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Preparing Future Physicians for Digital Practice: Evaluation of a Structured Telemedicine Education Program

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Abstract

Background:

The rapid digital transformation of healthcare highlights telemedicine as an essential component of clinical practice. However, insufficient training during undergraduate medical education remains a critical barrier to its widespread implementation. This study aimed to evaluate the effects of a structured telemedicine education program on medical students' telemedicine knowledge and consultation skills and to assess students' perceptions of the program.

Methods:

A quasi-experimental pretest–posttest control group study was conducted with 68 third-year medical students (intervention, n = 36; control, n = 32). The intervention group participated in a 15-week structured telemedicine education program developed using the ADDIE instructional design model. The program included theoretical sessions, observation of real telemedicine consultations, simulated patient encounters, and structured multisource feedback. The control group received a one-hour introductory session on telemedicine. Telemedicine knowledge was assessed using pre- and posttests, and consultation performance was evaluated at the end of the intervention period through standardized simulated patient encounters using a 20-item structured checklist. Students in the intervention group also completed a feedback form.

Results:

Baseline knowledge scores did not differ significantly between the groups ($p = 0.166$). Knowledge scores increased significantly in the intervention group ($p < 0.001$), and the median change score was greater in the intervention group than in the control group (2 [0–7] vs. 0 [– 8–4], $p < 0.001$). Telemedicine consultation performance was also significantly higher in the intervention group (median 19 [17–20]) than in the control group (median 10 [7–16], $p < 0.001$). Among intervention participants, 88.5% considered the program beneficial, 88.6% reported improvements in clinical and patient communication skills, and 74.3% intended to integrate telemedicine into their future clinical practice. Simulated patient encounters and structured feedback were particularly valued by students.

Conclusions:

A systematically structured, experiential telemedicine training program significantly enhances medical students' clinical consultation competence and knowledge. Integrating practice-oriented, simulation-based telemedicine modules longitudinally into the undergraduate curriculum prepares future physicians for effective and safe digital healthcare delivery.

Trial registration

ClinicalTrials.gov Identifier NCT07838467. Registered on 23 September 2026. Retrospectively registered.

Background

The rapid transformation in information and communication technologies (ICT) is fundamentally changing healthcare delivery models. This evolution, which transcends the boundaries of traditional medical practice, has introduced

concepts such as e-health, m-health, telehealth, and telemedicine into the literature. Today, the broadest umbrella term encompassing all these elements is "digital health". Rooted in e-health, digital health includes innovative fields such as artificial intelligence, big data, genomics, the Internet of Things (IoT), robotics, and machine learning [1]. In this ecosystem, e-health refers to the use of ICT in service, education, and research, while m-health is a sub-component encompassing the integration of mobile and wireless technologies [1].

The most critical element of this transformation with direct implications for clinical practice is telemedicine. Telemedicine refers to the delivery of healthcare services at a distance using information and communication technologies to exchange information for diagnosis, treatment, and the prevention of disease and injury [2]. In contrast to telemedicine, which primarily focuses on the remote delivery of clinical care, telehealth is a broader concept that also encompasses non-clinical activities, such as health education and healthcare management [3]. Although the terms telemedicine and telehealth are often used interchangeably in the literature [2], telemedicine fundamentally aims to improve individual and population health by enabling the delivery of high-quality and sustainable healthcare services at a distance through digital technologies [2,4].

Telemedicine applications are gaining increasing importance due to their potential to improve access to healthcare, enhance the patient care experience, and reduce healthcare costs [5]. Despite the growing demand for telemedicine, its widespread adoption remains limited. Insufficient training among physicians has been identified as one of the major barriers to its implementation [6–9]. Therefore, medical students should receive structured telemedicine training during undergraduate medical education and develop the technological and clinical competencies required for remote patient–physician interactions. Evidence suggests that these competencies can be developed through appropriate educational programs, supporting recommendations for the integration of telemedicine training into medical curricula [6,10].

Today’s medical students are the first generation of “digital natives” who grew up surrounded by digital technology [9]. Students’ natural comfort with technology can be supported through structured education. Without education, healthcare professionals will not be ready to benefit from digital health innovations. In this context, the integration of telemedicine education into the undergraduate medical education curriculum is critical for ensuring that future physicians graduate competent in this field [11, 12]. The effort to add telemedicine competencies to medical education is supported and encouraged by the AMA (American Medical Association). In 2016, the AMA called for the public adoption of a policy aimed at ensuring that medical students and residents are properly trained in the use of telemedicine in clinical practice. In addition, it has provided over US$12.5 million in grants to medical schools for innovative curriculum developments that can be implemented nationwide [13].

However, both national and international literature reveal a lack of a standardized telemedicine curriculum model for undergraduate medical education with robust theoretical and methodological foundations and high-level evidence of effectiveness [14]. Most existing approaches consist of temporary or limited interventions and are supported by relatively weak evidence. Despite a recognized urgency for educational interventions, a comprehensive framework is still lacking. Existing studies fail to provide concrete guidelines regarding when these training courses should be delivered, which core competencies must be covered, and which interactive instructional methods are most effective.

Aim and Research Questions

The aim of this study was to evaluate the effect of a structured telemedicine education program developed for medical students on their telemedicine knowledge and telemedicine consultation skills. The study also aimed to assess students’ satisfaction with and views on the program.

In line with this overall aim, the study addressed the following research questions:

RQ1: Is there a significant difference between pre-test and post-test telemedicine knowledge scores among students in the intervention group?

