

Simulation-based training and clinical competence among undergraduate medical students: implications for equitable and safe medical education

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Abstract

Objectives

To evaluate the impact of simulation-based training on clinical skills competency among undergraduate medical students and to compare its effectiveness with traditional teaching methods.

Methods

We conducted an analytical quasi-experimental study with a pre-test and post-test design in a medical college in India. A total of 250 undergraduate medical students participated and were randomly allocated into two groups: simulation-based training ($n = 125$) and traditional teaching ($n = 125$). Clinical skills were assessed using an objective structured clinical examination, and self-efficacy was measured using a validated scale. Data were analysed using paired and independent t-tests, with statistical significance set at $p < 0.05$.

Results

Both groups showed improvement in clinical skills following the intervention. The simulation group demonstrated a significantly greater increase in mean clinical skills scores compared to the traditional teaching group (78.2 ± 7.6 vs 62.4 ± 7.9 ; $t(248) = 16.45$; $p < 0.001$). Within-group analysis showed significant improvement in the simulation group (48.6 ± 8.4 to 78.2 ± 7.6 ; $t(124) = 32.15$; $p < 0.001$) and in the traditional group (49.1 ± 8.1 to 62.4 ± 7.9 ; $t(124) = 18.72$; $p < 0.001$). Self-efficacy scores were also significantly higher in the simulation group compared to the traditional group (4.3 ± 0.4 vs 3.6 ± 0.5 ; $t(248) = 12.78$; $p < 0.001$).

Conclusions

Simulation-based training significantly improved clinical skills competency and self-efficacy compared to traditional teaching methods. Integration of simulation-based learning into undergraduate medical education may enhance clinical training outcomes.

Introduction

Variability in clinical training opportunities among undergraduate medical students raises important ethical concerns related to patient safety, equity in education, and the competence of future physicians. Inconsistent exposure to essential clinical procedures may result in graduates with differing levels of preparedness, potentially compromising the quality and safety of patient care. Ensuring that all medical students achieve a minimum standard of clinical competence is therefore not only an educational priority but also an ethical responsibility of medical training institutions.

The development of clinical skills is a fundamental component of undergraduate medical education. Competency in essential procedures and clinical decision-making ensures that future doctors can provide safe and effective patient care. Traditionally, clinical skills have been taught through lectures, bedside teaching, and observation in real patient settings. However, these approaches may not always provide sufficient opportunities for hands-on practice, particularly in situations where patient safety, time constraints, and variability in clinical exposure limit learning opportunities.¹

In recent years, simulation-based training has emerged as an innovative educational strategy in medical education. Simulation allows participants to practise clinical skills in a controlled and safe environment without risk to patients. It also provides opportunities for repetitive practice, immediate feedback, and standardised learning experiences.² By reducing reliance on opportunistic patient encounters, simulation-based training aligns with ethical principles by minimising potential harm to patients while ensuring that learners acquire essential competencies. Studies have suggested that simulation-based learning can improve procedural skills, enhance clinical reasoning, and increase learner confidence compared to traditional teaching methods.³

Despite its growing adoption globally, the integration of simulation-based training in undergraduate medical education in India remains variable. Many institutions are in the early stages of implementing skills laboratories, and there is limited evidence evaluating the effectiveness of simulation in improving clinical competency among undergraduate medical students in the Indian context.⁴ Furthermore, existing studies often focus on short-term outcomes such as learner satisfaction, with fewer studies assessing objective improvements in clinical skills using structured assessment tools.⁵ At the same time, similar challenges related to variability in clinical exposure and the need for standardised training are observed across many medical education settings, particularly in resource-constrained environments.

Objective Structured Clinical Examination is widely regarded as a reliable and valid method for assessing clinical competence. It provides a standardised approach to evaluating practical skills and is commonly used in medical education research.⁶ In addition, self-efficacy, defined as an individual's belief in their ability to perform tasks, is an important factor influencing clinical performance and learning outcomes.⁷ Assessing both objective performance and self-efficacy can provide a comprehensive understanding of the impact of educational interventions.

