Journal of Multidisciplinary Healthcare

Dovepress
Taylor & Francis Group

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ORIGINAL RESEARCH

Improving Critical Care Teamwork: Simulation-Based Interprofessional Training for Enhanced Communication and Safety

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Background: This study evaluates a simulation-based interprofessional education (IPE) program implemented at the National Cheng Kung University Hospital between 2018 and 2023. The program aimed to improve teamwork, communication, and collaboration among healthcare professionals in high-acuity environments such as emergency departments and intensive care units (ICUs).

Methods: A prospective, mixed-methods approach was used to assess the program's effectiveness. The study enrolled 237 participants, including postgraduate medical trainees, nurses, respiratory therapists, and administrative staff. Two high-fidelity clinical scenarios—multiple trauma and respiratory distress with shock—were designed to simulate real-world emergencies. Participants' teamwork performance was evaluated using the Team Emergency Assessment Measure (TEAM), while qualitative feedback was collected via structured questionnaires and thematically analyzed.

Results: Quantitative analysis revealed significant improvement in leadership communication ($p = 0.0328$) and positive trends in teamwork dimensions such as completion and effective communication. However, global team performance showed only modest numerical gains. ($p=0.5201$) Qualitative feedback highlighted recurring themes such as unclear task delegation, delayed recognition of patient condition changes, and inconsistent use of communication techniques like call-outs and check-backs.

Conclusion: The simulation-based IPE program significantly enhanced interprofessional collaboration and clinical competencies among participants. However, specific areas, particularly communication, leadership, and situational awareness, require further attention in future training sessions. These findings underscore the importance of continuous refinement of simulation programs to prepare healthcare teams for high-stakes clinical scenarios effectively.

Keywords: interprofessional education, simulation-based learning, teamwork, healthcare collaboration, patient safety

Background

In modern healthcare, delivering safe, efficient, and patient-centered care heavily depends on effective interprofessional collaboration. This collaboration is crucial for addressing the complex needs of patients in a rapidly evolving healthcare landscape. Interprofessional education (IPE) is central to preparing healthcare professionals to work as integrated teams, breaking down traditional professional silos, and fostering a collaborative culture. A transformative innovation within IPE is the integration of simulation-based learning, which provides a controlled, risk-free environment where learners can practice, refine skills, and interact in realistic clinical scenarios.[1]

Simulation-based IPE facilitates the development of key competencies necessary for effective teamwork and communication. Research has shown that simulation enhances healthcare providers' ability to collaborate across disciplines, improving clinical decision-making and patient outcomes.[2] It also allows participants to gain hands-on experience in managing complex and high-risk situations, particularly those that are infrequent in clinical practice but have significant

Received: 14 October 2024
Accepted: 10 January 2025
Published: 22 January 2025

implications for patient safety. By providing an opportunity for experiential learning, simulation promotes critical reflection, enhancing learners' understanding of their roles within a healthcare team and improving team-based care.[3,4]

Simulation-based interprofessional training (SBIT) has emerged as a vital methodology for fostering communication, addressing hierarchical dynamics, and improving team cohesion in critical care settings.[5] By recreating realistic scenarios, SBIT enables healthcare professionals to practice handling challenging conversations, bolstering confidence and teamwork skills essential for patient-centered care.[4–7] Structured guidelines further help mitigate power imbalances, promoting equitable participation among team members and enhancing collaboration.[8] Moreover, in high-stakes environments such as neurocritical care, simulation training strengthens both technical and non-technical skills, fostering interdisciplinary cohesion. This cohesion, in turn, has been strongly associated with improved patient outcomes, underscoring the indispensable role of SBIT in advancing critical care practices.[4]

High-fidelity simulation (HFS) has emerged as a vital component in healthcare education, especially in high-stakes settings such as intensive care units (ICUs) and emergency departments. This advanced training method utilizes simulators that closely replicate real-life clinical scenarios, enabling healthcare teams to safely practice and refine both technical and non-technical skills.[9] By simulating complex and dynamic situations, HFS allows learners to gain hands-on experience in managing emergencies, improving their ability to make rapid and effective decisions without putting actual patients at risk.[9] One of the significant benefits of HFS is its ability to enhance teamwork and communication among healthcare professionals. By placing participants in realistic, collaborative scenarios, mirrors the pressures of real-life emergencies and promotes improved team dynamics and coordination.[10] This not only helps in skill development but also fosters a culture of interprofessional collaboration, a key factor in improving patient outcomes.

Studies have shown that HFS significantly boosts the confidence and competency of trainees. For example, research involving pediatric code training demonstrated that medical students using high-fidelity simulators reported greater confidence compared to those using traditional mannequins.[9] This boost in confidence typically translates into better performance in actual clinical settings, reinforcing the critical role of simulation-based learning in preparing healthcare professionals.

