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Patient Transport in the Time of COVID-19: Using Health Care Failure Mode and Effect Analysis with Simulation to Test and Modify a Protocol

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ORIGINAL RESEARCH

Patient Transport in the Time of COVID-19: Using Health Care Failure Mode and Effect Analysis with Simulation to Test and Modify a Protocol

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Introduction: In March 2020, in response to the COVID-19 pandemic, an interprofessional, interdisciplinary team at Maine Medical Center used Healthcare Failure Mode and Effect Analysis (HFMEA) and in situ simulation to rapidly identify and mitigate latent safety threats (LST) in patient transport protocols.

Methods: Following HFMEA steps, stakeholders representing a variety of disciplines assembled to address transport of patients with COVID-19. A process map was created to describe the process. With hazard analysis using table-top simulation followed by in situ simulation, we identified, categorized, and scored LSTs. Mitigation strategies were identified during structured debriefing.

Results: Fourteen LSTs were identified in the categories of infection prevention (4), care coordination (2), equipment (2), facilities (2), teams (2), clinical skills (1), and diagnosis and treatment (1). Of these, 10 had "critical" hazard scores. Mitigation solutions were tested with in situ simulation. Results were shared with leadership and led to changes in hospital-wide protocols.

Discussion: The COVID-19 pandemic presented an urgent need to create or adapt protocols to keep patients and staff safe. Our team combined simulation with HFMEA methodology to improve the safety of protocols for transporting patients with COVID-19. Simulation enabled recreation of real-world experience that exposed LSTs more thoroughly than mental walkthroughs alone. Use of HFMEA methodology supported quantifying identified LSTs and proposing mitigation strategies, while in situ simulation facilitated testing many proposed strategies.

Conclusions: HFMEA used with in situ simulation provides an effective method to efficiently and thoroughly probe a process for failure modes, providing practical mitigation strategies.

Keywords: simulation, COVID-19, patient transport, latent safety threats, healthcare failure mode and effect analysis

Healthcare simulation increasingly plays a role in patient safety through systems integration. When used for this purpose, the objective is to improve processes by enhancing safety and efficiency. In this capacity, simulation is a highly effective tool for identifying "latent" safety threats (LST) (those that have not yet caused harm) and testing solutions for remediation.[1]

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Healthcare Failure Mode and Effect Analysis (HFMEA) is a tool developed by the National Center for Patient Safety at the Department of Veterans Affairs that provides a proactive system to identify LSTs. This system counterbalances root cause analysis, a tool that analyzes harmful events *after* they occur.[2] HFMEA helps to identify "failure modes"

(FMs; the ways in which a process can fail), quantify the severity of those FMs, prioritize resources to address FMs by calculating a hazard score, and task stakeholder-participants with identifying mitigation solutions. Traditionally, HFMEA is a theoretical exercise in which stakeholders discuss each step of a process and brainstorm potential ways the process can fail.

Simulation enhances HFMEA by enabling realistic enactment of each step of a process, providing deeper insight than theoretical consideration alone.[3] In situ simulation (bringing simulation to the clinical care environment) goes further, allowing stakeholders to explore and share perspectives that may only be apparent in the environmental context in which they normally provide care. LSTs and effective mitigation strategies are often context-specific, and in situ simulation is ideally suited to reveal these context-specific LSTs and strategies.

The COVID-19 pandemic presented an urgent need to rapidly adapt healthcare systems with new processes and standards in response to novel stresses. The healthcare simulation community quickly embraced the challenge by sharing resources to help colleagues adapt and disseminate protocols for endotracheal intubation, code team responses, telemedicine skills, and appropriate use of personal protective equipment (PPE).[4,5,6] Maine Medical Center engaged the simulation team for this purpose.[7,8,9]

In March 2020, our hospital admitted a surgical patient with respiratory symptoms who was later diagnosed with COVID-19. A team of stakeholders, including simulation staff, assembled the night before the procedure to prepare and rehearse the plan. The patient underwent the operation uneventfully, after which the team reassembled to debrief. They identified safety concerns related to the process of transporting patients with COVID-19, as this process could lead to widespread environmental and personnel contamination.

