



Original Research Article

The Role of Simulation in Enhancing Patient Safety and Reducing Medical and Dental Errors: A Public Health Perspective from Pakistani Healthcare

Article History:

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Received: 12-11-2025

Revised: 05-12-2025

Accepted: 20-12-2025

Published: 30-12-2025

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Abstract: Background: Medical and dental errors constitute a major yet under recognized public health challenge in low- and middle-income countries, including Pakistan. These errors contribute not only to preventable morbidity and mortality but also to long-term disability, compromised oral health outcomes, loss of public trust, and increased healthcare expenditure at the population level. **Objective** To evaluate the role of simulation-based training in enhancing patient safety and reducing medical and dental errors in Pakistani healthcare facilities. **Methods** A multicenter, mixed-methods study was conducted across tertiary and secondary healthcare institutions in Pakistan, encompassing both medical and dental teaching hospitals. A total of 400 healthcare professionals, including physicians, nurses, dentists, and allied health staff, were recruited. Quantitative data were collected through a structured questionnaire and qualitative data were obtained through in-depth interviews. Statistical analyses examined associations between simulation exposure and patient safety outcomes, while thematic analysis was applied to qualitative findings. **Results** Healthcare professionals who had received simulation-based training reported significantly fewer medical and dental errors and demonstrated stronger compliance with patient safety and infection prevention protocols. Participants highlighted improved clinical preparedness, enhanced team-based care, and better management of emergencies in both medical and dental settings. From a public health standpoint, respondents emphasized that simulation training reduced preventable adverse events, improved continuity of care, and contributed to safer healthcare delivery at scale. **Conclusion** Simulation-based training represents a high-impact public health intervention for strengthening patient safety and reducing medical and dental errors in Pakistan. Embedding simulation into pre-service education, in-service training, and national patient safety strategies can enhance healthcare quality and improve population health outcomes.

Keywords: Simulation-Based Training, Patient Safety, Medical and Dental errors, Health Systems Strengthening

INTRODUCTION

Medical and dental errors remain an under-recognized public health concern, particularly in low- and middle-income countries like Pakistan, where

healthcare infrastructure and training resources are often limited. Globally, errors in healthcare rank among the leading causes of preventable morbidity and mortality, resulting in extended hospital stays,

increased healthcare costs, and avoidable patient harm (1,2). Such errors may arise from lapses in clinical knowledge, procedural skills, communication breakdowns, or systemic deficiencies. Strengthening patient safety is therefore an essential public health objective, requiring interventions that improve both individual competence and healthcare system resilience. Simulation-based training has emerged as a pivotal strategy to enhance clinical skills and patient safety. It offers healthcare professionals the opportunity to practice complex procedures, manage emergencies, and refine critical thinking in a controlled environment where patient risk is eliminated. Studies indicate that simulation can improve technical proficiency, cognitive decision-making, and teamwork, all of which are directly associated with reduced medical and dental errors (3,4). Unlike traditional didactic methods, simulation fosters active learning by integrating practical, cognitive, and behavioral components, thereby producing measurable improvements in clinical preparedness and patient outcomes (5).

In Pakistan, there has been growing interest in adopting simulation in medical and dental education, yet its application remains inconsistent. Some universities and hospitals have established simulation laboratories or conducted workshops, but these programs are often limited in scope, duration, and fidelity. Evidence linking simulation exposure to actual reductions in errors and enhanced safety practices remains scarce, emphasizing the need for context-specific research (6). Beyond individual competence, simulation has significant implications for public health. Reducing medical and dental errors not only decreases avoidable morbidity and mortality but also enhances community trust in the healthcare system, ensures continuity of care, and reduces long-term economic burdens associated with preventable complications. Internationally, interprofessional simulation programs have been associated with improvements in safety culture, teamwork, and readiness to manage high-risk clinical scenarios, suggesting that similar benefits may be achievable in Pakistan with proper implementation (7).