Given that patient safety incident rates in ICUs range from 2.0% to 70.0%, the urgency for effective training is clear.[11] HFS serves as a proactive tool to address these concerns by equipping healthcare teams with the necessary skills to manage critical situations effectively, ultimately improving patient safety.8 Through the realistic replication of ICU environments and scenarios, HFS enhances not only knowledge and technical skills but also critical non-technical competencies such as teamwork, communication, situational awareness, and coping abilities.[12] To maximize the effectiveness of HFS, it is crucial to design a simulation environment that closely mimics actual ICU conditions. Moreover, strategies must be implemented to reinforce both technical and non-technical skill development, ensuring that learners can apply these improvements to patient safety management in real-world settings.[12]

The objective of this study was to rigorously evaluate whether the integration of high-fidelity simulation-based training in critical care settings led to measurable improvements in clinical performance, particularly in handling complex and high-risk scenarios. In addition to assessing objective performance metrics, we also aimed to explore healthcare staff members' subjective perceptions regarding the impact of the simulation training on team dynamics, interprofessional communication, and the overall quality and safety of critical care delivery. Our evaluation sought to determine whether the simulation exercises enhanced the ability of healthcare teams to collaborate effectively under pressure, thereby contributing to safer and more efficient patient care.

Methods

Study Design

This study adopted a prospective evaluative mixed-methods approach to assess the impact of simulation-based IPE on teamwork and communication. Qualitative data were collected using self-rated TEAM scores, while qualitative feedback was obtained through structured post-simulation questionnaires and thematic coding. This study presents a comprehensive evaluation of an interprofessional education (IPE) program implemented at National Cheng Kung University Hospital from 2018 to 2023. The program focused on using simulation-based learning to enhance teamwork, communication, and collaboration among healthcare professionals from diverse disciplines. A prospective, observational study design was adopted to assess the effectiveness of this simulation program in improving interprofessional collaboration in high-acuity clinical environments, such as emergency departments and intensive care units (ICUs).

Participants

The participants were selected based on their current or anticipated roles in emergency and critical care environments. This targeted group included registered nurses, postgraduate medical trainees, respiratory therapists, and administrative staff, representing the interdisciplinary teams commonly found in real-world healthcare settings. Selection criteria emphasized the inclusion of those directly involved in patient care or supporting care delivery in high-stakes scenarios. Participation was voluntary and the program was offered at no cost, promoting accessibility to professionals across different departments of National Cheng Kung University Hospital.

Scenario Creation

Two complex clinical scenarios were meticulously designed for this simulation-based program: (1) multiple trauma and (2) respiratory distress with shock. These scenarios were developed through collaborative efforts from a panel of simulation experts, including emergency physicians, critical care specialists, and trauma surgeons. The scenario creation process was guided by internationally recognized frameworks such as Crisis Resource Management (CRM) from the Royal College of Physicians and Surgeons of Canada,[13] and Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS).[14] These frameworks provided the foundation for setting clear educational objectives, which were aligned with the competencies essential for managing high-pressure clinical situations.

The scenarios were designed to challenge participants' technical and non-technical skills, such as clinical decision-making, leadership, communication, and teamwork. Each simulation was carefully structured to reflect the complexity of real-life medical crises and included unpredictable elements to ensure participants remained fully engaged. The scenarios were conducted over three-hour sessions, allowing sufficient time for in-depth clinical decision-making and collaboration among the interdisciplinary team. A visual representation of the sequential activities is presented in Figure 1.

Program Structure

The simulation-based IPE program was divided into multiple units, with each session lasting approximately three hours. The sessions were structured to provide participants with a gradual immersion into the simulation environment. Prior to the commencement of each simulation, participants were given a detailed orientation by the simulation technologist, allowing them to familiarize themselves with the high-fidelity mannequin, medical equipment, and mock medications used in the simulations.

Before each scenario, participants received a comprehensive pre-briefing session that outlined their roles within the simulated clinical environment. These roles mimicked those found in real-life emergency situations and included physician leaders, assistant physicians, registered nurses, respiratory therapists, and administrative staff. Participants were provided with a detailed clinical script that outlined the scenario's background, location, and patient information. This pre-briefing was essential for ensuring clarity in role allocation and optimizing team collaboration.

The simulation environment was designed to replicate the high-pressure atmosphere of an emergency room or critical care ward at National Cheng Kung University Hospital. The setup included essential medical equipment such as defibrillators, resuscitation tools, and inotropic medications, enabling participants to perform real-time interventions such as intubation, administration of intravenous fluids, and initiation of inotropic support. The use of a high-fidelity mannequin allowed for dynamic, real-time alterations in the clinical scenario, with the mannequin's vital signs and condition changing in response to participants' actions.