Multiple contextual factors influenced thoughts around best practices for transporting patients with COVID-19. In March 2020, information and best practices were rapidly evolving. Notably, ongoing debate about the risk of contact versus airborne transmission existed.[10,11,12] PPE supply was tenuous due to a surge in worldwide demand and breakdown of the supply chain due to workforce outbreaks.[13] Staff anxiety was generally high as reports of widespread infection of healthcare workers circulated.[14,15]

The objective of our study was to test and propose improvements to operating room (OR) transport protocols for patients with or suspected to have COVID-19 to minimize risks of infection.

METHODS

The team assembled for one afternoon on April 7, 2020 to complete the bulk of an in situ simulation exercise guided by HFMEA. This exercise was co-facilitated by a physician (JK) representing anesthesia and a nurse lead (MC) representing simulation. Both facilitators are experienced simulation educators, and MC is also experienced in simulation-enhanced HFMEA processes. Planning and follow-up occurred in a 1- to 2-day period before and after the activity. Reporting to hospital leadership occurred the following week.

The HFMEA proceeded according to the steps outlined below and in Figure 1.

1. Define the topic and process

Transport of a non-intubated patient with or suspected to have COVID-19 to and from the OR was the process of focus.

2. Assemble the team

Leaders from anesthesia, simulation, and OR services identified additional stakeholders needed to fully explore the process. Table 1 summarizes the disciplines and departments that were invited to participate in the exercise.

3. Graphically describe the process

The team began by creating a process map (Figure 2) to describe the transport process from beginning to end.

4. Conduct a hazard analysis

Using this process map, we began our hazard analysis with a table-top simulation. In this step, we theoretically explored each step of the process, with involved stakeholders sharing their perspective. This interprofessional team collaboratively identified potential FMs and, where possible, explored the degree of severity (potential of harm to patient or staff) and probability (likelihood of occurring), as well as mitigation strategies (Figure 3).

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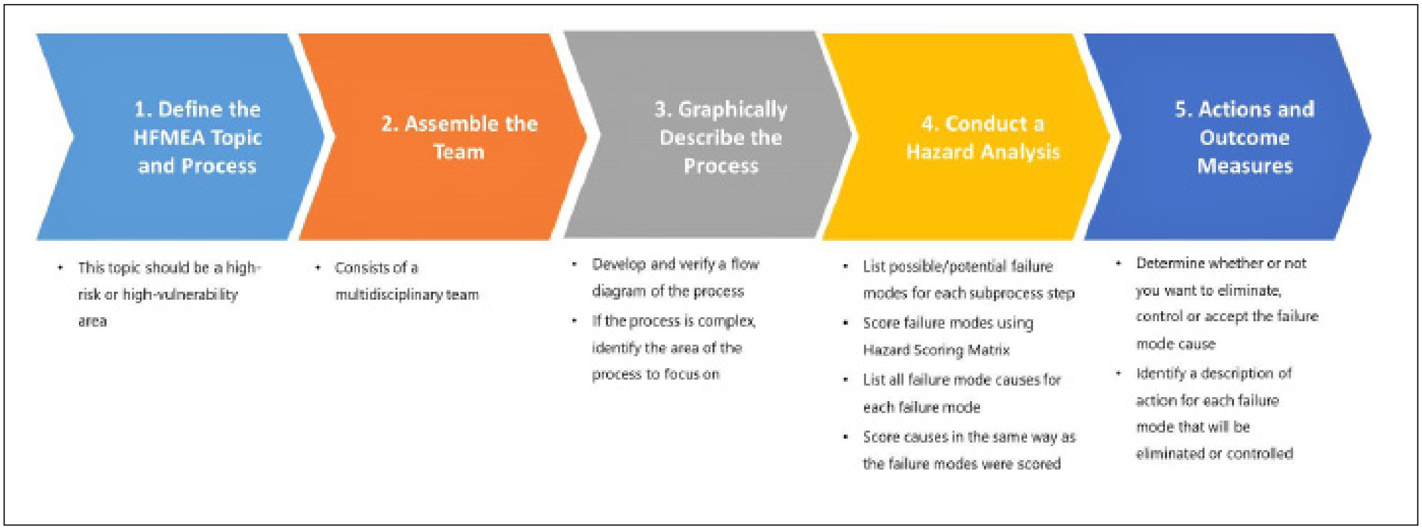