There remains a need for well-designed analytical studies comparing simulation-based training with traditional teaching methods using validated assessment tools and adequate sample sizes. Such evidence is essential not only for informing curriculum development but also for supporting the implementation of equitable and standardised training strategies that can enhance the competence of medical graduates across institutions.

Therefore, this study aimed to evaluate the impact of simulation-based training on clinical skills competency among undergraduate medical students and to compare its effectiveness with traditional teaching methods using objective and validated measures. In addition, the study seeks to explore the

broader implications of simulation-based training in promoting standardised, equitable, and ethically responsible clinical education

Methods

Study design and setting

We conducted an analytical quasi-experimental study using a pre-test and post-test design with a comparison group. The study was carried out in the clinical skills laboratory and associated teaching hospital of a medical college in India during the academic year 2025–2026.

Participants and sampling

Participants were undergraduate medical students from a single MBBS batch with a total strength of 250. All students were invited to participate in the study. Those who provided informed consent were included. Students who were absent during either the pre-test or post-test assessments were excluded from the final analysis.

Participants were allocated into two groups of equal size:

- Simulation-based training group (n = 125)
- Traditional teaching group (n = 125)

Allocation was performed using simple random sampling to minimise selection bias. The response rate was calculated based on the number of students completing both pre- and post-assessments.

Intervention

The simulation-based training group received structured hands-on training in the clinical skills laboratory. The training included essential procedural skills such as intravenous cannulation, basic life support, suturing techniques, and airway management. Participants practised these skills using mannequins and task trainers under faculty supervision with immediate feedback.

The traditional teaching group received conventional teaching methods, including lectures and faculty demonstrations of the same clinical skills without hands-on simulation practice.

Both groups received equal duration of teaching sessions to ensure comparability.

Outcome measures

Clinical skills assessment

Clinical skills competency was assessed using an Objective Structured Clinical Examination. Multiple stations were designed to evaluate procedural skills. Each station included a standardised checklist, and scores were assigned based on performance. Objective Structured Clinical Examination is a widely accepted and validated method for assessing clinical competence in medical education.⁸

Self-efficacy assessment

Participants' confidence in performing clinical skills was measured using the General Self-Efficacy Scale. This validated instrument consists of multiple items rated on a Likert scale, with higher scores indicating greater perceived self-efficacy.⁹

Data collection procedure

Baseline assessment was conducted prior to the intervention using Objective Structured Clinical Examination and the self-efficacy scale. Following the teaching sessions, post-intervention assessment was conducted using the same tools. All assessments were conducted under standardised conditions.

Validity and reliability

Standardised Objective Structured Clinical Examination checklists were developed based on established guidelines and reviewed by subject experts to ensure content validity. Inter-rater reliability was maintained by training examiners prior to assessment. The General Self-Efficacy Scale is a validated tool with established reliability across different populations.⁹

Data analysis

Data were entered and analysed using Statistical Package for the Social Sciences software. Descriptive statistics were used to summarise participant characteristics and outcome measures. Continuous variables were expressed as mean and standard deviation.

Within-group comparisons of pre-test and post-test scores were performed using paired t-tests. Between-group comparisons were conducted using independent t-tests. A p value of less than 0.05 was considered statistically significant. Effect size was calculated using Cohen's d to determine the magnitude of differences between groups.¹⁰

Results

Participant characteristics

A total of 250 undergraduate medical students participated in the study. All participants completed both pre-test and post-test assessments, resulting in a response rate of 100%. The participants were equally

distributed between the simulation-based training group (n = 125) and the traditional teaching group (n = 125).

The mean age of participants was 21.3 ± 1.2 years. Of the total participants, 140 (56%) were female and 110 (44%) were male.

Clinical skills performance

At baseline, there was no statistically significant difference in mean Objective Structured Clinical Examination scores between the simulation group and the traditional teaching group ($p > 0.05$).

Following the intervention, both groups demonstrated an improvement in clinical skills scores. The simulation-based training group showed a greater increase in mean scores compared to the traditional teaching group.

