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# Latent Safety Threats and Countermeasures in the Operating Theater

## A National In Situ Simulation-Based Observational Study

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**Introduction:** In situ simulation provides a valuable opportunity to identify latent safety threats (LSTs) in real clinical environments. Using a national simulation program, we explored latent safety threats (LSTs) identified during in situ multidisciplinary simulation-based training in operating theaters in hospitals across New Zealand.

**Method:** Surgical simulations lasting between 15 and 45 minutes each were run as part of a team training course delivered in 21 hospitals in New Zealand. After surgical in situ simulations, instructors used a template to record identified LSTs in a postcourse report. We analyzed these reports using the contributory factors framework from the London Protocol to categorize LSTs.

**Results:** Of 103 postcourse reports across 21 hospitals, 77 contained LSTs ranging across all factors in the London Protocol. Common threats included staff knowledge and skills in emergencies, team factors, factors related to task or technology, and work environment threats. Team factors were also commonly reported as protecting against adverse events, in particular, creating a shared mental model. Examples of actions taken to address threats included replacing or repairing faulty equipment, clarifying emergency processes, correcting written information, and staff training for clinical emergencies.

**Conclusions:** The pervasiveness of LSTs suggests that our results have widespread relevance to surgical departments throughout New Zealand and elsewhere and that collective solutions would be valuable. In situ simulation is an effective mechanism both for identifying threats to patient safety and to prompt initiatives for improvement, supporting the use of in situ simulation in the quality improvement cycle in healthcare.

(*Sim Healthcare* 17:e38–e44, 2022)

**Key Words:** In situ simulation, operating room, latent safety threats, countermeasures, system, redesign.

Adverse events in healthcare are common, yet evidence suggests that approximately 44% to 66% of these adverse events could be prevented<sup>1–3</sup> by identifying and correcting underlying latent safety threats (LSTs)—these being faults in healthcare systems that increase the risk of patient harm.<sup>4,5</sup> Examples of

LSTs include inadequate training, equipment design and maintenance,<sup>4</sup> poor hospital communication systems, work environments, procedures, and legislative policy.<sup>6</sup> Once identified, organizations can develop countermeasures and specific fixes to prevent these LSTs from precipitating patient harm.

Identifying LSTs through in situ simulation makes it possible to proactively address potential causes of error.<sup>7–10</sup> In situ simulation studies have explored LSTs in a variety of hospital settings.<sup>4,9–12</sup> Many of these in situ simulation studies have focused on single hospitals<sup>4,11,12</sup> and coded safety threats inductively, meaning that categories of events were formed uniquely in each study. For example, O’Leary et al<sup>11</sup> examined pediatric emergencies and identified knowledge deficits, clinical skill deficits, leadership problems, communication, resource use, preparation, and loss of situational awareness. Wetzel et al<sup>4</sup> undertook simulations in operating theaters (OT) and emergency departments and classified LSTs into equipment, medication, personnel, resource, or technical skills. There are some similarities in the factors identified between such studies; however, it is unclear whether differences in these findings represent differences in the specialties included, or in how the coding in each study was conducted, or in variation in the types of threats present at specific sites.

Collecting data from a national program of in situ simulations and using an established framework to analyze identified threats could provide more generalizable results to underpin national quality assurance interventions. Furthermore, operating

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C.S.W. is a minor shareholder in SaferSleep LLC (London, UK), a company that aims to improve safety in healthcare. The other authors declare no conflict of interest.

The NetworkZ program is funded by the Accident Compensation Corporation of New Zealand and supported by grants from the Australian and New Zealand College of Anaesthetists (2017 Douglas Joseph Professorship Grant, Project Number DJ17/001) and the Lottery Health Research Fund (Project Number: R-LHR-2017-49141).

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Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal’s Web site ([www.simulationinhealthcare.com](http://www.simulationinhealthcare.com)).

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DOI: 10.1097/SIH.0000000000000547

theaters are major sources of adverse events,<sup>13</sup> and thus, identifying threats in these settings is particularly important for improving patient safety.

