



The Effect of Standardized Patient Simulation on Nursing Students' Insulin Administration Skills

Standardize Hasta Simülasyonunun Hemşirelik Öğrencilerinin İnsülin Uygulama Becerileri Üzerindeki Etkisi

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ABSTRACT

Objective: Nurses are essential in diabetes care, but both nurses and students often lack knowledge in insulin therapy, which is critical for patient safety given the risks associated with insulin administration. This study aimed to compare the effectiveness of clinical practice alone and clinical practice combined with simulation in improving nursing students' knowledge and skills in managing insulin therapy in real-patient care settings.

Methods: The study was conducted using a quasi-experimental design. In the study, two groups of students, totaling 75 students, were formed and compared: one administered insulin therapy after simulations and interviews, and the other worked directly with real-patients. Both groups were assessed on their insulin therapy skills and knowledge.

Results: Results indicated that the experimental group showed significantly higher knowledge and performance scores than the control group.

Conclusion: The study concluded that clinical practice supported by simulation is more effective than clinical practice

Öz

Amaç: Hemşireler diyabet bakımında kritik bir role sahiptir; ancak hem hemşireler hem de hemşirelik öğrencileri, yüksek riskli bir ilaç olması nedeniyle hasta güvenliği açısından büyük önem taşıyan insülin tedavisi konusunda sıklıkla yetersiz bilgiye sahiptir. Bu çalışma, yalnızca klinik uygulama ile klinik uygulamaya ek olarak simülasyon kullanımının, hemşirelik öğrencilerinin gerçek bakım ortamında insülin tedavisini yönetmeye yönelik bilgi ve becerilerini geliştirmede ne ölçüde etkili olduğunu karşılaştırmayı amaçlamıştır.

Yöntemler: Çalışma, yarı deneysel bir tasarım kullanılarak yürütülmüştür. Çalışmada toplam 75 öğrenciden oluşan iki grup oluşturulmuş ve karşılaştırılmıştır: bir grup, simülasyon uygulamaları ve görüşmeler sonrasında insülin tedavisini uygulamış; diğer grup ise doğrudan gerçek hastalarla çalışmıştır. Her iki grup da insülin tedavisi becerileri ve bilgi düzeyleri açısından değerlendirilmiştir.

Bulgular: Bulgular, deney grubunun bilgi ve performans puanlarının kontrol grubuna kıyasla anlamlı derecede daha yüksek olduğunu göstermiştir.

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ABSTRACT

alone in enhancing students' insulin therapy management skills, with a direct impact on real patient care.

Keywords: Diabetes mellitus, insulin, nursing education, patient simulation, simulation training, subcutaneous injections

Öz

Sonuç: Çalışma, klinik uygulamanın simülasyon ile desteklenmesinin, öğrencilerin insülin tedavisi yönetimi becerilerini geliştirmede tek başına klinik uygulamaya göre daha etkili olduğunu ortaya koymuştur. Ayrıca bu yaklaşımın gerçek hasta bakımına doğrudan etki sağladığı sonucuna ulaşılmıştır.

Anahtar Kelimeler: Diabetes mellitus, insülin, hemşirelik eğitimi, hasta simülasyonu, simülasyon eğitimi, deri altı enjeksiyonlar

Introduction

The 2025 International Diabetes Federation Diabetes Atlas reports that approximately 589 million adults aged 20 to 79 years are currently living with diabetes globally, accounting for roughly one in every nine adults. Projections indicate that this number will rise to 853 million by the year 2050, reflecting a significant increase in the global disease burden. Alarming, more than 252 million adults are estimated to be living with undiagnosed diabetes, representing over 40% of all cases, which substantially elevates the risk of adverse health outcomes and mortality due to delayed intervention (1). In addition to type 2 diabetes, the global impact of type 1 diabetes (T1D) remains considerable, with an estimated 9.15 million individuals affected across all age groups in 2024, including 1.81 million under the age of 20. Within Europe, Türkiye has the highest adult diabetes prevalence, reported at 16.3%, equating to approximately 9.6 million individuals. This figure positions Türkiye among the top ten countries globally with the highest diabetes burden—a trend projected to continue until at least 2045 (2).