Faculty members and simulation technologists observed the simulation in real time from behind a one-way mirror, ensuring continuous monitoring of participants' performance. Faculty supervisors had full control over the evolution of the scenario, including the mannequin's responses and vital signs. An algorithm was used to dynamically adjust the mannequin's vitals based on the clinical interventions administered by participants. For example, if participants administered inotropes or large volumes of intravenous fluids, the algorithm would automatically adjust the mannequin's hemodynamic parameters after a predefined interval, simulating a real-life patient response.

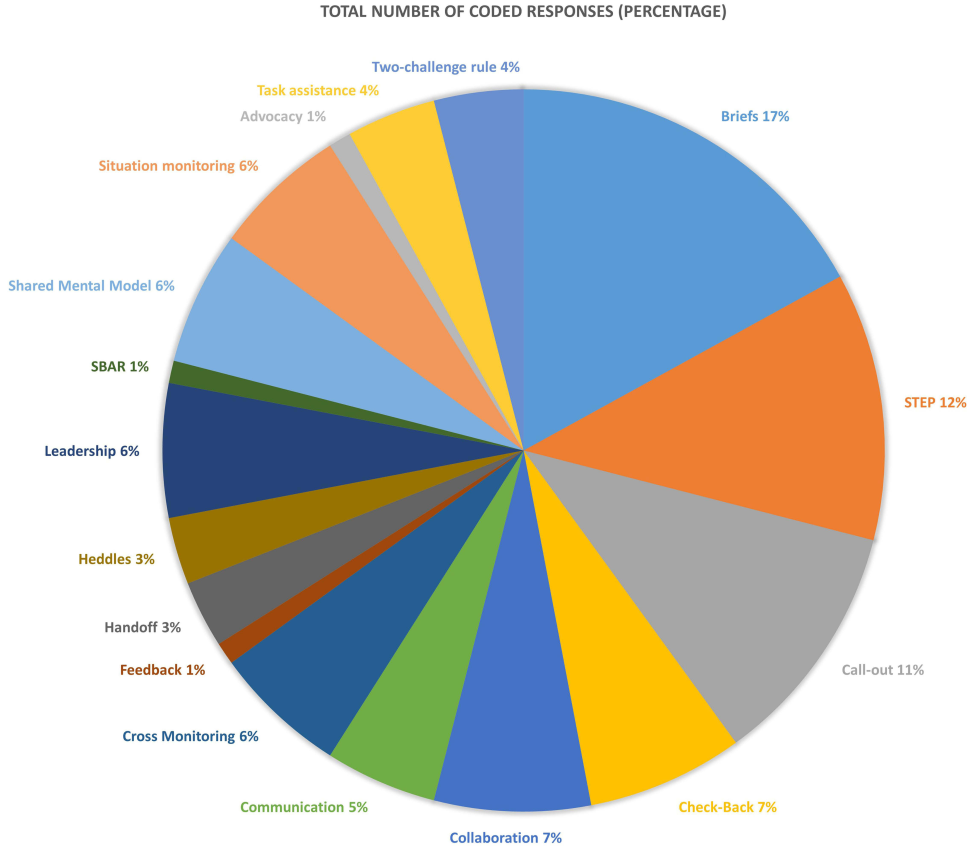

Figure 1 Pie chart showing the percentage distribution of participants' self-evaluations of personal weaknesses during the scenarios.

Debriefing Process

Following each simulation session, a structured debriefing process was conducted, led by faculty facilitators. This debriefing was divided into two phases: a video review of the scenario, followed by an interactive discussion. During the debriefing, participants reflected on their performance, focusing on both technical skills and the dynamics of team interaction. The facilitators guided participants through an analysis of their clinical decision-making, teamwork, and communication strategies, using the video footage to highlight key moments in the simulation.

The debriefing sessions also included a thorough evaluation of how well participants met the scenario's predefined learning objectives. Special emphasis was placed on interprofessional collaboration, with facilitators encouraging participants to critically examine the effectiveness of their communication and leadership during the scenario. By focusing on these non-technical skills, the debriefing process aimed to enhance future teamwork and patient safety in real clinical settings.

Data Collection

From 2018 to 2023, a total of 17 simulation sessions were conducted, each designed to replicate high-stakes emergency scenarios with interdisciplinary teams. Each session featured an emergency team consisting of 4–5 physicians, 2–3 nurses, and 1 respiratory therapist, supported by two staff members from the simulation skills center who managed equipment and provided logistical assistance. The scenarios were facilitated by a team of highly experienced professionals, including two senior emergency and critical care physicians, a senior nurse, a senior nurse practitioner, and a senior respiratory therapist. These facilitators were instrumental in guiding the progression of simulation exercises and providing in-depth feedback during structured post-simulation debriefings.

