Translation of *in situ* neonatal high-fidelity simulation training: identification and mitigation of latent safety threats

This study aimed to use *in situ* high-fidelity neonatal simulation training to identify latent safety threats in various neonatal scenarios. Having identified the threats, we then developed and implemented system improvement actions to mitigate them. We translated what we learnt from the mitigation process to real-life events. In this way we hope to improve upon our efficiency, quality of care, and patient safety.

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Keywords

high-fidelity *in situ* neonatal simulation training; latent safety threats; crisis resource management skills; quality improvement

Key points

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1. High-fidelity *in situ* neonatal simulation training on the neonatal unit helps develop technical and crisis resource management skills and can also identify latent threats in a system.
2. Once latent safety threats are identified, it is possible to implement a process to mitigate them.
3. Successful translation of mitigation processes to real-life scenarios indicates effective training and a patient-safe environment.

Background

Simulation, as defined by Gaba, is: "A technique, not a technology, to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner."[1] Simulation has been adopted in health systems and education with the aim to deliver high quality patient care and develop individual knowledge and technical and crisis resource management skills, along with team work.[2,3]

Besides education and training, simulation-based training is also used to identify latent threats, implement new equipment or processes, and target health outcomes. A systematic review of simulation-based learning shows that it is effective in preventing iatrogenic medical error and improving patient safety.[4]

Latent safety threats (LSTs) are defined as system-based threats to patient safety that can materialise at any time and often go unrecognised by healthcare professionals.[5] The threats generally fall under the categories of:

- medicines
- equipment
- environment
- knowledge and skills
- crisis resource management skills/human factors.

Latent threats can be identified during *in situ* simulation training. Mitigation strategies for an individual LST identified in a simulated environment can strengthen patient safety by preventing such threats from being translated to a real-life scenario.[6]

Objectives

In this study, we aimed to probe our existing systems[7] to identify any LSTs and implement a mitigation process. Our objectives were:

1. To identify LSTs during multidisciplinary *in situ* neonatal simulation training sessions on the neonatal unit.
2. To develop and implement an action plan to mitigate the LSTs, thus ensuring patient safety and improved quality of care.
3. To demonstrate the mitigation of LSTs by repeating the scenarios during the post-implementation period.
4. To demonstrate the translation of simulation-based learning into real events.

TABLE 1 and **FIGURE 1** show the steps and processes we took to identify and mitigate the LSTs.

Methods

We have been conducting *in situ* neonatal high-fidelity simulation training at the Level 2 neonatal unit of Lister Hospital since 2014. The training is conducted at the unit in a dedicated area designed as the neonatal simulation room and undertaken with pre-prepared scenarios based on clinical events. The training involves a multidisciplinary team of two members of the medical staff, two nursing staff and two trained facilitators.

Since early 2019, we began to identify LSTs at the end of each training session, using a locally-developed LST form. For each LST, we implemented an action plan

	Approach	Methods and tools	Outcome
Define the problem	Identify the LST during neonatal simulation training sessions	Categorise the LSTs and analyse them (using the 'fish bone' tool and driver diagram)	We identified the gap in the local system for each LST
Develop shared purpose	Develop multidisciplinary training sessions	Involve the local risk-management team, trust safety team and trust quality improvement team	We reported the LST at the monthly risk management meetings
Plan and implement changes	Develop a LST form and an action plan for each LST	At the end of each session, the facilitator completes the form by identifying the LSTs	We categorised the severity and implemented an action plan
Test and measure improvement	Review the LSTs Implement an action plan Repeat the training session	'PDSA' cycles Number of LSTs identified per session Use of a run chart	We mitigated a LST identified during a real event
Sustainability	Regular teaching Repeat the neonatal simulation training sessions Assess the LSTs	Discuss at the governance meeting Regular training sessions Dissemination through emails	We disseminated learning at departmental governance and safety meetings

TABLE 1 Steps for the identification and mitigation of LSTs.

to identify system improvement actions to be taken by the neonatal multidisciplinary team to address and mitigate the LST.

