Using Simulation to Support Evidence-Based Design of Safer Health Care Environments

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Abstract

The design of health care environments and the technologies used within them have tremendous influence on the performance of the professionals who care for patients in those spaces. In turn, the performance of those professionals greatly impacts the safety of the care that is delivered to patients. Active and latent safety errors can be greatly reduced by rigorous testing of the patient care environment.

- Prior to the approval of final design specifications and actual construction.
- After construction is complete before the first patients move in.
- On an ongoing basis once patient care is in progress.

While there are numerous types of testing that can be conducted, this manuscript will focus on the use of simulated clinical scenarios in realistic/real physical environments to detect and remediate weaknesses in the design of those environments with a focus on their use in perinatal centers.

Keywords

- simulation
- debriefing
- perinatal
- mothers and babies
- evidence-based design
- patient safety

Key Points

- Environmental design influences human performance.
- Realistic clinical simulation can improve the design.
- Simulation should be done on a continuous basis.

Designing and building hospitals are time-consuming and expensive, with costs often exceeding 1 billion U.S. dollars. In addition to the financial costs, there are substantial investments in time and personnel: from the initial idea to opening the doors, the timeline may exceed a decade and involve hundreds of personnel from both within and outside the hospital. And once the walls are up, the expense associated with any modifications to an area may far exceed the initial building costs of that space. Yet another important impetus to "get it right the first time" is the potential negative effect on human and system performance that ultimately may produce harm to patients. Thus, the need to ensure that hospital design optimizes human and system performance and minimizes the risk of near misses and adverse events is paramount.

Historically, health care design has been based on retrospective, postoccupancy observations and surveys of clinical outcomes over time. This is reflected in the published literature on this topic. The Agency for Healthcare Research and Quality produced a monograph and a DVD in 2007 that describes improvements in patient and staff satisfaction, patient safety, quality of care, employee retention, and return on investment.[1] Ulrich et al published a comprehensive review of evidence-based health care design in 2008, citing multiple outcomes that are highly relevant to patient care.[2] Another review by O'Callaghan et al described evidence-

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based design of neonatal intensive care units, highlighting several important design elements that produce measurable improvements in neonatal outcomes.[3] All of these reviews noted the relationship between specific design elements (based on retrospective observational data over time) and clinical outcomes, such as the effect of single-patient rooms in reducing hospital-acquired infections. More recently, prospective methods such as the use of layout modeling (building full-scale mockups) to allow visualization of actual physical spaces, computer-aided design of 2- and 3-dimensional representations, and the use of artificial intelligence to generate mathematical models to estimate workflows and footpath patterns have been described for use in both new construction and renovation.[4–6] In addition to these methods, other tools have been used to describe the economic outcomes of design strategies.[7]

Simulation and Debriefing: A Proactive Strategy for Evidence-Based Design

This manuscript will focus on the use of multidisciplinary health care simulation to assess the design of physical environments, whether these environments are either relatively simple prototypes/mockups, full-scale models, or the actual clinical environments themselves. LeBlanc et al described the use of simulation to study performance shaping factors in health care, including those relevant to the ergonomics and physicality of the work environment.[8] The term "simulation" in this context involves more than a simple walkthrough; rather, it represents a true-to-life portrayal of patient care. Immersing health care professionals (HCPs) in a simulated clinical environment populated with realistic visual, auditory, and tactile cues and requiring them to integrate multiple skill sets while working with colleagues, equipment and supplies under authentic time pressure evokes the same responses that they would display in the real clinical environment. This allows the environment to be probed for weaknesses that have the potential to lead to patient harm. Simulation-based testing is the standard in multiple industries where the environment and the activities conducted within it have the potential to create hazardous conditions and harm to human beings.

Two types of problems can be detected during simulated clinical events: an active error (AE) and a latent safety threat (LST). AEs in health care are defined as the events that occur prior to near misses or actual accidents resulting in patient harm.[9] AEs are typically committed by the HCPs who directly care for patients, occurring at the point of contact between a human and some component of the health care environment. LSTs refer to failures that reside in the design of some component of an environment that set the stage for AEs to occur.[9] LSTs may exist undetected for long periods of time before the right set of conditions occur that allow them to become manifest and result in patient harm. The goal of using simulation to support the design of safer health care environments is two-fold. During realistic simulated clinical scenarios, HCPs may commit AEs, and some of these AEs may be secondary to weaknesses in the physical environment. In addition, during the course of the simulation, LSTs may be detected. So how can the causes of AEs be identified and the presence of LSTs be exposed?

