection molding technique may be considered a contemporary restorative approach for managing esthetic concerns in anterior dentition within a minimally invasive framework. When applied in appropriate clinical situations, this technique may facilitate the delivery of esthetic and functional restorations while potentially supporting the preservation of healthy tooth structure.

The clinical case presented in this review illustrates that with careful case selection and meticulous execution, the injection molding technique can be effectively applied in the treatment of complex anterior carious lesions. However, the current body of evidence remains limited, particularly

with respect to long-term outcomes and comparative performance against alternative restorative approaches.

Consequently, further well-designed clinical and laboratory studies with extended follow-up periods are needed to better elucidate the clinical durability, esthetic stability, and material performance associated with this technique across diverse patient populations and clinical scenarios.

**Ethics Committee Approval:** Ethical committee approval was not required for this narrative review and illustrative clinical case in accordance with institutional guidelines.

**Conflict of Interest:** None declared.

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## CASE REPORT

# Filum Terminale Schwannoma Presenting as a Purely Cystic Lesion on Non-Contrast Magnetic Resonance Imaging: Case Report\*

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## Abstract

Spinal schwannomas are benign nerve sheath tumors that typically present as solid or heterogeneous, well-circumscribed masses with contrast enhancement on magnetic resonance imaging (MRI). A 61-year-old male presented with progressive low back and leg pain. Non-contrast MRI revealed an apparently completely cystic intradural mass at the level of the conus medullaris. Contrast-enhanced MRI demonstrated heterogeneous enhancement. The lesion was totally excised via laminectomy under intraoperative neuromonitoring and was found to originate from the filum terminale. Histopathological examination confirmed the diagnosis of schwannoma. This case highlights the importance of contrast-enhanced MRI for accurate differential diagnosis of intradural lesions, the role of intraoperative neuromonitoring in preventing neurological deficits, and the necessity of histopathological examination for definitive diagnosis.

**Keywords:** Cyst; Magnetic resonance imaging; Resection; Schwannoma

Schwannomas are benign, slow-growing, encapsulated tumors arising from the myelinated nerve sheaths of spinal nerve roots and constitute the most common benign intradural extramedullary tumors of the spine. They are typically solitary and predominantly solid lesions.<sup>[1]</sup> Although cystic degeneration may occur, purely cystic schwannomas within the spinal canal are uncommon.<sup>[2]</sup> These tumors are most frequently encountered in the lumbar region; however, schwannomas originating from the filum terminale are very rare.<sup>[3]</sup> So far, only two cases have been reported in the literature.

Accurate pre-operative diagnosis of these lesions can be challenging. Magnetic resonance imaging (MRI) is essential for lesion characterization, localization, and surgical planning. However, definitive diagnosis relies on histopathological examination.<sup>[4]</sup>

In this report, we present a case of a schwannoma originating from the filum terminale, which appeared entirely cystic on non-contrast MRI but was found to contain a solid component during intraoperative evaluation.

\*This case was presented in the 21<sup>st</sup> Congress of Nervous System Surgery as an oral presentation.

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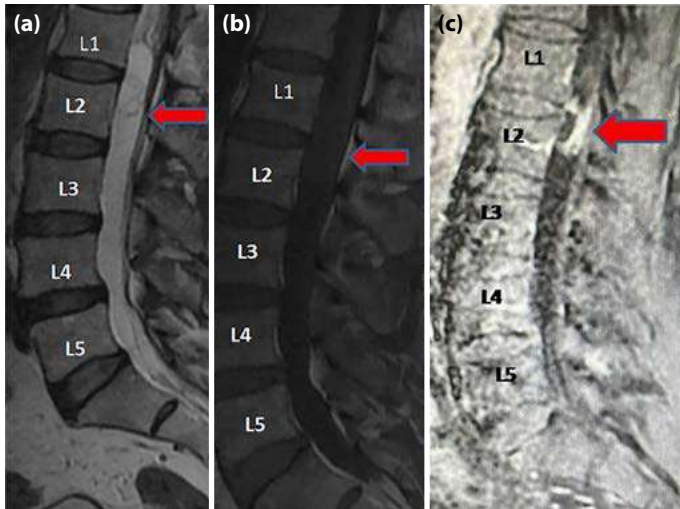
## Case Report

A 61-year-old male presented with a history of long-standing, progressively worsening intermittent low back pain and bilateral leg pain. His walking distance