According to projections by Satman et al. (3), over 9.2 million individuals in Türkiye are currently living with diabetes, including approximately 2.6 million older adults. Additionally, an estimated 17 million individuals, of whom 2.5 million are elderly, are affected by some stage of prediabetes. The prevalence of diabetes is anticipated to rise progressively, reaching 17.5% by 2030 and 19.2% by 2045, indicating a consistent upward trend in diabetes incidence across all regions of the country among both men and women in the coming decades (3).

Given the increasing prevalence of diabetes both globally and nationally, effective disease management relies substantially on the clinical competence of healthcare providers—particularly nurses. Both diabetes specialist nurses and general nursing staff hold a central role in improving patient outcomes and overall quality of life, contributing significantly from the early detection of diabetes to the prevention of associated complications (4). Contemporary research highlights that nurse-led care models are not only cost-effective but also associated with improvements in key

clinical indicators, such as glycemic control and decreased hospitalization rates (5). Furthermore, these interventions enhance patients' ability to engage in self-care activities, including medication adherence and lifestyle changes (6). These findings emphasize the critical need for ongoing professional development and institutional support to ensure that nurses are equipped to meet the demands of diabetes prevention and management effectively. Alkubati et al. (7) report that nursing students' inadequate insulin therapy knowledge "negatively affects the care and management of people with diabetes" and therefore recommend that nursing curricula include more detailed instruction on insulin management.

The literature shows that both nurses and nursing students are deficient in diabetes knowledge and management, especially insulin therapy management (8-10). Insulin is one of the most dangerous drugs that threatens the patient's life when administered incorrectly. The Joint Commission on Accreditation of Healthcare Organizations identified insulin as one of the five "high alert" drugs with the highest risk of patient harm due to medication errors (11). The wrong dose of insulin causes symptoms such as hypoglycemia or hyperglycemia in the patient. Such errors during drug administration lead to more severe complications in the future. Therefore, nursing students' knowledge and skills in insulin injection directly affect patient safety.

In traditional education, nursing students receive theoretical education in the classroom, develop their technical skills in the laboratory and learn the art and practice of nursing in the clinical setting. In the clinical setting, students are assigned patients, and the student provides care under the instructor's supervision. Ideally, traditional clinical experiences offer a broad range of learning opportunities. Students learn to think critically, apply their skills, and communicate with the patient, family, and healthcare team. However, the increasing number of undergraduate programs, practices related to patient safety, decreasing length of stay of patients and inequalities in clinical learning experiences have been a challenge for nursing programs (12). At the same time, problems in instructor-student interaction in clinical teaching, inadequate number of

instructors, high number of students, and the lack of clinical teaching environments in which students can acquire the desired skills cause problems in clinical teaching (13,14).

Due to such problems, simulation practice has rapidly increased in nursing education as an innovative and effective educational technique in recent years. Simulation provides students with an active learning experience modeled similarly to real situations. This creates a bridge by filling the gap between theory and practice (15). When the simulation-based training studies on insulin management in the literature were examined, it was observed that students performed this practice with confidence, and it was found that there was a significant increase in their knowledge and performance skills (16-18). The study's findings in which simulation-based training was used to improve nursing care for diabetes showed that perceived glycaemic management knowledge, insulin administration confidence and clinical appropriateness increased after training. These results show that simulation is an effective learning method in insulin management education and helps students gain a better command of diabetes care (19). Simulation-based education creates opportunities for nursing students to develop their knowledge, practice and skills in a safe environment.

Based on these points, this study was planned to compare the performance results of the management of insulin therapy of nursing students in simulation and real-patient care settings.

Study Hypotheses

H1: The students in the experimental group will have significantly higher levels of knowledge regarding insulin therapy compared to those in the control group.

H2: The students in the experimental group will demonstrate significantly higher insulin injection administration skills compared to those in the control group.