RQ2: Is the improvement in telemedicine knowledge scores significantly higher in the intervention group compared to the control group?

RQ3: Do students in the intervention group demonstrate higher telemedicine consultation performance than students in the control group?

RQ4: What are the satisfaction levels and perspectives of the intervention group students regarding the telemedicine education program?

Methods

Study Design

This study employed a quasi-experimental pretest–posttest control group design to evaluate the effects of a telemedicine education program on medical students' telemedicine knowledge and consultation performance. The independent variable was participation in the telemedicine education program, and the dependent variables were telemedicine knowledge test scores and telemedicine consultation performance scores.

Study Population and Sample

The study population consisted of third-year students studying at Selçuk University Faculty of Medicine during the Fall Semester of the 2023–2024 academic year. Convenience sampling, a non-probability sampling method, was used for sample selection. A total of 68 students were included in the study on a voluntary basis.

Intervention Group (n = 36): This group consisted of students who chose the telemedicine elective course and agreed to participate in the research. The intervention group received a structured telemedicine education program developed in line with the results of the needs analysis and national and international competency frameworks; this program included theoretical lectures, observation of real telemedicine consultations, and simulated patient applications.

Control Group (n = 32): This group consisted of volunteer students with similar age and gender characteristics to the intervention group. Following the pretest, the control group received a one-hour informational session covering the definition and applications of telemedicine, as well as an explanation of the procedures to be followed during the study. At the end of the semester, both groups completed the post-test and participated in an online simulated patient encounter. During the encounter, students' telemedicine consultation skills were assessed using a structured performance checklist.

Study Procedure

The development and implementation of the telemedicine education program for medical students were systematically planned and conducted using the ADDIE instructional design model.

Instructional Design of the Telemedicine Education Program: The ADDIE Framework

Analysis

To define the problem, the current curriculum of the university where the research was conducted and telemedicine applications in other medical faculties in Türkiye were examined in detail. The examination revealed that training in this field is offered in a limited number of faculties, mostly in the form of observation-based internships or theoretical modules during the clinical phase. Instead of these models, which focus on students passively observing the process, a competency-based and systematically structured curriculum was identified as a need. To establish the scientific foundation of the curriculum, a literature review was conducted across PubMed, Google Scholar, TR Dizin, and the YÖKTEZ databases focusing on telemedicine and digital health in undergraduate medical education. The findings guided the structuring of the needs assessment and the development of the curriculum. Subsequently, a multi-stakeholder needs assessment involving medical students, physicians, and members of the public was conducted to inform the learning objectives, content, and teaching methods of the program. Findings from the literature review and needs assessment were then mapped to the relevant competencies and learning objectives of the national core medical education curriculum and used to inform the design of the program.

Design

Based on needs analysis, literature, and field data, the course objective, learning goals, teaching methods, and assessment tools were determined. The learning objectives were developed based on Bloom's taxonomy and covered the cognitive, psychomotor, and affective domains. The learning objectives are provided in Additional file 1. Constructive alignment was established among the learning objectives, educational content, teaching methods, and assessment strategies. The program was structured around learner-centered, simulation-based, and experiential learning approaches. The alignment of the program components is presented as a matrix in Additional file 2.

Development

In line with the learning objectives, theoretical course materials were developed for six weeks of instruction and supported with clinical cases and visual materials. Zoom and Skype were selected for synchronous sessions, case discussions, and simulated patient encounters. Their audio, video, and screen-sharing functions were tested before implementation to ensure their suitability for telemedicine activities.

Expert Support and Institutional Collaboration: Students observed real telemedicine consultations conducted by a faculty member from the Department of Pulmonology who routinely provided telemedicine services in clinical practice. In addition, a faculty member in forensic medicine delivered a session addressing medical malpractice, patient rights, data security, and relevant legal regulations in digital healthcare.

Simulated Patient Scenarios: Clinical scenarios tailored to telemedicine were developed, encompassing chronic disease management (such as hypertension and diabetes) and acute symptom triage. These scenarios were portrayed by professional simulated patients with specialized training in medical simulation, thereby ensuring a standardized experiential learning and assessment environment for every student.

Development of Assessment Instruments: Three instruments were developed to evaluate the educational program: a knowledge test, a telemedicine consultation performance checklist, and a student feedback form.

The multiple-choice knowledge test was developed in accordance with the learning objectives of the program and finalized following expert review, pilot testing, and item analysis. Based on the results of this process, items were revised in terms of wording, distractors, and difficulty levels.

A 20-item structured checklist was developed to assess students' telemedicine consultation skills, including communication, history-taking in a telemedicine setting, privacy, and use of technology. Each item was scored dichotomously as "Done" or "Not done." The content validity of the checklist was evaluated through expert review by specialists from relevant clinical fields and medical education.

A student feedback form consisting of 5-point Likert-type items was developed based on similar instruments identified in the literature to assess students' perceptions of the educational program.

Implementation

The intervention was conducted during the fall semester of the 2023–2024 academic year. Theoretical sessions were delivered weekly in person, while students observed real telemedicine consultations through synchronous online connections. For practical skills training, the intervention group was divided into four groups of nine students. Each student conducted two live telemedicine consultations with professional simulated patients using predefined clinical scenarios. The sessions were conducted in private, technically equipped small-group rooms using Zoom or Skype. Students received multisource feedback from instructors, simulated patients, and trained peers after the encounters.