After a simulated event, those participating in it should be debriefed to extract their firsthand analysis of any problems that they encountered that either directly led to AEs in human and system performance or that uncovered LSTs. A debriefing is a discussion about a prior series of events, led by an individual or a group. The person or persons leading a debriefing may have been involved in the event that is being discussed or be a neutral observer. AEs and LSTs may be noticed both by those HCPs who were participants inside the simulation as well as those who observed their actions from the outside. Because of this, the most productive debriefings allow the flow of communication to be multidirectional—both between and among the leader(s) of the debriefing and those being debriefed (participants and observers). Debriefings should be dispassionate, fact-based, and conducted to detect AEs and LSTs, with the ultimate goal of improving human and system performance.[10]

To capture as much data as possible when conducting simulated clinical events, it is useful to generate an audiovisual record, not only of the event itself but also of the debriefing. When patient care is realistically simulated, it can be difficult if not impossible for those HCPs involved in the simulation to have sufficient situation awareness of everything that is done and said, especially if they are required to perform multiple manual tasks during that event. The same can be said for those observing the simulation, especially if they are not HCPs themselves and are unfamiliar with the interventions taking place during simulated patient care. Playback of the team members' activities and communication, as well as their interactions with the simulated environment, provides an objective and accurate account of the simulated clinical event and overcomes the limitations of debriefings that rely on memory alone; this is especially important with certain patient populations like the neonate, where several interventions by multiple HCPs may need to be performed simultaneously in a relatively small physical space. An added bonus is that these recordings can be reviewed at any time after the simulated clinical events and debriefings are completed, allowing additional post hoc analysis to be undertaken not only by those who attended the sessions but also by other professionals who may not have been present but who nevertheless play a role in the design process.

There are essentially two design and construction scenarios that can be encountered where simulation can be used to generate evidence for a safer environment: that of a completely new building or the redesign and renovation of an existing structure. With a new building comes the freedom to create something that is formulated to facilitate optimal human and system performance (within budgetary and regulatory limitations). Renovations have more restrictions, as design can be restricted by how easily the old structure can be adapted to meet new building codes as well, of course, by budgetary constraints. Regardless of whether one is dealing with new construction or renovation,

simulation can be used to optimize the design and, by extension, human and system performance and ultimately patient outcome, at three-time points:

- Prior to approval of final design specifications and actual construction.
- After construction is complete before the first patients move in.
- On an ongoing basis once patient care is in progress.

Realistic simulation of clinical events and effective debriefings of those events can be used to generate objective and subjective human and system performance data. That performance data can then be translated into information used to build an evidence base of design strategies for building and remodeling health care environments that enhance the effectiveness of care and reduce the risk of harm to patients.

Use of Simulation during the Design Process Prior to Construction/Renovation

While hospital building codes provide minimal requirements for clinical spaces, those requirements may need to be expanded based on local needs. In ►Fig. 1, a neonatal patient in a neonatal intensive care unit (NICU) lies on a radiant warmer surrounded by lifesaving technologies including an extracorporeal membrane oxygenation (ECMO) system, a ventilator, intravenous solution pumps, and numerous data displays. As is plainly visible, the space that allows direct access to the patient is limited to approximately six linear feet determined by the three horizontal sides of the radiant warmer. A large amount of additional floor space is taken up by the many devices used to administer care to and monitor the patient. Thus, even though building codes exist to provide a minimum amount of space to facilitate patient care in clinical environments, the types of care delivered in these environments may vary considerably from hospital to hospital and dictate that minimum standards be exceeded in certain instances. Because of situations such as these, simulating patient care (as it is delivered locally) during the design process is a critical step in ensuring that the final physical environment will be adequate to meet the needs of patient care in that specific facility.

The first step in using simulation to support evidence-based design is typically performed in an environment that bears a relatively low level of fidelity to an actual patient care environment but one that can be built at low expense and be easily and quickly modified. Such an environment is illustrated in ►Fig. 2. In this mockup of an NICU room, the internal dimensions of a patient care environment are created with 2×4 framing to which is applied a material such as Plasti Shield (*https://www.surfaceshields.com/corrugated-plastic-sheets/*), a lightweight, easily trimmed yet rigid material that can be used to simulate hard surfaces such as walls. This allows walls and any shelves, desktops, and other adherent structures to be easily repositioned to determine

Fig. 1 Multiple devices and data streams in a complex NICU environment. NICU, neonatal intensive care unit.

