The Effect of Simulation-Based Training vs. Web-Based Education on Anesthesia Provider Confidence in the Perioperative Management of Malignant Hyperthermia

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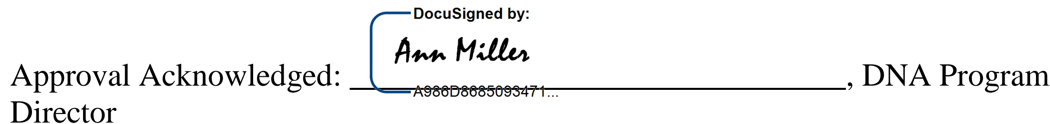

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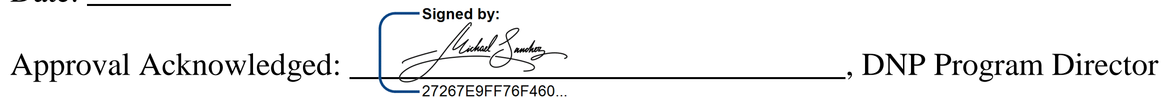

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Abstract

Background

Malignant hyperthermia (MH) is a life-threatening hypermetabolic condition triggered by volatile anesthetic gases and succinylcholine, causing excessive calcium release and muscle contraction. Genetic predisposition is marked by autosomal dominant inheritance in RYR1 and CACNA1S genes. Symptoms include increased end-tidal CO2, hyperthermia, tachycardia, and dark urine and can lead to severe complications and death. While MH inheritance is rare (1 in 100,000), genetic susceptibility is more common (1 in 2,000 to 1 in 3,000). Timely recognition is challenging due to varied symptom onset and masked symptoms. Simulation-based team training (SBTT) enhances clinical skills and teamwork, with semiannual MH drills recommended. The American Association of Nurse Anesthesiology (ANAA) suggests ongoing competency education and crisis team training through simulation to improve MH recognition and management, and patient outcomes.

Method

This was a quasi-experimental project with a pretest and posttest design. One benefit of using a pretest and posttest study involves the clear sequencing of the research process. It involves assessing a dependent variable (such as knowledge or attitude) before and after introducing an independent variable (like training or an informational session). While this resembles a traditional experimental design, it leans towards quasi-experimental methods because the participants typically are not randomly assigned. As a result, this design also aligns with correlation. Due to its quasi-experimental nature, it is challenging to establish direct causality in the outcomes; instead, connections between interventions and outcomes are inferred as associations.

Results

In a pre-survey of 14 participants, 71% correctly identified Malignant Hyperthermia Association of the United States (MHAUS) as the organization responsible for MH management, and high awareness of MH signs and symptoms was demonstrated, with 93% identifying muscle contraction, 100% tachycardia, and 93% masseter rigidity. Post-survey results showed improvements, with 92% correctly identifying MHAUS and similar high recognition of symptoms. Confidence in managing MH increased, with 77% strongly agreeing they could recognize symptoms and 85% strongly agreeing they knew the steps to take if a patient exhibited MH symptoms. All participants believed simulation training was more effective than web-based training in improving their ability to recognize and treat MH.

Discussion

This quality improvement project demonstrated significant improvements in knowledge, confidence, and preparedness in recognizing and managing MH among anesthesia providers. Key findings include increased correct responses regarding MH signs, symptoms, and treatments post-training, with 92% correctly identifying MHAUS and 100% identifying masseter rigidity. Confidence in recognizing MH signs rose from 71% to 77%, and all participants believed simulation training was more effective than web-based training. The study highlighted the benefit of simulation training, particularly for new graduates, in enhancing clinical competence and preparedness. These results

align with other research indicating the effectiveness of high-fidelity simulation in improving clinical skills and knowledge.

Keywords
Malignant hyperthermia, simulation, confidence, malignant hyperthermia management

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The Effect of Simulation-Based Training vs. Web-Based Education on Anesthesia Provider Confidence in the Perioperative Management of Malignant Hyperthermia

Introduction

Malignant hyperthermia (MH) is a rare but life-threatening complication that can occur during anesthesia. It is a hypermetabolic state that can lead to muscle rigidity, hyperthermia, acidosis, and potentially fatal cardiac arrhythmias. The precise occurrence rate of MH remains uncertain. Epidemiological investigations indicate that MH occurs in approximately 1 out of every 100,000 surgical cases among adults and about 1 out of every 30,000 surgical procedures in children. [1] The problem for anesthesia providers when managing malignant hyperthermia is that it requires prompt recognition, diagnosis, and treatment to prevent serious complications or death. MH can be difficult to diagnose and treat and requires a coordinated and multidisciplinary team approach. Failure to recognize and manage MH promptly can result in serious harm to the patient. As such, anesthesia providers must be highly trained and equipped to manage MH effectively. Regular simulation training can help anesthesia providers recognize and manage MH more effectively and smoothly, leading to better patient outcomes.

Purpose and PICO Question

This quality improvement project aimed to increase staff skills in MH signs and symptoms recognition, improve the staff knowledge of and confidence in the prompt treatment of MH, improve patient outcomes, and improve interdisciplinary communication. The plan was for a semiannual in-situ simulation for all anesthesia staff, in which a high-fidelity mannequin simulated an episode of MH. The plan, do, check, act model was utilized to plan and implement this project.

The PICO question was: For anesthesia providers (P), does semiannual simulation training (I) compared to the sole use of web-based educational training (C) improve overall perioperative management of malignant hyperthermia (MH) care and provider confidence (O)?

Problem Statement

Anesthesia providers have admitted to a lack of confidence in recognizing and treating MH in the OR, which may lead to poor patient outcomes, increased hospital costs, and decreased provider confidence and morale. The consequences of not addressing the issue of inadequate recognition and treatment of malignant hyperthermia can be severe and life-threatening; therefore, this issue should be evaluated.

Problem Identification

The under-recognition of MH is not a common occurrence but is considered a HILF, or high-impact, low-frequency, event characterized by a low probability of happening but potentially severe consequences. The primary concern revolves around the anesthesia providers' ability to identify and address MH during surgical procedures swiftly, coupled with a deficiency in confidence levels. Factors hindering immediate intervention encompass delayed recognition of MH, delayed readiness for administering dantrolene, and inadequate training in managing MH during critical scenarios.[2] In one cross-sectional study that surveyed Chinese anesthesiology providers, many respondents lacked awareness of the standard diagnosis and treatment protocols for malignant hyperthermia.[3] However, most demonstrated good knowledge regarding the drugs and clinical symptoms associated with malignant hyperthermia.[3] Tan et al. revealed that many anesthesiologists faced challenges such as limited access to dantrolene, insufficient

confidence in diagnosing and treating malignant hyperthermia, difficulties seeking professional assistance, and poor teamwork when dealing with malignant hyperthermia emergencies.[3] Additionally, the findings confirmed the inadequate training of Chinese anesthesiologists in managing malignant hyperthermia cases.[3] Although these results are reflective of the Chinese anesthesia providers, they are applicable to anesthesia providers globally, as malignant hyperthermia manifests uniformly. Timely recognition has proven difficult because of the variability of symptom onset, followed by the fact that symptoms may be masked by other intravenous drugs, including paralytics and beta-blockers, and because symptoms often mimic other processes such as sepsis, neuroleptic malignant syndrome, pain, and febrile nonhemolytic transfusion reactions.[4]

Background

Malignant hyperthermia is a hypermetabolic state caused by a triggering event such as the administration of volatile anesthetic gases and succinylcholine. This causes an excessive release of calcium in the cell and consistent muscle contraction and patient rigidity. The pathophysiology of MH is significantly influenced by two key components: the ryanodine receptor RYR1 found on the sarcoplasmic reticulum membrane and the voltage-gated calcium channel Cav 1.1 situated in the T-tubular membrane of myocytes. [5] The genetic predisposition to MH is marked by an autosomal dominant mode of inheritance in the RYR1 and CACNA1S genes.[5] Other signs and symptoms of MH include a sudden increase in end-tidal CO2, hyperthermia, tachycardia, dark urine, ventricular fibrillation, excessive bleeding, severe rhabdomyolysis, and death. Studies have shown that the first clinical symptoms are usually hypercarbia, sinus tachycardia, masseter spasm, and hyperthermia.[6] The incidence rate is estimated to be about 1 in

100,000 patients, with a mortality rate reaching 70%-80% without prompt recognition and treatment, illustrating this event to be a high-impact, low-frequency event.[2, 4]

Nonetheless, the actual frequency of individuals susceptible to MH is significantly greater, primarily because many individuals with genetic mutations linked to MH do not undergo anesthesia procedures throughout their lifetime. Estimates of genetic prevalence suggest a range of susceptibility between 1 in 2,000 to 1 in 3,000.[6,7]

No single clinical symptom is exclusive to an MH crisis. As a result, it is essential to maintain a broad range of differential diagnoses. Numerous medical conditions can exhibit similar symptoms, many of which are more common occurrences in the OR. Nevertheless, even though MH crises are rare, the key to ensuring positive patient outcomes is to remain vigilant and initiate treatment as promptly as possible. These factors explain why timely recognition has proven to be difficult; the variability of symptom onset proves to be the biggest reason, followed by the fact that symptoms may be masked by other intravenous drugs, including paralytics and beta-blockers, and because symptoms often mimic other processes such as sepsis, neuroleptic malignant syndrome, pain, and febrile nonhemolytic transfusion reactions.[4]

In a systematic review and meta-analysis, Panagioti et al. found that about 1 in 20 patients experience preventable harm while receiving medical treatment in the hospital.[8] Heuer et al. purported that simulation can improve participant confidence and lead to short-term improvement of clinical skills and interdisciplinary teamwork skills.[9] Further, Bienstock and Heuer explained that disciplines commonly train within their realm but rarely is interdisciplinary training completed together.[9] They stated that simulation-based team training (SBTT) has progressed the general evolution of simulation training,

resulting in better teamwork, communication, and improved non-technical human factors.[9] SBTT emphasizes individual and team conduct in everyday situations and high-pressure crises, all while giving significant attention to honing decision-making abilities, interpersonal interactions, and effective team leadership. Good teamwork and interprofessional cooperation are imperative in improving clinical performance and patient outcomes. The effectiveness of medical simulation is widely acknowledged, and its use for HILF events can enhance familiarity and offer practical exposure. The Malignant Hyperthermia Association of the United States (MHAUS) recommends that teams engage in simulated drills for MH annually, while the Anesthesia Patient Safety Foundation (APSF) recommends training every 6 months to confirm that the staff maintains muscle motor memory and learns the most updated guidelines and recommendations. That said, it would be prudent for hospitals to run semiannual MH in-situ simulations in the OR to increase staff confidence and proficiency in MH recognition and treatment.