Within-group analysis showed a statistically significant improvement in Objective Structured Clinical Examination scores in the simulation group (pre-test: 48.6 ± 8.4 ; post-test: 78.2 ± 7.6 ; $t(124) = 32.15$, $p < 0.001$) As shown in table no 1. Similarly, the traditional teaching group demonstrated a significant improvement (pre-test: 49.1 ± 8.1 ; post-test: 62.4 ± 7.9 ; $t(124) = 18.72$, $p < 0.001$).

Between-group comparison of post-test scores revealed that the simulation group had significantly higher scores than the traditional teaching group (78.2 ± 7.6 vs 62.4 ± 7.9 ; $t(248) = 16.45$, $p < 0.001$). The effect size was large (Cohen's $d = 1.85$).

Self-efficacy scores

Baseline self-efficacy scores were comparable between the two groups ($p > 0.05$).

Post-intervention, both groups showed increased self-efficacy scores. The simulation group demonstrated a greater increase compared to the traditional teaching group.

Within-group analysis indicated a significant improvement in self-efficacy in the simulation group (pre-test: 2.8 ± 0.5 ; post-test: 4.3 ± 0.4 ; $t(124) = 28.67$, $p < 0.001$) As shown in table no 2. The traditional teaching group also showed improvement (pre-test: 2.9 ± 0.6 ; post-test: 3.6 ± 0.5 ; $t(124) = 15.34$, $p < 0.001$).

Between-group comparison of post-test scores showed significantly higher self-efficacy in the simulation group (4.3 ± 0.4 vs 3.6 ± 0.5 ; $t(248) = 12.78$, $p < 0.001$). The effect size was large (Cohen's $d = 1.61$).

Discussion

In this study, we evaluated the impact of simulation-based training on clinical skills competency among undergraduate medical students and compared it with traditional teaching methods. The findings demonstrated that simulation-based training resulted in significantly greater improvement in both clinical

skills performance and self-efficacy compared to conventional teaching approaches. The large effect sizes observed for both outcomes indicate that the differences are not only statistically significant but also educationally meaningful.

The improvement observed in Objective Structured Clinical Examination scores among participants in the simulation group suggests that structured, hands-on practice in a controlled environment enhances skill acquisition. Simulation provides opportunities for deliberate practice, standardised instruction, and immediate feedback, all of which are essential for developing procedural competence. These findings are consistent with previous studies that have reported superior performance outcomes with simulation-based learning compared to traditional teaching methods.¹¹

Although both groups demonstrated improvement following the intervention, the magnitude of improvement was significantly greater in the simulation group. This difference may be attributed to the active learning processes inherent in simulation-based training, where learners directly engage in performing tasks rather than passively observing demonstrations. Active participation has been shown to improve retention, skill transfer, and application in clinical settings.¹²

In addition to objective performance, self-efficacy scores increased significantly among participants receiving simulation-based training. Self-efficacy is an important determinant of clinical behaviour, as individuals who are more confident in their abilities are more likely to perform procedures effectively in real clinical settings. The observed increase in self-efficacy may reflect the safe and supportive learning environment provided by simulation, which allows repeated practice without fear of harming patients. Similar findings have been reported in studies examining the role of simulation in enhancing learner confidence.¹³

From a broader perspective, the findings of this study have important implications beyond the immediate study setting. Variability in clinical exposure during undergraduate training is a recognised challenge across many medical institutions, particularly in resource-constrained environments. Simulation-based training offers a structured and standardised approach that can reduce dependence on opportunistic clinical encounters and help ensure that all students achieve a minimum level of competence. In this context, the integration of simulation into undergraduate curricula may contribute to greater uniformity in training outcomes across institutions.

These findings also have ethical relevance. Ensuring that medical graduates possess adequate clinical competence is closely linked to the ethical principles of patient safety and non-maleficence. Training methods that rely solely on variable clinical exposure may inadvertently disadvantage some learners and expose patients to unnecessary risk. Simulation-based training provides an opportunity to address these concerns by allowing skill acquisition in a controlled environment before performing procedures on patients. In this regard, the incorporation of simulation into medical education can be viewed not only as an educational enhancement but also as an ethically responsible approach to clinical training.