Figure 1. Overview of Steps in a Healthcare Failure Modes and Effects Analysis[19]

*Figure adopted from Reference 19-Nielsen DS, Dieckmann P, Mohr M, Mitchell AU, Ostergaard D. Augmenting health care failure modes and effects analysis with simulation. Simul Healthc, 2014;9(1):48-55

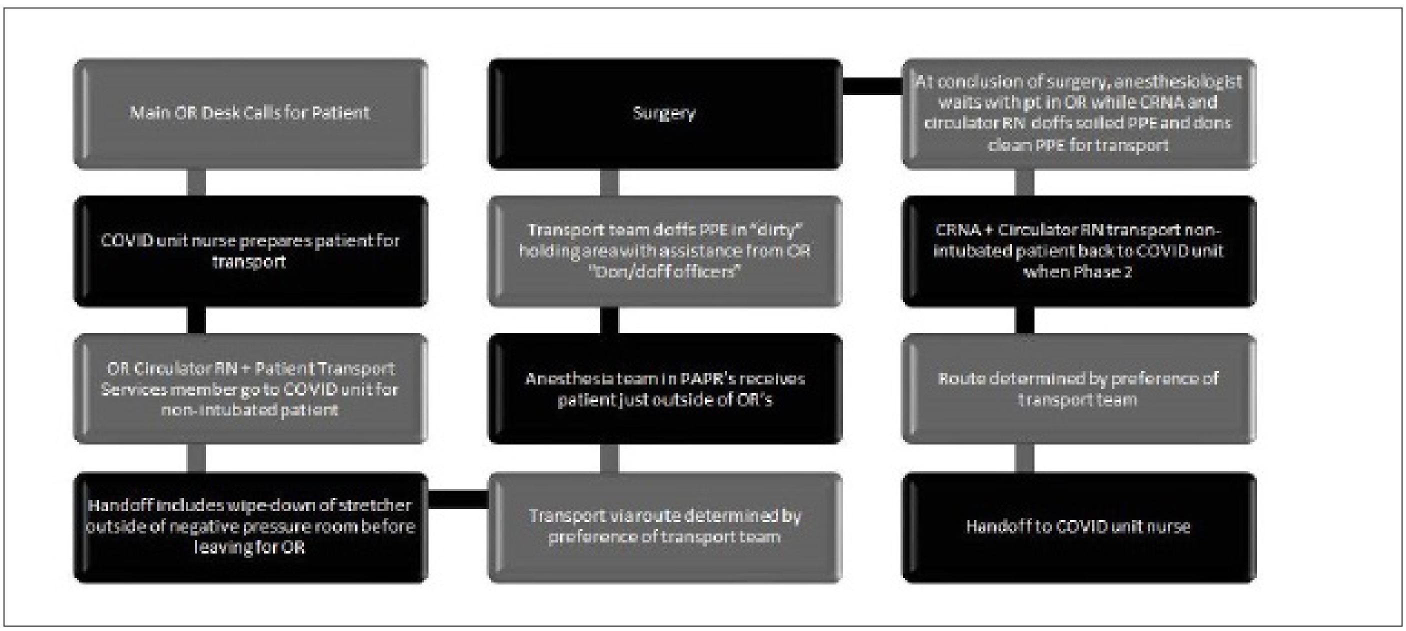

Figure 2. HFMEA Process Map for OR Transport of COVID-19 Positive Patient

The process map provided the shared mental model of patient transport the stakeholders used to guide their discussion and probe for failure modes. During its development, the assembled stakeholders walked through each step of the transport process in granular detail, with every stakeholder involved in a step providing their perspective of how that step works in practice.

