Marian University

Leighton School of Nursing

Doctor of Nursing Practice

Final Project Report for Students Graduating in May 2023

Malignant Hyperthermia Simulation

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Date of Submission: May 5, 2023

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Abstract

Malignant hyperthermia is a rare but potentially catastrophic syndrome that can occur during general anesthesia. High mortality rates occur when this complication is left untreated or when care is delayed. Due to the rare nature of this process occurring there are few surgical staff members that have previous experience to fall back on should a MH crisis present itself. For this reason, developing a simulation for MH is a great way to prepare staff members and departments for a malignant hyperthermia event. Many facilities do not follow the recommended annual training on MH response. The purpose of this project was to establish MH simulation within the surgery department of a critical access hospital as a means of preparing the staff for a future MH event. The goal was to establish the simulation and demonstrate both an increase in knowledge gained by the staff as well as an improved confidence in ability to recognize symptoms and implement current treatment methodologies for MH. Assessment of these goals included evaluation of the staff by pre/posttests to assess learning and survey reflecting staff opinions on their confidence in handling a future live event. The results demonstrated improvements in both knowledge gained as well as learner confidence ($p<0.01$). Simulation is an effective method for educating operating room (OR) staff on the management of MH. Participants within the study had improved knowledge, confidence, and voiced satisfaction with the program. This serves as a potential method to implement at additional sites to encourage departmental preparation.

Keywords: malignant hyperthermia simulation, malignant hyperthermia training, malignant hyperthermia anesthesia, MH simulation, MH training, and MH anesthesia

Malignant Hyperthermia Simulation

This project was submitted to the faculty of Marian University Leighton School of Nursing as partial fulfillment of degree requirements for the Doctor of Nursing Practice, Anesthesia track. Malignant Hyperthermia (MH) is a rare but serious medical condition that can arise during the intraoperative and postoperative phases of surgery. The incidence of MH is estimated to occur in 1 in 10,000- 250,000 anesthetic cases performed (Rosenburg et al., 2015). If MH is not rapidly recognized or left untreated the patient outcome is likely death (Mullins, 2017; Rosenburg et al., 2015). Previous simulations have demonstrated delays in recognizing early signs as well as improper mixing of treatment medications (Harrison et al., 2006). Implementation of a simulation-based MH scenario can strengthen the anesthesia provider's ability and instincts to recognize and appropriately intervene to save a patient from MH (Schaad, 2017).

Background

An MH crisis is an event that requires an attentive and proactive anesthetist to quickly recognize the syndrome and promptly intervene. The cascade of symptoms of MH such as hypercarbia, hyperthermia, acidosis, muscle rigidity, and hyperkalemia can quickly spiral out of control putting the patient at risk of severe harm and even death (Yang et al., 2020). The highly metabolic state induced during MH had a mortality rate around 70% in the 1970s but with the advent of dantrolene used as an antidote medication, and with rapid administration, MH mortality is currently estimated to be around 5-10% (Kim et al., 2019; Yang et al., 2020). MH is now understood to be caused by hypersecretion of calcium from the sarcoplasmic reticulum (SR) which leads to uncontrolled skeletal muscle metabolism (Rosenberg et al, 2003; Yang et al, 2020). Genetic mutations in the ryanodine receptor (RYR1) have been implicated in most genetically studied MH cases (Kim, Kris, & Tautz, 2019; Yang et al, 2020). In addition to a likely genetic component, MH is known to be triggered by several pharmacologic agents that are commonly administered within the perioperative setting such as volatile anesthetics (isoflurane, sevoflurane, desflurane), and the depolarizing muscle relaxant, succinylcholine (Kim et al., 2019; Yang et al., 2020). Although the triggering medications are very common, the frequency with which MH occurs is relatively rare. A five-year retrospective study in New York found an incident rate of 1 in 100,000 anesthetic surgical cases performed with a significantly higher proportion of patients being male (Brady et al., 2009). After subsequent epidemiological studies were performed, an even higher incidence of MH was discovered in Wisconsin, California, and Florida (Lu, Rosenberg, & Li, 2017). Although the exact incidence rate is not fully understood, MH events have been recorded to effect individuals from all ages and can occur in any race (Yang et al., 2020). Adding another layer of difficulty to MH incidence is that it can occur within minutes after administration of a precipitating agent, or it can occur hours after initial exposure. Additionally, there is evidence of MH crisis recurring in up to 20% of patients successfully treated during the initial MH event (Burkman, Posners, & Domino, 2007). Due to the varied onset and occasional recurrence of MH it is critical the anesthetist be able to recognize symptoms even when a causative agent is not being currently administered. Furthermore, all surgical staff including nurses, surgical technologists, and anesthesia team members should be educated on signs and symptoms of MH since this can occur after the surgical event. As a consequence of the rarity with which MH occurs in the clinical setting, it is likely that student anesthetists will not encounter this pathological state while in school and many providers go their entire career without experiencing MH firsthand (Mullins, 2017). Owing to the infrequency with which MH is encountered it is easy to not be prepared to quickly recognize symptoms or be familiar with current treatment strategies (Mullins, 2017). Further studies into provider preparation for MH crisis found that cognitive aids throughout the simulated event such as the Malignant Hyperthermia Association of the United States (MHAUS) hotline or a poster from MHAUS improved provider success in recognition of symptoms, mixing the reversal medication, and progressing through simulation scenarios with appropriate interventions (Harrison et al., 2006).

Problem Statement

Due to the rare occurrence of this event, most perioperative and post anesthesia staff members are unlikely to have much, if any, experience in managing a MH crisis. The rare nature of this event is good news as it carries a relatively high mortality but leaves most departments susceptible to errors and suboptimal treatment should a patient develop MH. It is essential to have properly trained staff to handle this anesthesia emergency in a calm, timely, and appropriate manner. Implementation of a simulation-based training exercise to manage a malignant hyperthermia emergency should be an important aspect of any surgery department preparation and education. Comparison of current educational practices should be performed with a simulation-based training exercise to evaluate improved provider response to MH emergency. This led to the PICO question: for surgical staff, what is the effect of a malignant hyperthermia simulation training on event knowledge and management confidence?

