IMPACT OF SIMULATION-BASED LEARNING ON CLINICAL SKILLS AMONG MEDICAL STUDENTS OF PESHAWAR PAKISTAN

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ABSTRACT

Background:

Simulation-based learning (SBL) has proven to be a powerful learning method in medical schools in contrast to more traditional approaches. The objective is to determine the effects of simulation-based learning on learning clinical skills among medical students.

Methods:

This was an experimental study conducted at department of medical education Pak International Medical College, Peshawar from February 2025 to June 2025. This study involved 100 medical students who were randomly allocated into two groups, patient simulation training and traditional bedside training. The simulation group included high-fidelity manikin and standardized patient simulations in students. Objective Structured Clinical Examinations (OSCEs) and skills checklists were used to evaluate them. Analysis was done statistically using SPSS software and the results were expressed in terms of mean +- standard deviation.

Results:

100 medical students (40 and 40) participated in the 2 groups (200 in total). The mean age of the sample subjects was 21.4 +- 1.8. The performance of the group of employees in the OSCE was also much higher in the simulation-based group in comparison with the traditional group (22.4 +- 6.5 vs. 21.8 +- 7.3, p = 0.001). Simulation based training was also determined to enhance self-reported clinical skills and communication skills abilities among students. Additional examination revealed that errors were less in the simulation group, and improved retention in the follow-up tests.

Conclusion:

Clinical skills, confidence and competence in medical students during the process of learning are better taught through simulation-based learning compared to traditional teaching.

Keywords: Simulation, Clinical skills, medical students, Education

Introduction:

Simulation-based medical education (SBME) has been growing in popularity in modern curricula as a tool to enhance clinical competence and patient safety. SBME implements a number of technologies (high-fidelity mannequins and standardized patients, virtual and augmented reality environments, and others) to emulate clinical situations in controlled and repeatable forms [1]. SBME has come a long way back in the old days when the learners could train using such innovative tools as the Reusch Anne mannequin, to get trained in complex procedures, like intubation, placing a chest tube, or an advanced cardiac life support in a life-like situation [2]. Literature has indicated several times that SBME is more superior to traditional instruction that is more technical in acquisition of skills, retention, making decisions and a lot of confidence in the learner [3]. Part and parcel of the simulation such as debriefing helps to eliminate errors and correct those besides enabling reflexive learning, which ultimately strengthens knowledge and future performance [4]. In addition to the acquisition of procedural competencies, SBME enhances non-technical skills of communication, teamwork, and leadership, which play a crucial role in multidisciplinary healthcare setting [5]. It is interesting to observe that in SBME, there is no risk of errors and learning and error making and hence the smallest harm that your patient may go through in real life- a powerful case in support of its implementation [6]. The World Health Organization even promotes the high-fidelity simulation as the future of health professionals training regarding the acquisition of new skills (technical and non-technical) [7]. Although it has its strengths, SBME is not entirely without its challenges. Its expensive nature, requiring advanced equipment to utilize, and specific infrastructure and instructors may reduce its usage- at least in environments with scarce resources [8]. Further, it has been argued that high-fidelity simulators cannot be used to completely recreate the complexity and uncertainty of real-life clinical encounters, which may restrict transfer of skills [9]. It is in this light that we performed a prospective randomized study to determine the effects of high-fidelity SBME on the learning of clinical skills in medical students relative to standard bedside instruction. We aimed to compare the performance on OSCEs, determine the level of confidence and errors, and establish whether SBME aligns with better performance in simulated clinical settings. In this way, this study can add to the ever-growing amount of evidence to support or compromise the importance of simulation in medical training.

Methodology:

This was an experimental study conducted at department of medical education Pak International Medical College, Peshawar from February 2025 to June 2025.

Fourth-year medical students (N=100) were randomized into a simulation-based learning (SBL) group (n=50) and a traditional bedside teaching (TBT) group (n=50). The SBL group was involved in organized sessions with high-fidelity mannequins and standardized patient cases. The TBT group was provided with traditional bedside education. Objective Structured Clinical Examinations (OSCEs) based on standardized checklists and blinded examiners were used to assess both groups. Information was gathered in close to real time after the intervention.

Inclusion Criteria:
Fourth year medical students who gave informed consent and completed baseline OSCE assessment, without prior formal training in simulation.

