POSITION PAPER

Using healthcare simulation in space planning to improve efficiency and effectiveness within the healthcare system

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ABSTRACT

Healthcare professionals are continuously being challenged to address the triple aim necessary for effective patient care: improving the quality and satisfaction of patients, improving the health of populations, and reducing per capita cost of healthcare. Today, innovation and cost-effective methods are a requirement to meet the triple aim given the current economic climate and financial limitations. Healthcare simulation is currently underutilised, particularly during the space or facility planning process in healthcare. This position paper will describe the process of implementing space simulations that were conducted between 2016 and 2018 in six different clinical settings that identified patient and provider safety concerns, and patient and provider needs. Simulation design and development along with the methodology for data collection and data analyses will be presented. Qualitative results will be presented to demonstrate the impact of the use of simulation to prevent critical and non-critical safety events.

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KEYWORDS

Simulation; space; patient safety; efficiency

1. Background

Typical facility space planning consists of needs assessment, operations analysis, space needs, and layout configuration using a combination of modelling and computerised simulation analysis looking at alternative processes (Miller, 2004). Little is written about space planning in healthcare; however, studies exist in the fields of engineering, real estate, and construction related to the use of simulation modelling for planning purposes (Jin, Nahangi, Goodrum, & Yuan, 2017; Shen & Shen, n.d.; Tawfik & Fernando, 2001). Simulations in these fields primarily focused on computerised or virtual simulations to determine user activity in space planning and construction layouts instead of building on real-world experience (Jin et al., 2017; Shen & Shen, n.d.; Tawfik et al., 2001). Further, research in these fields demonstrates cost reductions in replanning when utilising virtual simulations in engineering projects (Kikolski, 2017; Wynn & Clarkson, 2009). Simulation modelling has been used in designing new health systems and has identified areas to reduce cost (Adler et al., 2015; Silvay, 2015). For hospitals, the cost savings could be substantial as new construction for acute care hospital rose from \$30.8 billion in 2000 to \$54 billion in 2004 (Bazzoli, Gerland, & May, 2006) and has continued to grow by 2.3% in 2018 with an expected 1.9% increase in 2019 and 2020 (Statista, n.d.).

We argue that, at a minimum, the same benefits experienced utilising simulation modelling can also

be gained by utilising space simulations in healthcare facility planning. There is also a need to investigate the impact of environmental conditions on patient safety and ways to reduce patient safety threats (The Center for Health Design, 2011). We will further explore not only the cost and time benefits but the benefits to the quality of patient care, patient experience, and provider experience that can be gained with well-designed and contemplative space simulations.

Simulations can be developed to individually address particular healthcare facility concerns and provider needs. This innovative use of healthcare simulation to develop mock exam rooms allows providers an experiential learning opportunity. An added benefit to healthcare simulations is that most simulations can take place in a small clinical space that can be reused for different types of simulations; therefore, space and scale is not a significant issue as it would be in the construction or real estate arenas.

Simulations can also address specific patient needs and preferences using a parallel model. A 2016 survey by the American Hospital Association showed that 86% of health system/hospital executives believe that patient satisfaction is very important when deciding on design changes to healthcare facilities. They further noted that privacy and comfort are important to improve the patient experience (Hoppszallam, Vesely, & Morgan, 2016). However, of those surveyed, only 26% invite patients or community members to test live mock-ups (Hoppszallam et al., 2016).

Therefore, the benefits offered by space simulations have not been fully utilised in the healthcare system.

In situ or on location simulation which takes place in the live, clinical environment has been used successfully within the healthcare simulation to identify latent patient safety threats (Geis, Pio, Pendergrass, Moyer, & Patterson, 2011; Hamman, Beaudin-Seiler, Beaubien, Gullickson, Orizondo-Korotko, Gross, Fuqua & Lammers, 2010). Key components of healthcare simulation include pre-briefing, scenario design, and debriefing. We sought to translate the lessons learned from *in situ* simulation and integrate best practices for healthcare simulation into simulations designed to inform new clinical space development.