Data collection was performed immediately after each intervention to evaluate the effectiveness of the simulation-based interprofessional education (IPE) sessions on enhancing teamwork performance. The Team Emergency Assessment Measure (TEAM) tool was employed for both participant self-assessments and independent evaluations by facilitators, capturing quantitative data on critical aspects such as leadership, communication, and adaptability. Structured feedback forms were also distributed to gather qualitative insights into participants' experiences and perceived areas for improvement. To minimize bias, facilitators submitted their evaluations independently. All collected data were anonymized, aggregated, and analyzed to ensure a comprehensive assessment of the program's impact.

The TEAM tools was a validated tool developed by Cooper et al[15] to evaluate team dynamics and performance during emergencies. It was used to evaluate teamwork performance, focusing on leadership, task management, and inter-team communication in high-pressure environments. Its reliability and validity made it ideal for this study, where it was administered immediately after each simulation session. Participants completed self-assessments, while faculty facilitators provided external evaluations, generating data that offered insights into the IPE program's effectiveness in fostering interprofessional collaboration and enhancing healthcare teams' ability to manage critical situations.

Ethical Considerations

The study was conducted in accordance with the ethical standards of National Cheng Kung University Hospital and was approved by the hospital's institutional review board (IRB No. NCKUH-10102063 /ER-100-286). All participants provided informed consent before participating in the simulation exercises, explicitly affirming their voluntary participation and granting permission for the publication of anonymized responses and direct quotes in accordance with ethical standards.

Statistical Analysis

Quantitative data from the Team Emergency Assessment Measure (TEAM) were analyzed using descriptive statistics, including means and standard deviations, to summarize participants' perceptions of teamwork performance. Thematic analysis of qualitative feedback was conducted to identify common themes and areas for improvement. No inferential statistical tests were performed, as the study focused on evaluating trends and insights rather than hypotheses testing.

To assess whether the simulation training led to significant improvements in teamwork, pre- and post-simulation scores were compared using paired t-tests, individually. The analysis focused on comparing the baseline (pre-simulation) TEAM scores with those collected after the simulations (post-simulation) to determine the effectiveness of the intervention. The paired *t*-test was chosen to account for the within-subject design, as the same participants were evaluated both before and after the intervention. A p-value of less than 0.05 was considered statistically significant, indicating that any observed differences in teamwork performance were unlikely to have occurred by chance.

In addition to comparing overall performance, specific subdomains of teamwork, such as leadership, communication, and situational awareness, were examined to identify which aspects of interprofessional collaboration showed the most improvement. The analysis aimed to pinpoint key areas where the simulation exercises had the greatest impact on enhancing participants' skills.

The qualitative data from participants' self-evaluations, including weaknesses identified during the simulation scenarios, were analyzed using thematic coding. The themes derived from participants' reflections were quantitatively summarized and presented as percentages, providing insight into the most frequently cited areas for improvement. This thematic analysis allowed for a deeper understanding of the subjective experiences of the participants and was visually represented in a pie chart (Figure 1) to highlight the distribution of identified weaknesses across various themes, such as Brief, STEP, Call-out, and Check-back.

Results

Participant Characteristics

A total of 237 healthcare professionals participated in the simulation-based interprofessional education (IPE) program at National Cheng Kung University Hospital from 2018 to 2023. The participant cohort was predominantly female (61.6%, n=146), with males comprising 38.4% (n=91). The program included postgraduate medical trainees (45.9%, n=109) from various specialties, the largest groups being internal medicine (21.5%, n=51), surgery (10.5%, n=25), and pediatrics (5.5%, n=13). Other specialties represented included neurology (n=12), gynecology (n=7), and anesthesiology (n=1). Nurses made up a significant portion of participants (n=76), with the majority coming from the emergency department (25.3%, n=60),

https://doi.org/10.2147/JMDH.S500890

Table 1 Characteristics of Study Participants with Numbers and Percentages (N=237)

Characteristics	Number	Percentage (%)
Gender		
Female	146	61.6
Male	91	38.4
Postgraduate		
Internal medicine	51	21.5
Surgery	25	10.5
Pediatrics	13	5.5
Neurology	12	5.1
Gynecology	7	3
Anesthesiology	1	0.4
Nurses		
General ward	2	0.8
MICU	8	3.4
SICU	4	1.7
RICU	1	0.4
OPD	1	0.4
ER	60	25.3
Respiratory therapist	41	17.3
Administration staff	11	4.6

while smaller groups were from the medical intensive care unit (MICU), surgical intensive care unit (SICU), respiratory intensive care unit (RICU), and outpatient departments. Additionally, respiratory therapists (n=41) and administrative staff (n=11) were involved, ensuring that the program replicated real-world multidisciplinary teams (Table 1).