Fig. 2 Simulated NICU patient room. NICU, neonatal intensive care unit.

their optimal location. That same material can also be used to build replicas of various medical devices that stand on the floor (such as patient beds and ventilators) or are mounted on a wall (monitors, nurse call buttons, etc.) as seen in ►**Fig. 3**. Even though these replicas are built to occupy the same volume of space as the real device, their low mass means that simulated floor-standing devices can be moved around the room to different locations with little effort and simulated wall-mounted devices can be easily and quickly applied to different locations on the wall using Velcro, adhesive tape, or tacks. At this point, the HCPs who will be working in that space are enlisted to walk through it and discuss what they believe to be the optimal positioning of walls, equipment, and devices based on their experience. Many different configurations should be trialed and as much discussion as possible regarding the pros and cons of each option should be solicited to determine which design options are deemed the most acceptable. Next, HCPs are again recruited to participate in realistic simulated clinical scenarios conducted within each of those design options to determine if the results of the walk-through hold true during a *run-through*. What may look like a good design in two dimensions on paper or a computer screen may not prove to be adequate when examined in four dimensions (three-dimensional space plus time) during a realistic simulation. It is during a simulated clinical scenario that the real effects of a physical environment upon human and system performance can be seen. After each simulation, those in attendance should be debriefed and the key findings should be summarized to document how different room configurations affect the delivery of patient care and determine which design facilitates the optimal performance of the team. As mentioned previously, it is extremely useful to record the setup of the environment, the simulated clinical event itself, and all discussions conducted during the walk-throughs, the debriefings, and any additional discussions that take place.

Once the optimal design has been determined using simulation and debriefing in a low-fidelity environment, the process should be repeated by building a protype that possesses a much higher level of fidelity to the real patient care setting. Ideally, this environment will exactly match the planned real clinical environment and, therefore, include working medical equipment, actual clinical supplies, and patient simulators capable of simulating the anatomic features and physiologic changes seen in real human patients. Simulated clinical scenarios conducted in such an environment unfold with a sense of true-to-life time pressure that engenders highly realistic responses by the HCPs working within them. Although space, budget, and time constraints may act to limit the verisimilitude of this prototype, every effort should be made to come as close as possible to the real setting, as this will increase the likelihood that the data generated during simulation will be reflective of real-world clinical care and thus decrease the chances that AEs and LSTs will occur in that real setting. Once constructed, these prototypes can continue to serve the organization as the site of ongoing simulation and debriefing (see the next section).

Fig. 3 Simulated NICU bedside supply cart and attached waste disposal unit. NICU, neonatal intensive care unit.

Use of Simulation once Construction/Renovation Is Complete and Prior to Occupancy

Why is it that, despite many years of construction by experienced workers, thousands of hours of planning by highly trained professionals, and millions of dollars spent in the process, health care facilities nevertheless can be plagued by LSTs and AEs that are due to problems with the design of the physical environment? When testing is performed before construction, it typically involves only individual parts (subsystems) of a complex system, due to time, financial, and other practical constraints; however, when all of the subsystems are fully integrated and brought online, they may function differently than during testing as individual entities. Given the typical length of time between project genesis and completion, the workflows of the HCPs working within the walls may have changed and the environment as initially designed may no longer optimally enable those workflows. In addition, the disease states and acuity of the patients being cared for may also have changed in unanticipated ways (think onset of a pandemic), straining the functionality of the original design. For these reasons and others, it is not possible to anticipate every potential problem no matter how much time, effort, and money go into a project. Thus, it is highly desirable to test clinical environments once construction is complete and prior to the move-in of patients. While many institutions conduct staff orientation and "a day in the life" sessions, these do not provide comprehensive testing of clinical spaces.[11] It is here that simulated clinical scenarios can again be used to document that the physical environment functions in the manner in which it was designed, probe it for weaknesses, and remediate any problems that are detected.