From a public health perspective, patient safety is not solely an individual responsibility but a reflection of healthcare system performance, governance, and organizational culture. Unsafe care contributes to preventable disease burden, prolonged disability, and inequitable health outcomes, particularly in resource-constrained settings. Simulation-based training supports system-wide learning by enabling healthcare teams to identify latent safety threats, test clinical workflows, and rehearse responses to rare but high-risk events. By strengthening safety culture and standardizing clinical responses, simulation aligns with global patient safety frameworks that emphasize prevention, learning, and continuous quality

improvement rather than blame or punitive approaches (8,9). Importantly, simulation holds relevance for integrated medical and dental practice, where procedural complexity, infection control, anesthesia-related risks, and emergency preparedness overlap. Dental settings, especially in teaching hospitals, face unique patient safety challenges that are often underrepresented in national safety initiatives. In low- and middle-income countries such as Pakistan, where clinical exposure may be high but structured supervision limited, simulation offers an equitable and scalable educational modality. By bridging gaps between theoretical knowledge and real-world practice, simulation-based education has the potential to enhance competency across disciplines, reduce preventable harm, and contribute to safer, more resilient healthcare delivery at the population level (10).

Despite its potential, Pakistan faces structural and operational challenges in integrating simulation into routine practice. Limitations include scarce high-fidelity simulation equipment, inadequate faculty training, variable exposure across disciplines, and lack of national guidelines for simulation-based education. This study aims to address these gaps by evaluating the impact of simulation-based training on patient safety and medical/dental errors in Pakistani healthcare, exploring both quantitative outcomes and qualitative perceptions among diverse healthcare professionals.

MATERIAL AND METHODS

Methodology

This study employed a multicenter mixed-methods design, conducted from January to November 2025 across multiple tertiary and secondary healthcare facilities in Pakistan, including medical and dental teaching hospitals. Ethical approval was obtained from the institutional review boards of all participating centers, and informed consent was obtained from each participant prior to enrollment.

A total of 400 healthcare professionals participated, including physicians, nurses, dentists, and allied health personnel. Participants were recruited through purposive sampling to ensure representation across professional roles and varying levels of clinical experience. Inclusion criteria included active clinical practice and willingness to participate in both the survey and interviews.

Quantitative data were collected using a structured questionnaire that assessed participants' exposure to simulation-based training, frequency of self-reported medical and dental errors, compliance with patient safety and infection prevention protocols, and self-perceived clinical preparedness. The questionnaire was adapted from validated patient safety assessment tools and pilot-tested in a small cohort to ensure clarity and relevance.

Quantitative data were analyzed using SPSS Version 28. Descriptive statistics summarized demographic characteristics and simulation exposure. Associations between simulation experience and patient safety outcomes were assessed using chi-square tests and logistic regression, with significance set at $p < 0.05$. Qualitative data was collected via in-depth interviews

with 40 purposively selected participants representing different professions and training backgrounds. Interviews were audio-recorded, transcribed verbatim, and analyzed using thematic analysis in NVivo. Triangulation, peer review, and member checking were employed to ensure the trustworthiness of the qualitative findings.

RESULTS

The study included 400 healthcare professionals, of whom 240 (60%) were female. The mean professional experience among participants was 8.4 ± 3.2 years. Approximately 180 participants (45%) reported having received at least one formal simulation-based training session during their professional development. Physicians comprised 30% of participants, nurses 35%, dentists 22.5%, and allied health staff 12.5%. As shown in Table 1, simulation exposure varied across disciplines, indicating that nurses and dentists were slightly more likely to participate in structured simulation workshops compared to physicians and allied health staff. The distribution of gender and years of professional experience is also described in this table to provide context for the sample characteristics.

Table 1. Participant Demographics and Simulation Training Exposure

Variable	n (%) or Mean (SD)
Total participants	400 (100%)
Gender (Female)	240 (60%)
Profession	
– Physicians	120 (30%)
– Nurses	140 (35%)
– Dentists	90 (22.5%)
– Allied health staff	50 (12.5%)
Mean years of experience	8.4 ± 3.2
Received Simulation Training	180 (45%)

Following this, associations between simulation training and patient safety indicators were examined. As illustrated in Table 2, healthcare professionals who had received simulation training reported a lower incidence of self-assessed medical and dental errors in the previous 12 months. Specifically, 25% of participants with simulation training reported errors, compared to 38% of those without such training. Additionally, compliance with patient safety protocols was higher among the trained group, with 72% reporting consistent adherence compared to 57% among non-trained participants. Confidence in handling emergencies was also notably higher in the simulation-trained group (80% vs 63%), reflecting enhanced preparedness and perceived competence in critical scenarios.