DEFINITIONS – PROBABILITY (P)

Frequent (4)	Occasional (3)	Uncommon (2)	Remote (1)
Likely to occur *immediately or within a short period*	*Probably will occur* *may happen several times in 1 to 2 years*	*Possible to occur* *may happen sometime in 2 to 5 years*	*Unlikely to occur* *may happen sometime in 5 to 30 years*

DEFINITIONS – SEVERITY (S)

	Impact on patient	Impact on clinical staff
Catastrophic (4) *Failure would cause death or injury*	*Injury resulting in escalation in level of care, surgical procedure, permanent disability, or death*	*Injury resulting in permanent loss of function, requiring hospitalization, permanent or prolonged loss of ability to perform current duties*
Major (3) *Failure causes high degree of dissatisfaction*	*Non-life threatening delay in care or injury requiring medical attention without escalation in level of care, surgical procedure, permanent disability, or death*	*Injury requiring medical attention, resulting in temporary loss of function or missed work time*
Moderate (2) *Failure overcome with process improvement, minor performance loss exists*	*Significant negative impact on patient/family experience; varies from stated goals for patient/family experience*	*Reliability a source of work-related stress and anxiety for staff, introduces inefficiency that impacts frequently performed tasks, otherwise seen as negatively affecting wellness*
Minor (1) *Failure not noticeable to patient and would not affect delivery of the service*	*No significant negative impact on patient/ family experience*	*Minor nuisance that is not a significant source of stress or anxiety for the majority of staff who encounter the problem*

HAZARD SCORES (S x P)

	Severity *(S)*				
		Catastrophic (4)	*Major (3)*	*Moderate (2)*	*Minor (1)*
Probability *(P)*	*Frequent (4)*	*16*	*12*	*8*	*4*
	Occasional (3)	*12*	*9*	*6*	*3*
	Uncommon (2)	*8*	*6*	*4*	*2*
	Remote (1)	*4*	*3*	*2*	*1*

Figure 3. Key for HFMEA Assignment of Severity, Probability, and Hazard Scores. HFMEA aims to identify failure modes and help prioritize resources to address those failure modes by calculating a hazard score. Hazard scores are calculated by multiplying the probability (P) of an event happening with its expected severity (S), both of which are scored on a 4-point scale. The criteria for assigning these scores are detailed in the figure. In an HFMEA, any failure mode with a hazard score greater than 8 should receive immediate attention and mitigation.

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Table 1. Stakeholders Who Assembled for Healthcare Failure Mode and Effects Analysis

Stakeholder
Anesthesiology (physician and CRNA*)
OR circulating RN
COVID-19 floor unit RN
Respiratory therapy
OR patient transport services
Central patient transport services
Volunteer services (oversees transport services)
Special infectious disease team
Operative and perioperative quality and safety
Simulation center leadership

Abbreviations: CRNA, certified registered nurse anesthetist; OR, operating room; RN, registered nurse

The next phases of hazard analysis used simulation to accomplish 2 objectives, identified based on results from the table-top simulation. The first aimed to establish the optimal path of travel while minimizing the time spent outside of a negative-pressure room and the potential for environmental or personnel contamination. The second aimed to test the transport protocol under stress.

Optimizing the path of travel.

Table-top simulation revealed that several possible routes may be used to transport patients from a COVID-19 unit to the OR. Route selection was determined based on the preferences of the transport team. Recognizing that each route presents variable risk according to hallway traffic, elevator size, and time spent in transit, the goal of this exercise was to evaluate each route and determine whether one presented less overall risk than another. Four members of the team (3 in their usual roles [anesthesia provider, OR transport, patient transport] and a simulation team member collecting data) pushed an empty stretcher and intravenous pole from the COVID-19 unit to the OR along each potential path of travel. During each run, the data collector documented possible bystander exposure by measuring the number of open doors passed (both patient rooms and offices), and the number of nurse's stations and individuals encountered. Another team member tracked the transport time from the negative-pressure room to the threshold of the OR area.