Evaluation

The evaluation phase focused on students' telemedicine knowledge, consultation performance, and perceptions of the education program. Knowledge was assessed using pre and post tests in both groups, while consultation performance was evaluated at the end of the 15-week period through standardized simulated patient encounters using a structured checklist. In addition, students in the intervention group provided feedback on the program's content, teaching methods, and implementation.

Program Evaluation Using the CIPP Model

The education program was evaluated using the Context, Input, Process, and Product (CIPP) model.

Context

Context evaluation focused on identifying educational needs through the multi-stakeholder needs analysis and review of the relevant literature, existing curricula, and national competency framework. These findings informed the program objectives and learning outcomes.

Input

Input evaluation addressed the resources required for program implementation, including faculty expertise, professional simulated patients, technical infrastructure, financial support, educational materials, and assessment instruments.

Process

Process evaluation focused on the implementation of planned educational activities, student participation, simulated patient encounters, and feedback processes. Technical and operational issues encountered during implementation were also considered.

Product

Product evaluation focused on students' telemedicine knowledge, consultation performance, and feedback on the program. Knowledge was assessed using pre and post tests, while consultation performance was evaluated through standardized simulated patient encounters using a structured checklist.

Data Collection Tools

Data were collected using the Telemedicine Knowledge Test, Telemedicine Consultation Performance Checklist, and Student Feedback Form.

Telemedicine Knowledge Test

The test was administered in person under researcher supervision to both groups at baseline and at the end of the intervention period.

Telemedicine Consultation Performance Checklist

At the end of the intervention period, students in both groups completed a simulated patient encounter. Their performance was assessed in real time by a single evaluator using the structured checklist.

Student Feedback Form

The form was administered online to the intervention group at the end of the educational program

Data Analysis

Statistical analyses were performed using R version 4.3.3. The distribution of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed continuous variables were summarized as mean ± standard deviation, whereas non-normally distributed variables were presented as median [minimum–maximum]. Categorical variables were summarized as frequencies and percentages.

Baseline continuous variables were compared between the intervention and control groups using the independent-samples t-test or Mann–Whitney U test, as appropriate. Within-group changes in knowledge test scores from pretest to posttest were assessed using the Wilcoxon signed-rank test. Change scores, calculated as posttest minus pretest scores, were compared between the intervention and control groups using the Mann–Whitney U test. Telemedicine

consultation performance scores were also compared between groups using the Mann–Whitney U test. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. All statistical tests were two-sided, and a p value < 0.05 was considered statistically significant.

Results

A total of 68 individuals participated in the study, with 55.9% [n = 38] women and 44.1% [n = 30] men. In the intervention group [n = 36], 52.8% [n = 19] women and 47.2% [n = 17] men were included; while in the control group [n = 32], 59.4% [n = 19] women and 40.6% [n = 13] men were included. No statistically significant difference was found between gender and group distribution [p = 0.762]. The median age of participants was 21 [20–25] in the intervention group, 21 [20–27] in the control group, and 21 [20–27] overall. No statistically significant difference in age was found between the groups [p = 0.387]. The sociodemographic characteristics of the participants are shown in Table 1.

Table 1
Participant characteristics

Variable	**Intervention (n = 36)**	**Control (n = 32)**	**Total (n = 68)**	**p**
Sex, n (%)				**0.762**
Female	19 (52.8)	19 (59.4)	38 (55.9)	
Male	17 (47.2)	13 (40.6)	30 (44.1)	
Age, median (min–max)	21 (20–25)	21 (20–27)	21 (20–27)	**0.387**

Note: Data are presented as n (%) and median [minimum–maximum]. Pearson's chi-square test was used for sex, and the Mann–Whitney U test was used for age. A p-value < 0.05 was considered statistically significant.

Knowledge Test Scores

The mean pre-test score was 8.33 ± 1.91 in the intervention group and 7.72 ± 1.44 in the control group, with no statistically significant difference between the groups (p = 0.166).

In the intervention group, post-test scores were significantly higher than pre-test scores (p < 0.001). The median post-test score was 11 [8–14] in the intervention group and 8 [5–11] in the control group, with a statistically significant difference between the groups (p < 0.001).

The median change in knowledge scores from pre-test to post-test was 2 [0–7] in the intervention group and 0 [− 8 to 4] in the control group. The difference in change scores between the groups was statistically significant (p < 0.001).

Telemedicine Consultation Performance Scores

The median telemedicine consultation performance score was 19 [17–20] in the intervention group and 10 [7–16] in the control group. Performance scores were significantly higher in the intervention group than in the control group (p < 0.001). Comparisons of knowledge test and telemedicine consultation performance scores between the groups are presented in Table 2. The changes in knowledge scores from pre-test to post-test in both groups are presented in Figs. 1 and 2.

Table 2
Comparison of checklist, pre-test, and post-test scores between groups

Variable	Intervention (n = 36)	Control (n = 32)	p
Checklist, median (min–max)	19 (17–20)	10 (7–16)	**< 0.001**
Pre-test, mean ± SD	8.33 ± 1.91	7.72 ± 1.44	0.166
Post-test, median (min–max)	11 (8–14)	8 (5–11)	**< 0.001**

Note: Data are presented as mean ± standard deviation and median [minimum–maximum]. The Mann–Whitney U test was used for the checklist and posttest scores, and the independent-samples t-test was used for the pretest scores. A p-value < 0.05 was considered statistically significant.

Satisfaction and Feedback of Intervention Participants

The highest mean scores were recorded for active participation during small-group sessions (4.40 ± 0.81) and the positive impact of simulated patient encounters on professional self-confidence (4.40 ± 1.01). High ratings were also observed for items indicating that simulated patient consultations and structured feedback positively influenced their medical education (4.31 ± 0.96), simulated patient encounters facilitated learning (4.29 ± 0.99), and instructors maintained effective communication with students (4.26 ± 0.98).