NetworkZ is a multidisciplinary simulation-based in situ team training program for operating theater staff in public hospitals throughout New Zealand.<sup>14</sup> Its primary objective is to improve patient safety by enhancing interprofessional communication and teamwork. During the in situ simulation scenarios, systems and situational factors that may threaten patient safety were also identified. Therefore, as a secondary objective, we took the opportunity to gather information about the LSTs identified and discussed during the course debrief. Uniquely, the NetworkZ program provides an opportunity to study LSTs in real operating theaters on a national scale.

In the present study, we aimed to explore the LSTs identified during NetworkZ in situ training courses. The specific objectives of this study were to identify and describe the LSTs observed in operating theater simulations and to determine which threats are common among hospitals. We also sought to describe countermeasures and specific fixes made in response to the identified LSTs, as well as the behaviors and systems, which were judged to be protective factors against such threats.

## METHOD

We undertook a descriptive observational study of LSTs, protective factors, and countermeasures identified during surgical simulation as described in postcourse reports. Ethics approval was granted by the New Zealand Health and Disability Ethics Committee (Ref 16/NTB/143AM27).

### Study Context

In the NetworkZ program, the simulated patient presents for an operation for an acute surgical emergency in one of the specialties of general surgery, otorhinolaryngology, urology, orthopedics, or plastic surgery. During the case, the participants are challenged with critical events including hemorrhage, airway complications, or shock. A full multidisciplinary surgical team, composed of anesthetists, surgeons, technicians, and theater nurses, attends each course. Orderlies, trainee anesthetists, trainee surgeons, and postoperative care nurses also attended some courses, as would be typical of practice at each site. These teams use their own equipment, drugs and disposables, and their own safety procedures during simulations. Each simulation case scenario includes patient notes formatted for the local hospital site, standardized scripts for participants, and detailed guides about the evolution of vital signs in response to participant actions. Half-day NetworkZ courses are the most common and involve 2 scenarios, and a full-day course involves 3 to 4 scenarios. Further detail about NetworkZ courses, debriefing, instructor training, and implementation strategy is available elsewhere.<sup>14</sup>

Each scenario is followed by a structured debrief, when participants reflect on what happened and why and consider what they have learned that they can take back to clinical practice. Two debriefers facilitated each debrief and provided generic prompts about opportunities for improvement, rather than directing people to specifically discuss LSTs. Course instructors comprise local surgical, nursing, and anesthesia staff who undergo a 2-day training program, supplemented by

online modules. Course instructors may specialize in the technical aspects of running the simulator or in debriefing and facilitating. Over the timeframe of this study, 220 local staff were trained as debriefers. National NetworkZ faculty provided hands-on support for course implementation until local staff were confident in delivering the courses.

### Data Collection

NetworkZ course instructors were asked to provide a postcourse report that included a record of any LSTs identified during the simulations. The report form was designed by the national program manager, with input from academic colleagues. The national program manager or other national faculty, who had experience in LST identification, assisted with review or completion of reports. Threats noted by instructors or discussed during the debrief were included in the report. Hospitals were encouraged to nominate a course instructor at each site to act as a liaison to bring issues identified to the attention of local quality groups.

From February 2019, the report form was altered to prompt course instructors to record factors that protected against potential adverse events during the simulations (“protective factors”) and to identify specific actions to address the threats they had identified (“counter measures”). See Tables, Supplemental Digital Content 1, <http://links.lww.com/SIH/A634>, for the 2 iterations of the report template. The change was made to capture these details more systematically and to encourage local staff to address the actions they identified.

All course reports from the start of the program (March 2017) to November 2019 were included in the analysis. By the end of the November 2019, 21 hospital sites, representing 3 quarters of the health boards in New Zealand, had completed at least one-half-day course comprising 2 simulations. The 21 hospital sites were all publicly funded hospitals involved in the training of physicians and/or nurses. They comprised 10 small hospitals (0–200 beds), 6 medium hospitals (200–400 beds), and 5 large hospitals (400+ beds). The largest hospital in the sample was a 900-bed facility. Six of the participating hospitals (5 large and 1 medium) offered tertiary-level surgical care.