Protocol testing with stresses.

The second phase simulated transport per institutional protocol to and from the OR, and included a mildly agitated patient (played by JK) to simulate a high-probability, high-severity FM identified during the table-top exercise. This phase involved 2 scenarios.

The first scenario began in the patient room with a nurse educator from the COVID-19 unit who assumed the role of the bedside nurse in hospital-recommended PPE (N95 respirator, face shield, gown, gloves, and shoe covers). The nurse educator prepared the patient for transport. An OR nurse and OR transport team member collected the patient using the equipment, protocols, and PPE recommended at the time (hospital scrubs, surgical mask, contact precaution gown, and gloves). To simulate a mildly uncooperative patient, JK portrayed a well-meaning person who occasionally removed his surgical mask while talking or coughing.

The second scenario portrayed transport back from the OR with the personnel who would transport an uncomplicated, non-intubated patient with COVID-19 (OR nurse, OR transport, and certified registered nurse anesthetist). For the return trip, JK simulated a state of mild agitation resulting from anesthesia emergence: non-adherent to instructions to not touch surfaces or remove their surgical mask and inadvertently knocked sheets/pillows out of the stretcher while changing position. Stakeholders shadowed the transport team to observe the process from start to finish and captured video for subsequent review.

Following the simulations, the team debriefed to generate a list of FMs and mitigation strategies, and to consider participant perception of personal safety from infection transmission. The team then assigned severity and probability ratings to calculate hazard scores.

By consensus, changes to the transport protocol were proposed and reviewed by all team members and forwarded to the OR and anesthesia senior leadership for review and approval.

RESULTS

In the HFMEA framework (Figure 1), our results include findings from the hazard analysis as well as mitigation strategies identified in the fifth step "Actions and Outcome Measures." In the process of our hazard analysis, we identified FMs from 3 phases of testing: (1) theoretically exploring the process (table-top simulation), (2) optimizing the path of travel, and (3) stressing the protocols in place to evaluate their resilience.

1. Table-top simulation

The 3 major FMs, all with critical hazard scores, identified from the table-top simulation included: (1) path of travel was at the discretion of healthcare staff and could result in unnecessary exposure, (2) even mildly agitated or uncooperative patients increase the risks of environmental and staff exposure to infection, and (3) standard recommendations for PPE may not be sufficient for staff while transporting patients.

2. Paths of travel

Table 2 displays results from path-of-travel testing. Several factors proved important to consider for safety. Path 3 offered a larger elevator space, which minimized close contact, but the route was more heavily trafficked, with 2 times the incidental contacts of either alternative route. The other routes resulted in roughly equivalent incidental exposures, but Path 1 had a significantly smaller elevator space. Considering all factors, incidental contacts, elevator size, and time, Path 2 was recommended for usual path of travel.

Table 2. *Results of Path-of-Travel Testing*

	Path 1	Path 2	Path 3
Total time in transport, min:sec	*3:33*	*2:45*	*3:58*
Incidental contacts during transport			
Hospital visitor	*1*	*0*	*0*
Open door – patient room	*0*	*0*	*5*
Staff member	*6*	*4*	*8*
Open door – office or workroom	*2*	*4*	*3*
Nursing station	*1*	*0*	*1*
Total incidental contacts	*8 + desk*	*8*	*16 + desk*
Notes	*Smallest elevator, obvious path to radiology suites*	*Transport person could request doors to close ahead of patient*	*Largest elevator*

3. Simulation-enhanced transport with mildly agitated patient

Table 3 shows FMs, hazard scores, and mitigation strategies identified with simulation-based transport testing.

In this exercise, 13 LSTs were noted, of which 10 had critical hazard scores. Four of these LSTs were in the category of infection prevention, including the item with highest hazard score (12). This item noted that transport staff at the head of the bed could not maintain a 6-foot distance in an elevator or if a patient required assistance. To mitigate this risk, the team proposed a multi-faceted approach. To minimize close-proximity exposure, the group recommended a path of travel that avoided the smallest elevator. To better contain exposure at the source, the group recommended that nurses in sending units remind the patient of the importance of keeping their mask on at all times. Finally, to bolster personal protection, the group recommended transport staff by the head of the bed use a higher level of PPE.