Simulation Course Structure and Time Allocation

The simulation-based training sessions were meticulously organized, lasting approximately 150 minutes each. The sessions were designed to include various stages, beginning with an environmental introduction and familiarization with the high-fidelity mannequins, which featured realistic physiological responses, including pulse, pupillary reflexes, and heart and breath sounds (Table 2).

Each session involved two complex clinical scenarios: multiple trauma and respiratory distress with shock. The scenarios were designed by an interdisciplinary team of emergency physicians, critical care specialists, and surgeons, aiming to simulate high-pressure clinical environments reflective of real-world emergencies. Participants received a comprehensive pre-briefing on the scenarios, roles, and objectives, followed by a 15-minute simulation where audio and video recordings were synchronized for later review. After each scenario, participants engaged in a structured debriefing session, which included video review and discussions aimed at facilitating self-reflection, knowledge integration, and identification of best practices. These debriefing sessions, lasting 30 minutes each, were crucial for reinforcing teamwork, communication, and decision-making skills, ensuring that lessons learned were integrated into participants' future clinical practice.

Team Performance Evaluation

Team performance during the simulation sessions was assessed using the Team Emergency Assessment Measure (TEAM), a validated tool designed to evaluate key aspects of teamwork in high-pressure situations. Participants provided self-evaluations after each scenario. The mean scores reflected the overall strong team performance across multiple dimensions (Table 3).

Table 3 highlights the comparison of pre- and post-simulation TEAM scores across various teamwork dimensions. A statistically significant improvement was observed in the item "The team leader let the team know what was expected

Table 2 Simulation Course Time Planning Schedule

Item	Goals	Content	Time (Minutes)
1	Environmental introduction	Understanding of various software and hardware in the simulation room of the clinical skill center.	10
2	Functional understanding of high-fidelity mannequin	Learn about the various functions of the mannequin including pulse, pupillary reflex, heart sound, breath sound, bowel sound and various invasive treatments that can be implemented.	10
3	Scenario instruction	Introduce the background of the scenario. Assignment and introduction of team members.	15
4	Simulation (first scenario)	Conduct simulation training and synchronize video and audio recordings.	15
5	Video review and feedback	Use the video review to observe the performance of self and team in the scenario.	15
6	Discussion	Facilitate self-reflection, knowledge integration, and the identification of best practices and lessons learned. Enhance participants' abilities to handle complex situations and foster continuous improvement.	30
7	Simulation (second scenario)	Assignment and introduction of team members. Conduct simulation training and synchronize video and audio recordings.	15
8	Video review and feedback	Use the video review to observe the performance of self and team in the scenario.	15
9	Discussion	Facilitate self-reflection, knowledge integration, and the identification of best practices and lessons learned. Enhance participants' abilities to handle complex situations and foster continuous improvement.	30

Table 3 Self-Evaluations of Teamwork Performance Using the TEAM (Team Emergency Assessment Measure) Before and After Simulation

Items	Pre-simulation Mean (SD)	Post-simulation Mean (SD)	*p-value*
1 The team leader let the team know what was expected of them through direction and command	3.97 (0.73)	4.16 (0.65)	0.0328
2 The team leader maintained a global perspective.	3.92 (0.83)	3.95 (0.81)	0.7109
3 The team communicated effectively.	4.03 (0.80)	4.16 (0.83)	0.1686
4 The team worked together to complete tasks in a timely manner.	4.05 (0.78)	4.27 (0.65)	0.0582
5.The team acted with composure and control.	4.11 (0.77)	4.16 (0.65)	0.5345
6 The team morale was positive.	4.11 (0.81)	4.16 (0.83)	0.5708
7 The team adapted to changing situations.	4.19 (0.70)	4.14 (0.79)	0.5345
8 The team monitored and reassessed the situation.	4.24 (0.64)	4.16 (0.80)	0.4461
9 The team anticipated potential actions.	4.05 (0.78)	3.97 (0.87)	0.4128
10 The team prioritized tasks.	4.22 (0.67)	4.22 (0.67)	1.0000
11 The team followed approved standards/guidelines.	4.05 (0.81)	4.14 (0.75)	0.3729
12 On a scale of 1–10 give your global rating of the team's performance	5.38 (1.28)	5.45 (1.30)	0.5201

of them through direction and command", with scores increasing from 3.97 ± 0.73 to 4.16 ± 0.65 ($p = 0.0328$), as determined by a paired *t*-test. This indicates enhanced clarity in leadership communication following the simulation intervention. While not statistically significant, notable numerical improvements were seen in "The team worked together to complete tasks in a timely manner" (4.05 ± 0.78 to 4.27 ± 0.65, $p = 0.0582$) and "The team communicated effectively" (4.03 ± 0.80 to 4.16 ± 0.83, $p = 0.1686$), suggesting positive trends. Among the highest post-simulation scores were "The team prioritized tasks" (4.22 ± 0.67), "The team monitored and reassessed the situation" (4.16 ± 0.80), "The team morale was positive" (4.16 ± 0.83), and "The team acted with composure and control" (4.16 ± 0.65). Conversely, areas such as "The team anticipated potential actions" (3.97 ± 0.87) and "The team leader maintained a global perspective" (3.95 ± 0.81) scored relatively lower post-simulation, reflecting opportunities for targeted improvement. The global team performance rating also showed a slight increase from 5.38 ± 1.28 to 5.45 ± 1.30 ($p = 0.5201$).