Dadiz et al have described their experience using in situ simulation in a newly constructed neonatal intensive care unit prior to occupancy by patients.[12] They recruited 111 HCPs to participate as teams, ranging in size from 9 to 18 members, in simulated clinical scenarios involving both low and high acuity events. Members of the investigative team observed each scenario and documented how subjects interacted with the environment during simulated patient care. Each scenario was followed by a debriefing where subjects identified challenges and potential ways to overcome those challenges. All debriefings were recorded and transcribed; the transcripts were then used to identify 305 LSTs that were categorized into 4 main themes and 14 subthemes:

Main themes (subthemes in parentheses) are as follows:

- Relay of information (scripting, written, devices, and other).
- Workplace design (facilities, wayfinding, ergonomics, supplies, and equipment).
- Workflow processes (staffing, recruitment, roles, and workflow).
- Family and staff focus (family focus and staff training).

Each LST was classified as minor, major, or serious based on the potential for harm. These LSTs were then communicated to NICU and hospital leadership; subsequently,

interprofessional subcommittees worked with members of the investigative team to identify mitigation strategies. These strategies were then tested using additional simulated clinical events prior to communicating them to staff, integrating them into orientation and training, and implementing them during actual patient care. Follow-up data collection at 1 year revealed that, of the 305 LSTs, 276 (91%) were resolved and 10 (3%) continued to be addressed; a solution remained elusive for the remaining 19 (6%). The authors point out that many of the LSTs that were identified using simulation were interconnected; in addition, they acknowledge that while there are similarities in LSTs identified across institutions, there are also differences. All of the results and conclusions from this study and others argue for the comprehensive use of simulated clinical events in new health care spaces prior to patient occupancy.[13–15]

Use of Simulation on an Ongoing Basis once Patient Care Is in Progress

Once construction/renovation is complete and patients occupy the clinical environment, conducting simulations and debriefings should continue, ideally in those real clinical environments. While some hospitals are associated with (and in close proximity to) health care professions schools that house dedicated simulation centers, those centers typically do not mimic the actual hospital environment to a high degree of fidelity. Other hospitals have space set aside within their own facilities for simulation-based training; these spaces may also have varying degrees of fidelity to the real clinical environments, ranging from classrooms or similar traditional training environments to others that mimic the actual clinical environments where patient care is delivered. In generic environments, it is possible to probe human performance for weaknesses and address those weaknesses during debriefings. But when simulated clinical scenarios are conducted either in an environment that bears a strong resemblance and functionality to the authentic clinical environment or in the real clinical environment itself (in situ simulation), probing both human and system performance is possible. This facilitates the identification of weaknesses before they occur during actual patient care and provides an opportunity to proactively remediate these weaknesses before they can produce harm to real human patients.

Because it is extremely costly to build and equip enough space to replicate every unique clinical environment that exists in a hospital or clinic, in situ simulation offers the opportunity to probe all of facility's actual clinical environments. In situ simulation can add a more intense sense of realism to a scenario—working in real clinical environment, where actual patient care is delivered on a daily basis, engenders authentic responses by those HCPs participating in the scenario. It therefore not only allows them to discover their own human strengths and weaknesses but also facilitates a determination as to whether the design of the environment helps or hinders their performance. Even in the rare circumstance where the initial design enables optimal performance and was confirmed during preconstruction and preoccupancy simulation-based testing, the circumstances of patient care frequently evolve over time. The acuity of patients cared for in a particular environment may change and create new problems that the original design could not or did not anticipate. Workflows may metamorphose, either by active informed redesign or in response to informal "workarounds" that tend to develop when formal structured approaches fail to address needs. As new technologies are brought into the clinical environment, they may change how the HCPs interact with their physical environment and create new LSTs. Finally, the location and functionality of various components of the environment may shift through active intervention or passive neglect. All of these potential developments reduce the ability of the environment to facilitate optimal human performance. In situ simulation and debriefing can thus serve to ensure that the design of a clinical environment remains relevant over time, continuing to facilitate optimization of human and system performance for the life of the facility. Ongoing collaboration with professionals in a hospital's Patient Safety and Risk Management Departments to identify and track weaknesses in human and system performance, coupled with timely simulated clinical events that target those weaknesses, holds great potential to maintain the relevance of the clinical environment and improve patient safety on an ongoing basis. This is the rationale that underlies the Circle of Safety (►Fig. 4) that links neonatal outcomes in the delivery rooms and NICU at Packard Children's Hospital Stanford with the simulation-based training and research conducted at Packard's Center for Advanced Pediatric and Perinatal Education (CAPE, *http://cape.stanford.edu*).

