Imitating incidents: how simulation can improve safety investigation and learning from adverse events

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Summary Statement

One of the most fundamental principles of patient safety is to investigate and learn from the past in order to improve the future. However, healthcare organisations can find it challenging to develop the robust organizational processes and work practices that are needed to rigorously investigate and learn from safety incidents. Key challenges include difficulties developing specialist knowledge and expertise, understanding complex incidents, coordinating collaborative action and positively changing practice. These are the types of challenges that simulation is commonly used to address. As such, this paper proposes that there are considerable opportunities to integrate simulation more deeply and systematically into routine efforts to investigate and learn from safety incidents. This paper explores how this might be done by defining five key areas where simulation could be productively integrated throughout the investigation and learning process, drawing on examples of current practice and analogous applications in healthcare and other industries.

Imitating incidents: how simulation can improve safety investigation and learning from incidents

When things go wrong in healthcare, and when patients are harmed, it is essential that incidents are rigorously investigated so that systems and practices can be improved and similar events avoided in future. The need to learn from incidents has long been an organizing principle of patient safety improvement,[1,2] but healthcare organisations can find it challenging to develop the robust work practices and organizational processes that are required to investigate and learn from serious events.[3,4,5,6,7] This can be a serious problem. Poor quality or haphazard approaches to investigating and learning from incidents can have considerable and far-ranging consequences. They can allow safety problems to persist, exposing future patients to harm.[8,9] They can prevent harmed patients and families from being provided the truthful information they deserve.[10,11,12] They can leave healthcare staff working in suboptimal, frustrating and poorly designed healthcare systems.[13,14] And they can result in the misidentification of causal factors, leading to organisational resources being wasted on irrelevant or inappropriate issues.[15,16]

Accordingly, a range of recent initiatives in healthcare systems around the world aim to improve the quality, scope and impact of safety investigation in healthcare. This

includes a renewed focus on investigation methods that translate findings into practical improvements[17] and the establishment of national patient safety investigation bodies that are modelled on well-established approaches in other safety-critical industries.[9,18,19] Simulation has long played a major role in efforts to improve patient safety,[20,21] and many of the challenges commonly associated with investigating and learning from safety incidents are those that simulation is typically used to address,[22] such as developing practical expertise, exploring complex scenarios, improving organizational processes and strengthening social relations. This paper proposes that a closer and more systematic integration of simulation into routine activities of safety investigation would provide healthcare systems with a variety of opportunities to improve practices of investigation and enhance what organizations learn from incidents. The paper aims to develop a broad framework for understanding how simulation and investigation might be more systematically integrated across the entire process of investigating and learning from incidents, and to begin to map out a future vision for the rigorous application of simulation techniques to incident investigation. To do this, the key challenges in current approaches to investigating patient safety incidents are first described. Then, the paper defines five key strategies for using simulation that address each of these challenges and improve the practices of investigating and learning from incidents,

drawing on current practice and future potential strategies. The paper concludes by reflecting on how this work may be taken forward.

Investigative challenges

The core purpose of safety investigation is to systematically understand the past in order to improve the future.[23] Rigorous and routine safety investigation has been a fundamental feature of other safety-critical industries for many years but remains a relatively young discipline in healthcare—and may at times not even be recognised as a formal discipline that depends on specialised skills, knowledge, methods and tools. In aviation, for example, the history of formally investigating serious safety incidents reaches back over a century and is underpinned by well-established professional communities, institutional arrangements and sophisticated tools and methods.[24,25,26] Despite considerable effort over the past two decades, many healthcare systems have yet to develop equivalent institutional arrangements and professional communities that ensure safety incidents are routinely and robustly investigated and result in rapid, widespread and sustainable improvements.[27,28] The main challenges faced by healthcare systems in investigating and learning from patient safety incidents are fivefold, and each is at least partially addressable through simulation (Table 1).

First, safety investigation is a challenging and specialist task that depends on the work of expert safety investigators with highly specialised *knowledge and skills*. These specialist skills of investigation are not typically widespread in healthcare.[4,12] Second, investigating and responding to a serious patient safety event typically involves a range of organizations and professional groups working together. This requires robust *organizational processes* including effective resourcing, coordination and communication that are separated from any parallel activities concerning legal liability and blame. It is not uncommon for these processes to become confused in ways that undermine effective investigation and learning.[3,13] Third, systematically *analysing and addressing* the causes of patient safety issues can be deeply problematic. Serious safety incidents are complex and usually result from myriad interactions between human, technical, organizational and regulatory factors.[29] Solutions can be equally complex and moving from analysis to action remains a persistent challenge.[13,17] Fourth, it can be challenging to ensure that *lessons are embedded* in practice and that the findings and recommendations from investigations lead to material changes in practical work. Learning can only be said to have occurred when knowledge, activities and technologies on the frontline of healthcare are updated and improved.[30,31] Fifth, one of the most difficult aspects of learning from serious events is making sure that the lessons from investigations have

a *system-wide impact*, leading to improvements in safety across multiple organizations. At core, investigation and learning are only successful if similar serious events are avoided across a healthcare system, preventing other patients being harmed in the same way.[23,27]