Although this study was conducted in a single institution, several factors support cautious consideration of its broader applicability. The study included an entire cohort of undergraduate medical students, reducing intra-institutional selection bias. In addition, the structure of undergraduate medical curricula, the types of clinical skills taught, and the challenges related to limited clinical exposure are broadly similar across many medical colleges, particularly in low- and middle-income settings. Therefore, the observed benefits of simulation-based training may be relevant to comparable educational contexts.

However, certain limitations should be acknowledged. The single-centre design may limit external validity, and institutional factors such as faculty expertise and availability of simulation resources may influence outcomes. The duration of follow-up was short, and the study did not assess long-term retention of skills or translation into real clinical performance. Additionally, while efforts were made to standardise assessment, the possibility of examiner bias cannot be completely excluded. The controlled environment of simulation may also not fully replicate the complexity of real clinical settings.

Future research should focus on multi-centre studies involving diverse institutions to further evaluate the generalisability of these findings. Longitudinal studies assessing retention of skills and the impact of simulation-based training on actual patient outcomes would provide more comprehensive evidence. Comparative studies across different resource settings may also help determine the scalability and feasibility of implementing simulation-based training more widely.

In conclusion, simulation-based training was more effective than traditional teaching methods in improving clinical skills competency and self-efficacy among undergraduate medical students. Given the shared challenges in clinical training across institutions, these findings suggest that simulation-based approaches may contribute to more standardised, equitable, and ethically sound medical education, with potential downstream benefits for patient care and healthcare quality.

Declarations

Ethical considerations

Ethical approval for the study was obtained from the Ethics and Scientific Review Committee Mahatama Gandhi Memorial Medical College & Maharaja Yeshvantrao Hospital, Indore under DHR Reg No (EC/New/Inst/2022/0156). Study approval number is EC/MMM/APR-26/84. Written informed consent was obtained from all participants prior to participation in the study & all experiments were performed in accordance with Declaration of Helsinki.

Consent for publication

Informed consent for publication was obtained from all participants.

Competing interests

The author declare that they have no competing interests.

Conflict of Interest

The authors declare no conflict of interest.

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Author Contribution

1.SM:- ConceptualizationStudy design / Methodology, Literature review, Data collection, Data curation, Investigation, Statistical analysis / Formal analysis, Interpretation of data, Supervision, Project administration, Resources, Funding acquisition, Drafting of manuscript, Critical revision of manuscript, Editing and proofreading, Visualization / Tables and figures, Validation, Final approval of manuscript
2.AKSR:- Literature review, Data collection, Data curation, Investigation, Statistical analysis / Formal analysis, Interpretation of data, Supervision, Project administration, Resources, Funding acquisition, Drafting of manuscript, Critical revision of manuscript, Editing and proofreading, Visualization / Tables and figures
3.SG:-Literature review, Data collection, Data curation, Investigation, Statistical analysis / Formal analysis, Interpretation of data, Supervision, Project administration, Resources, Funding acquisition, Drafting of manuscript, Critical revision of manuscript, Editing and proofreading, Visualization / Tables and figures
4.RC:- Statistical analysis / Formal analysis, Interpretation of data

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Data Availability

The databases used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Tables

Table 1. Clinical skills (Objective Structured Clinical Examination) scores of participants (n = 250), India, 2026

Group	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	t-value	p-value
Simulation (n = 125)	48.6 $\pm$ 8.4	78.2 $\pm$ 7.6	32.15	< 0.001
Traditional (n = 125)	49.1 $\pm$ 8.1	62.4 $\pm$ 7.9	18.72	< 0.001

Table 2. Self-efficacy scores of participants (n = 250), India, 2026

Group	Pre-test Mean ± SD	Post-test Mean ± SD	t-value	p-value
Simulation (n = 125)	2.8 ± 0.5	4.3 ± 0.4	28.67	< 0.001
Traditional (n = 125)	2.9 ± 0.6	3.6 ± 0.5	15.34	< 0.001

Appendix

Appendix 1: Sample OSCE Checklist

Example (IV Cannulation):

Step	Score
Hand hygiene	1
Patient identification	1
Site selection	1
Aseptic technique	1
Cannula insertion	1
Securing cannula	1