Needs Assessment & Gap Analysis

Current educational practices covering MH readiness for this department are sparse and routine simulated competencies demonstrating appropriate treatment practices for a MH event did not exist. Several studies have indicated issues with providers preparing the antidote medication incorrectly, inability to properly diagnose the presence of a MH crisis or implementing inappropriate interventions to manage MH symptoms during simulated events (Harrison et al., 2006; Quick et al., 2017; Schaad, 2017). The simulation-based training exercises students and anesthesia providers have received for MH crises have been well-received and participants have responded favorably on surveys about the education received during simulated events (Harrison et al., 2006; Quick et al., 2017). Simulation-based training for MH with hospital operating room staff had favorable reviews and concluded with participants feeling empowered to treat MH should an event occur (Schaad, 2017). Additionally, the simulated environment with a debriefing afforded the participants an opportunity to ask questions and receive detailed explanations of critical aspects of the simulated emergency that would not normally occur in a live event (Schaad, 2017). The MH simulation empowered operating room (OR) staff to feel more prepared and comfortable handling a MH crisis should the need arise within the clinical setting.

Project Aim and Objective

The objective of this project was to improve the recognition, timeliness of treatment, comfort, and confidence of surgical caregivers when treating a patient that has developed Malignant Hyperthermia. By implementing a simulation-based approach, staff members are given the opportunity to experience a MH event without the added pressure of a real emergency. This method allows for learning promotion by encouraging discussion, feedback, questions, and addressing mistakes made during the mock event. Learning was assessed throughout the simulation as well as with pre-/posttest responses and surveys from participants. The expected outcome was to demonstrate an improved confidence and ability to recognize the signs and symptoms of MH as well as the appropriate treatment.

SWOT Analysis

As with any change to an educational program or intervention there are bound to be strengths and weaknesses. Performing a strengths, weaknesses, opportunities, and threats analysis (SWOT analysis) was important to reveal the shortcomings or major hurdles the program may encounter prior to or during implementation. The SWOT analysis of this project (Appendix D) demonstrated many strengths including a well-educated, collaborative workforce of potential participants. Additionally, there was buy-in from the surgery department nursing administration as well as the anesthesia department chair. Weaknesses for this simulation were identified as additional time constraints for staff members after their scheduled clinical working hours, recruiting staff members of the surgery department to actively participate in a simulation event, and lack of simulation equipment on site available to use that is relevant to this simulation. Opportunities from this simulation event included the framework for future MH simulations to be conducted at this site as well as additional sites. Further opportunities included staff carrying knowledge to other facilities or to use when educating future nurse anesthesia students performing their clinical rotations at this site. Threats to the simulation were identified as budget constraints to acquire needed equipment and no established simulation space dedicated to this simulation. The threat of COVID-19 or a pandemic closing clinical sites to non-essential employees was a very real possibility. Finally, if an emergency surgery case came in just before or during the simulation then multiple participants may have been pulled from the simulation to help a live case.

Review of Literature

Databases used for gathering research included PubMed, MEDLINE, and CINAHL. Search terms included: *malignant hyperthermia simulation, malignant hyperthermia training, malignant hyperthermia anesthesia, MH simulation, MH training, and MH anesthesia.* Critical to the search was reviewing current literature, so searches were limited to the years 2017-2022. Inclusion criteria composed of being published in the English language, peer-reviewed, and content consistent with the project. Additionally, the articles needed to include simulating a MH event with a facilitator and learner feedback or debriefing. Following identification and analysis, a final 10 articles with varying levels of evidence from 2 to 7 were included in this literature review (Appendix F).

Simulation

Simulation is the foundation for this project as well as the literature review. Simulation has become incredibly popular and prevalent in modern medical training (Kalaniti & Campbell, 2015). With the recent technological advancements and improvement in the quality of simulation mannequins and facilities, the level of fidelity associated with simulation has increased dramatically. Simulation provides a realistic patient scenario and environment without the threat of doing real patient harm. Participation in simulation also allows trainees the opportunity to develop clinical decision making, recognize knowledge deficiencies, and improve technical skills while receiving immediate feedback and debriefing post simulation. The knowledge, development of skills, and confidence gained during simulation can be critical when confronted with similar events in a real-life scenario.

Utilizing simulation for MH events is beneficial for providers to become more familiar with triggering agents, risk identification, symptoms, and treatment of this rare adverse event. Providers undergoing simulation training acknowledge they feel more prepared to manage a MH emergency during an actual crisis (Bansal, Dobie, & Brock, 2019; Matsco, et al., 2020; Shear, et al., 2018) . Due to the rare nature of MH, simulation is beneficial for both students and experienced practitioners to better understand the roles everyone should have during the immediate response phase of a MH event (Kim, T. et al., 2019; Quick et al., 2017; Schaad, 2017; Thompson et al., 2017).

While simulation can be an effective method of education and preparation for anesthesia providers there are other considerations that should be taken into account. Kim, T. et al investigated the cost associated with a simulation-based educational program as well as their cased-based design (2019). Their findings suggest that while students enjoyed the simulation and reported knowledge gain and increased confidence in treating MH, the expenses associated with running the number of simulations for their program were cost-prohibitive for continuing it as a simulation-based learning modality.