During this period, funding for the program was provided by the Accident Compensation Corporation, New Zealand's no-fault accident insurer.

### Framework for Analysis

We chose the *contributory factors framework* from the London Protocol<sup>15,16</sup> to code the content of course reports due to its comprehensive nature. This framework is inclusive of a broad range of system threats and subcategories of threats.<sup>17</sup> The set of “contributory factors” in the London Protocol range from proximal threats such as staff skillsets and patient characteristics to more distal threats such as management decisions and organizational processes.<sup>15,16</sup> The use of an established and comprehensive framework offers the possibility of consistency and comparability across studies, and this may, in turn, allow for a cumulative building of the evidence base around LSTs and human factors in healthcare.<sup>17</sup>

### Data Analysis

All text describing participant debriefing points and LSTs was extracted from the postcourse reports and imported into

NVivo 12 (QSR International, Melbourne, Australia). All threats were coded into the London Protocol subcategories (Table 1). Where an LST described in a report did not map onto any of the existing subcategories, an additional subcategory was developed. To assist with coding, we created a data dictionary that included a specific definition of each LST subcategory (see Table, Supplemental Digital Content 2, <http://links.lww.com/SIH/A635>, for the data dictionary).

Coding was conducted by 3 authors: a postdoctoral research fellow with a background in psychology (J.A.L.), a senior academic and expert in human factors (C.S.W.), and a practicing anesthetist (T.H.). Clinical and nonclinical coders conferred during coding and the development of the data dictionary until all felt that they were coding consistently. We also conducted a formal check of interrater reliability in a sample of 10 randomly chosen new events, which were independently coded without conferring by J.A.L. and C.S.W., and a  $\kappa$  score was calculated. Ratings were judged to be sufficiently in agreement ( $\kappa = 0.78$ ), and thereafter, J.A.L. coded the remainder of the reports. A further random set of 10 reports and reports, which included technical clinical terms or were ambiguous, were discussed with a consultant anesthetist (T.H.) as a final validity check. Categorization against the London Protocol subcategories was repeated for the protective factors and countermeasures described in reports. Items were considered protective factors, rather than LSTs if the content described something that was working well during the simulation.

We then calculated the number and percentage of reports and the number and percentage of sites, which identified each LST, protective factor, and countermeasure. Reports with insufficient information to allow reliable coding were excluded from these analyses. We used the strengthening the reporting

of observational studies in epidemiology guidelines to report our study.<sup>18</sup>

## RESULTS

### Postcourse Report Completion

From March 2017 to November 2019, 103 postcourse reports were submitted relating to 138 of the 153 NetworkZ courses run during the study period (a course response rate of 90.2%). Of these, 77 reports (74.7%) recorded LSTs with sufficient information to allow reliable coding using the London Protocol factor types. Occasionally, reports stated that no threats were identified during the simulation or left this part of the postcourse report blank.

### Coding

We identified 3 additional subcategories for coding LSTs not adequately captured by the factor framework of the London Protocol. These are marked with an asterisk in Table 2.

### Latent Safety Threats Identified

Table 2 presents the number of reports, the percentage of reports, and the percentage of sites where each of the latent safety factor types and subcategories was identified.

#### Patient Factors

Patient-related threats were rarely identified (4% of reports, 14% of sites), but those identified included the Jehovah's Witness status of the "patient" in one scenario, which generated additional technical and procedural challenges during cases involving blood loss.

#### Task and Technology Factors

Latent safety threats coded against "Task design and clarity of structure" often related to unclear or problematic processes regarding how to order blood products or laboratory tests on blood samples during an emergency.

The "decision-making aid" subcategory captured threats related to the availability of crisis checklists, cognitive aids and algorithms, and how they were used. Difficulty sourcing or using cognitive decision-making aids for crisis management was identified relatively frequently (26% of reports, 57% of sites). For example, crisis checklists were often: *"unable to find easily – mixed up with other stuff on defib & cover not displayed. Kept in different places"* (Course report #11).