Integrating simulation and safety investigation: five strategies

This paper proposes that deeply integrating simulation into the processes of investigating and learning from serious safety incidents provides opportunities to enhance the practices of safety investigation, develop more robust systems of analysis and improvement, and more reliably spread and embed lessons across healthcare systems. Each of the key challenges facing investigation and learning, described above, can be addressed through the careful and systematic use of five interconnected simulation strategies (Table 1), and each of these strategies are explored in turn below. Here, simulation is defined broadly as any technique that can replace or amplify real-world experiences for the purposes of reflective learning.[32] This spans role-play, table-top exercises, online or virtual reality simulations, task trainers and fully immersive simulations using standardised patients and other actors. These simulation strategies can support learning at multiple levels of a healthcare system,

from adaptation in individual skills and knowledge, to improvement in teamwork and collaboration, to reform and redesign of organisational systems and processes.[31]

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Immersive investigator training

Investigating serious patient safety incidents requires safety investigators to reliably apply expert knowledge and specialised skills to complex scenarios in which people are distressed and information is often ambiguous and contested. The work of investigators is highly varied, including interpreting clinical and organizational data; analysing system design and human factors; sensitively interviewing harmed patients, bereaved relatives and healthcare workers; and developing robust improvement recommendations. This requires a mix of deep technical expertise and practical skill. Immersive simulation-based training has long been used in other safety-critical settings such as aviation, where investigators are able to undertake multi-week simulated investigations as part of their training, from examining wreckage sites to handling media interviews.[33] Simulation-based training represents a key strategy for developing the practical skills and knowledge of safety

investigators,[34] and sensitising investigators to the biases that can adversely influence investigations.[35]

Some forms of table-top and online simulations are used in current investigation training or safety improvement activities.[36,37,38] However, there are significant opportunities to more systematically implement immersive investigator training, targeted at developing key competencies such as interviewing, evidence identification, systems analysis and recommendation development. In more intensive future forms, investigator training could take the form of simulating end-to-end investigations spanning multiple days or weeks, enacting the entire trajectory of a major investigation as a core component of investigator training. Simulations could recreate the conditions, challenges and interactions necessary in real-world investigation, beginning with the immediate aftermath of an incident, using actors to allow investigators to interview patients, families and staff, and simulating an examination of the incident setting, equipment, data and records. Simulation training could then move to the work of analysing and interpreting data, including liaising with stakeholders such as executives, regulators, coroners and media—played by actors—completed by developing a final report and recommendations. Any of these specific activities can be extracted as shorter task-oriented simulation scenarios, but longitudinal, end-to-end simulations would allow investigators to learn how to both

apply and integrate the various technical and social skills, investigative techniques and analysis methods required of them in high-fidelity simulations where there is no risk of causing further emotional distress to patients, families or staff. This approach would be analogous to the longitudinal immersive simulation training that is increasingly being used to support effective transition of interns.[39]

Improving investigative infrastructure

Patient safety incidents often result from a complex set of factors that span many different parts of a variety of organizations across a healthcare system. These include things like communication problems between ambulatory and secondary care, oversights by accreditors or regulators, and poor design decisions by equipment manufacturers. Investigating complex safety issues therefore requires a well-developed investigative infrastructure of robust systems, protocols and processes that allow investigations to effectively bring together and coordinate different participants such as patients, managers, clinicians, subject matter experts and executives; support efficient communication with all parties involved—especially patients and families; and span different units, departments or organizations where necessary. This investigative infrastructure can be challenging to develop in many healthcare

systems, particularly where it has emerged from prior administrative arrangements focused on the management of complaints or medico-legal risks, where processes are typically oriented to the resolution of individual cases rather than the examination of broader system safety issues.

In future, the infrastructure that supports effective investigation—such as communication channels, coordination mechanisms, information systems, management structures, and related policies and protocols—could be routinely tested and improved through different forms of simulation.[22] Similar activities are already used to explore and improve organisational processes related to patient safety. For example, table-top group simulations of patient safety systems can be undertaken with groups of healthcare executives to explore and reflect on safety strategies and accountability structures in healthcare organisations,[40] or to simulate and explore the relationship of local organisational activities with regional or national policy requirements.[41] Likewise, crisis management scenarios are commonly used to test organisational policies, develop leadership capacity and strengthen communication channels for dealing with organisation-wide crises.[42,43] These existing approaches could be extended and applied more directly to the organisational systems and processes that are required to manage major incident investigations by, for example, conducting annual in situ simulations of a major safety investigation to test and

improve the processes and protocols for investigating serious safety incidents. Ideally these would be conducted in collaboration with other organizations in a local health system and would include all key organizational participants—including executives and senior clinicians—to test organizational processes and strengthen communication channels across organizational boundaries—all while removed from the stresses of an actual adverse event. However implemented, simulations could target key competencies and organisational processes that include: initial response to an incident; liaising with and supporting patients, families and staff; coordinating with other healthcare organizations along the patient pathway; and communicating with other actors such as regulators, coroners and the media.