Knowledge and Confidence

With MH being such a rare event, it is common for providers to be delayed in recognizing the development of MH, properly treating the pathology, confidently knowing the reversal agent dosing, or implementing correct supportive care. Improved knowledge of the process as well as provider confidence in recognition and treatment were common themes identified in the articles (Kim, T. et al., 2019; Hardy et al., 2018; Matsco et al., 2020; Schaad, 2017; Thompson et al, 2017). Across various specialty providers and experience levels, an introduction or refresher simulation course provided practitioners with a simulated experience they normally do not receive in the clinical setting. Independent of specialty area or experience level, provider feedback voiced appreciation for the class as well as improved knowledge and confidence to correctly identify and treat a MH crisis in the future (Matsco et al., 2020; Quick et al., 2017; Schaad, 2017).

Use of Cognitive Aids

Cognitive aids assist healthcare providers with a list of appropriate treatment considerations as well as treatment algorithms for various health conditions. Cognitive aids were utilized for a variety of healthcare training and live scenarios. When a stressful emergency is coupled with a rare event there is often little to no real-life experience to fall back on. Having a cognitive aid can be critical during these stressful events when providers may be more likely to omit certain treatments. Cognitive aids have been developed for advanced cardiovascular life support, anesthesia machine checkouts, and cesarean section to help standardize care and promote improved patient outcomes (Harrison et al., 2006). While usage of an advanced cardiovascular life support cognitive aid may be beneficial for a cardiac emergency, a cognitive aid can also be used for MH management. The MH cognitive aid can be a beneficial tool during an emergency because it reminds the team of appropriate medication selection and dosing as well as listing common electrolyte and pathophysiological alterations that take place during such an event (Harrison et al., 2006). The usage of cognitive aids during simulated MH cases coincided with improved timing of both the recognition of critical event and time to administration of the antidote (Clebone, Watkins, & Tung, 2020; Gallegos & Hennen, 2022; Hardy et al., 2018; Shear et al., 2018). In some studies, the usage of a cognitive aid was delayed and resulted in missed critical components or delayed initiation of appropriate interventions (Clebone, Watkings, & Tung, 2020; Gallegos & Hennen, 2022). Cognitive aids have demonstrated to be effective in removing delays in elevating the patient to an appropriate level of care such as transfer from a surgery center to a facility capable of providing definitive treatment of a MH crisis (Bansal, Dobie, & Brock, 2019).

Theoretical Framework

The National League for Nursing (NLN) Jeffries Simulation Theory is a well-established framework for education utilizing simulation. The NLN Jeffries framework was created to assist educators in designing and implementing simulation experiences that facilitate learning (Jeffries, 2005). First developed in 2005, the Jeffries model has undergone several changes but currently settles on six main elements which include: context, background, design, educational practices, simulation experience, and outcomes (Cowperthwait, 2020). The NLN Jeffries model focuses on a dynamic experience between the facilitator of the simulation and the learner (Jeffries, Rodgers, & Adamson, 2015). This framework served to guide the design, implementation, and evaluation of the project. A visualization of the theoretical framework is included in appendix A. The quality of the simulation experience and knowledge gained is based off several variables during a simulated case. The attributes of the facilitator such as skill, educational techniques, and preparation are critical in creating a successful simulation (Jeffries, Rodgers, & Adamson, 2015). The attributes of the participant also affect the simulation experience. Attributes such as age, gender, anxiety, preparation, background knowledge, and self-confidence can significantly enhance the simulated event (Jeffries, Rodgers, & Adamson, 2015). The outcome from the NLN Jeffries theory focuses on the products of three key groups. These groups are the patient, participant, and the system. Due to the rarity of this event in a live situation the outcomes for patients down the road were not assessed. The outcomes for the system, and especially the participants, were much more accessible following the completion of the simulation.

Goals, Objectives, and Expected Outcomes

The focus of this project was to implement a simulated MH event. Specific additions to the educational model at this facility focused on adding a debriefing segment, hosting an interactive setting, working with an interdisciplinary team, and establishing collaboration.

Utilizing a pre and posttest format, participants in the simulation demonstrated an expanded knowledge base of the symptoms and process as well as the treatment of a MH event. Additionally, staff were able to identify weaknesses and processes necessitating change to better address a real-life MH event.

Project Design

This DNP project led to a quality improvement design by implementing an educational intervention for a clinical facility. Quantitative data was collected with pre and post-test questionnaires as well as a survey. The data that was collected was used to identify changes in knowledge gained, confidence, and satisfaction.

Project Site

The project site took place in the surgical department at a rural midwestern critical access hospital. Staff members from the site included perioperative and postoperative care members. Staff members included surgical technologists, nurses, certified registered nurse anesthetists, and an anesthesiologist. The types of anesthetic cases performed at this site include endoscopy, orthopedics, podiatric, general surgery, bariatric, ear, nose, and throat (ENT) services, as well as pediatric dental cases.

Methods

The surgical staff were recruited to participate in an educational intervention and simulation. Participants completed a five question pre- and post-test as well as a NLN survey to assess satisfaction and confidence at the end of the session. Between the pre-test and post-test, a briefing of the simulated patient occurred and then the MH event took place, all of which lasted approximately 30 minutes. Participants were given the opportunity to listen to feedback and debrief following the simulated event. During the briefing portion of the presentation was a demonstration of proper handling and mixing of the reversal agent Dantrolene.

Measurement Instruments

Student Satisfaction and Self-Confidence in Learning

The Student Satisfaction and Self-Confidence in Learning survey is a measurement tool produced by the NLN (Appendix B). The survey was a thirteen question Likert scale that first assessed how satisfied the learner was with the educational experience they just participated in and then assessed, with a greater number of questions, the learner’s perceived self-readiness to address this in the future on their own.

Knowledge Survey

Part of the educational process is retaining information for later use. Knowledge gain was assessed by establishing a baseline knowledge level with a pre-test prior to any educational or simulated learning. The pre/posttest was a basic five question tool (Appendix C). The test included two multiple choice questions, two select all that apply questions, and one true/false question. The questions were developed from content within the textbook *Nurse Anesthesia* (Nagelhout & Elisha, 2018).