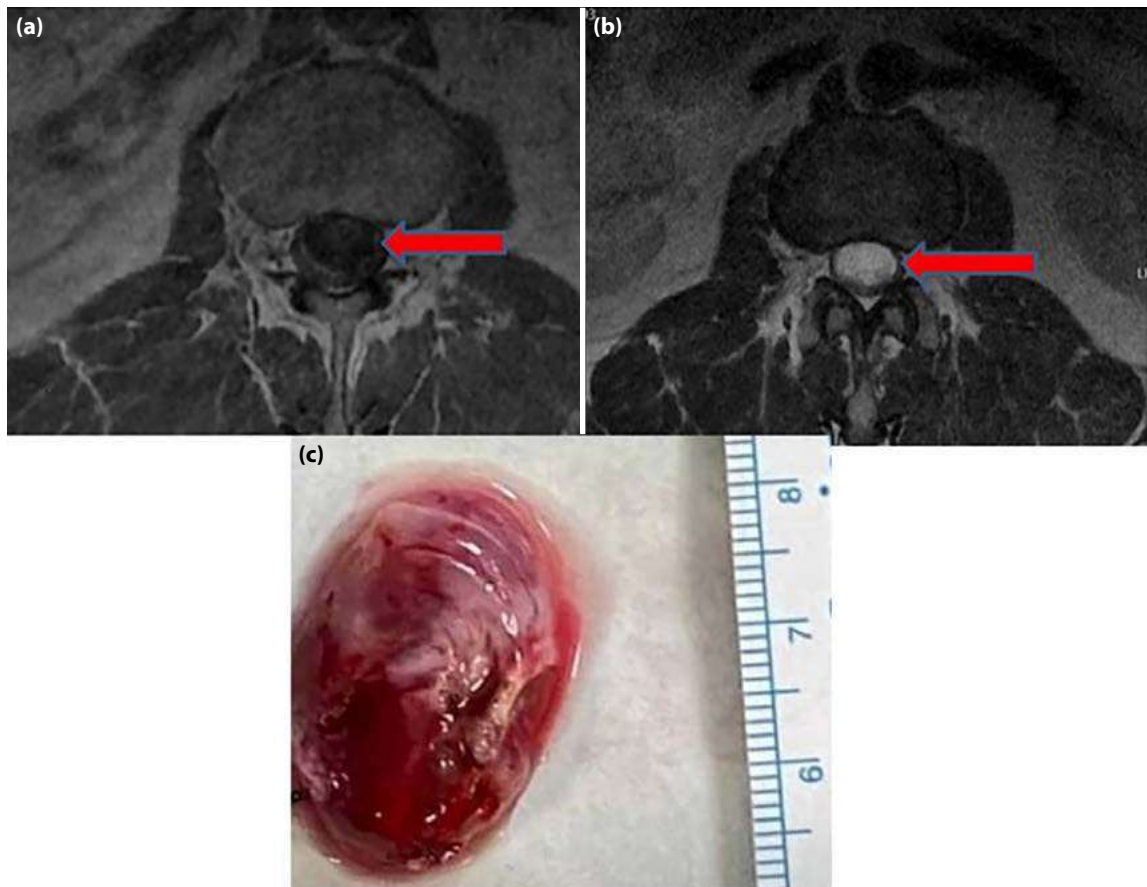
was reduced, with neurogenic claudication occurring at approximately 200 m. He had no history of trauma, infectious disease, or spinal disorders such as rheumatoid arthritis or ankylosing spondylitis, and no comorbidities, including diabetes mellitus or hypertension. Neurological examination was unremarkable. Deep tendon reflexes were normal, with no pathological reflexes observed. Sphincter function was intact.

Lumbar MRI performed at an external center demonstrated an apparently completely cystic lesion at the level of the conus medullaris. The lesion was hypointense on T1-weighted images and hyperintense on T2-weighted images (Figs. 1, 2). Contrast-enhanced MRI was subsequently performed, revealing heterogeneous contrast enhancement (Fig. 1).

A surgical procedure under general anesthesia was performed to remove the tumor via a posterior midline approach with L1 inferior-L2 superior laminectomies. Intraoperative neuromonitoring was employed during the surgery. Under microscopic visualization, the dura mater was opened at the midline. After opening the dura, the distal, predominantly cystic portion of the lesion was accessed



**Figure 1.** T2 (a) -T1 (b), and contrast-enhanced (c) magnetic resonance images on the sagittal plane.



**Figure 2.** T1 (a), T2 (b) magnetic resonance images on the axial plane, and macroscopic appearance of the lesion (c).

via careful dissection between the nerve roots. Further dissection revealed the solid component of the lesion.

The lesion was found to originate from the filum terminale. The filum terminale was repeatedly stimulated using a neuromonitoring probe and subsequently sacrificed, allowing complete excision of the lesion without any intraoperative complications (Fig. 2). Histopathological examination confirmed the diagnosis of cystic schwannoma. Immunohistochemically, the tumor cells were positive for S100, CD56, and vimentin, whereas glial fibrillary acidic protein, epithelial membrane antigen, and chromogranin A were negative. No adjuvant therapy was administered following surgery. The patient has been under clinical follow-up for approximately 2 years, with no evidence of recurrence or neurological deficit.