Exploring causal factors and solutions

A fundamental purpose of investigating incidents is to understand the practical problems that contribute to safety issues in healthcare, and to determine the changes that can address those problems and make care safer. This process can be challenging because incidents emerge from complex interactions between a wide variety of human, technical and organizational factors that combine in unexpected ways in real-world practice. Investigations need to grapple with the complexity of real-world

practice to understand the causes of incidents and to recommend appropriate solutions. Simulation offers valuable ways of both retrospectively exploring the underlying causes of incidents, as well as prospectively developing and testing solutions. Formal methods of safety analysis that are used in different healthcare settings can sometimes incorporate simulation techniques to recreate elements of an event or context to better understand the causal factors involved, including retrospective Root Cause Analysis,[4] prospective Failure Mode and Effect Analysis[22] and other systems-oriented incident analysis methods.[44] Equally, simulation is used to design, evaluate and test new healthcare products and services,[45] such as drug packaging[46] or new hospital facilities.[47] Likewise, different forms of simulation—such as virtual reconstructions or simulation centre re-enactments—are widely and routinely used in safety-critical sectors such as aviation to recreate serious incidents to understand how and why events unfolded.[48,49]

These current applications of simulation indicate that there are considerable opportunities to make more widespread use of simulation when investigating patient safety incidents and developing subsequent improvements in healthcare. One way would be to routinize the use of in situ simulation to recreate incidents as part of all major safety investigations. This might involve bringing a multi-professional team together in the original setting to re-enact a serious incident, allowing different

explanatory theories to be tested against real-world practice and providing opportunities to uncover hidden human factors and systems issues. One well-publicised example of this is the in situ simulation used to investigate the inadvertent injection of Chlorhexidine during a lower limb angiogram that led to a patient's leg being amputated, revealing a range of common human factors issues and potential solutions.[50] Likewise, investigation processes that deeply integrate simulation techniques into the development of safety improvements and recommendations following serious incidents could help underpin more practical, robust and reliable changes to organisational process and practice.[51]

Embedding lessons in practice

One of the key objectives of incident investigation is to improve safety by bringing about changes in knowledge, skills, practice and process at the frontline of healthcare delivery. This requires regularly developing safety recommendations and other insights from investigations and translating them into practice. Simulation offers a direct route for this. It is common practice for clinical simulation and team training scenarios to be derived from past experiences and to draw inspiration from prior events, both as a basis for improving clinical and teamwork skills[20,52] and as a route

to making broader modifications and improvements to local work systems, cognitive aids and care processes.[53] There have also been innovative attempts to more systematically link healthcare simulation training programmes to the findings and recommendations from recent local events and incident investigations.[54,55] This ongoing translation of the findings of past events into improved future practices is widely instituted and supported in other safety-critical industries, where safety investigation activities are closely linked to routine and regular simulation training programmes.[56] In airlines, for example, information on recent incidents is regularly shared with simulation training programmes to modify old scenarios or introduce new ones.[23]

Given the long experience in the healthcare simulation community of translating past events into future learning opportunities, there are clearly significant opportunities to use simulation to more systematically and routinely transform specific findings of incident investigations into practical improvements in care delivery. As with the other strategies defined here, fully realising these opportunities would require significant resourcing and leadership commitment to both deeply integrate simulation programmes into the routine delivery of healthcare, and to develop tight linkages between those simulation programmes and patient safety analysis and investigation teams. Examples of successfully integrating simulation education

programmes into the rapid design, development and implementation of new clinical and organisational practices demonstrates the importance of building strong relationships between simulation groups and other key patient safety and clinical units across a healthcare system.[51] More closely integrating safety investigation teams with simulation programmes raise important practical questions. For instance, patient safety investigation methods may need updating, to include a defined process to identify issues suitable for rapid improvement through simulation-based training. Equally, the outputs of investigations may need to be improved, to provide the level of practical and contextual detail required to develop high-fidelity simulation scenarios.[57] And simulation teams would need to become responsive and flexible to quickly adapt scenarios and develop updates. All of this would require significant organizational resourcing.