Incidental exposure due to unexpected patient behavior (eg, coughing in an elevator, touching a rail or wall, dropping a sheet or pillow) resulted in at least 4 LSTs, all with critical hazard scores. Mitigation solutions proposed to address these LSTs included bringing a supply of germicidal wipes along on transport and adding one transport staff that could stay behind to ensure decontamination without delaying transport. They also recommended a higher level of PPE for transport staff by the head of the patient to enable them to provide safe and immediate assistance to the patient when needed.

4. Actions and outcome measures

After presenting results to surgical services leadership, recommendations were forwarded to hospital senior leadership, including those involved with infection prevention. Based on the evolving international understanding of best practices and our findings, the hospital transport policy was revised (Appendix 1). Notable changes based on the simulation-enhanced HFMEA testing included: (1) changing PPE for the clinician expected to provide direct patient care, (2) changing PPE for the second and/or third transport providers given the challenge of 6-foot distancing in some elevators, (3) carefully considering a need for larger transport teams if the patient may require direct care, and (4) no longer involving patient transport services in transporting patients with COVID-19, unless the staff were serving as a “runner” ahead of the team to clear hallways or push elevator buttons.

DISCUSSION

Used together, HFMEA and in situ simulation were an effective means to prospectively detect LSTs in our protocol for transporting patients with COVID-19. With support from our surgical services and hospital leadership, our interprofessional team rapidly assembled key stakeholders who used table-top simulation guided by HFMEA and in-depth hazard analysis using in situ simulation to discover, explore, and mitigate these LSTs. Because these findings involved physical paths of travel with concerns about time, contact, and unsafe patient behaviors, simulation was an ideal tool to explore these LSTs. Using data derived from our simulations, we identified the optimal path of travel from among 3 routes that had previously been used, and illustrated the risks to the patient and staff when using the institutional best practices in place at the time. Our recommendations contributed to changes in the number and roles of personnel involved in transporting patients with COVID-19, as well as the PPE staff use. The broad applicability of our effort is supported by the fact that our findings were used to modify not only OR transport protocols, but also protocols used for the entire hospital.

Simulation is well-recognized as a useful safety tool to recreate real-world experience to explore and improve complex systems in healthcare.[16,17,18] In our study, the accurate simulation of transporting a patient exhibiting credible behavioral variability was an ideal modality to evaluate safety threats in our process. Watching the transport nurse hesitate to assist the patient due to concern for exposure to infection, as well as the nurse’s reported sense of vulnerability during debriefing, highlighted the need for enhanced PPE for at least one member of the transport team. HFMEA provides a useful framework to approach a process; identify, categorize, and quantify risk in the FMs; and propose solutions by engaging and involving all stakeholders in the process.[2] Together, HFMEA and simulation can generate a more thorough analysis than simulation alone.[3]

Table 3. Results of HFMEA and Simulation Testing

Step in the process map	HFMEA category	Potential failure mode	Failure effects	Severity (S)	Probability (P)	Hazard score (SxP)	Action plan
Route determined by preference of transport team	*Care coordination*	*Path of travel does not minimize exposure risk*	*Unnecessary exposure of bystander staff/ patients along path of travel*	*3*	*3*	*9*	*Identified optimal path of travel to ICU and patient floors*
	Facilities	*Transport staff unable to maintain a 6-foot distance**	*Increased risk to staff in elevators when assisting patient who removed their mask*	*3*	*3*	*9*	*Transport guideline changed to ensure proper PPE for transport staff; verbal engagement with patient before physical assistance with mask*
	Care coordination	*Bystander traffic unaware of a patient with COVID-19 traveling through pathway*	*Bystander traffic not prepared to institute safety measures to minimize risk of exposure*	*2*	*3*	*6*	*Transport staff will communicate that a patient with COVID-19 is traveling through pathway; staff along pathway close office doors*
Nurse from COVID-19 unit prepares patient for transport	*Clinical skill*	*Transport staff inconsistently communicates with patient about keeping their mask on during transport*	*Patient does not maintain mask over face and increases exposure to transport staff*	*3*	*3*	*9*	*Educate staff on importance of a pre-transport brief with patient to discuss keeping mask on and coughing under sheet to decrease potential contamination*