Qualitative Feedback on Personal Weaknesses

In addition to quantitative self-evaluations, participants provided qualitative feedback on their weaknesses during the scenarios. A thematic analysis of 100 coded responses revealed ten primary areas for improvement (Table 4). In the analysis of qualitative feedback, responses were categorized into recurring themes, resulting in a total of 100 coded responses derived from all simulation sessions. The percentages shown in Table 4 and Figure 1 represent the distribution of these themes as a proportion of the total coded responses, rather than the total number of participants who provided feedback. This approach ensures a focus on the frequency of specific issues or observations identified across all feedback comments.

The most frequently cited issue was related to briefs (17%), with participants highlighting unclear medication orders and lack of explicit directives. For example, some participants noted: "The medication orders were not clear enough" and

Table 4 Top 10 Qualitative Responses from the Participants' Self-Evaluations of Personal Weaknesses During the Scenarios (Total Coded Responses =100)

Themes	Total Number of Coded Responses (Percentage)	Selected Responses from the Participants' Feedback
Briefs	17 (17%)	"…the medication orders were not clear enough…" "…lack of clear instructions or directives…" "…unclear division of responsibilities…" "…no designated individuals assigned to specific tasks…"
STEP	12 (12%)	"…unaware of changes in the patient's condition…" "…failure to continuously assess the overall situation…" "…did not seek additional help in a timely manner…" "…delayed recognition of changes in the patient's condition…"
Call-out	11 (11%)	"…we didn't seek help sooner…" "…forgot to call the respiratory therapist for assistance…" "…delayed in requesting help…" "…did not promptly seek additional assistance…"
Check-Back	7 (7%)	"…lack of communication and timely execution of medical orders…" "…limited response from the physicians…" "…failure to respond audibly…"
Collaboration	7 (7%)	"…unclear team roles for collaboration…" "…incomplete allocation of tasks…" "…redundant tasks were performed…" "…lack of clearly defined roles or responsibilities…"
Cross Monitoring	6 (6%)	"…failed to maintain an overall view of the situation…" "…focused solely on resuscitation, neglecting other important details…" "…did not notice abnormalities on the EKG monitor…"
Leadership	6 (6%)	"…medication orders were not clear enough…" "…the team lacked a clear leader…" "…the leadership role was not prominent enough…"
Shared Mental Model	6 (6%)	"…the team did not know or understand each other well enough…" "…the team's ideas were not effectively shared or conveyed…"
Situation monitoring	6 (6%)	"…the emergency situation was detected too late…" "…took too long to find necessary materials, leading to delayed defibrillation…" "…delayed recognition of the issue resulted in late hemorrhage control…"
Communication	5 (5%)	"…insufficient information was conveyed…" "…lack of effective communication…"

"Unclear division of responsibilities led to confusion". This suggests that clearer, more structured briefings are needed to improve task delegation and role clarity during emergency simulations.

The second most common issue pertained to STEP (Situation, Task, Equipment, People) (12%), where participants identified a lack of continuous assessment and failure to monitor the evolving clinical situation effectively. One participant mentioned: "Delayed recognition of changes in the patient's condition negatively impacted the response time". This indicates a need for better situational awareness training and real-time reassessment strategies during simulations.

Other recurring themes included difficulties with call-outs (11%), where participants reported delays in seeking help, and check-backs (7%), pointing to gaps in communication and timely execution of medical orders. Participants also expressed challenges in collaboration (7%) and cross-monitoring (6%), with some indicating that team roles were unclear, leading to redundancies and task overlaps.

Leadership challenges were also evident, with 6% of participants noting that the leadership role was not prominent enough, and several highlighted the need for clearer command and control during critical moments. Issues related to the shared mental model (6%) and situation monitoring (6%) were similarly noted, with participants expressing that team members did not fully understand or convey their thoughts effectively, impacting overall team coordination.

Lastly, communication (5%) remained a notable area of concern, with participants frequently mentioning insufficient information exchange and lack of effective communication during critical moments. One participant remarked: "Important information was not conveyed clearly, leading to confusion among the team".