#### Individual (Staff) Factors

Individual staff factors were the most common LSTs identified in these reports (82% of reports, 90% of sites; Table 2). As the number of reports coded to knowledge and skills was high, we broke these down further in Table 3. The reports of knowledge and skill gaps (82% of reports, 90% of sites) often related to the use of a defibrillator (35% of reports, 57% of sites) and cardiopulmonary resuscitation (CPR, 29% of reports, 52% of sites). Common difficulties with defibrillators included appropriate choice of manual versus automatic mode on the defibrillator, difficulty operating the defibrillator in an unfamiliar mode, delays due to unnecessarily plugging the defibrillator into power sockets before use and limited knowledge, and confidence using the defibrillator. Cardiopulmonary resuscitation knowledge and skill gaps often related to the timing, speed and depth of compressions applied, and general knowledge and confidence. For example, a report identified that a surgeon discussed feeling underskilled to assist with a cardiac arrest,

**TABLE 1.** The Contributory Factors Framework From the London Protocol

Factor Types	Contributory Factor (Subcategories)
Patient factors	Condition (complexity and seriousness) Language and communication Personality and social factors
Task and technology factors	Task design and clarity of structure Availability and use of protocols Availability and accuracy of test results Decision-making aids
Individual (staff) factors	Knowledge and skills Competence Physical and mental health
Team factors	Verbal communication Written communication Supervision and seeking help Team structure
Work environment factors	Staffing levels and skills mix Workload and shift patterns Design, availability, and maintenance of equipment Administrative and managerial support Environment Physical
Organizational and management factors	Financial resources and constraints Organizational structure Policy, standards, and goals Safety culture and priorities
Institutional context factors	Economic and regulatory context National health service executive Links with external organizations

**TABLE 2.** Latent Safety Threats Coded Against London Protocol Factor Types and Subcategories: Number of Reports, Percentage of Reports, and Percentage of Sites Recording These Issues

	No. Reports (%)	No. Sites (%)
1. Patient factors	3 (4)	3 (14)
Condition (complexity, seriousness)	0	0
Language and communication	0	0
Personality and social factors	3(4)	3 (14)
2. Task and technology factors	31 (40)	16 (76)
Task design and clarity of structure	12 (16)	11 (52)
Availability and use of protocols	3 (4)	3 (14)
Availability and accuracy of test results	5 (6)	5 (24)
Decision-making aids	20 (26)	12 (57)
3. Individual (staff factors)	63 (82)	19 (90)
Knowledge and skills	63 (82)	19 (90)
Competence	1 (1)	5 (1)
Physical and mental health	2 (3)	10 (2)
4. Team factors	59 (77)	20 (95)
Verbal communication	38 (49)	15 (71)
Written communication	9 (12)	8 (38)
Supervision and seeking help	18 (23)	12 (57)
Team structure	7 (9)	7 (33)
Task distribution within team members*	35 (45)	14 (67)
Knowing names of team members*	17 (22)	10 (48)
5. Work environment factors	46 (60)	18 (86)
Staffing levels and skills mix	10 (13)	7 (33)
Workload and shift patterns	3 (4)	3 (14)
Design, availability, and maintenance of equipment	45 (58)	18 (86)
Administrative and managerial support	5 (6)	4 (19)
Environment	1 (1)	1 (5)
Physical	3 (4)	2 (10)
Issues related to medication storage*	15 (19)	12 (57)
6. Organizational and management factors	8 (10)	6 (29)
Policy, standards, and goals	3 (4)	2 (10)
Safety culture and priorities	4 (5)	4 (19)
Financial resources and constraints	1 (1)	1 (5)
Organizational structure	0	0
7. Institutional context	1 (1)	1 (5)
Economic and regulatory context	1 (1)	1 (5)
Links with external organizations	0	0
National health service executive	0	0

The total number of reports is 77 and the total number of sites is 21.