Data Collection

Data was collected by the DNP student facilitator. Data collection occurred immediately prior to the simulated event in the form of a pre-test as well as immediately after the debriefing period with the post-test and survey. Paper surveys were used to improve participant assessment prior to and following the simulation. Tests were numbered so that pre and posttest analysis would match the same participant. All surveys were collected in a folder by the facilitator and shuffled upon removal to ensure anonymity. No participant information was placed on the survey or tests.

Ethical Considerations

Risks involved with the simulation were minimal and would include participants feeling uncomfortable or embarrassed by not knowing how to properly treat a patient during an emergency simulation. During the evaluation portion of the project, responses to surveys and tests were kept secure and confidential. The DNP designer did not collect any personal information from the participants. Marian University Institutional Review Board granted approval for the project prior to implementation and the project did not gather any personal health information, involve vulnerable populations, or include any gathering of participant specimens.

Project Evaluation Plan

The goal of the project was to improve the staff's knowledge and confidence in treating a MH event in a timely and coordinated effort. Evaluation was assessed via two different assessments. The first was a short knowledge-based pretest and posttest to assess whether participants gleaned information and knowledge during the event and debriefing period. The second assessment assessed the staff's confidence in dealing with a MH event via the NLN survey. Data analysis included a paired t-test utilizing the computer software IBM SPSS.

Results

There were 17 participants involved in the simulation and project. These individuals were a mix of preoperative nurses, perioperative nurses, postoperative nurses, surgical technologists, physician anesthesiologist, nurse anesthetists, and department nurse management. All participants completed a pretest to establish a baseline knowledge foundation. The mean scores from pretests are 3.76 out of a possible 5 points awarded. Assessment of knowledge gained from the simulation was evaluated by comparing the pre and posttest results. Mean correct scores reflected a 25% improvement as they increased by 0.94 following the simulation (Table 1).

Table 1.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTest	3.7647	17	.97014	.23529
	PostTest	4.7059	17	.46967	.11391

Additional analysis of the two test results included a paired T-test demonstrated on Table 2. Included in the analysis is the p value of <0.001 which would indicate the results are statistically significant and promote the effectiveness of simulation on knowledge gain.

Table 2.

Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	PreTest - PostTest	-.94118	.89935	.21812	-1.40358	-.47878	-4.315	16	<.001	<.001

Posttest surveys assessed with the NLN Student Satisfaction and Self-Confidence survey identified the readiness of staff to feel prepared to intervene during MH crisis. Immediate feedback from the participants was overwhelmingly positive and many voiced appreciation for the educational experience they received. The NLN survey reflects an agree/disagree 5-point Likert scale. The NLN survey demonstrated the participants' satisfaction with the educational approach and their perceived confidence and ability to perform the event in a real-life scenario (Table 3).

Table 3.

Statistics

		Satisfaction_1	Satisfaction_2	Satisfaction_3	Satisfaction_4	Satisfaction_5	Confidence_1	Confidence_2	Confidence_3	Confidence_4	Confidence_5	Confidence_6	Confidence_7	Confidence_8
N	Valid	17	17	17	17	17	17	17	17	17	17	17	17	17
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		4.6471	4.1176	4.4118	4.7059	4.4118	4.1765	4.7059	4.4706	4.5882	4.8235	4.6471	4.4118	4.7647
Std. Deviation		.49259	.69663	.61835	.46967	.61835	.63593	.46967	.51450	.50730	.39295	.49259	.50730	.43724
Skewness		-.677	-.161	-.522	-.994	-.522	-.143	-.994	.130	-.394	-1.866	-.677	.394	-1.372
Std. Error of Skewness		.550	.550	.550	.550	.550	.550	.550	.550	.550	.550	.550	.550	.550

The mean scores for the NLN survey all fall within the range of 4.11-4.82 which would correlate with a response between 4 (agree) and 5 (strongly agree) when asked if they felt satisfied with the simulation and confident in carrying out the learned knowledge and skills.

Discussion

MH is a rare but serious complication from surgery and exposure to general anesthetics. Mortality is significantly increased by delayed or ineffective management of the crisis. The ability to simulate this event was critical for the surgery department to establish an effective treatment strategy, recognize weaknesses in treatment, and improve staff readiness for when a MH crisis does occur. Improvements in participant knowledge gained were apparent when comparing pre and posttest responses. For every test question, the sum of correct responses increased following the simulation. Interactions between the facilitator and the participants throughout the event as well as the debriefing following were incredibly important for participant knowledge gain. This was voiced as being a major bonus to the project as participants could correct improper medication errors, treatment plans, assessment findings, and have new considerations introduced that they initially did not have prior to interacting with the facilitator. The high Likert scores and verbalized responses during the debriefing period echoed similar responses to the published literature recorded by Matsco et al. and Quick et al. (2020; 2017). Participants were pleased to have experienced the simulation and expressed being receptive to learning other surgical events in a similar fashion.

Strengths and Limitations

A strength of the project is the demonstration of the effectiveness and overall reception the staff had for the implementation of the simulation. Debriefing included within the simulation is critical in facilitating knowledge gained and staff understanding what behaviors to change should a real event occur. Additional strengths of the simulation included the participation of interdisciplinary staff members with various roles within the department. Preoperative nurses brought a different perspective to the simulation compared to anesthesia and perioperative staff which contributed to improved interactions between facilitator and participants. Because the facilitator had a previously established working relationship with staff, the participants voiced a comfort and ease in asking questions throughout the experience. Limitations to the project include a rather small sample size and isolation to just one clinical site. Familiarity between the facilitator and participants may not occur at other sites. Expansion of the sample size and inclusion of multiple sites could add diversity in interactions, responses, and improve the strength of the findings. There were also varied interactions between participants and facilitator as some were more likely to ask questions and seek out additional information. Sampling bias is certainly a possibility with this study as convenience sampling was the method utilized for the project. Additional measurements that could be included in future projects would be additional testing months later to analyze retention of learned material.