Figure 1 presents a pie chart illustrating the distribution of qualitative responses from participants' self-evaluations, categorized by percentage. The largest portion of feedback corresponds to issues with Briefs (17%), followed by STEP (12%) and Call-out (11%). The chart visually highlights the key areas where participants identified both personal and team-based weaknesses. These include the need for improvements in communication, continuous situational awareness, effective leadership, and role clarity. The figure emphasizes the importance of addressing these critical elements to enhance overall team performance in managing complex clinical situations, as identified through simulation exercises.

Discussion

The findings of this study provide robust evidence supporting the efficacy of simulation-based IPE in improving teamwork, communication, and decision-making in critical care settings. Given the high-stakes and dynamic nature of critical care environments, the importance of fostering seamless collaboration among diverse healthcare professionals is paramount. This study reinforces the established advantages of simulation-based learning while identifying key areas where teamwork can be significantly enhanced through targeted training. Specifically, the study highlights improvements in situational monitoring, adaptability, communication, and leadership—competencies that are critical for managing the complexities and unpredictability inherent in critical care scenarios. These findings not only align with the study's objectives but also contribute meaningfully to the broader discourse on advancing interprofessional collaboration in healthcare.

Enhancing the Interpretation of Quantitative and Qualitative Findings

The integration of quantitative and qualitative data provides a comprehensive understanding of teamwork dynamics during SBIT. Table 3 demonstrate improvements in certain aspects of teamwork performance, such as leadership communication, with a statistically significant increase in the score for "The team leader let the team know what was expected of them trough direction and command". However, other areas, such as "The team communicated effectively" and "The team leader maintained a global perspective", showed modest or no significant improvement, underscoring persistent challenges in structured communication and holistic leadership.

These quantitative findings are further contextualized by the qualitative feedback in Table 4, which highlights recurring themes related to communication gaps and leadership issues. For instance, the themes of "insufficient communication" and "unclear tsk delegation" align with the quantitative scores for communication and leadership, suggesting that while numerical improvements were noted, participants perceived these areas as requiring further refinement. Specific feedback, such as "lack of clear instructions or directives" and "delayed recognitions of changes in the patients' conditions", emphasizes the need for more targeted training in structured communication techniques, such as call-outs and check-backs, as well as in situational awareness.

Interestingly, some high-scoring items in Table 3, such as "The team monitored and reassessed the situation" and "The team prioritized tasks", were mentioned less frequently in the qualitative data of Table 4. This contrast suggests that participants felt relatively confident in these aspects of teamwork, indicating the program's effectiveness in reinforcing certain critical skills.

The complementary relationship between Tables 3 and 4 highlights the importance of combining quantitative assessments with qualitative reflections in evaluating the impact of simulation-based training. While the TEAM tool provides structured and measurable insights into team performance, the qualitative feedback captures the nuanced, experiential aspects of teamwork that are not easily quantifiable. Together, these findings inform targeted strategies for further programs, such as emphasizing leadership under pressure, enhancing communication protocols, and fostering a shared mental model among team members.

Enhancement of Situational Monitoring and Adaptability

One of the key strengths identified through simulation-based training was the enhancement of situational monitoring, which plays a crucial role in maintaining patient safety. Healthcare teams trained through simulation demonstrated an increased ability to continuously monitor, assess, and reassess the evolving clinical conditions of patients, enabling them to detect and respond to subtle yet significant changes in patient status. This aligns with previous research emphasizing the importance of situational awareness in preventing medical errors and improving patient outcomes in critical care.[16,17] By practicing in a simulated environment that mimics real-life emergencies, participants were better prepared to anticipate and address complications, thereby reinforcing the importance of ongoing vigilance.[17]

Adaptability also emerged as a critical skill developed through simulation. In the dynamic and often chaotic context of emergency and critical care, adaptability—the ability to adjust actions and decisions in response to changing patient conditions—is indispensable. Our findings are consistent with the broader literature,[18,19] which highlights the value of simulation-based learning in fostering this flexibility. Simulation scenarios that introduce unexpected clinical developments challenge healthcare teams to think critically and make rapid adjustments to their care plans. By repeatedly engaging in these complex, evolving scenarios, participants became more adept at responding to uncertainty and adjusting their interventions in real-time.[18,19] This improvement in adaptability is particularly valuable in environments where timely clinical decisions can be the difference between patient recovery and deterioration.[16]

Structured Communication: Strengths and Areas for Improvement

While communication was identified as a strength in many areas, qualitative feedback revealed that there were still challenges with the consistent application of structured communication techniques, such as call-outs and check-backs. These tools are essential for ensuring clear, unambiguous exchanges of critical information during high-pressure situations. Structured communication frameworks emphasize the use of these techniques to improve patient safety by reducing communication breakdowns, which are a leading cause of errors in healthcare.[20]