## Discussion

Schwannomas are almost always benign, well-circumscribed tumors that arise from the clonal proliferation of Schwann cells. Although most cases are sporadic, some are associated with neurofibromatosis type 2, schwannomatosis, or Carney complex.<sup>[5]</sup> In our case, the tumor was sporadic and not associated with any syndromic condition, and no additional lesions were detected elsewhere in the body. More than half of these lesions are located in the intradural extramedullary compartment, approximately 25% are purely extradural, 15% have both intradural and extradural components, and intramedullary involvement is rare.<sup>[6]</sup> In our case, the lesion was confined to the intradural extramedullary compartment.

In the present case, although the lesion appeared purely cystic on non-contrast MRI, contrast-enhanced imaging demonstrated enhancement in the region corresponding to the solid component, which was also confirmed intraoperatively. These findings highlight the importance of contrast-enhanced MRI in accurately characterizing the lesion and in guiding intraoperative surgical decision-making. A review of the literature revealed only two previously reported cases of schwannoma arising from the filum terminale.<sup>[3,7]</sup> In the case reported by Passman et al.,<sup>[3]</sup> the lesion appeared completely cystic on the non-contrast series; however, heterogeneous contrast enhancement was observed following contrast administration. This finding is highly similar to our case. Similarly, in the case reported by Mattar et al.,<sup>[7]</sup> the lesion demonstrated an almost entirely cystic appearance on the non-contrast series, whereas nodular, homogeneous contrast enhancement was observed after contrast administration. Both previously

reported cases presented with low back pain and radicular pain. Similarly, our patient presented with low back and leg pain accompanied by gait disturbance. Apart from the lesion, no other pathology, such as disc herniation or spinal stenosis, that could account for the clinical symptoms was identified. In the post-operative period, the patient's leg pain improved markedly, and a progressive increase in walking distance was observed, from an initial distance of 200 m. Comparable clinical improvement was also reported in the cases described in the literature. In our case, to achieve complete resection of the filum terminale lesion, the filum was sacrificed after repeated confirmation with a neuromonitoring probe.

MRI remains the most reliable modality for the evaluation of spinal cystic lesions.<sup>[4]</sup> Tumors of nerve sheath origin can often be suggested by their characteristic MRI signal patterns; however, cystic schwannomas may pose a diagnostic challenge, particularly when they present as predominantly or completely cystic lesions. Schwannomas typically appear iso- to mildly hypointense relative to the spinal cord on T1-weighted images and markedly hyperintense on T2-weighted sequences. Areas of increased T2 signal intensity usually reflect cystic degeneration, whereas regions of relatively lower signal intensity may be associated with hemorrhage, increased cellularity, or fibrous tissue.<sup>[8]</sup>

The enhancement pattern of schwannomas after contrast administration is variable and may range from homogeneous to predominantly peripheral enhancement. In cases of intradural extramedullary cystic masses demonstrating rim or focal enhancement, schwannoma should therefore be considered prominently in the differential diagnosis. One of the distinguishing radiological features of cystic schwannomas is the presence of a well-defined, contrast-enhancing wall or focal enhancing component. This finding is generally absent in most other cystic spinal lesions.<sup>[8,9]</sup>

Nevertheless, differentiation from other cystic lesions such as arachnoid, epidermoid, dermoid, neuroenteric cysts, teratomas, and hydatid cysts may remain difficult based solely on imaging findings, particularly in the absence of contrast-enhanced studies.<sup>[5,9]</sup> In the present case, non-contrast MRI suggested a purely cystic lesion, which could have led to misinterpretation of the lesion's nature. However, contrast-enhanced MRI revealed focal enhancement corresponding to a solid component, which was subsequently confirmed intraoperatively. This underscores the critical role of contrast-enhanced MRI

**Table 1.** Radiological differential diagnosis of lesions demonstrating a cystic appearance on non-contrast magnetic resonance imaging in this region

| Lesion            | T1 signal                | T2 signal    | DWI                  | Contrast enhancement                                  |
|-------------------|--------------------------|--------------|----------------------|-------------------------------------------------------|
| Arachnoid cyst    | CSF-like                 | CSF-like     | No restriction       | None                                                  |
| Epidermoid cyst   | CSF-like                 | Hyperintense | Restricted diffusion | Minimal/none                                          |
| Neuroenteric cyst | Variable                 | Hyperintense | Usually none         | Rare                                                  |
| Tarlov cyst       | CSF-like                 | CSF-like     | None                 | None                                                  |
| Dermoid cyst      | Often hyperintense (fat) | Variable     | None                 | Variable                                              |
| Cystic schwannoma | Hypointense              | Hyperintense | Usually none         | Peripheral (rim), nodular, homogeneous, heterogeneous |

CSF: Cerebrospinal fluid; DWI: diffusion-weighted imaging.

not only in improving diagnostic accuracy but also in pre-operative planning and intraoperative decision-making for spinal cystic lesions. Radiological differential diagnosis of lesions demonstrating a cystic appearance on non-contrast MRI in this region is shown in Table 1.