Using Simulation to Develop a Modern Mothers and Babies Center

The Johnson Center for Mothers and Babies at Packard Children's Hospital at Stanford is currently undergoing a major renovation. The original labor and delivery (L&D) and NICU were designed in the 1980s; since then, numerous changes in building codes have been made, mandating extensive alterations in the renovated facility. In addition, the number and types of patients cared for within the Johnson Center have also evolved, creating the need for novel physical environments that were not envisioned during the design and construction of the original facility. Whether it is the renovation/updating of established environments or the design of completely new patient care settings, simulation and debriefing are playing an important role in transforming design and construction.[16,17]

The renovated L&D area of the Johnson Center will move from the second floor of the hospital to a larger space on the first floor, allowing room design to meet the current code. This move will also vacate space that then will be used to facilitate consolidation of neonatal critical care and intensive care beds that are currently spread out among three separate physical spaces on two separate floors of the hospital. L&D will house 14 labor rooms (LRs) where vaginal deliveries will

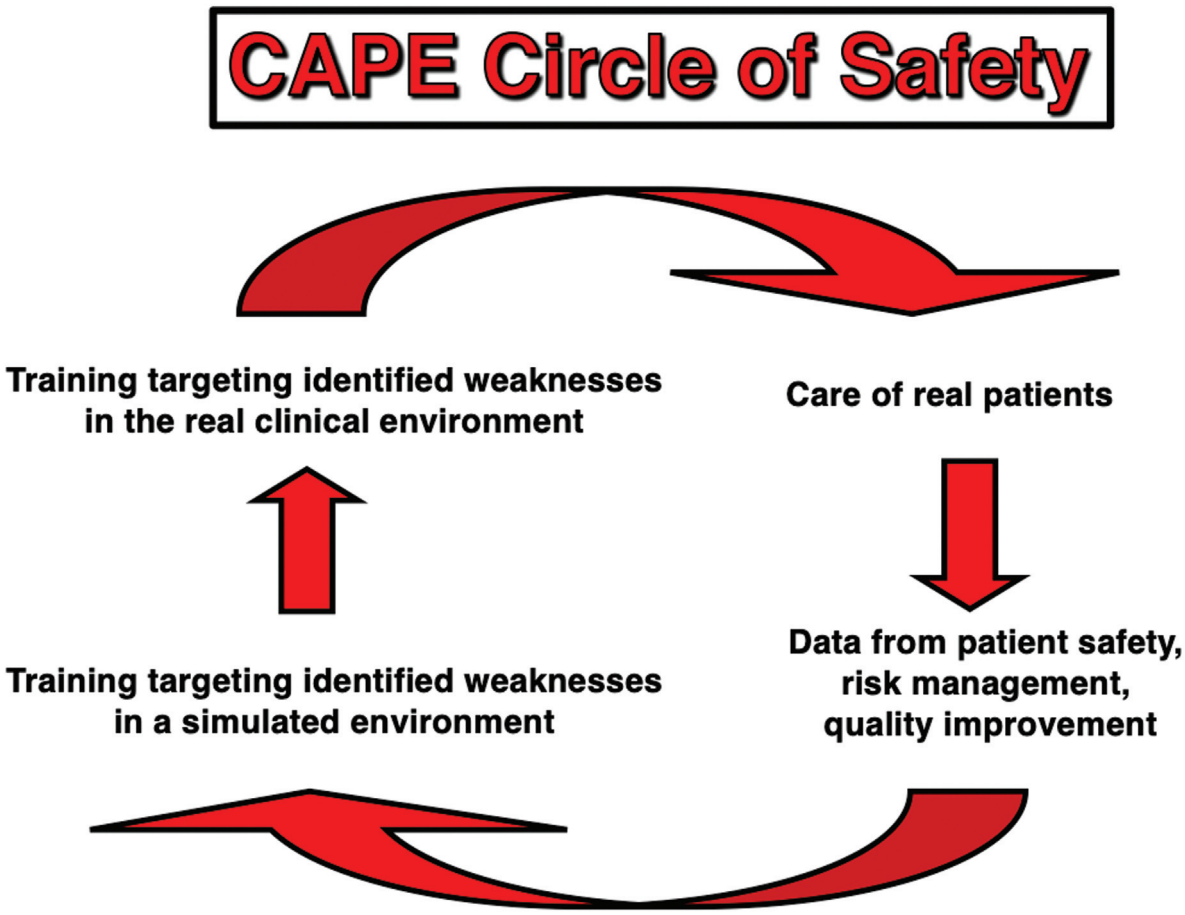

Fig. 4 The CAPE Circle of Safety. CAPE, Center for Advanced Pediatric and Perinatal Education.