Conclusion

Malignant hyperthermia is a serious and life-threatening complication that every facility performing anesthesia should be regularly prepared to manage. Training should include understanding susceptible patients, symptoms, and appropriate treatment of the condition. Delays in care contribute to increased mortality, which is why it is so imperative to have a staff that is confident in recognizing symptoms and knowledgeable of the steps to be taken next. Simulation is a viable method to promote the training and preparation of surgical staff for the possibility of a MH event. Participants within these simulations acknowledge they are better prepared, comfortable, and knowledgeable should they encounter MH. Debriefing following an event can help participants shore up knowledge deficiencies and promote confidence. Debriefing should be an aspect of any simulation event as an additional means of education.

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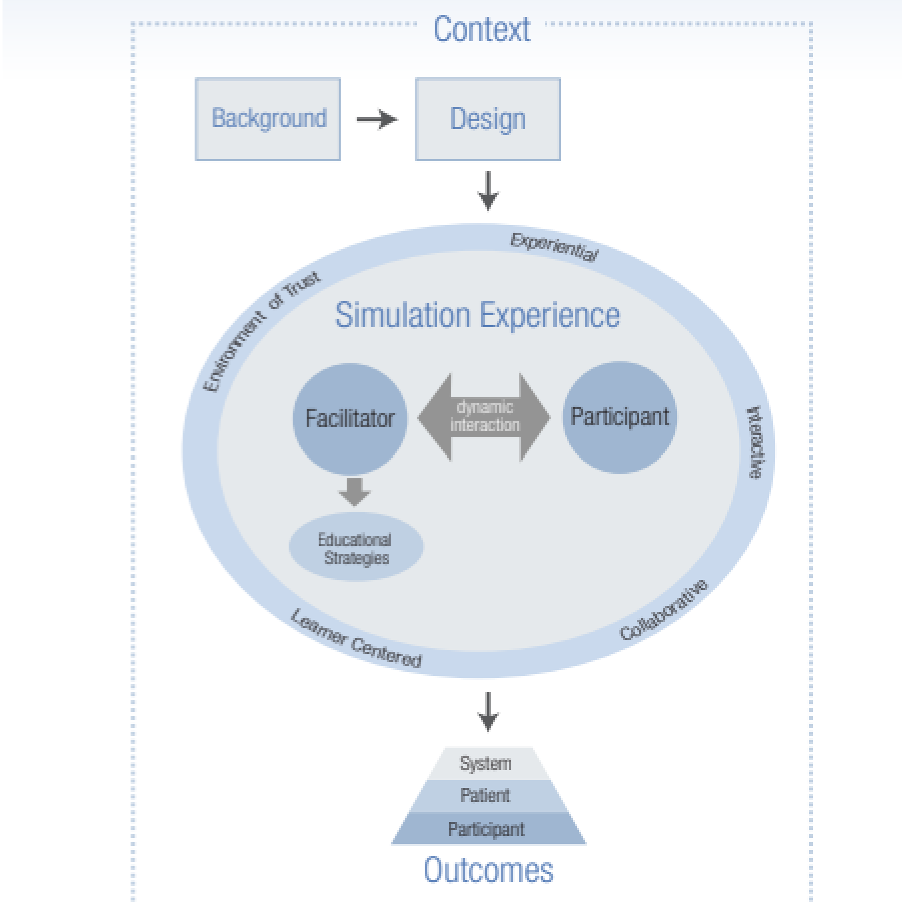
Appendix A

Figure: NLN Jeffries Simulation Theory



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Appendix B

Student Satisfaction and Self-Confidence in Learning

Instructions: This questionnaire is a series of statements about your personal attitudes about the instruction you receive during your simulation activity. Each item represents a statement about your attitude toward your satisfaction with learning and self-confidence in obtaining the instruction you need. There are no right or wrong answers. You will probably agree with some of the statements and disagree with others. Please indicate your own personal feelings about each statement below by marking the numbers that best describe your attitude or beliefs. Please be truthful and describe your attitude as it really is, not what you would like for it to be. This is anonymous with the results being compiled as a group, not individually.

Mark:
1 = STRONGLY DISAGREE with the statement
2 = DISAGREE with the statement
3 = UNDECIDED - you neither agree or disagree with the statement
4 = AGREE with the statement
5 = STRONGLY AGREE with the statement

Satisfaction with Current Learning	**SD**	**D**	**UN**	**A**	**SA**
1. The teaching methods used in this simulation were helpful and effective.	O 1	O 2	O 3	O 4	O 5
2. The simulation provided me with a variety of learning materials and activities to promote my learning the medical surgical curriculum.	O 1	O 2	O 3	O 4	O 5
3. I enjoyed how my instructor taught the simulation.	O 1	O 2	O 3	O 4	O 5
4. The teaching materials used in this simulation were motivating and helped me to learn.	O 1	O 2	O 3	O 4	O 5
5. The way my instructor(s) taught the simulation was suitable to the way I learn.	O 1	O 2	O 3	O 4	O 5
Self-confidence in Learning	**SD**	**D**	**UN**	**A**	**SA**
6. I am confident that I am mastering the content of the simulation activity that my instructors presented to me.	O 1	O 2	O 3	O 4	O 5
7. I am confident that this simulation covered critical content necessary for the mastery of medical surgical curriculum.	O 1	O 2	O 3	O 4	O 5
8. I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting	O 1	O 2	O 3	O 4	O 5
9. My instructors used helpful resources to teach the simulation.	O 1	O 2	O 3	O 4	O 5
10. It is my responsibility as the student to learn what I need to know from this simulation activity.	O 1	O 2	O 3	O 4	O 5
11. I know how to get help when I do not understand the concepts covered in the simulation.	O 1	O 2	O 3	O 4	O 5
12. I know how to use simulation activities to learn critical aspects of these skills.	O 1	O 2	O 3	O 4	O 5
13. It is the instructor's responsibility to tell me what I need to learn of the simulation activity content during class time..	O 1	O 2	O 3	O 4	O 5