Methods

Study Design

The study was conducted using a quasi-experimental design with a control-experimental group post-test design.

Study Sampling and Characteristics

The study was carried out with 3rd semester (experimental group) and 5th semester (control group) students studying in the university's nursing department in Ankara in the 2017-2018 academic year. In the nursing department where the study was conducted, education lasts 4 years and 8 semesters. Seventy-eight of the 3rd-semester students (out of 132 students) and Sixty-four of the 5th-semester students (out of 118 students) who were invited to the study volunteered to participate in the study. From the volunteer students, 40 students were selected from each group using a simple random number table, and the study

was completed with a total of 75 students (control group: 37; experimental group: 38) who fully participated in the study.

Ethical Dimension

In order to evaluate the ethical suitability of the research, the research protocol was submitted for approval by the Clinical Research Ethics Committee of a Ankara Yıldırım Beyazıt University Yenimahalle Education and Research Hospital, and permission was obtained from the relevant ethic committee (protocol no: 2017/38, date: 20.06.2017). Written permission was obtained from the nursing department where the research was conducted. All students and patients who agreed to participate in the study were informed, and the participants signed an informed consent form. Students who wanted to participate in the study but could not participate and who were in the control group were allowed to practice with the standardized patient (SP) after the completion of the study.

Data Collection Forms

The "insulin injection knowledge test" and "insulin injection performance evaluation form" were used for data collection. The researchers developed all data collection tools used in the study, the opinions of the experts for the evaluation of the suitability of measurement tools and five faculty members who are experts in the subject area for the evaluation of content validity were taken and corrections were made according to their suggestions.

Insulin Injection Knowledge Test: This test, prepared to measure the student's knowledge level about insulin injection, consists of 15 multiple-choice questions. Content validity was evaluated by 10 experts in nursing education and clinical assessment using the Davis technique. Items were scored on a four-point relevance scale, with ratings of 3 or 4 accepted as content-valid. The item-level CVI was calculated as the proportion of experts giving these ratings. CVI values ranged from 0.90 to 1.00, supporting the relevance of the items for the target population.

Insulin Injection Performance Evaluation Form: The form prepared to evaluate students' insulin injection performance levels during real-patient care consists of 24 steps, such as controlling blood glucose level, calculating insulin dose, informing the patient, and following up on nutrition. The "not observed", "incomplete/incorrect", and "correct/complete" options were given, and these categories were scored as 0, 1 and 2, respectively. The form's content validity was assessed by the same 10-expert panel using the Davis technique. Item-level CVI values ranged from 0.90 to 1.00, supporting its suitability for evaluating students' clinical examination skills.

Implementation of the Study

The knowledge and performance assessments of the control group students were carried out during the women's health and diseases nursing clinical practice

(5th semester) after two semesters of clinical experience (42 days/336 hours) following the theoretical education in the traditional approach and injection training on the model in the skills laboratory. On the other hand, the experimental group students performed SP interviews and debriefing sessions in addition to the process defined in the traditional method during the internal medicine nursing clinical practice (3rd semester). The experimental group of students worked under the guidance of the instructor for 2 days on subcutaneous injection practice with a low-fidelity simulator before starting clinical practice. In the laboratory study, the practice skills of all students were monitored by the instructor, and individual feedback was given to their performance. One week after the laboratory study, the experimental group students had individual interviews with a SP who simulated the scenario of a patient with diabetes receiving insulin therapy in the simulation laboratory (60 minutes). The scenario includes insulin therapy management, subcutaneous injection knowledge, patient care with diabetes and insulin dose calculation. Simultaneously, the students' practices were recorded on video. Immediately after the practice was completed, a debriefing session (30 minutes) was held with groups of 5 students. In the debriefing session, the video-recorded practices of the students were monitored by both the students and the researchers and were conducted using the Gather-Analyse-Summarise method. It was also possible for the students to evaluate themselves by providing feedback to each other about the deficiencies and performances of the practice.