The American Association of Nurse Anesthesiology suggests incorporating ongoing and annual competency education, including malignant hyperthermia crisis team training for the operating room (OR), post anesthesia care unit (PACU), and intensive care unit (ICU) teams; this will prepare the team to identify, respond to, and manage crises.[10] Simulation-based training should be developed to enhance and supplement the web-based competency classes most institutions already have in circulation. Introducing new simulation-based training mechanisms has allowed its learners to augment their skills, especially when opportunities for direct patient interaction are limited, as in malignant hyperthermia crises.[11] By creating a safe and controlled learning environment,

simulation enables learners to develop abilities in areas that may not be adequately addressed through traditional patient interactions.[11] Simulation offers an opportunity to evaluate and improve teamwork, leadership, situational awareness, and decision-making skills by simulating crisis management scenarios.[11] Collaboration and interprofessional cooperation are imperative in improving clinical performance and patient outcomes. As such, anesthesia providers must be highly trained and equipped to manage malignant hyperthermia effectively. Regular simulation training can help anesthesia providers recognize and address this emergency more effectively and smoothly, leading to better patient outcomes.

Scope of the Problem

A recent investigation that analyzed a comprehensive dataset of 9,745,539 inpatient discharge records revealed that the overall prevalence of MH was 1.68 cases per 100,000; in contrast, for surgical inpatient discharges, the prevalence was slightly higher at 2.37 cases per 100,000.[4] Notably, a greater incidence of MH was observed among surgical inpatient discharges. Additionally, it was observed that 11% of the 164 patients diagnosed with MH died.[4] In another study of 1,238,171 patients who underwent general anesthesia, the prevalence of MH was 1.37 cases per 100,000, and the fatality rate among MH-diagnosed patients in this study was 6%.[4] While malignant hyperthermia is rare, the consequences of delayed medical intervention resulting from inadequate recognition or knowledge of treatment are devasting. To illustrate, malignant hyperthermia has an alarming mortality rate of about 70%-80% when treatment is insufficient.[2,4] The institution of simulated experiences can instill provider knowledge and confidence to manage a malignant hyperthermia crisis appropriately.

Consequences of the Problem

The consequences of not addressing inadequate recognition and treatment of malignant hyperthermia can be severe and life-threatening. Anesthesia providers must be well-informed of clinical manifestations of MH because swift and accurate early diagnosis and prompt, appropriate management are of utmost importance for the survival of MH patients. The data unequivocally demonstrate that delays in diagnosing MH and commencing dantrolene treatment elevate the likelihood of complications.[4] The incidence rate is estimated to be about 1 in 100,000 patients, with a mortality rate of 70%-80% without prompt recognition and treatment.[2,4] Given these considerations, it would be wise for hospitals to conduct semiannual simulations of MH in the OR to enhance the confidence and preparedness of the staff in identifying and managing this condition.

Knowledge Gaps

After reviewing the literature, some gaps in knowledge should be addressed. There needs to be more information on the average delay between diagnosis and treatment of MH. What is the average time between the recognition of symptoms, diagnosis of MH, and the administration of dantrolene or Ryanodex? Such timeframes would serve as significant measures or indicators of workflow and trends; over time, these trends would denote improvement or decline in recognition and treatment.

Further, as the utility of simulation in healthcare becomes increasingly prevalent, there is a growing need for research that evaluates the effectiveness of simulation-based education compared to traditional, well-established training approaches. There is extensive documented evidence regarding the significance of simulation-based education and its impact on confidence and learning within the healthcare domain. However, a

notable gap in research exists in how simulation-based education translates to improved patient outcomes. It is imperative to gain a deeper understanding of how non-technical skills such as confidence and self-assurance develop through simulation, compared to other forms of training, yielding heightened patient safety and clinical outcomes during medical emergencies.[12]

Proposed Solution

Integrating semiannual in-situ simulation training as a component of the institutional competency-based education for anesthesia providers will serve to mitigate delayed recognition and treatment and bolster confidence in managing MH. Specifically, one OR suite will be designated for simulation throughout the day, where a simulated MH event will be repeatedly executed. OR teams comprised of the surgeon, circulating nurse, surgical technician, anesthesia provider, anesthesia technician, and any accompanying students or residents will rotate through the simulated events to complete the competency-based training. A high-fidelity mannequin will be employed for these simulations, enabling the programming and accurate display of various signs and symptoms. The team's task will involve simulating a surgical procedure while verbally articulating the signs and symptoms as they manifest. The team leader will be pivotal in assigning responsibilities and guiding the patient's treatment and care during the simulation. Following the simulation exercise, the team will engage in a debriefing session with the individual overseeing the simulation. During this debrief, participants will gain insights into the nature of MH, the key signs and symptoms to be vigilant about, the appropriate treatment protocols, and MH cart content and locations. Furthermore, the

session will address communication techniques. Ideally, this semiannual simulation initiative will evolve into a routine periodic training requirement for the OR staff.

The quality initiatives will be measured by a qualitative descriptive approach via pre- and post-simulation questionnaires completed by staff partaking in the simulation. The pre-simulation questionnaire will uncover the team members' baseline knowledge of MH, perceived confidence level in recognizing MH, and preparedness in managing MH. The post-simulation questionnaire will ask the same questions and ask for feedback on the simulation experience to modify future iterations of the exercise. If there is a sequential actual occurrence of MH, quantitative metrics will be compared to pre-simulation episodes of MH (if available) to see any improvements in treatment efficacy.

The participants will complete pre-simulation questionnaires, and simulation will ensue. To ensure measurements used in the project are reliable, intervention fidelity will be monitored by a checklist to ensure all components of the MH simulation are hit. Debriefing will allow some time for participants to reflect on cognitive processes and self-assess performance in treating MH. Post-simulation surveys will be completed. Actual future MH episodes' clinical outcomes will be compared to pre-simulation outcomes, should there be any actual events to relate to. The operational definition for clinical outcomes will be a measurement of the time frames from recognition of symptoms, diagnosis of MH, and administration of Dantrolene or Ryanodex. This definition will help further improve the data collection's validity by reducing measurement errors. Reliability is present as the research question and methods align with the objectives; it will be assessed by comparing findings with existing literature.

Summary

The question that was examined was: For anesthesia providers, does supplemental semiannual simulation training improve provider confidence and overall management of malignant hyperthermia (MH) care during surgery compared to the sole use of web-based educational training?

MH is an infrequent yet potentially fatal complication that may arise during surgery. Swift recognition of symptoms and immediate treatment are paramount to safeguard the most favorable outcome for the patient. Diagnosis is often missed because it mimics other issues, including neuroleptic malignant syndrome and sepsis. It has been shown that simulation-based education increases confidence in performance and short-term skill enhancement. It also improves interprofessional teamwork, communication, and non-technical human factors. With that being said, semiannual simulation of malignant hyperthermia in the operating room will enhance early MH recognition and treatment and bolster anesthesia provider confidence, thereby yielding positive patient outcomes.

Literature Review

This literature review aims to investigate current research on malignant hyperthermia education and provider confidence in diagnosis and treatment. The PICO components listed were utilized for the literature search.

- Population – Anesthesia providers
- Intervention –Simulation-based training in the recognition and treatment of MH
- Comparison – Web-based educational training
- Outcomes – Improvement in perioperative management MH care and provider confidence

Eligibility Criteria

The research articles considered in this literature review underwent inclusion criteria checks to guarantee the credibility of the presented evidence. The search was restricted to articles published in English in 2017 or later. The inclusion criteria for this project included full-text articles on topics that discussed malignant hyperthermia, simulation training, and/or crisis management. Papers were excluded if they were written in a language other than English and did not offer a full-text article.

Information Sources

This search was conducted from January 2023 to August 2023, and the databases included for this search included CINAHL, Scopus, and PubMed. In addition, a Google Scholar search was conducted. To improve the chances of finding all pertinent studies, the reference lists of all the articles retrieved were thoroughly examined. Databases and articles were accessed through the Florida International University library web portal services.

Search Strategy

The following search terms were used and were placed in a combination of ways utilizing Boolean operators AND and OR:

- Malignant hyperthermia
- Crisis management
- Simulation training
- High-fidelity training
- Emergency management
- Simulation-based education

The relevance of each retrieved article was evaluated by examining its abstract. If further review was needed, the complete article was read. The inclusion and exclusion criteria were applied to filter out papers that did not pertain to this article. Following the initial search, all subsequent articles retrieved were cross-referenced, and duplicates were removed. A critical appraisal of the research was completed with the retracted information placed in a literature review matrix.

Critical Review of Literature

Malignant hyperthermia (MH) is a life-threatening and rare pharmacogenetic disorder that is triggered using volatile anesthetics.[4] According to Klincová et al.,[5] the most typical symptoms of the condition include tachycardia, hypercapnia, muscle rigidity, hyperthermia, and the possible cause of hyperpyrexia and rhabdomyolysis in PICU. Considering that it is triggered by volatile anesthetics that result from anesthesia providers, it is classified as a preventable harm among the patients. The study by Panagioti et al.[8] highlighted that in anesthesia service provision, preventable patient harm could be 25% for incidences related to drugs and other treatments. Thus, MH is one of the preventable conditions despite the condition being difficult to establish a diagnosis. However, prompt diagnosis and treatment of the condition are required to ensure that fatal outcomes are avoided to ensure the safety of the patients.[4,5]

One issue that impacts the condition is the lack of awareness and limited knowledge of the condition from the anesthesia providers.[3] Limited information about the difficulties that the anesthesia providers encounter while diagnosing and managing MH means that an improvement in diagnosis and management of the condition becomes difficult. The cross-sectional study by Tan et al.[3] established that lack of competency in

managing the disease, difficulty in obtaining the dantrolene, poor teamwork, and difficulty in getting professional help were some of the main problems that anesthesia providers face in diagnosing and managing MH. Thus, awareness must be created through training and development for anesthesia providers to improve their knowledge and skills in diagnosing and managing MH to improve the patients' safety in accessing anesthesia services.