Overall, 88.5% of students perceived the telemedicine curriculum as beneficial, and 88.6% reported that the training enhanced their clinical and patient communication skills. Furthermore, 74.3% stated an intention to integrate telemedicine into their future clinical practice, while 65.7% expressed a desire for additional telemedicine education throughout their medical education.

Relatively lower mean scores were observed for items regarding whether observing real-time teleconsultations facilitated learning (3.80 ± 1.11), the demand for more telemedicine education throughout the medical curriculum (3.83 ± 0.98), and the adequacy of technical equipment (3.89 ± 0.90). Students' evaluation of the telemedicine curriculum is presented in Table 3.

Table 3
Student feedback on the telemedicine education program

Item	Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)	Mean ± SD
I found the telemedicine education useful.	2 (5.7)	0 (0.0)	2 (5.7)	18 (51.4)	13 (37.1)	4.14 ± 0.97
The telemedicine course was relevant to my medical education.	1 (2.9)	1 (2.9)	3 (8.6)	18 (51.4)	12 (34.3)	4.11 ± 0.90
The course helped me integrate my knowledge of basic and clinical sciences.	0 (0.0)	1 (2.9)	8 (22.9)	18 (51.4)	8 (22.9)	3.94 ± 0.76
The course improved my clinical skills and my ability to communicate with patients.	2 (5.7)	0 (0.0)	2 (5.7)	14 (40.0)	17 (48.6)	4.26 ± 1.01
The course objectives were clear.	2 (5.7)	0 (0.0)	1 (2.9)	21 (60.0)	11 (31.4)	4.11 ± 0.93
The duration of the course was adequate.	2 (5.7)	0 (0.0)	1 (2.9)	19 (54.3)	13 (37.1)	4.17 ± 0.95
The physical environment was adequate.	1 (2.9)	2 (5.7)	3 (8.6)	20 (57.1)	9 (25.7)	3.97 ± 0.92
The technical equipment was adequate.	1 (2.9)	2 (5.7)	4 (11.4)	21 (60.0)	7 (20.0)	3.89 ± 0.90
The course materials were adequate.	1 (2.9)	2 (5.7)	2 (5.7)	23 (65.7)	7 (20.0)	3.94 ± 0.87
The course content was appropriate to my needs.	2 (5.7)	1 (2.9)	2 (5.7)	17 (48.6)	13 (37.1)	4.09 ± 1.04
The knowledge gained was applicable to clinical practice.	2 (5.7)	0 (0.0)	3 (8.6)	17 (48.6)	13 (37.1)	4.11 ± 0.99
Participating in real telemedicine consultations facilitated my learning.	0 (0.0)	6 (17.1)	7 (20.0)	10 (28.6)	12 (34.3)	3.80 ± 1.11
Participating in real telemedicine consultations increased my interest in the topic.	2 (5.7)	3 (8.6)	8 (22.9)	7 (20.0)	15 (42.9)	3.86 ± 1.24
The instructor demonstrated sufficient knowledge of the subject matter.	1 (2.9)	1 (2.9)	2 (5.7)	16 (45.7)	15 (42.9)	4.23 ± 0.91
The instructor communicated effectively with students.	2 (5.7)	0 (0.0)	1 (2.9)	16 (45.7)	16 (45.7)	4.26 ± 0.98
The instructor provided satisfactory answers to questions.	2 (5.7)	1 (2.9)	2 (5.7)	15 (42.9)	15 (42.9)	4.14 ± 1.06
The course encouraged active participation.	0 (0.0)	2 (5.7)	1 (2.9)	13 (37.1)	19 (54.3)	4.40 ± 0.81
I would like to use telemedicine in my future practice.	2 (5.7)	2 (5.7)	5 (14.3)	10 (28.6)	16 (45.7)	4.03 ± 1.18

Item	Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)	Mean ± SD
I would like to receive more telemedicine education.	0 (0.0)	4 (11.4)	8 (22.9)	13 (37.1)	10 (28.6)	3.83 ± 0.98
Simulated patient encounters positively contributed to the educational experience.	2 (5.7)	0 (0.0)	0 (0.0)	16 (45.7)	17 (48.6)	4.31 ± 0.96
Simulated patient encounters increased my professional self-confidence.	2 (5.7)	0 (0.0)	1 (2.9)	11 (31.4)	21 (60.0)	4.40 ± 1.01
Simulated patient encounters facilitated my learning.	2 (5.7)	0 (0.0)	1 (2.9)	15 (42.9)	17 (48.6)	4.29 ± 0.99
Simulated patient encounters improved my clinical skills.	2 (5.7)	0 (0.0)	3 (8.6)	17 (48.6)	13 (37.1)	4.11 ± 0.99
I would like to participate in simulated patient encounters at different stages of medical education.	1 (2.9)	2 (5.7)	3 (8.6)	13 (37.1)	16 (45.7)	4.17 ± 1.01
The scenarios were realistic.	1 (2.9)	1 (2.9)	2 (5.7)	12 (34.3)	18 (51.4)	4.32 ± 0.94

Descriptive Analysis of Open-Ended Feedback

Student responses to the open-ended questions were analyzed descriptively, with similar content grouped and categorized under common thematic headings. The findings were supported by direct quotations from participant responses.