\*Items with an asterisk were added to the original London Protocol list as existing subcategories did not describe this threat.

which they attributed to the fact that they were not required to regularly attend skills courses in this area; “Surgeon felt ‘unhelpful’ during VF arrest, identified this as a deficit with updates not mandatory.” (Course report #9)

Gaps in knowledge about the existence of crisis checklists or which one to use were also common (30% of reports, 57% of sites; Table 2). Some simulation participants, particularly healthcare assistants and postoperative care nurses identified

**TABLE 3.** Individual Staff Factors: Knowledge and Skill Gaps Identified by the Number of Reports, Percentage of Reports, and Percentage of Sites Reporting This Issue

Skill-Type	No. Reports (%)	No. Sites (%)
Defibrillator use knowledge and skills	27 (35)	12 (57)
Crisis checklist existence, location, or use	23 (30)	12 (57)
OT familiarity	17 (22)	12 (57)
CPR knowledge and skills	22 (29)	11 (52)
Other procedural knowledge	14 (18)	11 (52)
Local blood system knowledge	16 (21)	10 (48)
Other equipment use	10 (13)	9 (43)
Awareness of equipment location	6 (8)	5 (24)
Rapid fluid infuser setup and use	6 (8)	5 (24)
Communication tool knowledge	1 (1)	1 (5)

The total number of reports is 77 and the total number of sites is 21.

**TABLE 4.** Protective Factors Described as Working Well During the Simulated Scenarios

	No. Reports (%)	No. Sites (%)
Individual factors		
Knowledge and skills	3 (4)	2 (10)
Team factors		
Shared mental model (briefings, recaps)	49 (64)	17 (81)
Leadership	16 (21)	9 (43)
Closed loop communication	15 (19)	10 (48)
Speaking up	13 (17)	8 (38)
Using people's names	3 (4)	2 (10)
Debriefing after event	2 (3)	2 (10)
Task sharing (backup behavior)	17 (22)	10 (48)
Using team skill mix	12 (16)	7 (33)
Good written communication	10 (13)	8 (38)
Supervision and seeking help	4 (5)	3 (14)
Task and technology factors		
Decision-making aids	7 (9)	6 (29)
Other	2 (8)	5 (24)

The total number of reports is 77 and the total number of sites is 21.

their lack of familiarity with the OT environment as limiting their ability to assist in a crisis (22% of reports, 57% of sites). For example, “HCA mentioned that she was not familiar with some of the equipment she was asked to get” (Course report #1) and “PACU staff are useful resource but not in OR [OT] enough to feel confident about location of items, how to integrate into team in critical events.” (Course report #39)

Deficits in knowledge about the local procedure for ordering blood were identified by nearly half of the sites (21% of reports, 48% of sites). Typically, this related to the process for obtaining blood in the case of activation of the massive transfusion protocol, including blood availability, timeframes involved, how the blood was transported from blood bank to the OT, and what information would be required by the blood bank when ordering blood.

### Team Factors

Suboptimal teamwork, such as gaps in the verbal communication of information between team members (49% of reports, 71% of sites), was identified as a potential patient safety threat. For example, in one debrief, the “staff described not having a clear idea of what they are called in for with acute patients.” (Course report #20)

Opportunities to improve the distribution of tasks between team members were frequently reported (45% of reports, 67% of sites). For example, “The team leader felt task overloaded, while other team members felt ‘helpless’ or ‘lost until given job.’” (Course report #29). Ways to support and free up the team leader were discussed in the debrief of the simulation, included delegating tasks such as drawing up of medications and performing CPR to others in the team.

Other threats related to difficulties in seeking help from others (23% of reports, 57% of sites). These often related to the use or effectiveness of the emergency bell and using team members' names (not remembering names or being unable to read name badges; 22% of reports, 48% of sites). Details in the reports indicated that participants sometimes had trouble recalling the names of staff that they had previously worked with a on multiple occasions.

### Work Environment Factors

Threats related to the design, availability, and maintenance of equipment were commonly reported (58% of reports, 86% of sites). Examples included shortages of emergency equipment in the department, identifying that existing equipment may not be the most appropriate, difficulty accessing equipment, and equipment faults (eg, when the lid of a rapid infusion device was closed the footpad landed on the STOP button and turned off the infusion).

### Organizational and Management Factors

Latent safety threats related to organization and management factors were less frequently identified (10% of reports, 29% of sites), and most cases in this group were related to policies, strategies, or goals (4% of reports, 10% of sites). These included the lack of treatment guides for specific events, and no established process for following up LSTs was identified in the simulations.