 Revised December 22, 2004

Appendix C

Pre/Post Test

1) What is the proper initial bolus dose of Dantrolene sodium?
    a. 1.5 mg/kg
    b. 2.5 mg/kg
    c. 5 mg/kg
    d. 10 mg/kg

2) Which of the following are possible Malignant Hyperthermia triggering agents? (Select all that apply)
    a. Succinylcholine
    b. Propofol
    c. Rocuronium
    d. Sevoflurane

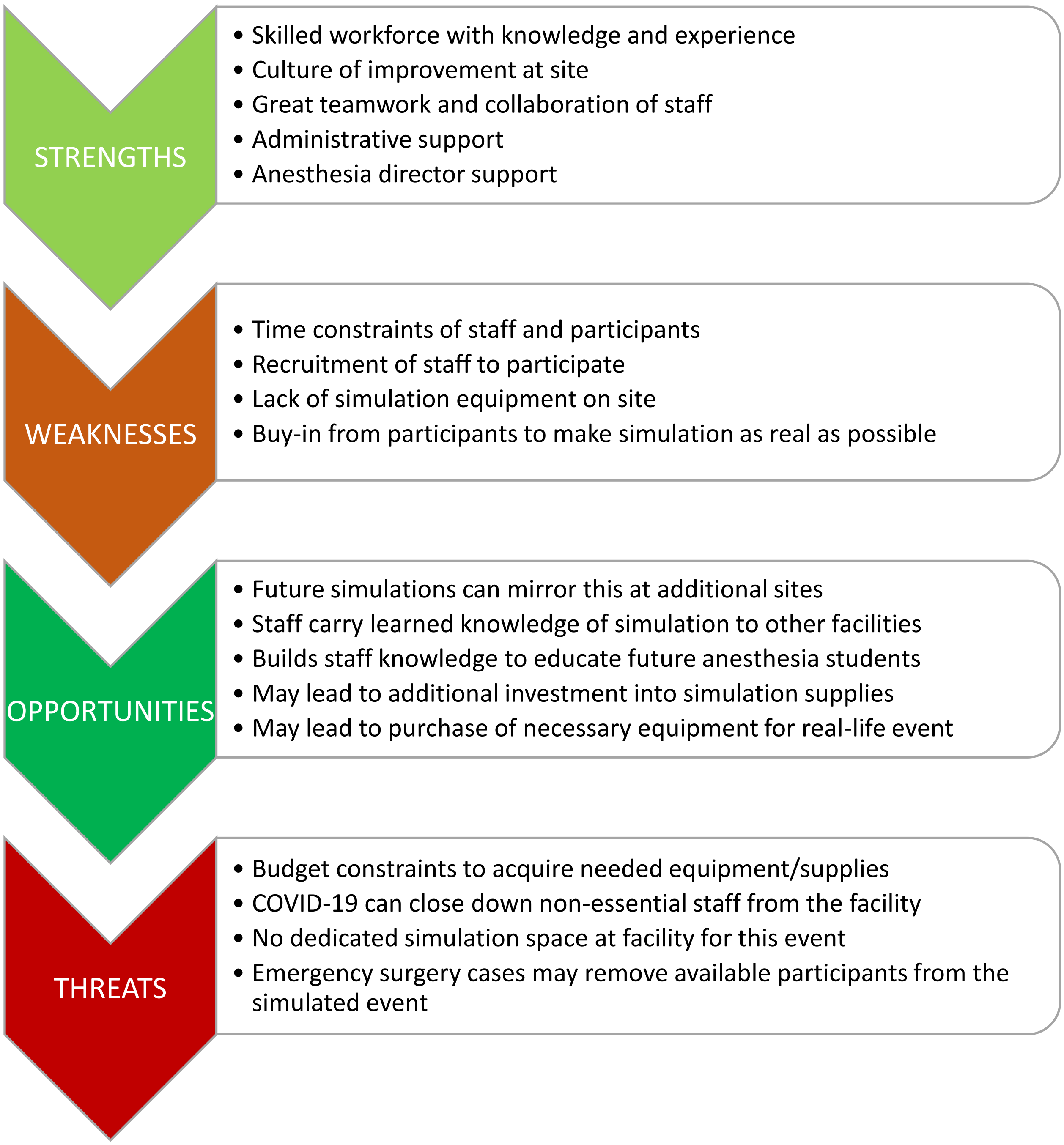
3) Which method for surgery would be acceptable for a patient with a history of malignant hyperthermia?
    a. General anesthesia without triggering agents
    b. Regional anesthesia
    c. Local anesthesia
    d. All the above

4) True/False Patients who experienced a MH event should be monitored in the ICU for 24 hours?

5) Which of the following are symptoms of malignant hyperthermia? (Select all that apply)
    a. Fever
    b. Tachycardia
    c. Increased EtCO2
    d. Masseter muscle spasm