Students' real-patient insulin administration performance was evaluated in the relevant practice area in the hospital in the last two weeks of clinical practice. Two researchers identified patients receiving insulin therapy in the clinics where the students were present. After obtaining the consent of the patient and the mentor nurse monitoring the practice by the researchers, the students were asked to administer insulin to these patients. Each student's performance was evaluated independently by the same two researchers using the real-patient performance evaluation form.

In the last week of the clinical practice, the control and experimental group students simultaneously participated in the post-test in two separate classrooms with similar characteristics (quiet, comfortable, well-lit). The post-test lasted 20 minutes, and two researchers were present with the students during it (Figure 1).

Statistical Analysis

The IBM SPSS Statistics 21.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) program was used for statistical analyses and calculations.

The distribution of knowledge and practice scores in the study was analysed by the Shapiro-Wilk test. All scores

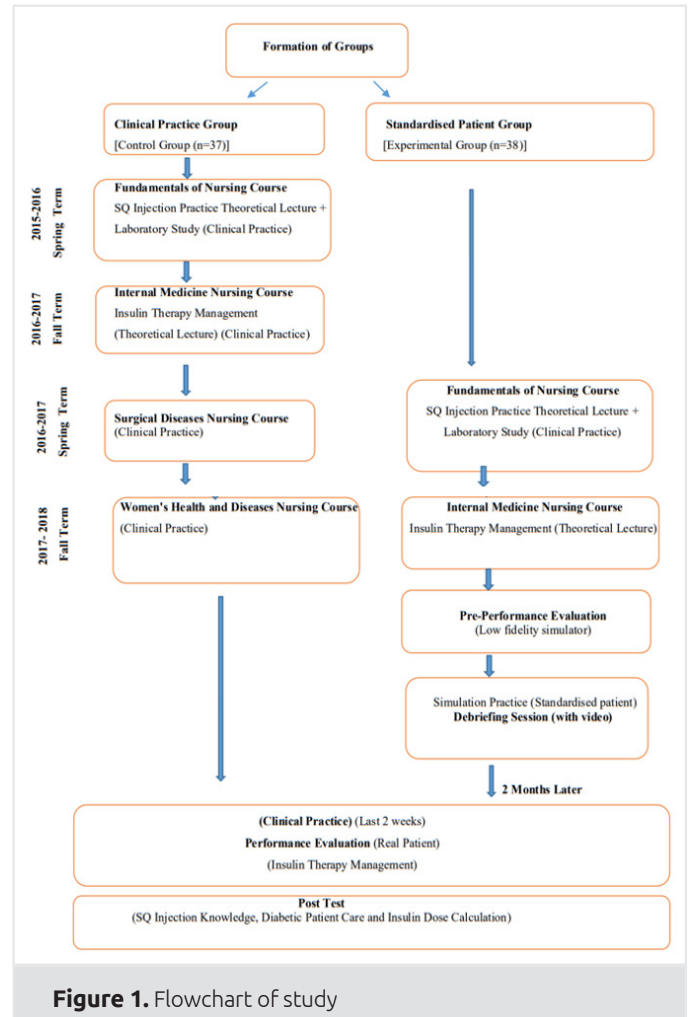


Figure 1. Flowchart of study

were expressed as mean $\pm$ standard deviation. Median (min-max) was given for scores that did not show a normal distribution, and number (%) was given for gender distribution. Knowledge and practice scores were obtained by converting the sum of the scores in the relevant form into a 0-100 scale.

The control and experimental groups were compared with the Mann-Whitney U test regarding post-test knowledge scores and real-patient performance scores. $P < 0.05$ was accepted as statistical significance level. During the evaluations, the researchers did not intervene in student performances in any way. In order to prevent bias, real-patient performance evaluations were collected by two researchers, and the data were coded and transferred to the computer by another researcher without specifying the experimental and control groups.