Three threats to safety culture and priorities (5% of reports, 19% of sites) were identified across the reports: the failure to use the World Health Organization Surgical Safety Checklist in emergency cases; an absence of regular checking of emergency equipment; and staffing practices that failed to meet professional guidelines.

### Institutional Context Factors

Threats related to the institutional context were seldom identified within the reports (1% of reports, 5% of sites). The single case related to nurses being accredited to check blood but not to connect it to an intravenous infusion line, which limited their ability to assist in an emergency.

### Protective Factors

The protective factors identified as working well during the simulation often related to the team factors category of the London Protocol. Often, specific verbal communication techniques were reported as working well, particularly the use of communication techniques that enabled the team to create a shared mental model (Table 4). Other aspects of team behavior, team skill mix, decision-making aids, and knowledge and skills were also identified as working well during the simulation. Existing knowledge about the massive transfusion protocol system was specifically identified as a strength after the simulated massive hemorrhage scenario. Follow-up actions included in the postcourse reports often indicated an interest in embedding these behaviors into normal practice. At other times, the follow-up actions indicated that these good practice behaviors were already part of business-as-usual.

### Countermeasures and Specific Fixes Taken in Response to Identification of LSTs

In 14 (18%) of the 77 reports course instructors described specific local actions taken at their hospital after the identification of LSTs as a consequence of the in situ simulation course (Table 5). Some of these actions were one-off fixes (eg, repairing or purchasing equipment), and some were longer-term countermeasures to risk (eg, staff training, establishing a process for the regular checking of emergency equipment, and clarifying local processes).

## DISCUSSION

Through in situ simulations, we identified examples of LSTs across the full range of factor types in the London Protocol.

**TABLE 5.** Countermeasures and Specific Fixes Taken in Response to Identified Patient Safety Threats, Categorized Against the London Protocol System

	No. Reports (%)	No. Sites (%)	Examples
Task design and clarity of structure	2 (3)	2 (10)	Met with local blood bank to clarify the process of ordering blood products in an emergency.
Availability and accuracy of test results	1 (1)	1 (5)	New blood analyzer machine ordered for theater suite to reduce time for blood gas results.
Knowledge and skills	6 (8)	5 (24)	Staff training on defibrillator use, Advanced Cardiac Life Support (ACLS) protocol, and location of emergency equipment.
Written communication	3 (4)	3 (14)	Incorrect written information corrected about process for ordering blood products or blood tests.
Design, availability, and maintenance of equipment	4 (5)	3 (14)	Equipment repaired, emergency bells replaced, process of regular checking of emergency stock established, setup of emergency trolley improved

The total number of reports is 77 and the total number of sites is 21.

Latent safety threats pertaining to individual staff members, team factors, the task or technology, and the work environment were featured in most reports. These same types of LSTs were widely reported across the 21 hospital sites, with individual and team factors reported in 90% or more of sites, and threats related to task and technology, and work environment factors reported in upward of 75% of sites. Latent safety threats related to the clarity of the task, access to decision-making aids, and equipment design, availability, or maintenance were also commonly reported. The similarities in LSTs identified across a nationwide cross-section of hospital operating theaters build on previous research focused on single hospital sites.<sup>4,11,12</sup>

Our study provided a snapshot of the early actions taken to address these LSTs. Specific fixes often included purchasing or repairing equipment, and countermeasures to threats included clarifying emergency processes and establishing a process for regular checking of emergency equipment.

The threats identified in this study, such as suboptimal communication and teamwork, excessive workload, medication storage, and equipment failures are largely consistent with investigations of real-life patient harm events.<sup>19,20</sup> This suggests that simulation is an effective method for identifying latent threats relevant to patient safety in the real world. The present study builds on existing in situ simulation studies in other specialized settings<sup>4,11</sup> including neonatal intensive care units,<sup>10,11</sup> cardiac intensive care,<sup>10</sup> obstetric settings,<sup>9</sup> operating theaters and emergency departments,<sup>4</sup> and “various locations around the hospital.”<sup>12</sup> Together, our findings highlight the pervasiveness of shortfalls in individual skills, team function, task clarity, and the work environment.