Vicariously probing systems

A persistent challenge in patient safety concerns how to spread lessons from incidents to other organizations and across entire healthcare systems.[27] These processes of vicarious learning—where organizations proactively learn from events that occur elsewhere[58]—can be challenging because the context in which an incident

originally occurred may differ in important ways from contexts in other settings. The relevance and importance of lessons learnt in one organization may therefore not be readily apparent in other settings. Likewise, safety improvements will typically need to be modified and adapted to work elsewhere. As such, vicarious learning depends on organizations actively using incidents that occur elsewhere as a trigger to test and analyse their own systems and adapt safety recommendations to their local context. Simulation provides a range of techniques to test and reflect on current work practices and organisational processes, and is often used in healthcare to identify hidden or latent safety risks in current clinical systems,[59,60,61] or prepare for major crises such as outbreaks of highly communicable diseases.[51] 'Systems-probing' has long been advocated as a key function of healthcare simulation,[22,62] and other sectors actively use systems-probing simulations to manage and regulate risk. For example, the safety and soundness of financial institutions is regularly explored with simulated virtual 'stress tests' that test the impact of extreme economic events.[63]

Systems-probing simulations therefore represent a key mechanism to support vicarious learning from serious safety incidents across healthcare systems. Routinely attempting to recreate incidents that have occurred in other healthcare organisations—such as a wrong-route high-risk medication incident in cancer units—allows the safety of local systems to be examined. This is often done informally,

through storytelling or ‘trigger videos’ of serious incidents that prompt reflection on and inquiry into local systems and practices.[22] Anecdotally, high-profile and emotionally engaging films that retell the story of serious incidents[51,57] appear to have triggered widespread reflection and change.[64] More resource intensive in situ simulations of major events can provide a richer view of actual, rather than imagined, work processes, and have been used to drive change in local systems and practices such as relating to obstetric emergencies.[53] There are also opportunities for regulators, accreditors and other system supervisors to more formally incorporate systems-probing safety 'stress tests' in their assessment regimes. For example, processes of hospital inspection or accreditation could routinely include a simulated test based on serious incidents experienced elsewhere, such as a table-top simulation of a major equipment or power failure, or the multi-organization coordination that is required in rapidly diagnosing and treating a child seriously ill with sepsis.[65] If resourced appropriately and integrated into routine practice, vicarious systems-probing simulations offer one route to turning passive incident investigation reports into active processes of vicarious learning that could help ensure lessons travel widely around a healthcare system.

Conclusion: Simulating investigation and investigating simulation

This paper proposes that deeper and more systematic integration between the field of simulation and activities of safety investigation offers a broad range of opportunities for enhancing how healthcare systems routinely understand and learn from safety incidents. Five key strategies are proposed to help healthcare systems maximise what is learnt from past incidents, and address some of the core challenges that healthcare organisations commonly face in incident investigation (Table 1). These strategies span the entire process of investigating and learning from incidents: improving investigator training, strengthening organizational systems, supporting analysis methods, embedding lessons in practice and widely sharing improvements. To date, healthcare simulation techniques have been applied in each of these areas in some form, and in some areas are well-advanced. By defining a framework of five key strategies, this paper aims to provide a broader view of how simulation can be applied in an integrated way to investigating and learning from patient safety incidents, as well as to begin outlining a future vision of potential practice in each of these areas as a spur for future research.

Developing this work further will require considerable effort, both in research and in practice. The vision of deeply integrating simulation into the fabric of healthcare delivery is a long-standing aspiration for many in the simulation community,[22,32,51] and the framework described here represents an elaboration of a small part of that. As such, further integrating simulation into the routine activities of incident investigation faces similar challenges. One of the main challenges concerns organizational resourcing and capacity. Bringing more sophisticated forms of simulation into routine investigative activities—such as in situ recreations of incidents or longitudinal immersive education programmes for investigators—would likely require significant investment, along with specialist expertise and technical support that is not yet widely available. Likewise, simulation programmes and organisational structures would likely need considerable redesign to support the routine engagement of many different organizational participants in incident simulations, from senior executives to frontline staff, and would need to be appropriately resourced to respond rapidly and flexibly to the regular release of investigation findings and recommendations. These all represent major organizational challenges that would need ambitious and committed support from healthcare leaders. The framework described here also points to a wide range of important avenues for future research, which would require a broad programme of work. In the broadest of terms, these questions concern the optimal design, purpose

and modality of simulation techniques that can support processes of investigating and learning from past incidents at different levels of a healthcare system. Given the long time periods that can unfold between implementing new simulation techniques and resulting changes in organisational systems and processes, any programme of research would need to develop careful evaluation strategies to examine both the long-term impacts on safety performance and organisational design, as well as shorter-term changes in practices and knowledge. Engaging with these issues in research and practice, and more closely integrating simulation with investigation, points to a variety of ways that healthcare can build a more robust, integrated and system-wide approach to investigation and learning. It also offers rich opportunities to further explore and expand the boundaries of healthcare simulation as a fundamental safety improvement strategy.

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