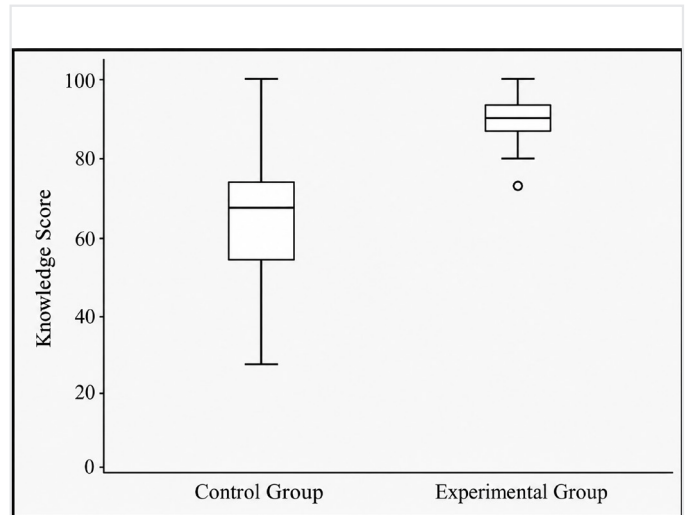
The inter-rater reliability between two observers was assessed by intraclass correlation coefficient (ICC) estimates and their 95% confidence intervals (CIs) based on a single measurement, absolute-agreement, two-way mixed-effects model.

Results

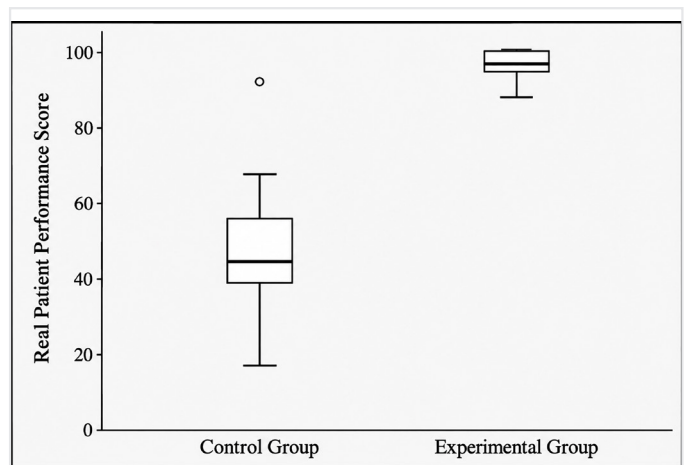
In the study, 86.5% (n=32) of the control group and 84.2% (n=32) of the experimental group were female students. The median age of the control group was 21 (19-25) years, and the experimental group was 20 (19-22) years.

Graphic 1 illustrates the distribution of insulin therapy management knowledge test scores for the control and experimental groups. The results indicate that the experimental group had higher knowledge scores compared to the control group. The median score for the experimental group was notably higher, with a narrower interquartile range, suggesting greater consistency in knowledge acquisition. In contrast, the control group displayed a wider range of scores, with lower median and minimum values. Additionally, the presence of an outlier in the experimental group suggests some variability in the scores, though overall, participants in this group demonstrated superior knowledge compared to those in the control group. These findings suggest that the intervention applied in the experimental group was effective in enhancing the knowledge of the management of the insulin therapy. The median of the insulin therapy management knowledge test of the experimental group was 93.33 (min: 66.67-max: 100.00), which was significantly higher ($p<0.001$) than the control group 66.67 (min: 26.67-max: 100.00) (Table 1).

The median real-patient performance score of the management of the insulin therapy of the experimental group was 95.83 (min: 87.50-max: 100.00). It was significantly higher than the performance score of the control group ($p<0.001$) which was 43.75 (min: 16.67-max: 91.67) (Graphic 2). It was found that statistically significant differences existed between the experimental and control groups across all 24 performance steps ($p<0.05$). These differences were significant at $p<0.001$ for 22 steps, whereas Item 2 (controlling the physician's order) and Item 17 (injecting the drug into the tissue in 10 seconds) showed significance at $p=0.025$ and $p=0.015$, respectively (Supplementary Table S1).