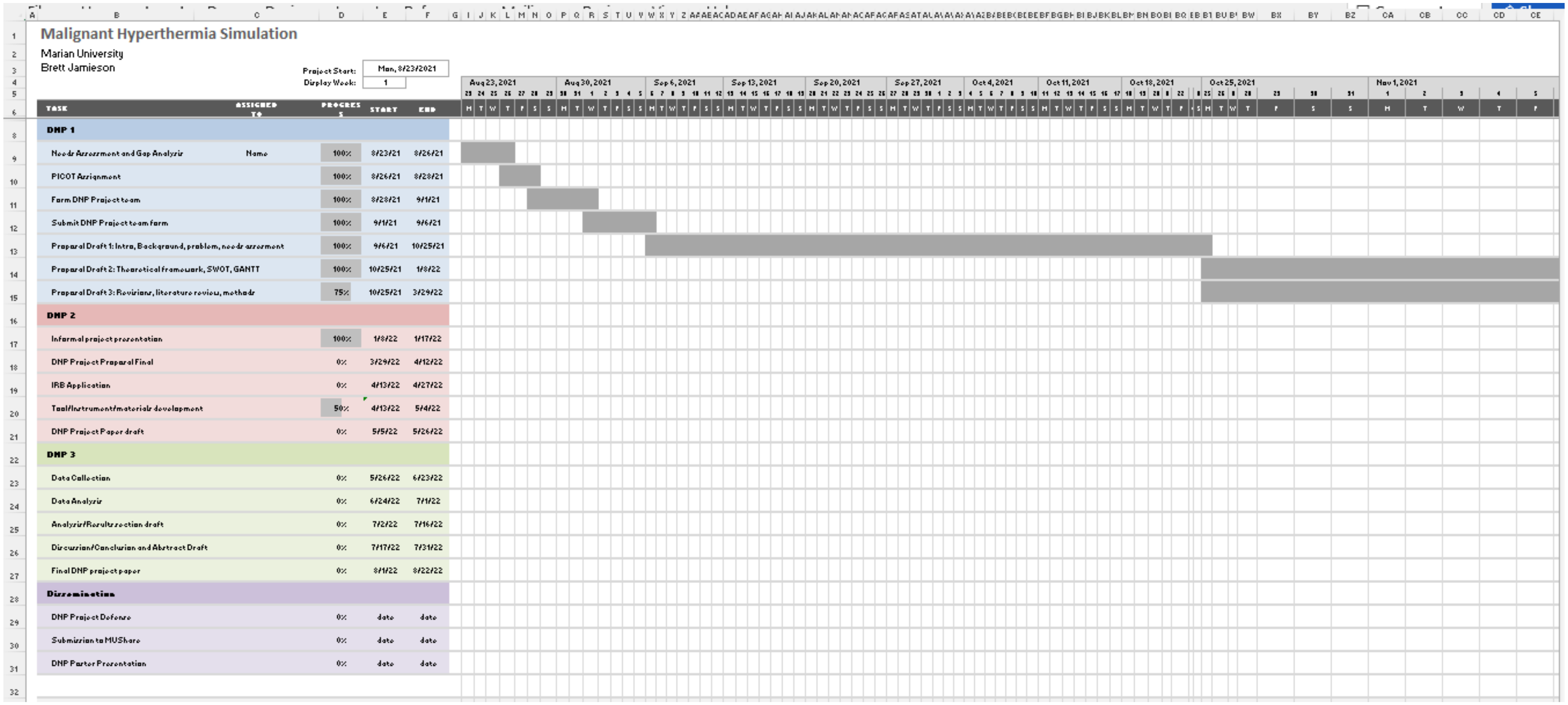
Appendix D

SWOT Analysis



Appendix E

GANTT Chart



Malignant Hyperthermia Simulation

Marian University

Brett Jamieson

Project Start: Mon, 8/23/2021

Display Week: 1

TASK	ASSIGNED TO	PROGRESS	START	END
DNP 1				
Needs Assessment and Gap Analysis	Name	100%	8/23/21	8/26/21
PICOT Assignment		100%	8/26/21	8/28/21
Form DNP Project team		100%	8/28/21	9/1/21
Submit DNP Project team form		100%	9/1/21	9/6/21
Proposal Draft 1: Intro, Background, problem, needs assessment		100%	9/6/21	10/25/21
Proposal Draft 2: Theoretical framework, SWOT, GANTT		100%	10/25/21	1/8/22
Proposal Draft 3: Revisions, literature review, methods		75%	10/25/21	3/29/22
DNP 2				
Informal project presentation		100%	1/8/22	1/17/22
DNP Project Proposal Final		0%	3/29/22	4/12/22
IRB Application		0%	4/13/22	4/27/22
Tool/Instrument/materials development		50%	4/13/22	5/4/22
DNP Project Paper draft		0%	5/5/22	5/26/22
DNP 3				
Data Collection		0%	5/26/22	6/23/22
Data Analysis		0%	6/24/22	7/1/22
Analysis/Results section draft		0%	7/2/22	7/16/22
Discussion/Conclusion and Abstract Draft		0%	7/17/22	7/31/22
Final DNP project paper		0%	8/1/22	8/22/22
Dissemination				
DNP Project Defense		0%	date	date
Submission to MUShare		0%	date	date
DNP Poster Presentation		0%	date	date