Call-outs involve explicitly verbalizing key information to the entire team, ensuring that all members are aware of important changes in patient status or interventions being initiated. Check-backs, on the other hand, require the receiver to confirm that the message was correctly heard and understood, thereby closing the communication loop. Despite the known benefits of these communication tools, feedback from participants indicated that they were not always applied consistently during the simulation exercises. This inconsistency can lead to critical information being missed or misinterpreted, especially in fast-paced environments where multiple team members are simultaneously engaged in different tasks.[21]

The gap in the consistent use of call-outs and check-backs suggests that while the foundational elements of communication are being taught, further emphasis is needed on ensuring these structured techniques become an ingrained part of clinical practice. Previous studies have similarly noted that even well-trained teams can struggle with maintaining structured communication during crises, pointing to the need for ongoing reinforcement and practice.[21,22] By integrating more focused communication drills into simulation training, future programs can help address these lapses and ensure that all team members are proficient in these essential communication strategies.[23,24]

Leadership and Task Clarity

Leadership emerged as another area requiring targeted improvement, particularly in maintaining an overarching awareness of the clinical situation while effectively directing the team. Effective leadership in critical care involves not only the ability to delegate tasks and provide clear directives but also the ability to maintain a broad perspective on the evolving clinical situation.[25] Leaders who can balance these responsibilities are better positioned to guide their teams through complex, high-pressure situations.[25] However, feedback indicated that leadership, particularly in maintaining situational awareness while managing team dynamics, was challenging during the simulation scenarios.

This finding aligns with existing research showing that leadership training in critical care must focus on both technical and non-technical skills, including the ability to synthesize information from various sources while overseeing the actions of the team.[26] Simulation-based training provides an ideal platform for honing these skills, as it allows leaders to practice managing teams in high-stress environments without the risk of harm to real patients. Future training programs should include more explicit leadership development components that focus on maintaining a global perspective while managing team responsibilities.[27,28]

Task clarity also emerged as a point of improvement, with participants citing unclear role delegation as a source of confusion during the simulations. Effective teamwork in emergencies relies on clear and precise role allocation, ensuring that every team member knows their specific responsibilities. Previous research has demonstrated that when team roles are not clearly defined, task redundancy and delays in care can occur, ultimately compromising patient safety.[29] The feedback from participants in this study suggests that more structured pre-simulation briefings, where roles and responsibilities are delineated, could help mitigate these issues.[30]

Implications for Future Training

The thematic analysis of participant feedback also highlighted challenges with situational awareness and cross-monitoring. Cross-monitoring refers to the ability of team members to observe and verify each other's actions, ensuring that potential errors are caught before they result in patient harm. In critical care, where the margin for error is slim, effective cross-monitoring is essential for preventing mistakes and ensuring that care is delivered safely and efficiently. However, feedback indicated that team members sometimes failed to maintain a broad situational awareness, leading to oversights into patient care.

Addressing this issue will require future simulation training programs to place greater emphasis on the principles of cross-monitoring and team situational awareness. By incorporating more complex, multifaceted scenarios into training sessions, teams can practice maintaining a broader view of the clinical environment while simultaneously managing their responsibilities.[31] Additionally, encouraging regular communication checkpoints during simulations can help reinforce the development of shared mental models, ensuring that all team members are aligned in their understanding of the patient's condition and the care plan.[32]

Limitations

This study has several limitations. First, being conducted at a single institution, the findings may not be generalizable to other healthcare settings with different team dynamics and resources. Future multi-institutional studies are needed to validate the results. Second, reliance on self-reported data and facilitator evaluations may have introduced response bias. While we attempted to mitigate this with external assessments, using objective measures like independent video reviews could offer more unbiased results. The study focused on specific high-acuity scenarios, such as trauma and respiratory distress, which may not capture the full range of critical care challenges in other settings. Expanding the variety of simulated scenarios in future research could address this gap. Additionally, the long-term impact of the simulation training was not assessed. Future longitudinal studies could determine whether the improvements in teamwork and communication are sustained and lead to better patient outcomes. Lastly, the diverse experience levels of participants were not controlled for, which could have influenced the results. Future studies might stratify participants by their prior training to explore how different backgrounds affect the effectiveness of simulation-based education.

Conclusion

This study highlights the effectiveness of simulation-based IPE in enhancing critical teamwork skills, including situational monitoring, adaptability, communication, and leadership, in high-stakes critical care settings. The findings, however, underscore the need for further improvements in areas such as the consistent application of structured communication techniques, clearer role delineation, and stronger leadership during dynamic clinical scenarios. By refining simulation training programs to address these gaps, healthcare institutions can better prepare their interdisciplinary teams to respond effectively to the complexities of critical care, ultimately enhancing patient safety and clinical outcomes.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This article represents the author's personal views only.

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