2. Overview

We utilised the tools and techniques commonly seen in healthcare simulation where individuals and teams interact in a simulated environment to improve care. The purpose of these simulations was (1) to identify potential safety or care concerns before building and/or renovating clinical space and (2) to reduce expenditures during renovations and/or new space construction. We further hope that these findings will be utilised and incorporated in the planning phase of new spaces in the healthcare system. Simulations took place within an unused open space within the academic medical centre that allowed for the development of mock clinical settings. Simulations included space-based mock exam and other clinical care processes based on institutional needs and requests from clinical departments. This project received IRB approval (E160720005).

3. Simulation design

Six space simulations were designed to mimic six different clinical settings including an infusion clinic, a multidisciplinary care clinic, a primary care clinic, an intraoperative magnetic resonance imaging clinic, a dermatology clinic, and an intensive care unit in which extracorporeal membrane oxygenation (ECMO) could be used. The settings were chosen based on requests from clinical departments who were renovating or moving to a new clinical location. Each simulation utilised equipment typical of each clinical unit to ensure the accuracy of size and utility in each clinical setting.

In addition to routine and emergency patient care operations, we also sought to determine the optimal placement of electrical outlets, equipment, and/or technology used in patient care. Each simulation lasted approximately 15 min, being cognizant of potential participant time constraints. All simulations took place after approval of space renovation or space building, but before the equipment was ordered and/or placed, and

before electrical/mechanical plans were finalised. Therefore, each simulation had a predetermined floor plan to use with specific height, length, and width dimensions of each room. Clinical settings varied between outpatient (i.e., primary care clinic) and inpatient settings (i.e., ECMO, infusion). Each simulation included providers, healthcare staff, administrative staff, and patient advocates to obtain provider and patient perspectives. Additional participants included infection control and regulatory personnel whose involvement varied based on the individual needs of each simulation. Each simulation had a minimum of two different space plan configurations for participants to experience and/or observe. Simulation participants were pre-briefed to orient them to the simulation, then they participated in and/or observed the scenario, finally, they were debriefed and discussed the events that occurred.

4. Simulation evaluation

Two types of evaluations were used for each space simulation: a space simulation survey (specific to each simulation and type of participant) and a simulation evaluation survey (standard format for each simulation). The space simulation survey questions were developed based on a needs assessment which included discussions with clinical faculty and staff, and input from our facilities and information technology departments to ensure feasibility of offered options and placement of items based on each clinical simulation.

Separate space simulation surveys were developed for providers and patients. Therefore, each simulation had two space simulation surveys per simulation. Sample questions from the 12 questionnaires are provided in Tables 1 and 2. Utilising the survey, participants provided written feedback at the conclusion of and/or during the simulation using a combination of closed- and open-ended questions.

Provider safety questions focused on hazards, equipment accessibility and patient visibility. Patient safety questions focused on hazards and privacy.

Table 1. Sample provider questions from the space simulation survey.

Data type	Sample question
Quantitative, Qualitative	Would providers have adequate visibility from outside and/or within room? Yes or No. Explain.
Qualitative	Please comment on the height of the wall and opaque divider:
Quantitative	Which type of workstation would be most suitable for this cubicle layout? Countertop mounted monitor, Mobile workstation, SurfacePro tablet and cart
Quantitative	As a provider, which cubicle layout do you prefer? Type 1 – Open, Type 2 – Semiprivate, Type 3 – Combination
Qualitative	What are your concerns about each layout?
Qualitative	What concerns do you have using a standard supply cart in the room?

Table 2. Sample patient or observer questions from the space simulation survey.

Data type	Patient/ observer	Sample question
Qualitative	Observer	What did you observe during the following processes? Opening Encounter, Intake, MD-APP encounter, In-room procedures, Human-computer interaction, Departure, Other thoughts
Quantitative, Qualitative	Patient	Is there sufficient storage space for personal belongings in this layout? Yes or No. Explain.
Qualitative	Patient	What other accommodations would you need to feel comfortable in this space?
Qualitative	Patient	What do you like best about each layout?
Qualitative	Patient	What are your concerns about each layout?
Quantitative, Qualitative	Patient	Would this layout provide the appropriate level of privacy for a patient? Yes or No. Explain
Qualitative	Patient	How many electrical outlets would you need access to?
Qualitative	Patient	What chair features are important to you?