Appendix F Literature Review

Reference in APA format	Level of Evidence	Variables	Sample	Instruments	Results
Bansal, V.K., Dobie, K.H., & Brock, E.J. (2019). Emergency response in the ambulatory surgery center. *Anesthesiology clinics, 37*(2), 239-250.	Level VII, Expert Opinion	The impact of simulation	The participants were full time first year undergraduate students (n = 9) undertaking the RN BSc (Hons) Adult Nursing program, nurse educators (n = 3) who facilitated simulation sessions and registered nurse mentors (n = 4) who supported students in practice.	A small-scale narrative case study. Semi-structured interviews by telephone and via e-mail. The interviews were tape recorded and transcribed verbatim. Video recordings of student simulation experiences.	Data analysis through progressive focusing revealed that the nurse educators viewed simulation as a means of helping students to learn to be nurses, whilst the nurse mentors suggested that simulation helped them to determine nursing potential. The students' narratives showed that they approached simulation learning in different ways resulting in a range of outcomes: those who were successfully becoming nurses, those who were struggling or working hard to become nurses and those who were not becoming nurses.
Clebone, A., Watkins, S.C., & Tung, A. (2020). The timing of cognitive aid access during simulated pediatric intraoperative critical events. *Paediatric anaesthesia, 30*(6), 676-682.	Level II- retrospective randomized control trial	Use of a cognitive aid or not during an intraoperative event	89 anesthesia clinicians in 143 intraoperative events	Cognitive aid from the Society for Pediatric Anesthesia	Use of a cognitive aid after implementing critical interventions improves emergency event management
Gallegos, E., & Hennen, B. (2022). Malignant hyperthermia preparedness training: Using cognitive aids and emergency checklists in the perioperative setting. *Journal of perianesthesia nursing: official journal of the American Society of PeriAnesthesia Nurses, 37*(1), 24-28.	Level III- Quasi experimental	Use of a cognitive aid and individual perceptions of use of a device during an emergency	Convenience sampling. n=13, perioperative staff	Stanford emergency manual cognitive aid	Improvement perception of the use of a cognitive aid as well as increased likelihood of utilizing a cognitive aid during a malignant hyperthermia event
Hardy, J.B., Gouin, A., Damm, C., Compere, V., Veber, B., & Dureuil, B. (2018). The use of a checklist improves anaesthesiologists' technical and non-technical performance for simulated malignant hyperthermia management. *Anaesthesia, critical care & pain medicine, 37*(1), 17-23.	Level II, Randomized control trial	Use of checklist during a simulated MH event	n=24 anesthesiologists divided into 2 groups, one with a checklist for MH treatment and no checklist/control group	Use of the French Society of Anaesthesia and Intensive Care checklist for Malignant Hyperthermia crisis	Anesthesiologist treatment and initial bolus of dantrolene for a MH crisis was completed faster with the group using a MH checklist than the control group. Reduction of medical errors, improved communication, and improved treatment of symptoms occurred with the crisis checklist group as well.

Kim, T.W., Singh, S., Miller, C., Patel, S., Koka, R., Schiavi, A., &Schwengel, D. (2019). Efficacy and cost comparison of case-based learning to simulation-based learning for teaching malignant hyperthermia concepts to anesthesiology residents. *The journal of education in perioperative medicine: JEPM, 21*(4), E631.	Level II- Randomized control trial	Simulation based learning group and case-based learning groups	n=54 anesthesia residents varying in years 1-3 of experience within residency	Pre- and posttest developed by Johns Hopkins residency faculty and approved for use by the Malignant Hyperthermia Association of the United States (MHAUS)	Both the case-based and simulation-based learning groups demonstrated similar learning and test results in the post test immediately following the experience as well as in 4-month follow-up posttest scores. Simulation-based learning was calculated to be a 17-fold increase in cost expense over case-based learning methods
Matsco, M., Marich, M., & Parke, P. (2020). Setting the foundation for an in situ simulation program through the development of a malignant hyperthermia simulation in the operating room. *Journal of continuing education in nursing, 51*(11), 523-527.	Level V- Case study	Simulation-based educational case study	Case study, educational simulation	Debriefing tool following simulated MH event	Participants and administration enjoyed the learning environment reflected in a simulated event. Since the simulated MH event, this led to additional simulated events within the health system to help educate staff on necessary treatment protocols and emergency management.
Quick, J., Murthy, R., Goyal, N., Margolis, S., Pond, G., &Jenkins, K. (2017). Malignant hyperthermia: An anesthesiology simulation case for early anesthesia providers. *MedEdPortal: the journal of teaching and learning resources, 13,* 10550.	Level VI-Qualitative study	Individual assessment of reception of educational style, opinions of simulation design, and knowledge gained.	n=24 medical students with 2 weeks of anesthesia training	Pre and post survey, open-ended questions designed to elucidate participant feedback	The simulation was well-received by participants and a good methodology of how to educate/simulate rare emergency crisis that may occur within the operating room.
Schaad, S. (2017). Simulation-based training: malignant hyperthermia. *AORN journal, 106*(2), 158-161.	Level III-Quasi experimental design	Instructor/simulation variation depending on which of the four simulation groups the participant was placed in	n= >100 staff members	An educational PowerPoint presentation prior to the simulation, checklist during the simulation of important points, a debriefing session immediately following the simulation to better assess strengths/weaknesses and address important educational takeaways	The use of malignant hyperthermia simulation improved teamwork and collaboration among the OR staff when encountering an emergency. Staff members better understood their roles and the importance of the other team members during a MH crisis. Improved clinical competency and recognition of MH symptoms occurred.
Shear, T.D., Deshur, M., Benson, J., Houg, S., Wang, C., Katz, J., Aitchison, P., Ochoa, P., Wang, E., & Szokol, J. (2018). The effect of an electronic dynamic cognitive aid versus a static cognitive aid on the management of a simulated crisis: A randomized controlled trial. *Journal of medical systems, 43*(1), 6.	Level II- Randomized control trial	Using an electronic cognitive aid during the simulation or using a printed out cognitive aid	n= 34 second and third year anesthesia residents, 19 in the static cognitive aid group and 15 in the electronic cognitive aid group	Electronic cognitive aids and static cognitive aids utilized during MH simulation	Use of an electronic cognitive aid facilitated more checklist items to be correctly performed when compared to a static cognitive aid, this included proper dosing of the first line medication treatment of dantrolene.

Thompson Bastin, M.L., Cook, A.M., & Flannery, A.H. (2017). Use of simulation training to prepare pharmacy residents for medical emergencies. *American journal of health-system pharmacy: AJHP: official journal of the American society of health-system pharmacists, 74*(6), 424-429.	Level III- Quasi experimental design	Survey results after completing three separate emergency preparation simulation training scenarios.	n=13, 9 PGY1 pharmacy residents, 4 PGY2 pharmacy residents	Evaluations on simulation training based on three specific areas of simulation training: bleeding and malignant hyperthermia, sepsis, and stroke and status epilepticus.	Simulation training for medical emergencies including malignant hyperthermia improved pharmacy residents perceived preparedness both immediately after and at a 6 month post-simulation mark

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