occur and three operating rooms (ORs) in which cesarean sections (C-S) will take place. All of these rooms will be significantly larger (by approximately 50%) than the current spaces. A major aspect of the design of these spaces that was directly influenced by the use of simulation and debriefing is the location of the neonatal beds and the orientation of the maternal bed in the ORs. The initial plan was to place the neonatal beds (two beds will be placed in each room to accommodate twins) beyond the foot of the maternal bed to maximize the available space for the HCPs caring for the mother and her newborn(s). However, when operative delivery was simulated, it was noted by the obstetric nursing staff and the parent advisor participating in the simulated deliveries that the mother (who would be lying supine on the operating table) would not be able to see her newborn or the neonatal team members providing care. Solving this problem required moving the maternal bed from the center of the room to a location closer to the wall to the mother's right. This repositioning enabled the neonatal beds to be positioned along the wall to the mother's left, providing her with a direct line of sight of her newborns and the neonatal teams caring for them. Simulation of a cesarean section and neonatal resuscitation by obstetric and neonatal team members confirmed that this repositioning, although creating slightly more constrained spaces for each team, would nevertheless allow for safe and effective patient care. This is a direct example of simulation positively influencing not just maternal and neonatal clinical care but also enabling a major patient satisfier.

Because the obstetric service at Packard Children's Hospital is caring for an increasing number of complex maternal and fetal patients, the remodeled L&D environment will necessarily house technologies that will enhance data presentation and facilitate translation of that data into actionable information. One of these technologies is a sophisticated data display designed specifically for use during C-S deliveries. This technology was developed by obstetric team members and funded by a grant from the Agency for Healthcare Research and Quality (AHRQ; grant no.: P30 HS023506). The design of this display relied heavily on the use of simulation in an iterative manner, producing sequential improvements in its usability.[18]

The prior location of L&D on the same floor of the hospital as the NICU allowed for the initiation of resuscitation of the newborn in the delivery room and, when required, rapid transport of the neonatal patient to the NICU located just feet away. The move of L&D to the first floor of the hospital precludes such rapid transport, greatly altering the workflow of the neonatal resuscitation teams.[19,20] The necessity to transport critically ill neonates out of L&D, into an elevator, out of the elevator, and the into the NICU on a separate floor mandates that several procedures formerly performed

shortly after a neonate's birth in the NICU will now need to take place outside the NICU in L&D prior to transport. Because a physical environment that enables not only resuscitation but also stabilization of a critically ill neonate requires unique resources and more physical space than can be found in either an LR or an OR, a novel space, the neonatal resuscitation and stabilization suite, is being developed. This space will easily accommodate two neonatal patients and facilitate numerous invasive procedures that may be required to stabilize critically ill preterm and full-term newborns (►Table 1). Extensive time, effort, and other resources will be necessary to support simulation-based testing to ensure that these invasive procedures can be accomplished in the neonatal resuscitation and stabilization suite both safely and efficiently.

Similar to L&D, the types of patients cared for in the NICU at Packard Children's Hospital have evolved since its original design. Fetuses with the renal disease typically have low levels of amniotic fluid (known as oligohydramnios and anhydramnios) that, in turn, negatively impact fetal lung development; if severe, this can result in lethal pulmonary hypoplasia. Recently, innovative investigative therapies such as amniotic fluid replacement delivered into the maternal uterus have produced a population of newborns requiring aggressive treatment of renal and pulmonary disease, including therapies such as dialysis and high-frequency ventilation. Another relatively recent innovation is the use of hypothermia to treat neonates with hypoxic-ischemic encephalopathy (HIE); studies have shown that reducing the body temperature of patients with HIE improves their long-term neurologic outcomes. Because the sickest of neonates may require ECMO, dialysis, and therapeutic hypothermia simultaneously, the modern NICU must be designed to accommodate these unique technologies. None of these innovations in patient care were anticipated when the original Packard NICU was designed, leading to challenging situations such as the one depicted in ►Fig. 1. Realistic simulation of the care of a patient requiring these therapies (including the time pressure that is often associated with this care) in a physical environment that is equipped with the appropriate devices at the bedside, coupled with objective debriefing of these simulated clinical events, is necessary to both ensure safe and efficient patient care and reduce the risk of costly redesigns.