Recommendations for Curriculum and Course Structure

Participants provided several recommendations regarding the structural design of the course. A frequently emphasized suggestion was the integration of the telemedicine curriculum as a mandatory course rather than an elective. In addition, students highlighted the necessity of expanding the program to reach broader cohorts and covering all medical students. They also recommended reducing classroom-based theoretical lectures, restructuring session durations, and making the curriculum more practice-oriented.

Key illustrative student quotations included:

"Telemedicine could be a mandatory course instead of an elective." (Student 3)

"To ensure more medical students learn telemedicine, it could be incorporated into the core curriculum committees rather than remaining an elective." (Student 11)

"I think it should be more widespread." (Student 18)

"It should be integrated into the formal curriculum so that more medical students can benefit from it." (Student 24)

"The proportion of classroom-based theoretical lectures should be reduced." (Student 29)

"The duration of theoretical sessions could be shortened." (Student 35)

Enhancement of Technological Infrastructure and Digital Support

Several participants emphasized that technological infrastructure should be upgraded to enhance the educational impact of telemedicine education.

"To advance telemedicine education, a robust internet infrastructure is essential." (Student 7)

"It should be supported by artificial intelligence tools." (Student 14)

Clinical Integration and Advanced Practice

Participants recommended deeper integration of telemedicine education into clinical training. In particular, they noted that conducting teleconsultations with real patients during the later clinical years would provide greater educational value.

"Teleconsultations with real patients could be provided in subsequent clinical years." (Student 21)

"Conducting practice sessions in out-of-classroom clinical settings would be much better." (Student 33)

Overall Educational Satisfaction

A substantial majority of participants reported high overall satisfaction with the telemedicine curriculum. Students highlighted that the training contributed significantly to their professional development, exerting particularly positive impacts on their communication skills, digital history-taking competence, and professional self-confidence. Furthermore, simulated patient consultations were consistently emphasized as the most instructional, engaging, and high-yield component of the educational program.

"It was a beneficial course that contributed positively to our professional lives." (Student 40)

"It was a very instructional and positive process." (Student 24)

"Thank you for improving my telemedicine skills and increasing my professional self-confidence." (Student 17)

"The most useful elective course I have taken so far." (Student 12)

"Interacting with the simulated patient was the best part of the course." (Student 53)

"Overall, it was a very productive elective. It is a training that will be extremely useful in the future; I definitely want to incorporate telemedicine into my medical career and explore it further during my medical studies." (Student 5)

"I acquired knowledge and skills that will benefit me in future clinical rotations and after graduation. Thank you, professor." (Student 8)

"Out of all the courses I have taken in medical school over these three years, I believe this will have the most positive impact on my future medical career." (Student 6)

However, some participants also noted aspects of the training process that warrant improvement. Specifically, criticisms were raised regarding time management, the density of theoretical content, and the scheduling of practical sessions.

Discussion

The increasing digitalization of healthcare has made telemedicine an important component of contemporary healthcare systems. Despite this rapid transformation, knowledge of telemedicine and access to relevant educational opportunities remain limited among healthcare professionals and medical students. In the present study, a needs assessment was first conducted among medical students, physicians, and members of the public to identify their knowledge, awareness, and expectations regarding telemedicine. Based on these findings, a structured telemedicine education program was developed.

When the effect of telemedicine education was evaluated, a significant increase was found between pre-test and post-test scores in the intervention group, while no change was observed in the control group. These findings show that structured telemedicine education, developed in line with needs analysis and literature, is effective in increasing both knowledge level and telemedicine application performance. Similar studies in the literature strongly support this finding. For example, in a multidisciplinary and application-based telemedicine training program, an average increase of 10% was found in pre- and post-test results measuring students' knowledge level, and it was reported that the program had positive effects on telemedicine skills [15]. Similarly, it was shown that after a two-day intensive telemedicine education applied to first-year medical students, the students' knowledge scores increased statistically significantly [16]. In a structured telehealth curriculum integrated into internal medicine internship, a significant improvement was found in the knowledge, skills, and self-confidence levels of students regarding telemedicine applications [17]. In addition, it has been stated that in telemedicine education programs where theoretical knowledge and clinical practice experiences are presented together, students achieve a more significant improvement in their knowledge level and awareness [18, 19]. In a multicenter study conducted on medical students and family medicine residents, the vast majority of participants stated that they observed improvements in their knowledge, skills and attitudes after the training and found the program effective [20]. Furthermore, it has been reported that after an introductory telemedicine model applied to second-year medical students, there was a significant increase in both the telemedicine knowledge level and self-confidence of the students [21].

One of the most striking findings in our study is that, when the checklist results are evaluated, the telemedicine interview performance of the students who received the training intervention was significantly higher than that of the control group. These findings suggest that participation in the structured telemedicine program was associated with better telemedicine consultation performance. The literature also reports that simulated patient interactions and structured feedback processes improve both verbal and nonverbal communication skills of students, and that this improvement positively impacts face-to-face clinical performance [22]. In a training study aimed at improving patient-centered communication skills, it was shown that simulated patient applications and instructor feedback increased students' self-confidence and improved their communication skills in a virtual environment [23]. Similarly, it is stated that standard patient interviews, small group work, and application-based sessions in structured telemedicine training improve students' telemedicine patient interview conducting skills [24]. This suggests that supporting theoretical training with practical sessions can have a stronger impact on learning outcomes.