TABLE 2 shows some of the scenarios used during the high-fidelity simulation training. Each scenario was based on recent events at the unit. Using an adapted Yorkshire Contributory Factors Framework,[8,9] latent threats were differentiated into five main categories, namely: equipment, medication, technical, resources and crisis management skills/ human factors.

Equipment: for example, equipment used not fit for purpose, incorrect use of equipment, lack of skill and knowledge of equipment and consumables.

Medication: for example, correct drugs, correct dose, timely administration, correctly prescribed, correct use of monograph.

Technical: for example, difficulty with clinical procedure, unfamiliar with procedure, knowledge deficit, skills deficit.

Resources: for example, correct use of guidelines/ policies, protocol/monograph unclear or too complicated.

Crisis resource management skills/human factors: for example, team factors (conflicting goals, lack of respect, poor delegation, distraction, inexperience, insufficient staff, stress and fatigue, lack of situational awareness), communication (poor communication between staff, handover problems, escalation process not completed), leadership (inappropriate delegation, unclear responsibilities, lack of team supervision, failure to escalate, unreceptive to team views, prioritisation).

The latent threats were differentiated

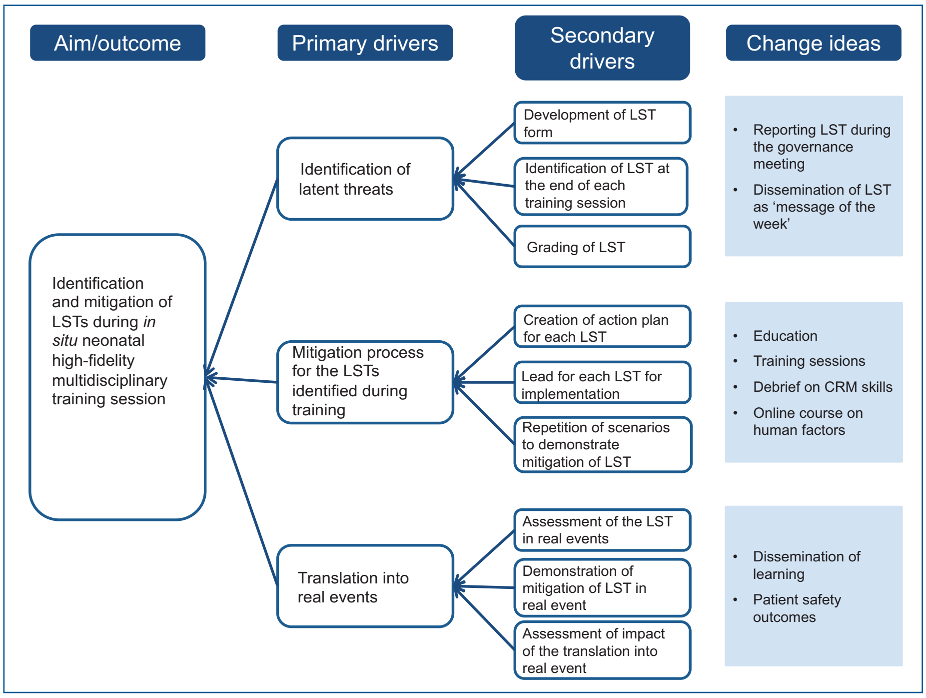

FIGURE 1 The driver diagram for the process of identifying and mitigating LSTs. Key: CRM=crisis resource management.

with respect to their severity using the RAG rating tool.[10] An action plan was developed for individual LSTs and the person responsible for implementation was identified. The LSTs and the updates on implementation of the action plan were reported at the monthly departmental risk management meetings. The progress on implementation was reviewed fortnightly and information was disseminated at other meetings, including unit meetings and senior nursing meetings.

Since October 2019, we have been repeating the same scenarios in the simulation sessions and during debriefs. We continue to identify new LSTs and collect data to assess whether the previously identified LSTs have been mitigated.

We used two plan-do-study-act (PDSA) cycles. PDSA cycle 1 was used to identify the latent threats during the *in situ* high-fidelity simulation training and PDSA cycle 2 was applied to demonstrate the mitigation of the LSTs after the implementation of the action plan.