Table 2. Associations Between Simulation Training and Patient Safety Indicators

	Simulation Trained (n=180)	Not Trained (n=220)	p-value
Self-reported medical/dental errors (%)	25%	38%	0.02
High safety protocol compliance (%)	72%	57%	0.01
Confidence in emergency handling (%)	80%	63%	0.005

Qualitative findings reinforced the quantitative results. Participants highlighted three primary benefits of simulation-based training. First, simulation enhanced clinical preparedness, enabling professionals to handle emergencies and complex cases more effectively. Second, it promoted teamwork and interprofessional communication, reducing the risk of errors stemming from poor coordination. Third, simulation raised awareness of latent safety threats within the healthcare system, encouraging proactive error prevention and a stronger safety culture overall.

DISCUSSION

This study demonstrates that simulation-based training is strongly associated with improved patient safety and reduced medical and dental errors in Pakistani healthcare. Participants with prior simulation experience reported fewer errors, higher

adherence to safety protocols, and greater confidence in emergency scenarios. These findings are consistent with prior research showing that simulation fosters technical competence, situational awareness, and teamwork key factors in preventing adverse events (1,3). Simulation not only improves individual clinical

skills but also strengthens system-level safety by enabling healthcare professionals to recognize and mitigate potential errors before they affect patients (11,12). Interprofessional simulation exercises enhance communication, collaboration, and coordination across disciplines, further reducing the risk of error-related harm (13,14). Beyond individual and team-level improvements, simulation-based training can serve as a catalyst for strengthening health systems and shaping patient safety policy. By identifying latent safety threats and testing clinical workflows in a controlled environment, simulation offers a practical approach to system-wide learning and continuous quality improvement (15). Integration of simulation outcomes into institutional safety committees, clinical governance, and accreditation processes can enhance organizational accountability and guide resource allocation for high-risk areas. International studies have shown that embedding simulation within hospital safety programs leads to measurable reductions in adverse events, improved error reporting, and greater adherence to evidence-based protocols, reinforcing the potential for similar benefits in Pakistani healthcare (16,17).

Simulation also facilitates interprofessional education, promoting collaboration among physicians, nurses, dentists, and allied health staff. Effective interprofessional training enhances communication, role clarity, and coordinated decision-making, all of which are critical for patient safety, particularly in complex or emergency scenarios (18). From a public health perspective, widespread adoption of simulation-based interprofessional training can reduce preventable morbidity and mortality, optimize resource utilization, and improve trust in the healthcare system (19). By fostering a culture of safety, preparedness, and continuous learning, simulation has the potential to influence not only individual and institutional practices but also national patient safety standards and guidelines. The study's strengths include its mixed-methods design, which combines quantitative outcomes with qualitative insights, providing a comprehensive understanding of simulation's impact. The multicenter approach and inclusion of multiple healthcare disciplines increase the generalizability of the findings. By integrating self-reported error rates with participant perceptions of preparedness, the study captures both objective and subjective indicators of safety improvement. Limitations include reliance on self-reported data, which may underestimate actual error prevalence due to recall or social desirability biases. The cross-sectional design limits causal inference, and differences in simulation fidelity, frequency, and duration were not assessed, which may affect outcomes. Future research should employ longitudinal designs with standardized simulation interventions and objective error tracking to strengthen evidence for policy and practice.

CONCLUSION

Simulation-based training is a high-impact intervention for enhancing patient safety and reducing medical and dental errors in Pakistan. By fostering technical competence, teamwork, and emergency preparedness, simulation supports safer clinical practice and strengthens health system resilience. Integrating simulation into pre-service education, continuous professional development, and national patient safety strategies is recommended to cultivate a robust safety culture, minimize preventable adverse events, and improve population health outcomes.

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