Provider-need questions focused on equipment (i.e., placement, number, type), types of equipment (i.e., different models, features), and types of technology (i.e., mobile, tablet, wall-mounted) that are necessary for optimal patient care in a given clinical setting. Patient-need questions focused on the quality of visit (i.e., television placement, windows), comfort (i.e., chair features), and equipment needs (i.e., outlets for patient use).

Quantitative and qualitative data were collected from simulation participants and those evaluating the overall environment for each simulation. Demographic data included the number and type of providers, and the clinical unit represented in each simulation. Additionally, quantitative data were calculated for closed-ended questions included in the space simulation surveys that focused on the provider or patient preferences or missing equipment. Provider and patient preference data were presented as a percentage for each choice for each simulation. Missing equipment data were presented in a tabular format which included the number of times each piece of equipment was listed in the surveys. Missing data were not included in data analysis. A summary document of data analyses was shared with clinical administration and C-Suite executives.

Qualitative data were collected utilising open-ended questions in the space simulation survey. Participant responses were grouped based on similarity of content and presented in a tabular format for each simulation. Qualitative data included observations, patient safety concerns, recommendations, and overall concerns. Questions varied based on the clinical setting but had a consistent focus of provider safety, patient safety, provider needs, and patient needs. Missing or illegible data were not included in data analysis. Qualitative data were analyzed utilising thematic analysis and were reported to clinical

administration and C-Suite executives in a summary document. For this paper, we are presenting a selection of the qualitative data from the six simulations so the reader can understand the breadth and depth of information obtained from the space simulations.

The simulation evaluation survey (Figure 1) was also utilised for each simulation. This is an additional written evaluation used after every simulation at our simulation centre. This survey was created at our centre and provides data in a consistent format for analysis as well as provides insight into what went well and what needs improvement with each simulation event. The simulation evaluation survey collects quantitative and qualitative data. Quantitative data include participant demographics (staff, resident, student, faculty, etc.). Data include nine questions using either a 5- or 3-point Likert scale, and three open-ended questions. The goal of this survey is to provide information on simulation effectiveness, participation, and areas of improvement. This data is presented in an aggregate manner to key stakeholders, and is summarised below for these six space simulations. We believe that the combination of both the space simulation survey and the simulation evaluation survey allowed us to obtain specific and useful information for each space simulation.

5. Discussion

All space simulations utilising a mock clinical space were successful in identifying major and minor safety and patient care concerns for providers and patients related to layout and amenities (Table 3). Some concerns revolved around equipment placement and access to patients during an emergency while other concerns focused on quality of care. Additionally, information related to provider and patient preference was identified to ensure the correct equipment model, and/or room features were considered and incorporated into the final space configuration to improve provider and patient experiences (Table 4). The planning and facilities group reported their findings from the simulation and are continuing to work on additional projects. We are working on closing the loop to document changes made pre- and post-construction. A summary document was shared with each clinical department after the simulation to provide them with recommendations that would enhance provider and patient satisfaction, and patient safety. The level of adoption of recommendations from the space simulations has varied based on the status of each project. The infusion clinic has not completed construction yet; therefore, we are unable to report on any implementation changes based on the space simulation recommendations. The multidisciplinary care clinic has completed construction and is seeing patients.

Course/Event Name _____ Date _____

I am a: (please check one) I. Participant _____ II. Observer _____ III. Participant and Observer _____

Hospital Staff: (please circle one)	
Nurse	Physician RT Pharm PT OT PCT Other (specify) _____
Resident: (please circle one)	
Anes	EM Medicine Neuro OB-GYN Peds Surgery Other (specify) _____
Student: (please circle one)	
Nursing	Medicine Opt Dent PUH CAS Eng Business Health Professions (select dept:) CDS HSA NUTR OT PT
Other: _____	
Faculty: (please circle one)	
SON	SOM SHP SOO SOD SOPH CAS SOEng SOB Other (specify) _____
External to UAB: ☐	

		Agree	↔	Neutral	↔	Disagree	
The objectives for this event were met.		5	4	3	2	1	
The learning experience was valuable.		5	4	3	2	1	
This debriefing and/or feedback was valuable.		5	4	3	2	1	
This experience will improve my performance in actual clinical setting.		5	4	3	2	1	
I would recommend this event to others.		5	4	3	2	1	
		Agree		Too Short		Too Long	
The length of time for this event was appropriate.							
The length of time for the debriefing and/or feedback was appropriate.							
If there was a teamwork component to this course please answer below:		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
The teamwork/communication objective was met		5	4	3	2	1	
My teamwork/communication skills improved because of this experience.		5	4	3	2	1	