Graphic 1. Distribution of insulin therapy management knowledge test scores in the control and experimental groups



Graphic 2. Control and experimental group insulin therapy management real patient performances

Table 1. Comparison of knowledge and real patient performance scores of the experimental and control groups

	Experimental	Control	p
Knowledge scores			<0.001
Mean $\pm$ SD	90.83 $\pm$ 7.80	65.41 $\pm$ 17.63	
Median (min-max)	93.33 (66.67-100.00)	66.67 (26.67-100.00)	
n	38	37	
Real patient performance scores			<0.001
Mean $\pm$ SD	96.66 $\pm$ 3.23	46.73 $\pm$ 13.31	
Median (min-max)	95.83 (87.50-100.00)	43.75 (16.67-91.67)	
n	38	37	
SD: Standard deviation			

Table 2. Interobserver agreement for real patient performance evaluations based on intraclass correlation coefficients

Type of performance evaluation	Intraclass correlation coefficient	95% confidence interval	Level of agreement	Reference range
Real patient evaluation	0.972	0.950 - 0.984	Excellent	>0.90
Reference range: <0.50, Poor: 0.50-0.75, Moderate: 0.75-0.90, Good: >0.90 excellent				

Two observers independently evaluated participants' insulin administration performance in real-patient care settings. The ICC for their performance scores was 0.972 (95% CI: 0.950-0.984). There results indicated an excellent intra-rater agreement (Table 2).

Discussion

This study was designed to compare the effectiveness of clinical practice following simulation practice with actual clinical practice environments in improving the knowledge and skills of nursing students in insulin therapy management. The results indicated that students with real clinical practice with real-patients scored average on the diabetes mellitus knowledge test. On the other hand, students who had simulation practice before the clinical experience scored significantly higher on the insulin management knowledge test. The findings suggest that simulation-supported clinical practice was associated with higher knowledge and insulin administration performance scores than clinical practice alone.

In the study by Moxley et al. (19), simulation-based didactic education on diabetes care supported significant improvements in students' knowledge, confidence, and clinical practices. This finding aligns with other studies showing that simulation is more effective than traditional teaching methods in fostering clinical skills (20,21). Eom et al. (20) demonstrated that SP-based training improved nursing students'competencies and problem-solving skills. This finding confirms the potential of simulation-based education to bridge the gap between theoretical knowledge and clinical practice (20).

Simulation-based education provides students with a safe opportunity to experience situations they may encounter in real clinical settings, thus helping to bridge the gap between theory and practice. While emphasizing the impact of simulation-based education on the development of clinical skills, this study also highlights that the high-performance scores achieved in real-patient care suggest that simulation-based education is an effective learning tool in laboratory settings and clinical environments. Hayden et al. (12) reported that high-fidelity simulation experiences, accounting for up to half of traditional clinical hours, produced comparable program outcomes and clinical readiness among new graduates. Given that students who participated in simulation demonstrated higher scores in diabetes knowledge and insulin management skills compared to those who only completed clinical internships, the results of this study provide evidence supporting

the value of simulation-based education as an effective teaching strategy, including the use of SPs to enhance students' insulin therapy management skills.

According to our study's findings, students who interacted with SPs obtained significantly higher real-patient insulin therapy management performance scores than students with relatively extended clinical experiences in hospitals. Furthermore, the control group, consisting of students who only participated in clinical internships, exhibited deficiencies in several steps of safe medication administration. These results are consistent with previous studies that highlighted nursing students' inadequate skills in verifying medication rights before administration (22,23), recognizing patients, and performing medication calculations for accurate dosing (24-26).

However, it should also be noted that real clinical experiences should supplement more than simulation-based education. As Fischer-Carlidge et al. (27) notes, simulation exercises may not always fully replace real-patient experiences. Therefore, as in this study, clinical practice supported by simulation exercises emerges as an effective method for maximizing students' knowledge and skills (27).