To demonstrate the translation of the simulation-based training and the mitigation of LSTs to real-life events, we collected data on the time taken to prescribe and administer medications, use of a Replogle tube, insertion of cerebral function monitor (CFM) leads and interpretation of amplitude-integrated electroencephalography (aEEG) during real-life scenarios.

Results

We conducted 22 multidisciplinary high-fidelity *in situ* neonatal simulation training sessions on the unit from January 2019 to December 2020, which included the post-intervention period. We trained a total of 88 neonatal staff, both medical and nursing staff in equal numbers. The breakdown of trainees was:

- specialty trainee grade 4-7 = 22%
- clinical fellows grade 1-2 = 26%
- General Practice Vocational Training Scheme = 7%
- nursing staff band 5-7 = 45%

A total of 67 LSTs were identified during this period, with an average of 3.0 threats per session. Other studies have found an average of 1.1 LST per session.[11,12]

The latent threats identified were categorised as:

- equipment = 22.3%
- medications = 17.3%
- technical = 19.4%
- resources = 12%
- crisis resource management skills = 29%.

TABLE 3 shows a sample of some of the LSTs and the mitigation processes.

1. Preterm baby born at 27 weeks' gestation with respiratory distress syndrome
2. Preterm baby with sepsis
3. Antenatal diagnosis of agenesis of corpus callosum: ethical issue
4. Antenatal diagnosis of trisomy 18: ethical and communication scenario
5. Antenatal diagnosis of severe post-haemorrhagic ventricular dilatation, which was planned for feticide but delivered prior to the procedure: challenges regarding parental acceptance
6. Preterm baby with tracheoesophageal fistula
7. Antenatal diagnosis of congenital diaphragmatic hernia
8. Preterm baby born at 35 weeks' gestation with antenatal diagnosis of gastroschisis
9. Hypoxic ischaemic encephalopathy (HIE) grade 2 progressing to grade 3
10. HIE grade 2 in a preterm baby born at 34 weeks' gestation
11. Preterm baby born at 28 weeks' gestation delivered in accident and emergency department
12. Meconium aspiration with persistent pulmonary hypertension of the newborn
13. Pneumothorax

TABLE 2 Examples of scenarios used for *in situ* neonatal high-fidelity simulation training based on real events, 2019-2020.

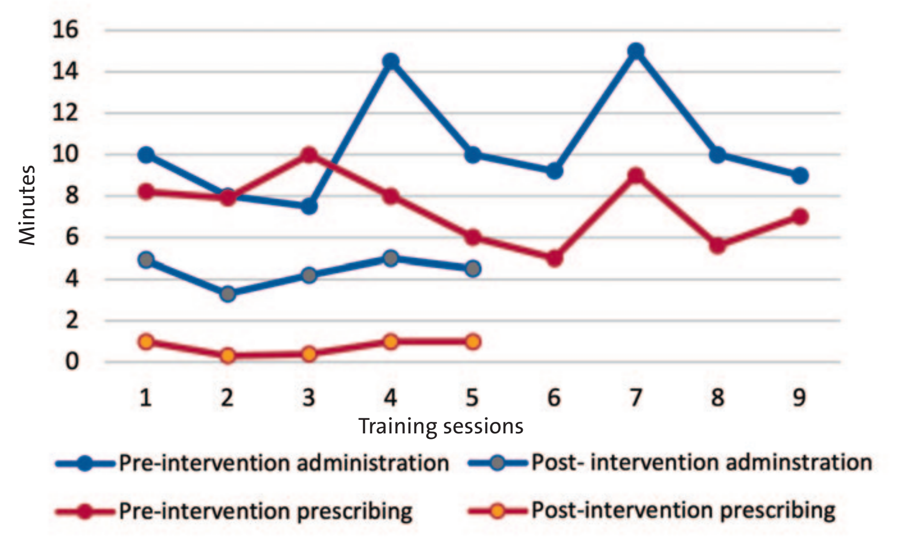

FIGURE 2 Mitigation of the threat of delay in administration of pre-medication for intubation.

Case study

An example of one of the LSTs identified is discussed. During a scenario, we identified a threat of delay in the prescribing and administration of pre-medication for intubation. The intervention process included:

- training sessions on prescription writing by a pharmacist for the medical staff at induction
- training session for neonatal nurses
- development of a laminated monograph for pre-medication doses and attachment of this to the intubation trolley.