Studies have suggested the use of high-fidelity simulation training to help in the diagnosis and management of MH.[12-20] According to Heuer et al.,[13] simulation-based training uses real and true-to-life learning environments similar to real-life healthcare situations. In their systematic reviews, the authors established that simulation-based training among allied health professionals improves subjective measures such as short-term skills, confidence, and sustained skill enhancement.[13] In life-threatening conditions and emergencies, high-fidelity simulation-based training improves knowledge and performance among healthcare professionals.[12] However, the study by La Cerra et al.[12] indicates that further studies are needed to explore the effectiveness of the high-fidelity simulation-based training on the competence of healthcare providers and patient outcomes. This is answered by research by Henrichs et al.[14], who found that among student nurse anesthetists, high-fidelity simulation training improves the overall patient outcomes and performance of the participants in anesthetic emergencies. The results from the studies by Heuer et al. and Henrichs et al. are further confirmed by Baptista et al.,[15] who established that nursing students who take part in high-fidelity simulation training are more satisfied with the learning process as it results in improved decision-making and more recognition.

McCoy et al.[16] compared simulation-based and standard training for medical students in high-quality cardiopulmonary resuscitation. The study established that students who underwent high-fidelity simulation training could adhere to the AHA guidelines more closely than those who underwent standard training. This shows that high-fidelity simulation training is superior to standard emergency training. Tallo et al.[17] reported similar results and compared three methods of training students for mechanical ventilation in emergency settings. The authors found that simulation for mechanical ventilation in emergency settings offers long-lasting knowledge compared to the other types of training for the students. Fischer et al.[18] also found the same results: the students in their study who were trained using simulation had improved knowledge, better clinical skills, and better interpretation of real clinical cases than students trained using traditional face-to-face teaching. This means that the students can deal with real-time emergency scenarios as they have better knowledge and skills. In another study by McCutcheon et al.[19], blended learning, including simulation-based learning, offered more pedagogical value than online learning in educating undergraduate nurses about clinical supervision skills. In determining the stressors-related clinical simulation, Boostel et al.[20] found that simulation affects the students' perception of stressors, resulting in improved self-evaluation and critical thinking on the responsibility associated with learning.

Overall, the studies show that high-fidelity simulation training would benefit anesthesia providers by improving their awareness and knowledge of the diagnosis and management of MH. This will ensure that the patient's safety is protected so that MH does not threaten the patients' lives. Safety is critical for patients requiring anesthesia, and improved knowledge and awareness for anesthesia providers in the diagnosis and

management of MH means that there will be better management of the condition, enhancing the safety and quality of the services, especially the recognition after using volatile anesthesia.

Please see the literature review tables on the next page.

Citation	Design/Method	Sample/Setting	Major Variables Studied and their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Tan L, Yu H, Yan J, et al., 2023. The knowledge profile, competence and pending problems of Chinese anesthesiologists in dealing with malignant hyperthermia: a cross-sectional study.	Cross-sectional study that consisted of an online, self-administered, electronic questionnaire survey to determine the competency and pending problems about MH.	The survey was extensively circulated among anesthesiologists, ensuring that questionnaires were dispatched to at least one medical facility in every province and municipality throughout China, with the exception of Hong Kong, Macao, and Taiwan.	The questionnaire consisted of 4 parts. The first section contained inquires related to the participants' knowledge of MH, encompassing symptoms, diagnosis, treatment, and their personal clinical approaches for managing MH. The third section focused on the participants' competence in MH management, including familiarity with MH clinical grading scores, confidence in identifying MH patients, and confidence in handling MH crises. Response	Statistical analyses were carried out with SPSS version 25.0. The data were described using frequencies, percentages, and the mean with its corresponding standard deviation. To assess variances between participant groups, independent samples *t*-tests, chi-square tests, or rank-sum tests were employed. A significance level of less than 0.05 was deemed as statistically significant for all the tests.	Questionnaires were completed and submitted by 1511 anesthesiologists, and 1357 of these were deemed valid. Out of the 1357 valid responses, a mere 2 participants managed to accurately respond to all 7 knowledge statements. Just under 84% of anesthesiologists claimed their hospital did not stock dantrolene for MH emergencies, and the preferred method of obtaining it was to borrow urgently from the nearest hospital.	When comparing the master's degree (MD) and PhD groups with the bachelor's degree (BD), it was observed that both the MD and PhD groups had a higher mean competency scores ($p = 0.002$ and $p = 0.004$, respectively). Additionally, anesthesiologists from secondary and lower-level hospitals received lower competency scores when compared to those from tertiary hospitals ($p = 0.003$ and $p = 0.006$, respectively). Moreover, there was a significant trend in the relationship between	This pioneering online survey, the first of its kind to investigate the competence and unresolved issues related to MH among anesthesiologists in China, reveals that the primary challenges faced by most anesthesiologists during MH crises are difficulties in procuring dantrolene, a lack of confidence in MH management, challenges in obtaining professional assistance, and deficiencies in teamwork.	The study design presents certain limitations. Because the research originated from West China Hospital of Sichuan University, it had an easier time publicizing and promoting the study in the Sichuan province, which led to 40.97% of respondents coming from this region. Additionally, a majority of the hospitals involved were tertiary hospitals, and there were fewer primary hospitals participating. Moreover, multiple anesthesiologists from the same hospital were

			options for these three aspects were presented on a 5-point Likert Scale, ranging from 1 (not competent at all) to 5 (extremely competent). The total competency score for each participant was calculated as the sum of their scores for these three questions. The final section required participants to assess the quality of current continuing education on MH.			professional titles and competency scores, which higher professional titles ($p < 0.001$). Of the 1357 respondents in total, only 31% mentioned that their hospital had provided MH continuing education. Concerning personal experience with MH simulation training, merely 27% had received such training within the past year, and 26.1% had undergone simulation training a year ago, and a substantial 46.9% had never received any simulation training. The most common methods of teaching were		encouraged to take part in the survey. These aforementioned limitations could introduce bias. Nonetheless, the authors believe that the hospitals included in the study represent medical institutions of various levels across different provinces in China, and the study still provides valuable insights into the state of MH rescue practices in the country.

						textbooks and literature (75.8%), web-based training (74.1%), and intra-departmental teaching (57.4%).		

Citation	Design/Method	Sample/Setting	Major Variables Studied and their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Yang L, Tautz T, Zhang S, et al, 2019. The current status of malignant hyperthermia.	This article was a review of current knowledge and is non-research-based.	The topic for review was malignant hyperthermia.	Topics discussed include the epidemiology, molecular mechanism, clinical presentation, diagnosis, diagnostic methods, and treatment.				MH is a rare event that arises from the release of calcium ions from the sarcoplasmic reticulum, which results in uncontrolled hypermetabolism in skeletal muscles. Genetic mutations in the RYR1 and CACNA1S genes have been identified as the underlying causes. The clinical presentation can vary significantly, making early diagnosis	Although this article had a low level of evidence, it provided current knowledge of MH, serving as a great foundation for MH-related research.

							challenging. Clinical diagnostic methods for MH involve the in vitro contracture test, and genetic testing.	

Citation	Design/Method	Sample/Setting	Major Variables Studied and their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Klincová M, Štěpánková D, Schröderová I, et al. 2022. Malignant hyperthermia in PICU – from diagnosis to treatment in the light of up-to-date knowledge.	This was a narrative review article that is non-research-based.	The article provided an overview of current knowledge and recommenda-tions regarding the identification, treatment, and further management of MH in the pediatric intensive care unit (ICU).	This article covered topics of concern regarding MH in the PICU including triggers, symptoms, and differential diagnosis. It discussed when MH can be encountered, the identification of patients at risk for MH, management, treatment, and lastly, follow-up care and diagnostics.				This comprehensive review compiled recent and pertinent information with the aim of bridging the knowledge gap for non-anesthesiology providers regarding MH. MH is an uncommon disorder that can lead to common symptoms such as hypercapnia, tachycardia, hyperthermia, and muscle stiffness. The key to successful treatment lies in initiating it at	Although this is provided a low level of evidence, it offered current knowledge of MH, serving as a great foundation for MH-related research. Further, it bridged the gap between anesthesia in the OR and the post-operative care.

							swiftly as possible, as early intervent-ion yields better patient outcomes. This involves identifying and eliminating triggers, administering dantrolene, initiating cooling measures, and addressing any adverse effects. Additionally, every suspected MH crisis should be referred to an MH diagnostic center, and the patient and their family should be kept informed.	

Citation	Design/Method	Sample/Setting	Major Variables Studied and their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
La Cerra C, Dante A, Caponnetto V, et al[1], 2019. Effects of high-fidelity simulation based on life-threatening clinical condition scenarios on learning outcomes of undergraduate and postgraduate nursing students: a systematic review and meta-analysis.	A systematic review and meta-analysis were conducted based on the Cochrane Handbook and its reporting was checked against the Preferred Reporting Items for Systematic Reviews and Meta-Analysis checklist.	The overall sample of nursing students (*n* = 3042) had sample sizes ranging between 17 and 352 participants composed of undergraduate students (85.7%) and post-graduate students (14.3%). They had a mean age of 25.7. The studies included in this meta-analysis were based on a quasi-experimental design with a pseudo-randomized allocation to	Studies used a variation of both HFPS (intervention group) and other training approaches (control group). Simulation sessions were based mainly on cardio-circulatory scenarios (54.5%) and respiratory scenarios (29.1%). Within the control group, most used lectures (31.1%), no intervention (24.4%), or low-fidelity manikin (11.1%).	Subjective outcomes, including satisfaction, self-confidence, and self-efficacy were measured by self-rating tools (i.e., Resuscitation Self-Efficacy Scale, Satisfaction with Clinical Experience Simulation Scale, etc.). Objective outcomes including knowledge and performance, were measured by direct observation or other objective instruments	As this was a systematic review and meta-analysis, individual results obtained by the statistical tests from each study were not included in this review.	HFPS sessions showed significantly larger effects for knowledge and performance than any other method of instruction. There was no significant difference between HFPS and control groups for satisfaction, self-confidence, and self-efficacy.	This systematic review assessed how HFPS impacts the learning outcomes of nursing students when exposed to scenarios involving life-threatening clinical conditions. Similar to previous reviews, HFPS appears to enhance students' understanding and their ability to perform tasks that are regarded as objective measures in existing	While the studies included exhibit strong internal validity, it's worth noting that only a limited number of them followed an experimental design. Therefore, given the potential for confounding factors and selection bias in the non-experimental studies, it's advisable to approach the results of this meta-analysis with caution, especially in

		groups (87.9%), while the rest of the studies were RCTs (12.1%). Studies were published from 2006-2017.		such as the ACLS Mega Code Performance Score Sheet and written examination. Three independent raters screened the retrieved studies using a coding protocol to extract data in accordance with inclusion criteria. For each study, outcome data were synthesized using meta-analytic procedures based on a random-effect model and computing effect sizes with a 95% CI.			literature. When considering competence as the combination of knowledge, performance, psychomotor skills, and clinical solving, it becomes evident that HFPS can be viewed as a significant instructional approach that can play a role in nurturing nursing competence.	light of the considerable heterogeneity observed. There was also a lack of data about the participants' characteristics, measurement tools, duration of the session and briefing and debriefing modalities; these limit the analysis and interpretation of results.