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Table 3 (cont). Results of HFMEA and Simulation Testing

Step in the process map	HFMEA category	Potential failure mode	Failure effects	Severity (S)	Probability (P)	Hazard score (SxP)	Action plan
CRNA + circulator RN transport non-intubated patient back to COVID-19 unit	*Care coordination*	*Insufficient number of transport staff to manage agitated patient**	*Agitated patient removes surgical mask and contaminates staff and environment*	*3*	*3*	*9*	*Guideline changed to increase the number of transport team members to 3*
	Diagnosis and treatment	*Transport staff unable to safely transport patient while maintaining a 6-foot distance*	*Increased risk to staff in elevators when assisting patient with surgical mask*	*3*	*3*	*9*	*Guideline changed to ensure proper PPE for transport staff; educate staff about verbal engagement with patient before physical assistance with mask*
	Facilities	*Extraneous hallway equipment along path of travel*	*Transport difficulty increased*	*3*	*2*	*6*	*Communicate with staff on units to remove extraneous equipment before patient transport*
	Equipment and devices	*Insufficient monitoring equipment during transport*	*Delayed recognition and treatment of patient decompensation*	*3*	*3*	*9*	*Transport patient with portable pulse oximeter at a minimum due to the potential of rapid decompensation*
	Equipment and devices	*Excessive transport equipment*	*Transport difficulty increased*	*3*	*2*	*6*	*Minimize necessary equipment (eg, remove maintenance IV); place equipment on stretcher (eg, IV pumps)*
	Infection prevention	*Transport staff at head of bed not able to maintain 6-foot distance due to small elevators**	*Increased risk to staff at head of bed*	*3*	*4*	*12*	*Educate staff at head of bed to wear N95 mask, eye protection, and gown*

Table 3 (cont). Results of HFMEA and Simulation Testing

Step in the process map	HFMEA category	Potential failure mode	Failure effects	Severity (S)	Probability (P)	Hazard score (SxP)	Action plan
CRNA + circulator RN transport non-intubated patient back to COVID-19 unit	*Infection prevention*	*Patient contaminates surfaces that may be touched by transport or bystander staff*	*Increased risk to transport and bystander staff*	*3*	*3*	*9*	*Assign transport staff to monitor and immediately decontaminate surfaces with portable germicidal wipes*
	Infection prevention	*Patient coughs in elevator*	*Dwell time of virus increases risk to elevator traffic after transport*	*3*	*3*	*9*	*Discussed identified risk with infection prevention and environmental services*
	Care coordination	*Agitated patient contaminates side rails, linen, pillow*	*Increased risk to transport staff post-transport*	*3*	*3*	*9*	*Enhance PPE recommendations for transport staff; bring portable germicidal wipes and assign transport staff to post-transport decontamination*
	Infection prevention	*Insufficient dry time after transport surfaces are decontaminated*	*Increased risk to transport and bystander staff*	*4*	*1*	*4*	*Educate transport team on sufficient dry time after surface decontamination*

Abbreviations: CRNA, certified registered nurse anesthetist; HFMEA, Healthcare Failure Mode and Effect Analysis; ICU, intensive care unit; IV, intravenous; PPE, personal protective equipment; RN, registered nurse.
*Failure modes identified only during in situ simulations.