The threats identified in this study are particularly relevant to the capacity of a hospital to mount an effective emergency response for at least 2 reasons. First, many of the threats were related to team factors, equipment, knowledge, or skills required in an emergency. Second, LSTs are particularly dangerous when time is critical, patient presentations are complex, and where workloads may exceed the available resources.<sup>21,22</sup> During the simulations, staff who were proficient in critical tasks were often task overloaded, leading others to reflect that they also needed to be skilled and confident at emergency responses. Identifying these LSTs as widespread issues across New Zealand Hospitals supports interventions to improve the readiness of hospital staff to respond effectively to clinical emergencies, which would in turn be expected to increase the resilience of the organizations in which such staff worked.<sup>23</sup>

Analysis of the simulation postcourse reports identified team factors as an area where improvements could be made to bolster patient safety. Conversely, these team factors, particularly having a shared mental model, were also the most common protective factors reported; when working well, they helped the team to respond more effectively to the challenges of the case. Poor teamwork has been widely implicated in patient adverse events, including deaths<sup>19,24–26</sup> and delayed response.<sup>27</sup> Developing expertise in working in multidisciplinary teams has become a key competence for members of healthcare teams.<sup>28,29</sup> Programs to improve teamwork have the potential to make a large impact on patient safety.<sup>30,31</sup> Tools to promote a shared mental model, such as briefing and structured recap, are a core part of the NetworkZ team training program and were often noted as protective factors during simulations.

### Strengths, Limitations, and Future Research

Our study adds considerable weight to the existing literature on in situ simulation as a quality and safety tool at a national level, by using the standardized contributory factors framework from the London Protocol<sup>15,16</sup> and including reports from many different hospitals around New Zealand.

Using routinely collected data from postcourse reports has the advantage of authenticity but some limitations in terms of completeness. The data may underreport the true rate of LSTs present during in situ simulation, as some threats may not have been identified or recorded. Local course instructors did not receive specific training in LST identification, meaning that some potential threats may have been overlooked. Protective factors and actions to address threats will have been underreported as these were not specifically prompted for in the first iteration of the postcourse report form. We avoided making comparisons between sites because of variation in the personnel participating in simulations at each site and the change in forms midway through the study. Many latent safety issues identified during in situ simulations or real cases in the OT may partly arise because of institutional and organizational factors, but identifying distal factors at the root of safety issues seems to be a challenge in patient safety research.<sup>32</sup> Further research could proactively collect more in-depth information about the causes of threats identified during in situ simulation to better understand the linkage with underlying organizational factors.

Data on specific actions taken in response to LSTs identified during the in situ simulations may be incomplete. We

included only actions that were both proposed and reported as completed in our analysis. Some actions may have been completed outside of the timeline of the current study, specifically those requiring managerial approval or with budgetary implications, as these changes typically take longer to occur. Delays or failure to address threats identified during simulation is common,<sup>4,33</sup> but obviously problematic.<sup>33</sup> Future research could identify in greater detail how institutions respond to threats identified during in situ simulations and how to ensure that this source of information is effectively incorporated into hospital quality improvement programs.

## CONCLUSIONS

Reports after in situ simulations identified large numbers of LSTs across a range of factor types. These highlighted potential threats to the ability of OT teams to respond optimally to an emergency situation. Many of the threats were widely reported across the 21 hospital sites in the study. Postsimulation reports identified many factors that were protective against these threats, as well as many examples of actions taken to address threats.

The pervasiveness of LSTs suggests that they are of widespread relevance to OT departments throughout New Zealand and elsewhere, with potential for collective solutions. The findings also support the value and validity of in situ simulation as an effective mechanism both for identifying threats to patient safety and to prompt local initiatives for improvement. Incorporating in situ simulation into the quality improvement cycle in hospital operating theaters may offer important opportunities to improve patient safety.

## ACKNOWLEDGMENTS

The authors thank Kaylene Henderson for being instrumental in the development of the postcourse report form and in the collection of report data. The authors also thank the local course instructors for their time in completing the postcourse reports.

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