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Panagioti M, Khan K, Keers RN, et al.,[2] 2019, Prevalence, severity, and nature of preventable patient harm across medical care settings: systematic review and meta-analysis.	A systematic review and meta-analysis were conducted and reported in accordance with the Reporting Checklist for Meta-analyses of Observational Studies (MOOSE).	The authors included quantitative observational studies such as cohort (prospective or retrospective) and cross-sectional studies in any geographical area in any medical care setting published from 2000 onwards.	The primary outcome was the prevalence of preventable patient harm, which is defined as unanticipated, unforeseen accidents that are a direct result of the care dispensed rather than the patient's underlying disease. The second outcome was the severity and types of preventable patient harm, which were classified into mild, moderate, and severe.	Data was pooled in Stata 15 utilizing the metaprop command. Univariable and multivariable meta-regression analyses were done applying the metareg command to assess how study-level moderators influenced the occurrence of preventable patient harm. Moderators were selected and assigned codes through collaborative agreement, ensuring that	The search yielded 7313 citations. After removing duplicates and reviewing the titles and abstracts, 6522 were excluded. After full-article review, 241 more were excluded. In the end, 66 studies reporting 70 independent samples were included in the review.	There was a pooled sample of 337,025 patients; 28,150 of them experiences harmful incidences, and 15,419 experienced preventable harmful incidents. Fifty-five percent of these harmful incidences were preventable. The most common study design was retrospective or cross-sectional (71%), then prospective (29%). Fifty studies used a standardized Likert scale to	The authors results confirm that preventable patient harm represents a significant issue in various healthcare settings. Key areas that require immediate attention include reducing major causes of preventable harm, such as medication-related incidents, and greater focus on advanced medical specialties. It is important to also gather more evidence	This study has some limitations. First, the occurrence of preventable patient harm showed significant disparities among the studies, and these differences were only partially clarified by the meta-regression analysis. There are likely other pertinent factors that contributed to the unexplained diversity. Next, a crucial requirement for

				each moderator value was derived from a minimum of eight studies. Variables meeting the significance threshold ($p < 0.10$) were included in a multivariable meta-regression model. To account for situations where proportions were typically small, the Freeman-Turkey Double Arcsine transformation was used to stabilize variances. Subsequently, a random-effects meta-analysis was		facilitate the consensus decisions for the preventability of patient harm among the reviewers. The other 20 studies used implicit agreed criteria to reach consensus regarding the preventability of patient harm among the reviewers. The most common types of preventable patient harm were related to drugs, other therapeutic management, and invasive medical and surgical procedures. Preventable patient harm was more prevalent in	in areas like primary care and psychiatry, focusing on vulnerable patient populations, and addressing healthcare challenges in developing nations. Enhancing the criteria and methods for assessing and reporting preventability in future research is vital for the reduction of patient harm in medical care settings.	the review's practicability was that the published reports of the studies had to include information about preventable patient harm. Studies that did not contain data were excluded. However, in the majority of studies, the primary focus was on overall patient harm, with preventable patient harm being mentioned as a secondary aspect. Furthermore, only one-third of the studies conducted an analysis of the severity and

				conducted using the DerSimonian-Laird method.		patients treated in surgical and intensive care units compared with patients treated within across general hospitals.		types of preventable patient harm. There is indication that preventable patient harm is not merely a matter of public health but also results in a substantial opportunity cost. The additional duration of hospitalizations linked to medical mistakes is approximately 2.4 million hospital days, translating into an extra $9.3 billion in charges in the United States.

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Heuer A, Bienstock J, Zhang Y.[3] 2022, Simulation-based training within selected allied health professions (AHP): an evidence-based systematic review.	A systematic literature review, conducted in accordance with the PRISMA Statement	Criteria for inclusion are studies that use subjective and objective outcomes to evaluate simulation-based training (SBT); studies on method(s) of presimulation training, post-stimulation training, orientation processes, and/or debriefing assessment; studies published between 2010-2020	Data extracted from the articles included authors, publication date, study purpose, population, design, study intervention, study setting, primary results, and Cochrane risk of bias. The study setting is described as the specific place where the simulation occurred, while the practice setting is	In accordance with the PRISMA framework, a RoB assessment for each study was included and guided using the Cochrane Risk of Bias assessment tool.	All the studies included were deemed “unclear,” except for 3 which were “low RoB”, and 1 which was “high RoB.”	After applying eligibility criteria and conducting full-text reviews, 33 articles were included. Several of the studies were characterized as observational or mixed methods and designs other than randomized controlled trials (RCTs). The most common modalities of simulation were manikins (37%), a	Concerning the effects of SBT on outcomes, it seems that its influence is mainly observed in short-term objective measures, such as immediate skill enhancement following the simulation intervention, or subjective assessments like increased participant confidence. Studies focusing on SBT’s impact on more enduring	A practical implication from this study is the necessity for forthcoming research endeavors, especially well-designed, sufficiently powered RCTs that specifically investigate the utilization and effects of simulations in allief health.

		and those conducted in the US or Canada. Exclusion criteria included articles that do not analyze participation in SBT and instead generally discusses use and benefits; studies involving students, residents, doctor's and nurses; papers related to military/combat; books, conferences, and theses; studies that compare different equipment instead of addressing	defined as the specific location where AHP practice was discussed in each article. Specific terms where created, utilized, and defined for article assessment and data extraction. The terms were: subjective outcome, objective outcome, equipment, level of fidelity, study setting, and recording tool. Objective measures included procedural/performance success,			combination of manikins and simulated actor (33%). Most articles described used of high-fidelity manikins (82%), while the rest used low-fidelity. The most common setting was stationary simulation centers or laboratories (34%). 49% of the articles mentioned using audio and visual recording. 55% of the manuscripts reported only the use of objective outcomes measures. 18% of the	indicators like intermediate and long-term skill retention in these fields appear to be rare, and there were no studies found regarding improved patient outcomes because of SBT. This study has demonstrated that many AHPs are still embracing this method for improving their skills. However, it has also revealed substantial diversity in how and to what extent	

		outcomes; and studies written in languages other than English. All studies were placed in EndNote, duplicates were deleted, and full-text screening was completed.	errors, and skill retention. Subjective measures included participants' perceptions of skill performance, knowledge, safety, and confidence.			manuscripts reported only the use of subjective measures. 27% described using both. None of the articles reported quality patient outcome metrics such as length-of-stay or mortality.	AHPs employ SBT. Although the potential benefits of SBT seem encouraging, particularly in specific contexts like acute care, there remains a need for further investigation into the specific conditions that optimize its effectiveness.	

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Baptista RCN, Paiva LAR, Gonçalves RFL, Oliveira LMN, Pereira MCR, Martins JCA.[4] 2016. Satisfaction and gains perceived by nursing students with medium and high-fidelity simulation: a randomized controlled trial.	The design is a randomized control trial posttest design with control group. The researchers followed the guidelines of the Consolidated Standards of Reporting Trials (CONSORT).	The sample included fourth-year students pursuing a bachelor's degree in nursing who performed medium and high-fidelity simulated practice in a simulation center. Different randomizations processes were created utilizing the Statistical Package for Social Sciences (SPSS).	The control group is the medium-fidelity environment, while the experimental group is the high-fidelity environment.	A satisfaction scale and a scale of perceived gains from simulation were applied to both the control group and the experimental group. Both scales were Likert-type. The alpha value of the satisfaction scale determined by the authors was 0.914 and, in this study, it was 0.893. The alpha value of the scale of	Students exhibit high levels of satisfaction across all dimensions of the simulated clinical experiences as well as in their overall assessment. The average satisfaction ratings for both groups range from 77.77% (SD 11.29) to 90.04% (SD 7.46). Students view simulated practice as a highly significant component of their teaching and learning	Statistical significance is observed in both the realism dimension and overall satisfaction. Additionally, there is a statistically significant contrast in the dimension of recognition/ decision concerning the perceived gains from simulation.	Students express high levels of satisfaction with the realism provided by high-fidelity simulated practice, and they believe that it enhances their ability to recognize and make decisions more effectively when compared to medium-fidelity simulations.	The study had a relatively limited sample size when presenting and discussing the most crucial data regarding gains from both medium and high-fidelity simulation. Nonetheless, considering the scarcity of randomized studies focusing on students' perceived gains from simulation, this study can

				perceived gains determined by the authors was 0.951, and for this study, it was 0.912. Statistical analysis was completed and a significance level of $p < 0.05$ was recognized.	journey, with average improvements in both groups ranging from 75.55% (SD 10.45) to 82.99% (SD 9.13).			still be deemed valuable. Further, it is important to note that the study took place in a single location and was specifically designed for assessing and intervening with critically ill patients. This limits applicability of the results to broader contexts and diverse healthcare settings. This study holds significant relevance for educators, as it underscores the potential of these

								teaching methods to cultivate students' interests and motivation, thereby promoting active participation in their learning.