In a systematic review, digital educational methods were reported to be as effective as traditional approaches in enhancing medical students' communication skills. Online modules, virtual patient simulations, and video-assisted feedback were particularly beneficial, with blended digital learning demonstrating effectiveness comparable to traditional training [25]. Similarly, an interactive virtual respiratory module incorporating telemedicine consultations and standardized patient encounters was positively received by preclinical medical students. Most students reported improvements in their telemedicine communication and differential diagnosis skills [26]. Other studies have similarly reported that telemedicine encounters increased students' awareness of assessing mood and affect through a screen and encouraged more detailed history taking when physical examination was limited [27, 28].

In our study, students also reported that conducting telemedicine consultations with simulated patients increased their professional self-confidence. Consistent with this finding, telemedicine modules integrated into a pre-clerkship preparatory course significantly improved students' self-confidence in performing telemedicine, particularly in structured history taking, digital patient communication, and intra-team communication [29].

However, some studies indicate that virtual education cannot completely replace in-person clinical training and remains limited, particularly in developing physical examination skills [26]. This view is further supported by findings demonstrating that students exhibit lower performance, especially in remote physical examination and objective data collection [30]. Indeed, a recent telemedicine clerkship study conducted with third-year medical students reported that while students' belief in the strengths of telemedicine—such as effective medical history taking, time management, and spatial accessibility—increased significantly after the training, their concerns regarding the inability to physically touch the patient and the risk of misdiagnosis during remote consultations persisted [31]. Similarly, it is noteworthy that students reported their physical examination skills remained constrained and expressed that telemedicine practices made the importance of in-person examinations even more apparent [32]. To mitigate these limitations—which emerge as one of the most challenging areas for students in telemedicine simulations—video-assisted feedback sessions are reported to enhance student comfort, self-confidence, and readiness [24].

Student feedback highlighted several positive aspects of the program, including active participation, simulated patient encounters, increased self-confidence, and improved clinical skills. Most students reported that the telemedicine education provided knowledge that was directly applicable to clinical practice and contributed meaningfully to their professional development. In addition, instructor–student communication, clarity of the course objectives, and the structured organization of the practical sessions were rated highly.

Despite the overall success of the training program, technical equipment and physical environment ratings were lower than other items in the current study, supporting the technology-related communication barriers described in the literature. It has been reported that technical disruptions in telemedicine environments—such as video lag and background noise—can negatively affect the educational process and potentially weaken the physician–patient therapeutic relationship [33, 34]. Furthermore, inadequate technical infrastructure as well as organizational and logistical challenges in digital learning environments are emphasized as critical limitations that must be addressed in telemedicine education [29].

Conversely, some of the students noted that encountering these minor technical glitches served as a valuable preliminary experience for potential issues they might face in future clinical practice. Indeed, another study demonstrates that minor technical problems encountered during telemedicine sessions are mostly easily resolved and do not hinder the continuity of education [35].

Students’ suggestion that telemedicine education should be integrated into the curriculum as a mandatory rather than an elective component indicates that they considered telemedicine an important competency for future clinical practice. This is consistent with the broader literature, which emphasizes the systematic integration of eHealth and telemedicine education into medical curricula to prepare future healthcare professionals for digital health practices [36]. Similarly, the reported need for more telemedicine training in previous studies aligns with the findings of the present study [27]. Furthermore, students’ demand for greater emphasis on telemedicine in the curriculum as their knowledge increased is consistent with current trends in medical education [16].

In addition to curriculum integration, the timing of telemedicine education is also important. Previous studies have emphasized that remote consultation skills should be introduced early in medical education and developed progressively, particularly given their growing role in future clinical practice [28, 35, 37, 38].

In the present study, the program was delivered to third-year medical students at the transition between preclinical and clinical training. This allowed students to encounter telemedicine at a stage when they were beginning to apply their foundational medical knowledge in clinical contexts and develop patient–physician communication and clinical skills. Student feedback suggesting more opportunities to engage in telemedicine with real patients, in addition to simulated patient encounters, indicates that telemedicine education may benefit from extending beyond a single stage of the curriculum.

Accordingly, a progressive and longitudinal approach could be considered, beginning with fundamental concepts and simulated patient encounters in the early years and advancing to supervised telemedicine consultations with real patients during clinical years.

From a future projection perspective, the current study determined that students exhibited remarkably high attitudes and motivation toward incorporating telemedicine applications into their future professional careers. This finding is entirely consistent with studies in the literature demonstrating future healthcare professionals' visionary outlook regarding digital health technologies [15, 16].

For example, the literature reveals that an overwhelming 93% of students intend to utilize telemedicine, particularly for the long-term follow-up of chronic and elderly patients [39]; another study positions telemedicine as a strategic tool to improve patient care quality and resolve geographic disparities in rural and underserved areas [40]. In a study examining the contribution of telemedicine training to clinical skills and professional adaptation, 90% of students stated that this experience would make a valuable contribution to their clinical training, and 80% stated that telemedicine would have an important place in their future professional lives [17]. The statements obtained in studies conducted with first-year medical students and using integrated models, that "the knowledge and skills acquired in this process will be highly functional in future clinical practices" directly support the current research results [32].

When all these findings are evaluated with a holistic approach, it is thought that structured telemedicine training provided from the early stages of medical education maximizes students' professional adaptation to digital health applications, objectively improves their clinical skills, and contributes to the development of a highly positive and visionary attitude towards the future use of telemedicine among physicians.

This study has several potential limitations. First, because the research was conducted at a single center and the sample was limited to a specific class level, the generalizability of the findings to different institutions, cohorts, or educational models may be restricted.