In recognition of the value of simulation and debriefing, the redesigned Johnson Center will include a dedicated physical space that will mimic the various patient care environments in L&D and the NICU in high fidelity. In addition, it will also be capable of simulating deliveries that occasionally occur in other locations outside of the Johnson Center, such as the emergency department and the hospital lobby. This physical space will consist of a simulation environment, debriefing room, control room, and vestibule. It will be located within the hospital within easy walking distance of the NICU, making it accessible to clinical staff working on a 24/7/52 basis. This will allow for several critically important activities to be integrated into daily workflows:

Table 1 Neonatal resuscitation and stabilization procedures

1	Physical examination
2	Weight assessment
3	Monitoring: electrocardiogram
4	Monitoring: hemoglobin-oxygen saturation
5	Monitoring: end-tidal CO_2
6	Monitoring: respiratory function
7	Venipuncture
8	Arterial puncture
9	Heelstick
10	Nasogastric tube insertion
11	Administration of supplemental oxygen: blowby
12	Administration of supplemental oxygen: nasal cannula
13	Administration of supplemental oxygen: continuous positive pressure ventilation
14	Positive pressure ventilation: bag-mask
15	Positive pressure ventilation: T piece-mask
16	Tracheal intubation
17	Mechanical ventilation: conventional
18	Mechanical ventilation: high frequency
19	Central venous cannulation: umbilical vein
20	Central venous cannulation: jugular vein
21	Central venous cannulation: percutaneous intravenous central catheter
22	Central arterial cannulation: umbilical artery
23	Intraosseous needle insertion
24	Peripheral intravenous cannulation
25	Peripheral arterial cannulation
26	Cutdown: arterial
27	Cutdown: venous
28	Chest compressions
29	Medication administration: intravenous
30	Medication administration: intratracheal
31	Medication administration: intramuscular
32	Medication administration: surfactant
33	Medication administration: nitric oxide
34	Volume administration (crystalloid)
35	Blood product administration
36	Radiography: chest
37	Radiography: abdomen
38	Radiography: long bones
39	Radiography: cranial ultrasound
40	Radiography: abdominal ultrasound
41	Echocardiography
42	Point-of-care ultrasound
43	Thoracentesis (needle)
44	Paracentesis
45	Pericardiocentesis

Table 1 (*Continued*)

46	Laryngoscopy (emergency)
47	Bronchoscopy (emergency flexible)
48	Bronchoscopy (emergency rigid)
49	Tracheostomy (emergency)
50	Transcutaneous pacemaker wire placement (emergency)
51	Phototherapy
52	Near-infrared spectroscopy
53	Electroencephalography
54	Therapeutic hypothermia
55	Exchange transfusion
56	Atrial septostomy
57	Cannulation for extracorporeal membrane oxygenation

- Briefing real events.
- Debriefing real events.
- Simulating future planned interventions.
- Facilitating the integrated training of multidisciplinary (obstetric, anesthesia, and neonatal) teams scheduled training programs for local, regional, national, and international audiences.
- Testing of new technologies and procedures prior to deployment in patient care areas.

When completed, this will be one of very few health care simulation environments that is designed to mimic a specific real clinical environment, intended for use primarily by practicing HCPs (as opposed to students or trainees), and accessible at all hours of the day, every day.

Conclusion

Realistic simulation and debriefing of clinical events prior to the approval of final design specifications and actual construction, after construction is complete before the first patients move in, and on an ongoing basis once patient care is in progress generate objective and subjective human and system performance data. That performance data can then be translated into information used to build an evidence base of design strategies for building and remodeling health care environments that enhance the effectiveness of care and reduce the risk of harm to patients. While not the highest level of evidence, rational conjecture lends credence to the premise that enhanced human and system performance during realistic simulated clinical scenarios can and does translate into a similar level of performance during actual patient care. Thus, using multidisciplinary teams of HCPs working in simulated or actual clinical environments populated by functional medical equipment, patient care supplies and human patient simulators, to generate objective and subjective human and system performance data will effectively create an evidence base of design strategies for building and remodeling health care environments that will ultimately enhance the effectiveness and safety of patient care.

Conflict of Interest

None declared.

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