Citation	Design/ Method	Sample/Setting	Major Variables Studied and their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/ Level
McCoy CE, Rahman A, Rendon JC, et al.[5] 2019. Randomized controlled trial of simulation vs. standard training for teaching medical students high-quality cardiopulmonary resuscitation.	This article's design was a prospective, randomized, parallel-group study.	The study was carried out at the University of California Irvine Health Medical Education Simulation Center, spanning a during of eight months. All fourth-year medical students who were participating in a mandatory emergency medicine clerkship were considered eligible.	The practical skills training in this course was the same for both the intervention and control groups, except for the type of manikin they were assigned to. The intervention group received their training using a high-fidelity human patient stimulator, while the control group underwent training using the standard CPR procedural tasks trainer known as Resusci Anne.	Data abstracted was converted to Stata file format and then analyzed with Stata. Continuous variables were reported as means with 95% confidence intervals using the Kruskal-Wallis rank sum test. A two-tailed alpha < 0.05 represented statistical significance. The sample size calculations	With a two-tailed alpha of < 0.05, and a beta of 0.2, 34 subjects per group were needed to detect a difference between groups with a power of 0.8.	Primary outcomes - The mean compression depth was 4.57 cm (95% CI) for the SIM group and 3.89 cm (95% CI) for the standard (STD) group, p=0.02. The compression fraction was 0.724 (95% CI) for the SIM group and 0.679 (95% CI) for the STD group, p = 0.01. The mean compression rate was 123.3 per minute (95%	The findings indicate that high-fidelity simulation training resulted in CPR performance that closely aligned with the American Heart Association (AHA) CPR guidelines. Additionally, participants trained using simulation had quicker response times activating EMS, which is the initial step in the algorithm.	The primary outcome of high-quality CPR included four performance outcome measure-ments, which increases the potential for type 1 error. This study contributes to the body of simulation literature as most of the current literature uses non-experimental study designs. This prospective, RCT design carries less risk of bias than non-

			Performance measures studied include chest compression rate, depth, recoil, and compression fraction, Compression rate was defined as the number of chest compressions delivered per minute. Compression depth was defined as depth of chest compression from neutral position of the sternum in centimeters. Chest recoil is defined as allowing the sternum to fully (100%) return to its neutral position before	were based on an effect size of a 5 mm difference in compression depth between the two groups.		CI) for the simulation (SIM) group and 116.1 per minute (95% CI]) for the STD group, p=0.06. The mean percentage of chest compressions that were accompanied by full chest recoil was 0.954 (95% CI) for the SIM group and 0.941 (95% CI) for the STD group, p=0.83. Secondary outcomes - For our secondary outcome, the time to activation of EMS was 24.7 seconds (95% CI) for		experimental designs. The random- ization enhanced the author's ability to attribute variations in study outcomes to the intervention more confidently than other research designs.

			the next chest compression. Compression fraction was defined as the proportion of time CPR was delivered while the patient was without a perfusing rhythm. Secondary outcome was time to emergency medical services.			the SIM group and 79.5 seconds (95% CI) for the STD group, $p = 0.007$.		

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Fischer Q, Sbissa Y, Nhan P, et al.[6] 2018. Use of simulator-based teaching to improve medical students' knowledge and competencies: randomized controlled trial.	Prospective randomized controlled trial. The objective of this research was to contrast conventional in-person instruction with simulator-based instruction in terms of their effectiveness in acquiring knowledge about coronary anatomy and interpreting coronary angiograms.	A total of 118 participants who were fourth-, fifth-, or sixth-year medical students from Paris Descartes University, none of whom had interven-tional cardiology experience. The study was conducted at the Institute for Therapy Advance-ment.	There is a control teaching group made up of 59 participants, and a simulator group made up of 59 participants. The control group received a course taught utilizing PowerPoint while the simulation group received a simulation-based course with the same information.	Following the course, all participants were given an exam consisting of 40 multiple-choice questions, testing them on coronary anatomy, angiographic projections, and real coronary angiography interpreta-tion. Student satisfaction was evaluated by a question-naire.	Continuous data are described as mean (SD) and are likened with the use of a Student *t*-test. Categorical data is presented as percentages and compared using a chi-square test. All analyses were completed utilizing SPSS version 22.0, and a significance level of 0.05 was used.	The global score was not significantly different between the fourth-, fifth-, and sixth-year students. Overall, the students in the sim group had higher scores (59.8%) when compared to students in the control group (43.8%). Students in the simulation group scored higher in each subsection of the exam. Student	This study revealed that when compared to traditional teaching methods, high-fidelity simulator-based instruction in coronary angiography significantly enhances students' comprehen-sion of coronary artery anatomy, spatial awareness, and the ability to interpret real clinical cases. Further, simulator-	Evaluation bias was limited by keeping teaching and evaluation times identical for both groups. This RCT lacks a sample size calculation, a small sample, and has no long-term evaluation assessing retention. The editorial note appended to the article highlights that the study was no pre-registered and was granted an

						satisfaction was deemed excellent in both groups, but higher in the simulation group (98%) compared with the control group (75%).	based instruction has the potential to enhance clinical competencies.	exemption from the International Committee of Medical Journal Editors (ICMJE) guidelines, which typically require advance registration of randomized trials. This exemption was granted on the basis that the study did not involve patients, thereby eliminating the need for registration. Readers are advised to exercise caution when evaluating the

								credibility of the study's assertions, as the absence of registration implies that the authors retain the option to alter their outcome measures retroactively.

Citation	Design/ Method	Sample/ Setting	Major Variables Studied and their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/ Level
McCutcheon K, O'Halloran P, Lohan M.[7] 2018. Online learning versus blended learning of clinical supervisee skills with pre-registration nursing students: a randomised controlled trial.	This article is a posttest only randomized controlled trial and followed the CONSORT guidelines for reporting RCTs. While there are not any explicit instructions tailored for documenting an online or blended learning instructional approach, the description of the teaching methods and procedures has followed the GREET statement for reporting	The sample consisted of a class of 122 under-graduate nursing students who were enrolled at North Ireland institute.	All students received an online clinical supervision training app. The control group participated in an online discussion forum, while the intervention group had a face-to-face tutorial. The online discussion forum is centered on theory and aims to equip students with the skills needed to build knowledge, critically assess, and	In this study, three data collection instruments were employed and collectively administered as a unified data collecting tool. The first and third instruments utilized a Likert rating scale, prompting respondents to indicate the degree of their agreement of disagreement with a set of statements on a five-point scale. Instrument two, on the other hand, consisted of 10 multiple-	An independent samples t-test was performed to compare the average scores on the modified Manchester Clinical Supervision Scale between two groups: the online group and the blended learning group. The results showed that the blended group had a more favorable position on the scale, with a mean of 85.5 and a SD	The authors have confirmed all three hypothesis in that participants who received clinical supervision skills training via a blended learning approach will score higher in terms of: motivation and attitude (as measured by modified Manchester Clinical Supervision Scale); knowledge (as measured by a multiple choice assessment);	Blended learning offers distinct advantages over online learning alone when it comes to instructing under-graduate nursing students in clinical supervision. These advantages are evident in various aspects, including students' motivation and attitudes toward learning clinical supervision, their	One limitation included the fact that the study population was restricted to one under-graduate nursing cohort, thereby limiting the generaliz-ability of the findings. Further, the sample size was slightly lower than the suggestion made by the power calculation. Further, there was modification of a

	evidence-based practice educational interventions, in conjunction with the TIDieR checklist and guidance.		apply management and leadership theories within various inquiry-based learning situations. The in-person tutorial was designated to delve into the practical methods of clinical supervision and foster the essential communi-cation abilities needed for effective engagement in clinical supervision as a supervisee.	choice questions, chosen to assess students' understanding of clinical supervision after completing training, in order to test the research hypothesis. Instrument three was chose as the methods to explore the students' satisfaction with their learning experience. A power analysis was conducted and a SD of 18 was employed for a two-sided independent *t*-test. The results indicated that having 63 participants in each group would provide	of 9.78. In contrast, the online group had a lower mean of 79.5 and a SD of 9.69. This was statistically significant (p=0.001). Further, participants in the blended group had a higher success rate in the knowledge test than participants in the online group, and this difference is statistically significant (p = 0.015). Lastly, participants in the blended group indicated a higher level of satisfaction than participants in	and learner satisfaction (as measured by a training evaluation).	satisfaction with the learning approach, and their comprehend-sion of clinical supervisee skills. The findings provide valuable new insights into the potential benefits of incorporating blended learning into under-graduate nurse education programs, particularly in the context of teaching clinical supervision. Additionally, the study contributes to the existing body of	measurement instrument to accommod-ate nurses already engaged in clinical supervision. Modification of any measuring instrument may affect the validity and reliability. However, the Cronbach's Alpha for the tool obtained in the trial data was 0.88 and suggests the tool as used was reliable. Additional constraints could have emerged as a result of the effectiveness of the interventions.

				80% statistical power at a significance level of 0.05 to detect a difference between the groups in terms of motivation and attitudes. These factors were assessed using a modified Manchester Clinical Supervision Scale and were expected to show a medium effect size (Cohen's d = 0.5).	the online group, with difference being statistically significant (p = 0.001).		knowledge regarding the effectiveness of blended learning in higher education across various disciplines.	The lack of real-time interaction in the online discussion forum might have contributed to the low student engagement, satisfaction, and learning outcomes in the online format.

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Boostel R, Felix JVC, Bortolato-Major C, Pedrolo E, Vayego SA, Mantovani MF.[8] 2018. Stress of nursing students in clinical simulation: a randomized clinical trial.	This study was a randomized clinical trial.	It was conducted in the skill and high-fidelity clinical simulation laboratory at a public university located in the southern region of Brazil, spanning from August 2015 to December 2016. The study's population included individuals enrolled in the undergraduate nursing program,	The control group attended an explanatory lecture on cardiothoracic physical examination, followed by a traditional hands-on practice session in the skill laboratory. On the other hand, the experimental group followed the same sequence, beginning with the explanatory lecture, then the traditional practice in the skill laboratory, and	To assess students' perception of stressors, they completed the modified KEZKAK question-naire, which gauges stress factors encountered by nursing students during clinical practice. The question-naire employs a Likert-type scale with response options ranging from 0-3, correspond-ing to the	Prior to the laboratory session, there were notable differences between the two groups in two items, with the control group expressing greater level of concern. However, following the laboratory session, there were significant differences between the two groups in seven items. In the experimental group, six items were identified as significantly	In the control group, there was a noteworthy reduction in the perception of four items as stressors. In. contrast, the experimental group exhibited a substantial increase in perceiving nine out of the 31 items as stressors and a significant decrease in one item.	The results indicated that employing high-fidelity simulation as a teaching approach heightened the perception of stressors linked to feelings of inadequacy and interpersonal interactions with patients, the multi-disciplinary team, and peers, when compared to the traditional skill laboratory practice. This rise in stress	This study was approved by the Human Research Ethics Committee. There are some limitations when considering the generaliz-ability of the research findings. The students had no prior exposure to high-fidelity clinical simulation, and there was only one simulation session conducted. The study contributes

		encompassing both male and female students aged 18 and over, who voluntarily chose to partake in the research.	concluding with a high-fidelity clinical simulation.	extent of concern the questions provoke among the students. Data analysis employed descriptive statistics, which included calculating measures of central tendency and determining absolute frequencies and percentages. Stress scores derived from the KEZKAK question-naire were organized in tables and subjected to statistical examina-	more stressful. In contrast, the control group highlighted only one item, specifically item 16 (“seeing a patient die”), as significantly more stressful.		levels appeared to be associated with the students’ ability to self-assess and critically reflect on their responsibility for learning and the imperative to acquire the necessary competencies for patient care.	valuable insight to the field of nursing. It highlights that students’ primary stressors are associated with feelings of inadequacy and difficulties in interpersonal relationships. Further, it underscores the role of simulation in raising students’ awareness of their responsibility in patient care.

				tions, which involved estimating absolute frequencies and percentages. To compare groups and assess changes within groups, the Mann-Whitney and Wilcoxon tests were employed, respectively. A significance level of 5% ($p < 0.05$) was applied to all tests.				