We were able to demonstrate a post-intervention reduction in time for the prescription and administration of pre-intubation medication (**FIGURE 2**).

Following the intervention process, we were able to demonstrate that we could mitigate most of the LSTs identified in our simulation training. We also attempted to demonstrate translation of the mitigated latent threats to real-life events. During a real event, the preparation and administration of pre-medications prior to intubation, was timed and noted to improve in terms of reduced preparation and administration time (average time = 6.5 minutes). Translation of the training was also observed in:

- a reduction in the preparation time for phenobarbitone (from 14 to 5.6min), dopamine (from 15 to 8min), and adenosine (from 15 to 5min)
- appropriate insertion of a Replogle tube by neonatal nurses qualified in specialty (three events; 100% success)
- use of cling film and monitoring of bowel perfusion in gastroschisis (one event; 100% success)
- CFM lead insertion by neonatal nurses qualified in specialty (three events; 80% success)
- interpretation of CFM traces (three events; 70% success).

Discussion

In our study, we identified 67 LSTs during simulation training. We not only reported them during the risk management meeting, but also tested the efficacy of our system improvement by repeating the simulation training. We have also demonstrated the mitigation of some of the threats in real-life events.

Wetzel et al[13] suggested that the improvement achieved after identifying LSTs during a multidisciplinary simulation training is the best objective evidence of the effectiveness of the training. Our study has not only provided this evidence, but is also one of the few studies to demonstrate the mitigation of latent threats identified during *in situ* simulation

Category of risk and latent threat	System improvement actions	Dissemination
Drugs 1. Delay in prescribing and preparation of pre-medication for intubation 2. Adenosine monograph not available in the drug folder 3. Difficulty encountered in preparation of phenobarbitone and dopamine	1. Training sessions for the medical staff at induction 2. Training session for neonatal nurses 3. Development and redesigning of monographs 4. A laminated monograph for pre-medication doses and preparation for easy access	1. Clinical governance meeting 2. Unit meeting 3. Guideline's meeting 4. Risk management meetings 5. Pharmacy memo on changes and implementation of monograph
Resources 1. Unavailability of cling film to cover intestines in case of gastroschisis 2. Absence of tools to monitor gut perfusion	1. Defined area identified to store cling film on the unit 2. Adaptation and implementation of tool for monitoring gut perfusion in gastroschisis	1. Posters identifying location of cling film 2. Unit meeting 3. Risk management meeting
Equipment 1. Inappropriate CFM lead, insertion and interpretation 2. Chest drain set up 3. Neopuff set-up and delivery of adequate positive end-expiratory pressure (PEEP) 4. Use of transport incubator 5. Replogle tube insertion	1. Development of an in-house training programme, led by neonatal consultant and unit neuroprotection link nurse 2. Implementation of a competency assessment document and guidelines for chest drain, Neopuff and Replogle tube set up	1. Programme displayed on the unit education board 2. Step-by-step guidance attached to CFM monitors 3. Unit meeting 4. Risk management meeting
Crisis resource management/human factors 1. Closing loop 2. Leadership 3. Prioritisation 4. Parent communication 5. Teamwork	1. Team attendance at human factors foundation training 2. Implementation of weekly leadership development session facilitated by trust leadership associate director 3. Team attendance at trust leadership and development programmes	1. Discussion during supervisor meeting 2. Additional training requirements discussed at appraisal and incorporated in the unit training needs analysis

TABLE 3 Some examples of LSTs identified during the high-fidelity *in situ* simulation training and mitigation process.

training, following the implementation of an action plan.

The scenarios in our high-fidelity simulations were based on real-life events. The advantage of using real-life events over standardised scenarios is that we can identify the existing LSTs in the system that could affect patient safety.[14] We developed a robust process of mitigating the LSTs identified by implementing system-wide changes with the help of regular training for the medical and the nursing staff and a multidisciplinary approach.