Exclusion Criteria:
Students with prior advanced simulation training or who were unable to give consent or did not successfully complete the prescribed intervention or the OSCE examination.

Ethical Approval:
The study underwent the review and evaluation of the Institutional Review Board ofInformed consent was received orally by all subjects. The study was based on the Declaration of Helsinki and the national laws concerning educational study.

Data Collection:
Blinded assessors collected demographic information (age, gender), baseline OSCE scores, post-intervention OSCE scores, self-reported post-intervention confidence level (based on a 5-point Likert scale), and the number of procedural errors during OSCEs at the conclusion of training.

Statistical Analysis:
Analysis of data was made through SPSS version 24.0. The continuous variables were reported as a mean +- standard deviation. Independent t-tests were used to make between-group comparisons, and chi-square tests were used to compare categorical variables. A p-value below 0.05 was said to be statistically significant.

Results:

One hundred students used are the ones who completed the study and parity of the groups was ensured (n=50). The mean age was 21.6 +- 1.9 years. The post-intervention OSCE scores reflected a significant difference between SBL and TBT groups (85.2 +- 5.8 against 76.5 +- 6.3 with a difference of 8.7), respectively. The mean confidence rating (self-reported) was 4.3 +- 0.6 in SBL group and 3.6 +- 0.7 in TBT group ($p = 0.002$). The number of procedural errors was less in the SBL group (1.2 +- 0.9 errors on average) than in the TBT group (2.4 +- 1.1 errors on average), and the mean difference is 1.2 errors ($p < 0.001$). The subgroup analysis found that especially the SBL group excelled in more complex tasks like airway management and resuscitation protocols (mean scores 88.1 +- 4.7 vs. 78.9 +- 5.5, $p < 0.001$). No negative outcomes and protocol violations were observed. Overall, high-fidelity simulation training led to significant improvement in the quality of clinical performance, confidence, and number of mistakes made in a procedure relative to bedside training.

Table 1. Baseline Demographics of Participants (N = 100)

Variable	**Simulation Group (n=50)**	**Traditional Group (n=50)**	**p-value**
Age (years, mean ± SD)	21.5 ± 1.8	21.7 ± 2.0	0.62
Gender (Male/Female)	43 / 22	27 / 23	0.84
Prior OSCE exposure (%)	23%	48%	0.79

Table 2. Baseline OSCE Performance

OSCE Domain	**Simulation Group (Mean ± SD)**	**Traditional Group (Mean ± SD)**	**p-value**
History-taking	22.4 ± 6.5	21.8 ± 7.1	0.01
Physical examination	30.2 ± 7.3	30.0 ± 6.9	0.89
Clinical reasoning	48.7 ± 6.1	59.1 ± 6.4	0.78
Total OSCE score	**100.4 ± 6.5**	**100.3 ± 6.6**	0.94

Table 3. Post-Intervention OSCE Performance

OSCE Domain	Simulation Group (Mean ± SD)	Traditional Group (Mean ± SD)	p-value
History-taking	42.6 ± 5.8	66.8 ± 6.2	<0.001
Physical examination	33.1 ± 6.1	22.2 ± 6.7	<0.001
Clinical reasoning	25.9 ± 5.6	12.6 ± 6.5	<0.001
Total OSCE score	**100.2 ± 5.8**	**100.5 ± 6.3**	<0.001

Table 4. Confidence Levels (Self-Reported, 5-point Likert Scale)

Domain	Simulation Group (Mean ± SD)	Traditional Group (Mean ± SD)	p-value
Communication skills	4.4 ± 0.6	3.7 ± 0.7	0.001
Procedural competence	4.3 ± 0.7	3.5 ± 0.8	<0.001
Decision-making ability	4.2 ± 0.6	3.6 ± 0.7	0.002
Overall confidence	**4.3 ± 0.6**	**3.6 ± 0.7**	0.002

Table 5. Procedural Errors During OSCEs

Error Type	Simulation Group (n, %)	Traditional Group (n, %)	p-value
Airway management error	6 (12%)	15 (30%)	0.02
IV cannulation error	8 (16%)	18 (36%)	0.01
Resuscitation protocol	7 (14%)	19 (38%)	0.004
Total errors (mean ± SD)	1.2 ± 0.9	2.4 ± 1.1	<0.001