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Tallo FS, Vendrame LS, Baitello AL.[9] 2020. Comparison of three methods for teaching mechanical ventilation in an emergency setting to sixth-year medical students: a randomized trial.	A randomized, multicenter, open-label controlled trial was conducted to assess the effectiveness of three teaching approaches for mechanical ventilation: clinical case-based discussion, simulation, and an online tutorial. Participants completed a validated questionnaire regarding their knowledge of mechanical	The study involved voluntary sixth-year medical students from 11 medical colleges who willingly accepted the researcher's invitation. All of these participants were in the second semester of their medical program and had previously taken part in training sessions related to adult	There were 4 groups: one for each teaching method, and one group remained as the control. The control group attended an 8-hour course that was not related to mechanical ventilation and answered the questionnaire as well. During simulation, students operated the artificial ventilator and observed the outcomes of its changes with the simulator. In	Following the simulation taxonomy, the authors utilized a high-fidelity scenario. During this process, the instructor assessed the group of students' responses to various actions and provided immediate feedback. In the case-based discussion, the approach was built upon fundamental principles (structured discussion, realism, relevance,	In the multivariate analysis, when individuals who had not received mechanical ventilation classes during undergraduate are compared to those who did, the latter group demonstrates a 27% increase in their scores, which is statistically significant (*p*-value = 0.001). Similarly, when individuals	89.1% of the students reported never attended a mechanical ventilation as part of their under-graduate program. The case and simulation groups had the highest scores for overtime retention. The post-training test showed no difference between the scores in the simulation and clinical case groups, whereas the overtime	Results of the study show that in comparison with other forms of training, simulation of mechanical ventilation provides long-lasting knowledge in the medium term.	Strengths of the study include the multi-center characteristic and the fact that authors used a validated instrument. There is no risk or harm from the study interventions or findings.

	ventilation. This questionnaire was administered before the training, immediately after, and again 6 months after the in-person instruction.	intensive care, emergency room procedures, and anesthesia. These training sessions were conducted at the participating universities' campuses and were led by the same researcher for all the groups.	the discussion-based format, a similar sequence was followed, but students did not engage in "hands-on" practice; instead, the instructor demonstrated the procedures. Both of these methods were recorded and saved on DVDs, which were later used to create an online tutorial for a randomly selected group.	engagement stimulation, challenging problems). A consistent set of structured questions was applied to each scenario, but students did not have direct interaction with the ventilator; instead, the instructor demonstrated all aspects. In the online modality, the case-based approach was recorded, removing the direct interaction between students and the instructor. Participants were provided with DVDs containing the	who had 0-1 hour of training are compared to those who received more than 4 hours of training, the latter group exhibits a 20% increase in their scores, which is also significant (p-value = 0.001).	exam illustrated significant difference between the case-based and simulation groups.		

				recorded material. A Quasipoisson Regression was utilized to compare the score between groups over time, with an interaction between the variables group and time, with the necessary contrasts being calculated.				

Citation	Design/ Method	Sample/Setting	Major Variables Studied and their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/ Level
Henrichs B, Thorn S, Thompson JA.[10] Teaching student nurse anesthetists to respond to simulated anesthetic emergencies.	This study has a cross-sectional design. The aim of this research was to determine whether there were statistically significant differences between students exposed to the same performance criteria in simulated life-threatening anesthetic emergencies at three different time intervals and those who only experienced	Full-time SRNAs were enlisted for this study, which was conducted at a nursing school associated with a level 1 trauma hospital located in a large urban area in the Midwest region of the United States. Through convenience sampling, students in their 3rd term were designated as the control	The control group was made of 6 SRNAs in their final semester who simulated 13 critical anesthetic emergency scenarios once. This was the program's usual curriculum. The study group consisted of 6 SRNAs who faced the same 13 scenarios in semesters 3, 5, and 7.	The student's task involved identifying the emergency and delivering the proper treatment by executing specific tasks. The student's performance was assessed by determining whether they correctly executed the prescribed action (indicated by a "yes" response), or if they failed to do so (indicated by a "no" response). Two faculty members, who	Out of the 13 scenarios, there was a score of 100% for nine scenarios during the third session. Participants scored 100% on four of the scenarios during the second session; there were no perfect scores on just the second session. Lastly, 11 of the 13 scenarios showed	The results showed no significant difference in demographic variables between the control and study group. The study group performed better on their third attempt than the control group who only performed each scenario once throughout their program.	Engaging in recurrent simulated anesthetic scenarios enhances the overall performance of SRNA students in the simulated laboratory setting. However, to make the necessary curriculum adjustments viable, it is essential to consider the effects on faculty and the increased use of simulation services.	This research follows a cross-sectional design, and for a more compre-hensive assessment of performance, it may be necessary to track students over an extended timeframe. The program's admission capacity allowed for a maximum of 6 students to be admitted in a single cohort each year, leading to a limited annual intake

	the scenarios once. The theoretical framework utilized to support and guide the study was Ericsson's approach.	group, and students in the 7th term were designated as the study group.		observed the student in the simulation laboratory during each of the 13 life-threatening emergency scenarios, individually scored each action to ensure interrater reliability. Due to limited sample size, the Friedman test was selected. Subsequent to identifying overall differences through the Friedman tests, follow-up analyses were conducted using Wilcoxon signed rank tests to	improve-ment in the second session over the first.			of students, and consequently, a small sample size. Further, the sample size was from a single geographic region. Enhancing the robustness and possibly uncovering diverse outcomes could be achieved by increasing the number of participants. These limitations inhibit the generaliz-ability to other programs.

				pinpoint the specific pairs of sessions that exhibited significant differences.				

Organizational Assessment

This section offers a comprehensive organization assessment (SWOT) at the immersion site, aiming to unveil the intricacies of the clinical setting. This assessment identified stakeholders and committees, evaluated available resources, meticulously examined policies and procedures, defined the project's scope, and established a conceptual framework or theoretical underpinning to steer the project's course. This section describes the present state of affairs within the clinical site concerning the evidence-based goal of improving the recognition and care of an MH crisis. Further, it introduces a set of goals and outcomes adhering to the SMART criteria, as advocated by the Institute of Medicine, that served as the stepping stones to bridge the gap between the existing conditions and the project's ultimate objective. Next, the paper will delve into the intricate workings of the project and what the execution plan is. Lastly, the conceptual underpinning and theoretical framework that guided the project will be discussed, lending depth and structure to the project and facilitating a more robust and informed approach.

Primary DNP Project Goal

Malignant hyperthermia (MH) is a rare but life-threatening complication that can occur during anesthesia. It is a hypermetabolic state that can lead to muscle rigidity, hyperthermia, acidosis, and potentially fatal cardiac arrhythmias. The precise occurrence rate of MH remains uncertain. Epidemiological investigations indicate that MH occurs in approximately 1 out of every 100,000 surgical cases among adults and about 1 out of every 30,000 surgical procedures in children.[1] The problem for anesthesia providers when managing malignant hyperthermia is that it requires prompt recognition, diagnosis, and treatment to prevent serious complications or death. MH can be difficult to diagnose

and treat and requires a coordinated and multidisciplinary team approach. Failure to recognize and manage MH promptly can result in serious harm to the patient. As such, anesthesia providers must be highly trained and equipped to manage MH effectively. Regular simulation training can help anesthesia providers recognize and manage MH more effectively and smoothly, leading to better patient outcomes.

This community hospital is Florida's largest private, independent, not-for-profit teaching hospital, boasting over 4,000 employees, 500 volunteers, 672 available beds, 26 fully equipped operating suites, and a team of 650 physicians. Its mission is to provide high-quality healthcare to the diverse community enhanced through teaching, research, charity care, and financial responsibility. They prioritize ensuring convenient healthcare access for their patients by instituting multispecialty offices across the tri-county area of South Florida. Their medical network spans many facilities, which include three emergency centers. Moreover, as one of the six distinguished teaching hospitals in the state, this community hospital plays a pivotal role in shaping the regional and national healthcare landscape through medical training and research initiatives.

The most influential facet the hospital has to offer this project is that it is a teaching hospital. The foundation and culture of education are already rooted in the facility, allowing the project’s implementation to be less challenging and possibly even welcomed with open arms. Teaching hospitals play a crucial role in training the next generation of healthcare providers. The effectiveness of medical simulation is widely acknowledged, and its use for high-impact, low-frequency (HILF) events can enhance familiarity and offer practical exposure. The Malignant Hyperthermia Association of the United States (MHAUS) recommends that teams engage in simulated drills for MH

annually, while the Anesthesia Patient Safety Foundation (APSF) recommends training every 6 months to confirm that the staff maintains muscle motor memory and learns the most updated guidelines and recommendations.