Due to the quasi-experimental design, participants were not randomly assigned to study groups. The intervention group consisted of students who voluntarily enrolled in the telemedicine elective, which may suggest that these students had higher baseline interest and motivation regarding digital health and telemedicine.

Furthermore, this study assessed only short-term educational outcomes; long-term knowledge retention, skill sustainability, and transferability to real clinical settings were not evaluated. Consequently, definitive conclusions cannot be drawn regarding the long-term learning outcomes or the sustained impact on real patient care.

Telemedicine consultation skills were evaluated using simulated patient encounters and a structured checklist. While simulation provides a standardized assessment environment, it may not fully capture the complexity of real-world clinical practice, patient diversity, or unpredictable clinical scenarios. In addition, performance anxiety associated with the formal assessment setting might have influenced student outcomes.

Minor technical and internet connectivity disruptions occurred during the implementation process. Additionally, practical sessions on remote physical examination skills remained limited in scope due to technological constraints.

Conclusions

In this study, students who participated in the structured telemedicine education program developed based on the needs analysis and relevant literature demonstrated improvements in their telemedicine knowledge, while their performance in conducting telemedicine consultations was higher than that of the control group. Students' positive evaluations of the program also supported its acceptability. In particular, their perceptions that simulated patient encounters and feedback facilitated learning, helped them identify areas for improvement, and increased their professional self-confidence suggest that practice-based learning experiences constituted an important component of the program.

In light of these findings, telemedicine training should not remain confined to standalone elective courses; rather, it should be systematically integrated into the medical curriculum through a longitudinal approach starting from the early years. Initiating the training in the preclinical phase with fundamental communication skills, medical ethics, and simulation-based scenarios, followed by supervising real-patient consultations during clinical clerkships, will ensure sustained learning continuity. Furthermore, strengthening institutional digital and technological infrastructure is of critical importance to maintaining instructional efficacy and overcoming the limitations associated with remote physical examinations.

Future research should focus on replicating this educational model across diverse medical schools using large-sample, multi-center, and randomized controlled trial designs to enhance generalizability. Additionally, conducting longitudinal studies to evaluate the retention of acquired competencies into internship and post-graduation clinical practice, alongside investigating the integration of artificial intelligence-driven simulation tools, will significantly advance the quality of digital transformation in medical education.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Gazi University Ethics Committee (Approval No: 2023/514 Date: 04/2023), and institutional permission was obtained from Selçuk University Faculty of Medicine. All participants provided informed consent prior to participation in the study. The study was conducted in accordance with relevant ethical guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

RMU contributed to the conceptualization and design of the study, development and implementation of the telemedicine education program, data collection, data analysis and interpretation, and drafting of the manuscript. ÖC contributed to the conceptualization and design of the study, supervision of the research, interpretation of the findings, and critical revision of the manuscript. Both authors read and approved the final manuscript.

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Data Availability

The datasets generated and/or analyzed during the current study are not publicly available due to participant privacy and confidentiality considerations but are available from the corresponding author on reasonable request.This study was supported by the Gazi University Scientific Research Projects Coordination Unit under Project No. 8964.