Although radiological findings may be highly suggestive, definitive diagnosis of schwannomas relies on histopathological examination. Histologically, schwannomas are composed of spindle-shaped cells with pale eosinophilic cytoplasm, arranged in densely cellular Antoni A areas and loosely organized Antoni B areas. The cystic changes observed in schwannomas are thought to result from degenerative processes within Antoni B regions or from ischemic necrosis secondary to tumor growth.<sup>[10]</sup> In our case, histopathological evaluation confirmed the diagnosis of schwannoma.

Complete surgical excision remains the cornerstone of treatment for spinal schwannomas, as total resection significantly reduces the risk of recurrence and is associated with favorable long-term outcomes. In the present case, total resection was achieved, aided by the use of intraoperative neuromonitoring and microsurgical techniques, allowing safe removal of the lesion.<sup>[4]</sup> The patient experienced significant post-operative clinical improvement, consistent with outcomes reported in the literature. These findings further support complete surgical resection as an effective and safe treatment strategy, even in rare and atypical presentations such as heterogeneous schwannomas originating from the filum terminale.

Conclusion

Contrast-enhanced MRI is essential for the accurate evaluation of lesions that appear purely cystic on non-contrast imaging, guiding both diagnosis and treatment planning. In schwannomas originating from the filum terminale, complete surgical excision can be safely achieved with the

use of intraoperative neuromonitoring. When necessary, sacrifice of the filum terminale may be required to ensure gross total resection and optimal clinical outcomes.

**Ethics Committee Approval:** This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

**Informed Consent:** Written informed consent was obtained from the patient for publication of this case report and accompanying images.

**Conflict of Interest:** The authors declare no competing interests that could have influenced the objectivity or outcome of this research.

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## LETTER TO THE EDITOR

# Spinal Muscular Atrophy Screening in Türkiye: From Awareness to Clinical Outcomes

 **Okan Sökmen**

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Dear Editor,

I read with great interest the article entitled “Awareness and Attitudes Toward Spinal Muscular Atrophy (SMA) Carrier and Newborn Screening Programs in Türkiye: A Cross-Sectional Study in Family Health Centers” by Özbaş et al.<sup>[1]</sup> The authors should be commended for providing valuable data on a recently implemented nationwide screening initiative.

The study clearly demonstrates that information and awareness play a significant role in individuals’ willingness to participate in SMA screening. These findings are of great importance, particularly for Türkiye, where both premarital carrier screening and newborn screening have recently been integrated into national health policies. As the authors emphasize, increasing public awareness is essential to improve the effectiveness of these programs.

In recent years, the clinical management of SMA has changed significantly. The use of disease-modifying therapies such as nusinersen, onasemnogene abeparvovec, and risdiplam has improved the natural course of the disease.<sup>[2–4]</sup> Studies have shown that starting treatment before symptoms appear leads to much better motor and survival outcomes.<sup>[2–4]</sup> Recent studies also show that newborn screening enables early diagnosis and timely treatment, which is directly associated with better clinical outcomes.<sup>[3]</sup> Therefore, SMA screening

programs should be considered not only as a tool for early diagnosis but also as a crucial step in enabling early and life-changing treatments.

In our country, nusinersen is widely used and remains the primary treatment option under the national reimbursement system.<sup>[2]</sup> Although new treatment options such as risdiplam have entered clinical use, access is limited by certain criteria. Onasemnogene abeparvovec gene therapy is available only in limited settings due to cost and restrictions related to health policies. These factors further increase the importance of screening programs for early diagnosis and timely treatment. This is particularly relevant, as recent evidence shows that early diagnosis and timely treatment can significantly modify the course of the disease and long-term clinical outcomes.<sup>[4,5]</sup>

Considering the relatively high carrier frequency and the nationwide implementation of screening programs, increasing public awareness in Türkiye is especially important. However, it is also important that individuals not only access screening but also understand its clinical value. In this context, the role of primary care physicians and structured genetic counseling is very important. Open and effective communication at the primary care level may help translate awareness into actual participation in screening programs. However, it is still unclear how awareness translates into real screening uptake, early treatment, and

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long-term neurological outcomes. Future studies focusing on these points would provide valuable information about the real-world impact of screening programs.

In conclusion, this study provides important insight into public awareness of SMA screening in Türkiye. In the current treatment era, increasing awareness is not only a public health goal but also a key factor for early diagnosis and effective treatment.

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