The American Association of Nurse Anesthesiology suggests incorporating ongoing and annual competency education, including malignant hyperthermia crisis team training for the OR, PACU, and intensive care unit (ICU) teams; this will prepare the team to identify, respond to, and manage crises.[21] Simulation-based training should be developed to enhance and supplement the web-based competency classes most institutions already have in circulation. Introducing new simulation-based training mechanisms has allowed its learners to augment their skills, especially when opportunities for direct patient interaction are limited, as in malignant hyperthermia crises.[11] Simulation enables learners to develop abilities in areas that may not be adequately addressed through traditional patient interactions by creating a safe and controlled learning environment.[11] Simulation offers an opportunity to evaluate and improve teamwork, leadership, situational awareness, and decision-making skills by simulating crisis management scenarios.[11] Collaboration and interprofessional cooperation are imperative in improving clinical performance and patient outcomes. As such, anesthesia providers must be highly trained and equipped to manage malignant hyperthermia effectively. Regular simulation training can help anesthesia providers recognize and address this emergency more effectively and smoothly, leading to better patient outcomes.

This community hospital currently does not offer MH-simulated learning. It would be prudent for it to run semiannual MH in-situ simulations in the OR to increase staff confidence and proficiency in MH recognition and treatment.

The project sponsor assisting this project was Dr. Yasmine Campbell DNP, CRNA, APRN, CNE, CHSE. Her accomplishment of becoming a Certified Healthcare Simulation Educator (CHSE) benefitted this project's development; she has expertise in simulation with great insight. She has many accolades that proved to be beneficial in the development of the simulation content. As the DNP clinical preceptor, Dr. Campbell served as the main point of contact regarding clinical content and the clinical institution. She collaborated closely to facilitate the progress of the DNP project.

Participants included alumni from a CRNA program in South Florida. The number of participants was approximately 10. This population was vital to the project because it is often this demographic that interacts with the onset of malignant hyperthermia in their patients; most participants were the ones to designate treatment.

SMART Objectives

For this DNP quality improvement project, the following SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) objectives were identified:

- Objective 1
    - Specific: Increase the percentage of anesthesia providers who can correctly identify MH symptoms during the in-situ simulations.
    - Measurable: By the end of the project's first year, assess the percentage of staff correctly identifying MH symptoms during simulations.

- Achievable: Provide staff with regular training and resources to improve their knowledge and skills.
- Relevant: Enhancing staff's ability to recognize MH symptoms is directly related to the project's goal of improving patient outcomes and safety.
- Time-bound: Achieve a 20% increase in correctly identifying MH symptoms within 1 year of project initiation.

- Objective 2
  - Specific: Enhance interdisciplinary communication and teamwork during MH simulations.
  - Measurable: Evaluate staff feedback on communication and teamwork during simulations utilizing the surveys.
  - Achievable: Implement debriefing sessions after each simulation to discuss communication and teamwork.
  - Relevant: Effective interdisciplinary communication is vital for timely and coordinated MH management.
  - Time-bound: Achieve a 15% increase in staff satisfaction with interdisciplinary communication within the project's first year.
- Objective 3
  - Specific: Improve the average time staff takes to initiate appropriate MH management measures during in-situ simulations.
  - Measurable: Measure the time staff takes to initiate MH management during each simulation and calculate the average.

  - Achievable: Provide training and clear protocols for MH management during the simulations.
  - Relevant: Faster initiation of MH management can significantly impact patient outcomes.
  - Time-bound: Achieve a 20% reduction in the average time taken to initiate MH management within the first 6 months of the project.

Description of the Program Structure

Conducting a baseline organizational needs assessment is pertinent to collecting data and evidence demonstrating the need to instill this QI project. An evaluation of the current program structure was performed. Doing so highlighted specific areas of concern, existing gaps, and the urgency of action required. Existing data, statistics, or MH treatment and management reports were examined. Further, a search was completed for information on previous MH occurrences, patient outcomes, and recorded complications. An analysis of patient outcomes associated with MH cases was conducted, including available data on mortality rates, morbidity, and the impact on patient recovery postoperatively. Using this information, a root cause analysis was conducted to identify contributing factors and system failures, recognizing areas needing improvement. The installation of this project would allow further assessment of the current structure by facilitating the collection of feedback from all anesthesia staff involved in patient care. Further, surveys or interviews would be conducted to gauge their perceptions of the current MH management and their self-confidence in recognizing MH symptoms. Additionally, this project identified gaps or areas of non-compliance in competencies or

MH management by regulatory and accreditation standards, such as the Joint Commission.

By collecting and analyzing these data points, a strong case was made to implement this QI project and secure buy-in from stakeholders, as it demonstrates the urgency and potential benefits of the project.

Organizational SWOT Analysis

The SWOT (Strength, Weaknesses, Opportunities, and Threats) analysis matrix is a valuable tool for assessing the internal and external factors that can impact the success of a QI project. This analysis serves as a foundation for informed decision-making and strategic planning; it helps to develop a more comprehensive understanding of the community hospital's readiness for the QI project and how to navigate challenges and capitalize on opportunities.

Strengths

One strength of this project is that it improved patient outcomes by employing evidence-based practice. Better results lead to happier and more satisfied patients, increasing patient confidence in the community hospital to care for themselves, their family, and their friends. This, in turn, aids in cultivating a favorable image for the organization, which is appealing to its stakeholders.

Another strength of this project was that it involved in situ training instead of training in a simulation center. Anesthesia providers and other OR staff might refrain from engaging in simulated exercises in a simulation center because they perceive stress linked to their performance, fear the potential consequences of subpar performance, and face challenges related to time commitment and the distance to the simulation facility. In-

situ simulation training might remedy this issue, enabling participants to train in a nearby, more familiar setting.[21]

A considerably significant strength the community hospital holds is that it is already a teaching hospital with the foundation of growth and academia at its core. This community hospital has a dedicated, skilled anesthesia workforce passionate about providing excellent patient care. MH simulation training would benefit novice residents and students, and this project's installation should be completed with fluidity and ease.

Weakness

This site's biggest weakness is attributed to the daily workload it faces. It may be challenging to reserve an OR for simulation because of the volume of cases each day. However, there was an old OR that may be available for use. Further, because of how busy staff are, taking staff away for 30 minutes to run through the simulation may be difficult. It could be advantageous to have staff come in on their day off, before their shift starts, or after it ends; however, it would be at a price since the community hospital would have to pay staff for the extra time. Providing an online educational module would be more convenient; however, evidence has shown that blended learning, including face-to-face instruction and some online features, will increase motivation, attitudes, knowledge, and satisfaction more than online learning alone.[20]

Opportunities

An opportunity this site offers is attributed to the fact that this is a teaching hospital with a residency program. Many offers and grants are available to capitalize on to fund the initiation of this project. Further, the staff are passionate about new evidence-

based practices and keep up with new research findings. Lastly, key stakeholders support medical education. Their support of implementing best practices should be easy to gain.

Another opportunity is that the community hospital already has a high-fidelity mannequin that can be used as the patient simulating MH. The education department has already made this considerable expense, allowing funds received to be used elsewhere.

Threats

The biggest threat to implementing this project is staff willingness and outlook. Resistance to change is a common barrier in healthcare and could be seen as unsettling, disruptive, and burdensome. Next, some staff members may perceive a lack of relevance because most have never encountered a case of MH. They may not see the immediate benefits of training.

Conceptual Underpinning and Theoretical Framework

Utilizing theoretical frameworks in nursing care and evidence-based practice is integral to delivering high-quality care. Frameworks provide a structured foundation that guides nursing professionals in their decision-making process and patient care. In an ever-evolving field like healthcare, where there is a constant influx of new research and knowledge, theoretical frameworks serve as valuable tools for understanding, applying, and changing evidence-based practices. Further, they allow nurses to connect theory with practical application, fostering an environment where knowledge, experience, and best practice work synergistically to optimize patient outcomes. The theory that will be applied to this project is the middle-range self-efficacy theory.

Theory Overview

Self-efficacy is a middle-range theory developed within the broader framework of social cognitive theory, which Albert Bandura developed. This theory explains and predicts the factors and processes that influence an individual's self-efficacy beliefs and their subsequent effects on behavior.[22] It refers to an individual's confidence in their ability to perform a specific task, achieve particular goals, or successfully engage in certain behaviors. Middle-range theories are more specific and focused and help explain and predict phenomena. In the case of self-efficacy, the middle-range theory seeks to elucidate the factors that influence an individual's perceived self-efficacy and its effects on their behavior.[22]

Bandura identified four primary sources of self-efficacy judgment as the main determinants of an individual's perceived self-efficacy: enactive attainment, vicarious experience, verbal persuasion, and physiological feedback.[22] Enactive attainment refers to an individual's actual behavior performance and is considered the most influential source of self-efficacy.[23] Successful performance strengthens self-efficacy beliefs, while repeated failures can negatively impact one's self-efficacy. Other influence factors include preconceptions, perceived task difficulty, perceived effort, and previous attempts. Vicarious experience involves observing similar individuals successfully performing the same behavior. Its impact on self-efficacy depends on factors such as the individual's exposure to the behavior, clarity of directions, and the use of self-modeling.[22] Minimal experience and ambiguous directions can have a more significant impact on self-efficacy. Verbal persuasion positively affects self-efficacy; it involves being encouraged by others that one has the capabilities to master a specific behavior.[22] Lastly, physiological

feedback involves individuals relying on their physiological states, such as arousal, pain, and fatigue, to assess their abilities.[22] Higher arousal states, such as increased heart and respiratory rates, can limit performance and decrease confidence in one's ability to perform a behavior. Interventions, such as deep breathing and positive manifestations, can help individuals interpret physiological feedback differently and cope with physical sensations, leading to enhanced self-efficacy.

Theory/Clinical Fit

The middle-range self-efficacy theory is a relevant and suitable framework for an education and self-confidence project. Self-efficacy is often used to understand and influence behavioral change. This project aims to change OR staff behavior by enhancing skills and confidence in MH management. Increasing OR staff's self-efficacy in MH recognition and management can empower them to take prompt and efficient actions during a crisis. This aligns with the project's goal of improving patient outcomes and safety. Further, this self-efficacy theory is quantifiable, making it easy to measure and evaluate the project's impact.[22]

One of the four primary sources of self-efficacy judgment was enactive attainment. This refers to the individual gaining confidence and self-efficacy through actual hands-on experiences and successful performances. In situ simulation training provides OR staff with a realistic and immersive learning experience of an MH crisis. This hands-on training allows them to practice their skills and decision-making in a controlled yet authentic environment. Experiencing successes in a simulated MH situation can significantly boost the participant's confidence in their ability to recognize and manage MH when they encounter it in the OR setting. This enhanced self-efficacy is

rooted in the idea that they have the skills and knowledge to handle the situation effectively. Further, in situ training allows the OR staff to learn from their mistakes in a safe and controlled environment, a key component of enactive attainment. Simulation participants can reflect on their actions, identify areas for improvement, and adjust their efforts to enhance their self-efficacy in subsequent simulations and clinical experiences.