Two things I liked/learned today:

Two things I wish we had focused on or that could be improved:

Comments/Suggestions/Recommendations:

There was no evidence of commercial bias in this activity: ☐ Agree ☐ Disagree☐ I do not wish for this anonymous information to be used for research or presentationPsychological and physical safety resources can be found at: <http://www.uab.edu/simulation/images/Safety.pdf>

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Figure 1. OIPS simulation evaluation.

They did utilise recommendations from the space simulation to guide choice and placement of equipment. The primary care clinic space has recently opened and data are being collected about provider satisfaction with the space. IT solutions were deployed based on provider feedback provided in the simulation. The intraoperative

magnetic resonance imaging clinic did not move forward due to cost issues. The dermatology clinic has also recently opened, and initial reports are that patient flow issues addressed in the simulations are working well. The ECMO intensive care unit has also recently opened although it is not yet at full capacity and *in situ*

Table 3. Patient safety and care concerns identified through the space simulation survey.

Safety concerns	Care concerns
"The booms need to accommodate the most complex procedures"	"Should be more than 2 feet of space to access patient"
"Have to wait 10 seconds to get to the patient in an emergency situation for MRI to be safely out of way."	"Neither [cabinet] provides enough space for surgical instruments, wound care products, etc."
"The room doors open to the sterile field during a left craniotomy."	"Concern for space for procedures when there are 4–5 people in the room."
"Patient [may] fall getting to bathroom"; "Incline in bathroom floor can be an issue"	"Alcohol and hand sanitizer need to be at the patient point of use (mounted on wall where the patient and staff can use it)"
Lack of visibility of patient "due to equipment being in the way"	"Need more O2/suction outlets"
Remove cords running across floor as it is a potential safety hazard	"Hard to get board under patient"

Table 4. Provider and patient preferences identified through the space simulation survey.

Provider preferences	Patient preferences
"Space for writing is very limited"	"[Should] use curtains instead of doors"
"Need more cabinet space overhead to hold med tray organizer"	"Artwork [should be incorporated] into room"
"Potential heater/cooler equipment that would fit on the ECMO cart"	"Hooks for purses", "Patient [should be able to] control their own light sources."
"Addition of extra bedside table"	"Half tilt chair was not comfortable"
"Consider use of camera in ceiling to allow medical staff to see the patient"	"Patient likes the provider not having a barrier with computer." "Patient likes rolling computer better."
"Countertop space is appropriate."	"Patient likes movable cart."

simulations are being planned to test room usage. Significant changes in the floor plan were made after the simulations in this mock unit resulting in a complete change of the unit before construction.

Participants found the simulations to be a valuable learning experience. In particular, the feedback of those who would be providing direct care in the proposed settings was deemed valuable by administrators and planners. Ongoing assessment is necessary to determine strengths and weaknesses of simulation activities, and to allow for opportunities of improvement. Information from assessments should be analyzed and summarised to inform C-suite administrators on next steps in facility and space planning. The use of simulations can reduce costs by ensuring appropriate equipment is ordered and that safe and effective configurations are approved. Further, the use of simulation can identify the ideal placement of electrical and mechanical features which can result in tremendous construction cost savings and time savings resulting in timely facility opening.

6. Conclusions

This paper introduces the importance of integrating healthcare simulation techniques in space planning to address the triple aim, primarily by enhancing cost-efficiency and patient care improvement. Simulation used for space planning requires minimal resources outside of physical space, provider and/or staff time, and patient time. We hope this paper encourages others to continue to research space-based simulations and enhance current literature with papers focused on concrete outcomes and enhancements from simulation utilisation. Further, we hope the healthcare community will continue to utilise and explore options to use simulation techniques to improve patient care through innovative design initiatives. While the simulations discussed in today's position paper focused primarily on multidisciplinary clinics within an academic healthcare centre, space simulations can be used in virtually every healthcare setting with appropriate investment of people and process.

Disclosure statement

No potential conflict of interest was reported by the authors.

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