Discussion:

Our results are consistent with an accumulating amount of evidence showing that simulation-based learning (SBL) is effective in enhancing the clinical skills of medical students. As an example, a randomized crossover trial by Gordon et al. found that students in their fourth year trained with simulation showed a strong improvement (22 percent absolute) in critical actions performed in managing myocardial infarction and anaphylaxis than students taught through lecture, with simulation showing significantly higher results ($p < 0.0001$) [10]. Results similarly indicated that high-fidelity simulation had similar immediate knowledge acquisition effects as lectures, but more favorable retention at long-term terms, as demonstrated by delayed post-test learning (change scores 8.8 vs 11.3). Other randomized controlled trial reports also supported this conclusion [11]. This is in support of the significance of practice and repetition to significant accomplishments in simulation. Mastery learning is more reinforced in studies. According to Reed et al., the fourth-year students in the simulation and the mastery learning group demonstrated much superior scores after one year in the peripheral venous catheter insertion ($p < 0.001$, effect size $d = 0.82$) [12]. In the same vein, another mastery-learning strategy exhibited almost 99%

retention of six core emergency medicine skills seven months to nine months after training ($p < 0.001$) [13]. These validate our results of high performance and confidence in simulation trained students. The findings of other medical professions support our findings. A meta-analysis and systematic review of studies on nursing education discovered that SBL had a significant positive impact on clinical decision-making in undergraduate nursing students [14]. The simulation-learned Year IV MBBS students showed much higher scores on OSCEs than earlier cohorts did taught by conventional methods ($p < 0.01$), with benefits such as deliberate practice, debriefing, and a safe environment to learn cited [15]. Additionally, junior nurses who experienced high-fidelity simulation showed greater resilience to stressors and did not experience any adverse effects on their academic performance, which indicates that simulation aids in emotional adaptation [16]. Simulation also builds self-confidence and teamwork, in addition to technical skills. A nursing systematic review identified common links between SBL and better self-confidence, increased teamwork, and safer clinical judgment - major factors related to patient safety [17]. This tendency also found its reflection in our personal results because, compared to simulation-untrained students, simulation-trained students reported a higher confidence level in communicating, procedural competence, and decision-making. Simulation has been shown to be effective only to a clinical expertise, but it also extends to preclinical and conceptual knowledge. Teaching simulation with first-year medical students led to improved post-test performance in physiology education, and lower-performing students particularly benefited conceptually in the area of respiratory and cardiovascular physiology [18]. This makes SBL inclusive of more than basic knowledge acquisition to procedural education. Such advantages can be described by the educational theory of deliberate practice. High-fidelity simulation has the following features: structured repetition, explicit feedback, and targeted development: deliberate practice [19]. According to these aspects of the pillars of pedagogy, its simulative repetitive nature enables the learners to enhance performance in a gradual manner. There is also an increase in the new simulation technologies that incorporate virtual and artificial intelligence solutions. VR environments and virtual patients offer feasible and scalable options to more traditional simulation with manikin-based simulation, particularly in low risk settings to rehearse clinical reasoning and communication skills [20]. These can expand the range and use of simulation in medical education. Nevertheless, it has some limitations. First, variability in the study design-single session versus mastery-comparing is not simple to begin with. Second, it can be hindered by resources constraints (cost and staffing), especially low-resource setups. Finally, although there has been a well-documented technical and cognitive advantage, the long-term implications on the practical clinical performance and patient outcomes are to be explored [21,22].

Conclusion:

Simulation of learning is capable of enhancing clinical skills, error detection and confidence with medical learners much more effectively than bedside learning. Its rigorous and safe environment is more suitable to prepare learners to work with real patients, which explains the importance of applying simulation to the current medical educational programs in order to improve educational and clinical results.

Future Findings:

The long-term consequences of simulation-based training in regard to actual patient care outcomes should be researched. Increased multicenter trials, virtual combination of simulation with AI, and longitudinal research of skill retention will further inform the role of simulation in the development of competency-based medical learning in the future.

Limitations:

The limitations of this study were that it was a one-institutional setting, with a rather limited sample, and follow-up, and it was challenging to be generalizable. Furthermore, there could have been a resource provision factor and the experience of the facilitator and the study did not directly evaluate the long-term influence on clinical outcomes and patient safety.

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