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Figures

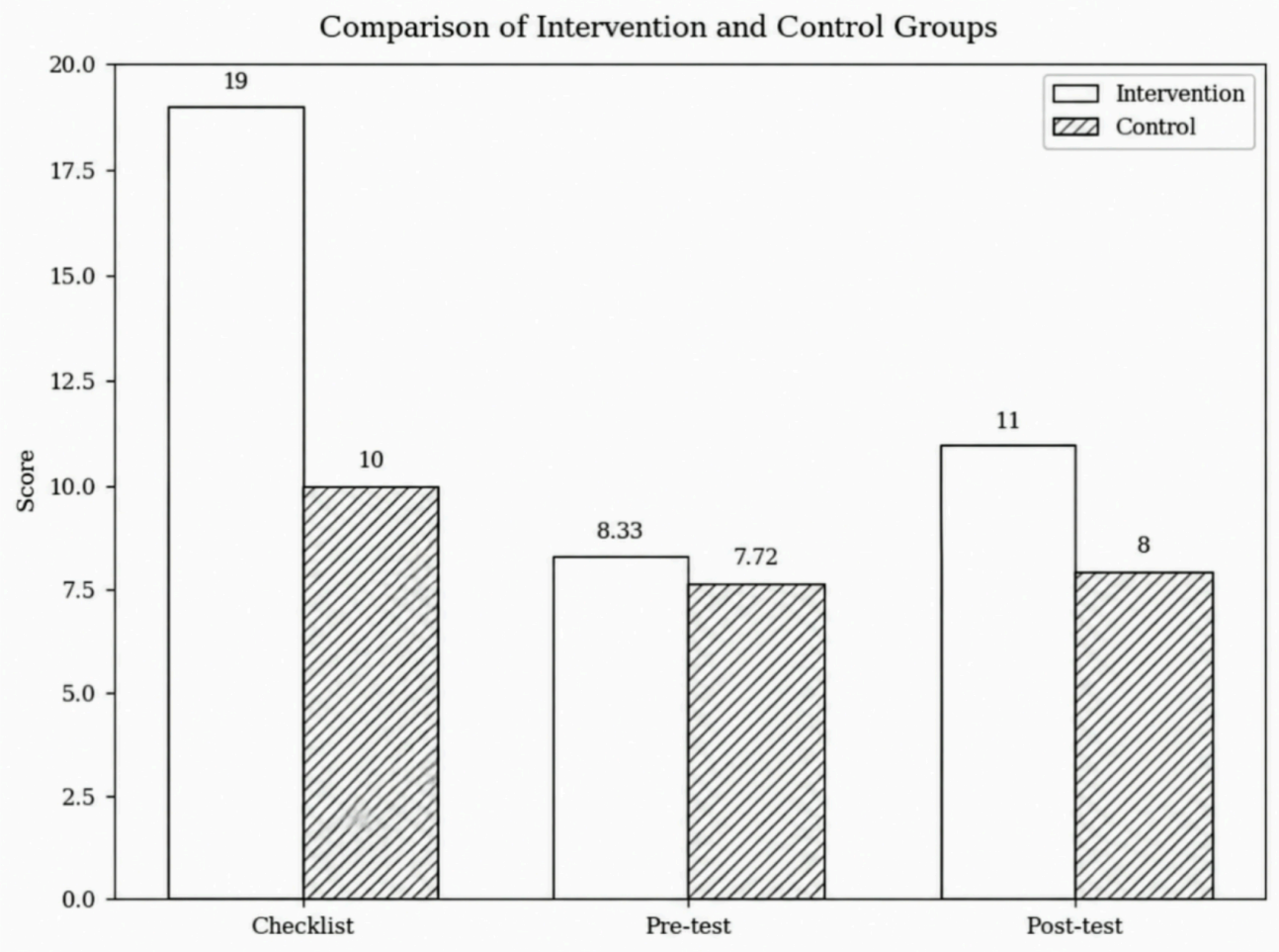


Figure 1

Comparison of checklist, pre-test, and post-test scores between the intervention and control groups.

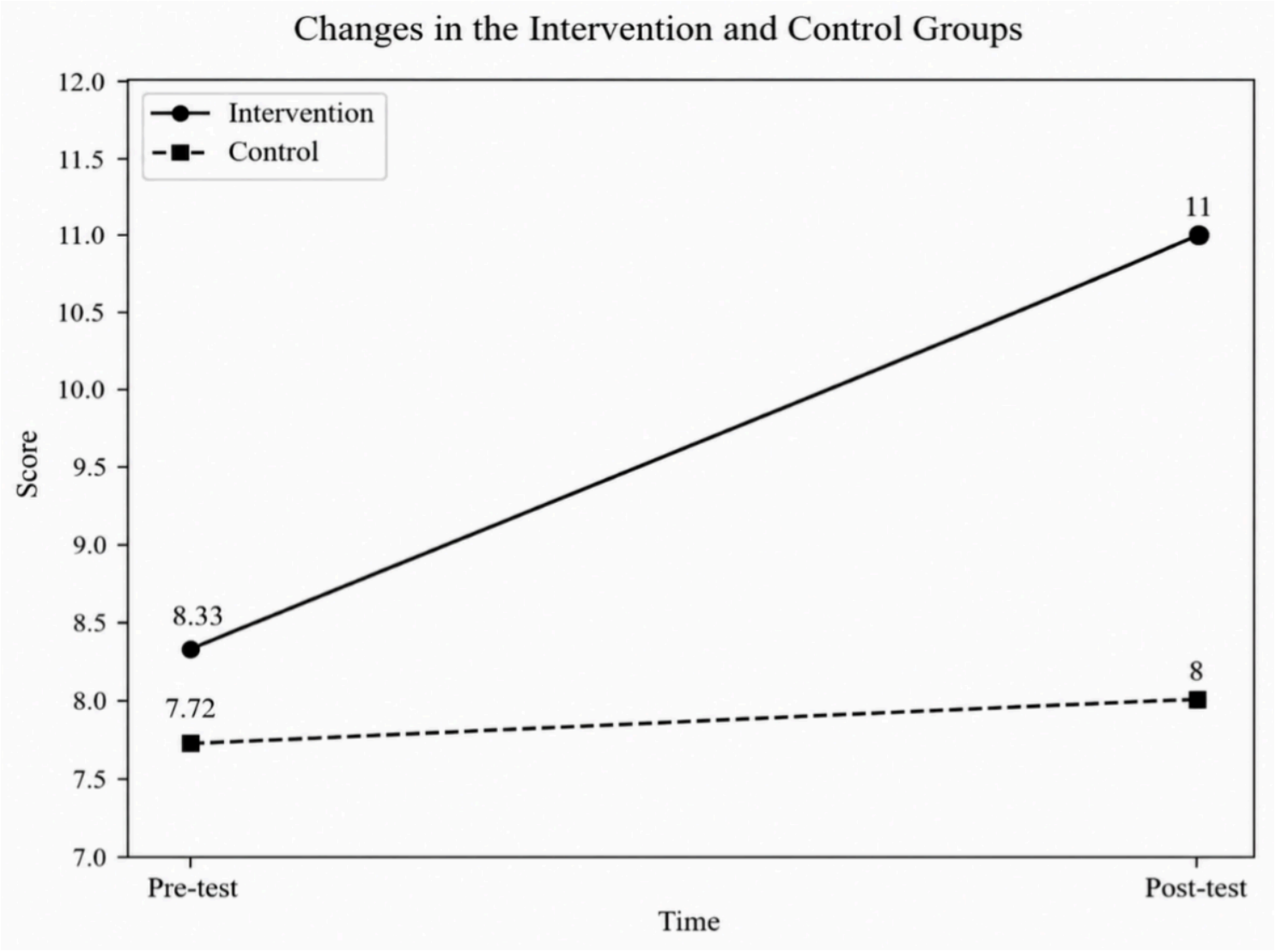


Figure 2

Changes in pre-test and post-test scores in the intervention and control groups

Supplementary Files

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