In the year after SARS-CoV-2 arrived, multiple reports have described how simulation can help to rapidly evolve healthcare processes driven by a novel threat to society.[20,21,22] OR protocols are just one high-stakes area in which COVID-19 markedly changed usual practices. Lie et al described a similar but larger-scale endeavor to use in situ simulation to improve OR preparedness in their Singapore hospital. Their study, though broader in scope, identified the transport process as the first major LST detected.[23] Patient transport is a high-risk event, as it often results from a change in patient condition and invariably involves a hand-off between teams of providers. Just before COVID-19 was officially labeled a pandemic, a group from Singapore identified patient transport as a high-risk event for nosocomial spread. They wrote a letter to the journal *Critical Care* that proposed 5 areas of safety concern to help guide other hospital's policies for transporting patients with COVID-19.[24] They identified patient safety, safety of healthcare workers and transport staff, bystander safety, rescue and contingency plans during transport, and post-transport decontamination as areas of risk. Each of these areas was reflected in FMs identified in our study (Table 3). These recommendations were based on their own early experience, and they hoped that by sharing their *retrospective* experience, other hospitals could learn and avoid harm to patients or staff. Our approach, using HFMEA and in situ simulation, enabled *prospective* experience that enhanced safety at our institution.

Eight months into the COVID-19 pandemic, Van Zundert and colleagues called for the review of airway and patient management workflows using proven patient safety tools, such as HFMEA and simulation.[25] They cited the incomplete understanding of the risks of SARS-CoV-2 transmission and uncertainty around PPE and best clinical practices to reduce infection risk, as ongoing threats to the physical and emotional safety of healthcare workers. Levy and colleagues combined HFMEA with in situ simulation in an iterative fashion to safety test a field hospital before caring for patients.[26] A group in Latvia used simulation and HFMEA to decrease risk of SARS-CoV-2 transmission in their emergency department. In their study, 2 major areas of LSTs included PPE and the need to establish or revise protocols.[27] In our testing, our team found that PPE recommended for personnel transporting the patient was likely insufficient to protect staff in the event of even minimal changes in a patient's condition. By revising policies to include equipment that protects individuals at the head of the bed from airborne infection, at minimum, staff could respond to the patient's needs and still maintain personal protection. This change has become even more relevant with our evolving understanding of the predominantly airborne risk of infection.[10,11,12]

Our table-top exercise revealed that patient transport personnel were likely inadvertently put in positions of previously unanticipated risk of infection. In theory, patient transport personnel do not have direct patient care responsibility or patient contact, and thus they use standard precautions to prevent infection. By including transport personnel as stakeholders in our hazard analysis, we discovered that, in practice, personnel may not be able to avoid direct patient contact if the patient requires basic assistance. Also, personnel might be near a patient for previously unanticipated lengths of time (eg, waiting for a ride to arrive when discharged). Following our exercise, hospital leadership revised policies to ensure transport personnel were not involved in transporting patients with COVID-19, unless they were used as a front runner without being near the patient.

Limitations

This project was time-sensitive in addressing an immediate need to prevent infection during a global pandemic. As such, we could not conduct iterative rounds of simulation to test all identified mitigation strategies. Re-testing with relevant stakeholders ensures that the proposed mitigation strategies are practical and achievable. Although we found that post-transport decontamination or emergent decontamination after inadvertent exposure during transport was an important LST, we omitted an important stakeholder from our exercise: environmental services.This omission resulted in an incomplete analysis of the threats of infection and lingering action items, highlighting the importance of involving all stakeholders to completely understand, analyze, and diminish safety concerns.

This work was rooted in a local context, probing our center's protocol and using available resources. In situ simulation is resource intensive. To plan and execute this exercise required support from leadership at the highest levels, the time of multiple stakeholders across several disciplines, and a simulation center capable of in situ simulation with expertise in HFMEA. These resources may not always be readily available.

CONCLUSIONS

The COVID-19 pandemic required rapid changes to multiple healthcare protocols to minimize infectious risk to patients and staff. This need presented a unique opportunity to demonstrate the power of HFMEA combined with simulation to rapidly provide actionable, practical solutions to problems, both anticipated and unforeseen. Using these methods, we prospectively identified multiple FMs in existing OR transport protocols, quickly proposed solutions, and partnered with hospital leaders to optimize safety.

Conflict of interest: None

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