Furthermore, Whittingham et al.'s (28) study highlighted that a smartphone application developed to strengthen nursing students' clinical skills, such as subcutaneous injections and blood glucose measurement, effectively increased their confidence and performance. These results suggest that technology-enhanced learning supports skill development and enables students to play a more active role in evaluating themselves and their peers. The development of the application through international collaboration underscores the global applicability of technology-based learning across different cultural contexts. Similarly, Skoy et al. (29) conducted a cross-comparison study using two simulators to teach subcutaneous injection techniques. They found that students' confidence and perceived competence increased while anxiety decreased after practicing with both simulators. The only significant difference on performance was observed in students who first practiced with the injection pad and then transitioned to using the simulated arm. Ultimately, students' injection skills and their perceived confidence, competence, and anxiety levels did not vary significantly depending on the type of simulator used (29).

In other studies related to the management of insulin therapy, Ramchandani et al. (30) found that human

patient simulation-based education for parents of newly diagnosed children with T1D provided positive feedback in their diabetes self-management learning process and suggested that this educational model could be extended to other chronic diseases. Faulds et al. (31) also noted that simulation-based education increased accessibility and acceptability among insulin pump users, indicating that this platform could enhance self-management in diabetes care. Similarly, Dubovi et al. (32) found that computer-based simulations had positive effects on diabetes management and understanding of biochemical processes in adolescents with diabetes. Another study testing the applicability and acceptability of simulation in therapeutic patient education (S-TPE) for diabetic adult patients and educators demonstrated that S-TPE is a promising technique for improving diabetes management (33).

In conclusion, this study demonstrates that simulation-based education is an effective method for developing complex skills such as insulin therapy management, as seen in the broader literature. Simulation-based education appears to be an effective teaching strategy that promotes the development of knowledge and skills for a wide range of learners, from nursing students to clinical practitioners and patients. However, it should be acknowledged that simulation is not always the ideal method and must be supported by real clinical practices. This study underscores the need for further research to examine the long-term outcomes of integrating simulation-based technologies and to test their applicability across various disease management scenarios (34,35). Future studies on the long-term impacts of simulation-based education and its practice in different clinical scenarios will further enhance the quality of nursing education and highlight the importance of ongoing research in advancing nursing education.

Study Limitations

Our study was conducted at a single university, and our results cannot be generalized. Since the pre-test scores of the students were not measured, it is impossible to see the initial levels of knowledge and skills regarding insulin management and the progress over time. It is suggested that studies involving a larger sample group and addressing several centers be conducted. In our study, only a single simulation practice has been included since conducting a real-patient performance evaluation was necessary. Students can participate in different simulation practices to compare the differences between clinical practice hours.

Conclusion

The findings indicated that simulation-supported clinical practice was associated with higher knowledge and insulin administration performance scores among nursing students compared with clinical practice alone. This difference was also observed during insulin administration in real-patient care settings. Integrating low-fidelity simulation activities

with SP simulation in the later years of nursing education may provide students with opportunities to update their knowledge and practice their skills in a structured learning environment. These findings reflect improvements in observed student performance rather than patient-level clinical outcomes.

Ethics

Ethics Committee Approval: In order to evaluate the ethical suitability of the research, the research protocol was submitted for approval by the Clinical Research Ethics Committee of a Ankara Yıldırım Beyazıt University Yenimahalle Education and Research Hospital, and permission was obtained from the relevant ethic committee (protocol no: 2017/38, date: 20.06.2017).

Informed Consent: All students and patients who agreed to participate in the study were informed, and the participants signed an informed consent form.

Footnotes

Authorship Contributions

Concept: H.T., M.E., Design: H.T., Ş.S.K., M.E., Data Collection or Processing: H.T., B.V.İ., Ş.S.K., Analysis or Interpretation: B.V.İ., M.E., Literature Search: H.T., B.V.İ., Ş.S.K., B.Ş.K., Writing: H.T., B.V.İ., Ş.S.K., B.Ş.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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Supplementary Table Link: <https://d2v96fxpocvxx.cloudfront.net/688d2d00-d207-464d-89b6-73f393f4f50c/content-images/3f53a160-1380-4167-ab98-c3ba25296db2.pdf>

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