We were able to identify an average of 3.0 LSTs per training session. LSTs per session reported in the literature vary between 0.8 and 1.8,[11-13] and those most commonly reported relate to equipment and resources.[11]

The target of interventional translation simulation is to increase patient safety and improve the performance of the health service.[15,16] We were able to translate some of our simulation-based learning to real-life events by assessing whether the LSTs identified were mitigated in clinical settings.[3] However, some events are rare and it is important to note that the behaviour of participants in a simulation-based environment may not be reproducible in real life. The translation of the mitigated LSTs to real-life events was assessed at short intervals after the implementation of the changes in the system. Hence, we were unable to demonstrate the sustainability of our approach.

Conclusion

High-fidelity *in situ* neonatal simulation training should be used to identify and mitigate latent threats in a system; this will enable staff to deliver high quality care leading to improved patient safety.[17,18]

Author contribution

CB conceptualise this study and was responsible for writing the first draft of the manuscript. GM and CB designed the latent threat proforma. All authors facilitated the training sessions and contributed to the writing of the final version of the manuscript.

References

1. **Gaba DM.** The future vision of simulation in health care. Qual Saf Health Care 2004;13:i2-i10.
2. **Cheng A, Lin Y.** The role of simulation in teaching pediatric resuscitation: current perspectives. Adv Med Educ Pract 2015;239.
3. **Brazil V.** Translational simulation: not 'where?' but 'why?' A functional view of in situ simulation. Adv Simul (Lond) 2017;2:20.
4. **Sarfati L, Ranchon F, Vantard N, et al.** Human-simulation-based learning to prevent medication error: a systematic review. J Eval Clin Pract 2019;25:11-20.
5. **Alfredsdottir H, Bjornsdottir K.** Nursing and patient safety in the operating room. J Adv Nurs 2007; 61:29-37.
6. **Dadiz R, Riccio J, Brown K, et al.** Qualitative analysis of latent safety threats uncovered by in situ simulation-based operations testing before moving into a single-family-room neonatal intensive care unit. J Perinatol 2020;40:29-35.
7. **Sollid SJM, Dieckman P, Aase K, et al.** Five topics health care simulation can address to improve patient safety: results from a consensus process. J Patient Saf 2019;15:111-120.
8. **Lawton R, McEachan R, Giles S, et al.** Development of an evidence-based framework of factors contributing to patient safety incidents in hospital settings: a systematic review. BMJ Qual Saf 2012;21:369-80.

9. **Royal College of Nursing.** Patient safety and human factors. 2021 online at: www.rcn.org.uk/clinical-topics/patient-safety-and-human-factors/publications
10. **National Patient Safety Agency.** A risk matrix for risk managers. NHS NPSA: 2008.
11. **Couto TB, Barreto JKS, Marcon FC, et al.** Detecting latent safety threats in an interprofessional training that combines in situ simulation with task training in an emergency department. Adv Simul (Lond) 2018;3:23.
12. **Knight P, MacGloin H, Lane M, et al.** Mitigating latent threats identified through an embedded in situ simulation program and their comparison to patient safety incidents: a retrospective review. Front Pediatr 2018;5.
13. **Wetzel E, Lang T, Pendergrass T, et al.** Identification of latent safety threats using high-fidelity simulation-based training with multidisciplinary neonatology teams. Jt Comm J Qual Patient Saf 2013;39:268-73.
14. **Patterson M, Geis G, Falcone R, et al.** In situ simulation: detection of safety threats and teamwork training in a high risk emergency department. BMJ Qual Saf 2012;22:468-77.
15. **Fransen A, van de Ven J, Banga F, et al.** Multi-professional simulation-based team training in obstetric emergencies for improving patient outcomes and trainees' performance. Cochrane Database Syst Rev 2020;12:CD011545.
16. **Colman N, Stone K, Arnold J, et al.** Prevent safety threats in new construction through integration of simulation and FMEA. Pediatr Qual Saf 2019;4:e189.
17. **Lame G, Dixon-Woods M.** Using clinical simulation to study how to improve quality and safety in healthcare. BMJ Simul Technol Enhanc Learn 2020;6:87-94.
18. **Fawke J, Cusack J.** Neonatal simulation – training a workforce for the future. Infant 2011;7:9-12.