The second primary source of self-efficacy judgment was vicarious experience. Observational learning is learning from the experience of others in simulation and allows participants to see how others might handle MH scenarios.[22] The simulated exercises were be in groups, facilitating observational learning and role modeling. Post-simulation debriefs allowed for peer feedback and the introduction of the third primary source of self-efficacy judgment—positive feedback. This enabled reviewers to applaud good behavior and constructively criticize behavior that should be modified.

Theory Evaluation

The Peterson and Bredow framework involves six questions that help guide nurses and other healthcare providers in critically evaluating and implementing research evidence into clinical practice.

The target population for this quality improvement project included anesthesia providers and all OR staff who are responsible for managing emergencies such as MH. The problem of interest lies in the anesthesia providers' capacity to promptly detect and manage MH intraoperatively and their lack of confidence. MH can be difficult to diagnose and treat and requires a coordinated and multidisciplinary team approach. Failure to recognize and manage MH promptly can result in serious harm to the patient.

The intervention or area of interest in the self-efficacy theory is the enhancement of self-efficacy in MH diagnosis and management. Integrating semiannual in-situ simulation training as a component of the institutional competency-based education for anesthesia providers served to mitigate delayed recognition and treatment and bolster confidence in managing MH. Specifically, one OR suite was designated for simulation throughout the day, where a simulated MH event was repetitiously executed.

The comparison intervention was web-based competency training, and the outcome of interest was improved self-efficacy in perioperative management MH care and provider confidence. This enhanced self-efficacy was expected to lead to more effective responses in clinical MH crises and ultimately improve patient outcomes in MH emergencies.

The self-efficacy theory's time frame involves implementing simulation and training to enhance provider and staff confidence. Outcome measurements were done before and after the simulation. The pre-simulation questionnaire uncovered the team members' baseline knowledge of MH, perceived confidence level in recognizing MH, and preparedness in managing MH. The post-simulation questionnaire asked the same questions and asked for feedback on the simulation experience to modify future iterations of the exercise.

Setting and Participants

The setting for this project was a 672-bed not-for-profit, academic medical facility in Miami, FL. The foundation of growth and academia at its core makes it an optimal location for implementing this project. Participants included all OR staff, including surgeons, circulating nurses, surgical technicians, anesthesia providers, anesthesia

technicians, and any accompanying students or residents. These participants were grouped into OR teams rotating through the simulated events to complete the competency-based training. The sample size should be well over 100, as this simulation was considered involuntary and a portion of the competency requirements for employment.

Procedures/Methodology

This is a quasi-experimental project with a pretest and posttest design. One benefit of using a pretest and posttest study involves the clear sequencing of the research process. It involves assessing a dependent variable (such as knowledge or attitude) before and after introducing an independent variable (like training or an informational session).[21] While this resembles a traditional experimental design, it leans towards quasi-experimental methods because the participants typically are not randomly assigned. As a result, this design also aligns with correlation. Due to its quasi-experimental nature, it is challenging to establish direct causality in the outcomes; instead, connections between interventions and outcomes are inferred as associations.[21]

Participant Recruitment

Participation in this simulation exercise was involuntary for employees because it will be utilized as a competency. The American Association of Nurse Anesthesiology proposes integrating continuous and yearly competency education. These would encompass specialized training for handling malignant hyperthermia within the OR, PACU, and ICU; this approach aims to equip the teams to recognize, react to, and effectively handle critical situations.[21] To complement the existing web-based

competency programs, this facility will follow the recommendation to hold simulation-based training for an enriched learning experience.

Data Collection

The assessment of quality initiatives involved a qualitative descriptive method, utilizing pre- and post-simulation questionnaires completed by the staff. The initial questionnaire aimed to uncover team members' foundational knowledge of MH, their perceived confidence in recognizing and managing MH, and their preparedness to handle such situations. The subsequent post-simulation questionnaire reiterated these questions and sought feedback on the simulation experience, aiming to refine future iterations of the exercise. In the event of an actual sequential occurrence of MH, quantitative measures were compared to pre-simulation MH episodes, if available, to gauge improvements in treatment effectiveness.

Participants completed the pre-simulation questionnaires before engaging in the simulation. The intervention's consistency was monitored through a checklist to ensure all aspects of the MH simulation were covered, safeguarding the reliability of measurements in the project. The operational definition for clinical outcomes focused on the timing of the symptom recognition, MH diagnosis, and the administration of Dantrolene or Ryanodex. This definition aimed to enhance the validity of data collection by minimizing measurement errors. Reliability was ensured by aligning research questions and methods with project objectives and comparing findings with existing literature.

Employee names were left out of data collection. Instead, participant ID numbers were used. Other demographic data included gender, age, the position name, and years of experience within that position.

Data Analysis

The choice of statistical methods for evaluating data in this quality improvement initiative aimed at enhancing the recognition and management of MH using both descriptive and inferential statistics. Measures of central tendency, such as mean, median, and mode, were used to describe the central value of data regarding the time taken to diagnose MH and initiate Ryanodex or dantrolene during simulation. Histograms illustrated the scores' distribution related to perceived staff confidence pre- and post-simulation. *T*-tests compared means between two groups, such as comparing the time taken to recognize MH symptoms between new and seasoned employees. Lastly, Chi-square tests examined associations between categorical variables, evaluating the association between staff training levels and the ability to manage simulated MH scenarios correctly.

Protection of Human Studies

Protecting subject privacy and confidentiality is vital when conducting a research project involving human studies. Informed consent was obtained from all participants. It clearly explained the purpose, procedures, risks, benefits, and measures to protect confidentiality and data. It also explained how data would be used. Personal identifiers were removed from all data to maintain confidentiality, and participant ID numbers were used instead.

Data Management

Data will be stored electronically on a password-protected computer with encryption and updated security software. Identifiable information within paper records were stored securely in a locked bin within the facility, and access was restricted to authorized individuals involved in the study. Electronic and paper records will be disposed of properly after the project and when records are no longer needed. Electronic records will be permanently deleted, and paper records will be securely shredded.

Timeline

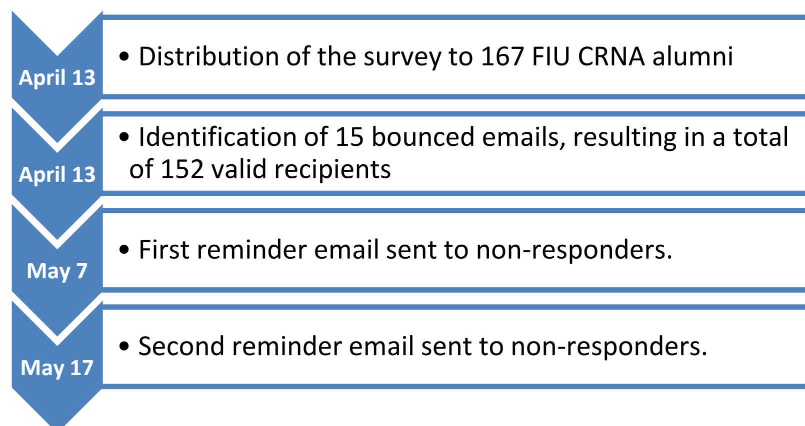
Creating a comprehensive timeline requires careful planning and consideration. Within months 1 and 2, the project involved defining research objectives and methodologies and developing the proposal and informed consent. The DNP student prepared and submitted the IRB application for approval. During months 3 and 4, the DNP student waited IRB feedback and addressed any concerns and requested modifications. IRB approval must be granted before beginning data collection. During months 5 and 6, the focus of the project was to recruit participants and obtain informed consent. Next, simulation training and pre- and post-surveys were implemented. Analyze data using statistical methods. Once simulation training has ended and data has been analyzed, DNP student completed the final report and prepared the presentation for defense.

Results

The initial steps and timeline of interventions are as follows. The project began with (a) a distribution of the survey to 167 FIU CRNA alumni on April 13, 2024; (b) identification of 15 bounced emails, resulting in a total of 152 valid recipients on April

13, 2024; (c) First reminder email sent to non-responders on May 7, 2024; and (d) Second reminder email was sent to non-responders on May 17, 2024. No modifications were made to the project or survey during this period.

Figure 1. Timeline of Interventions



The key process measures and outcomes were designed to evaluate the effectiveness of simulation-based training in improving MH recognition and management skills among anesthesia providers. Process measures include the survey distribution and response rate, while the outcome measures include the pretest and posttest scores, assessing changes in knowledge and attitudes regarding MH care. Several contextual elements interacted with the intervention, the first being participant engagement. The response rates were influenced by the timing of reminders and alumni engagement levels. In addition, technical issues, such as bounced emails, reduced the initial pool of participants.

Demographics

Of the 165 potential participants, 15 consented to and completed the survey. Nine (60%) were male, and six (40%) were female. Three were between the ages of 21 and 30,

nine were between the ages of 31 and 40, two were between the ages of 41 and 50, and one was between the ages of 51 and 60. Nine (60%) were Hispanic or Latino, while the remaining six (40%) were not Hispanic or Latino. Black or African Americans made up 27% of the respondents, 67% were White, and 7% listed themselves as "other." One (7%) of the respondents reached their Master of Science in Nursing (MSN), while the remaining 14 (93%) reached their Doctor of Nursing Practice (DNP). Seven (47%) of the respondents were new graduates, having less than 1 year of CRNA experience. Five (33%) had 1-2 years of CRNA experience. One (7%) had 3-5 years of CRNA experience. Two (13%) had greater than 10 years of experience.

Pretest Survey Results

Of the 16 participants who consented to the survey, 14 completed it, resulting in a 12.5% attrition rate. When asked about the organization responsible for MH management recommendations, 71% correctly identified MHAUS. For the signs and symptoms of MH, 93% of participants identified muscle contraction, 100% identified tachycardia, and 93% identified masseter rigidity. Incorrect responses included a sudden decrease in EtCO2 (14%) and bradycardia (7%). Regarding diagnoses that mimic MH, 57% correctly chose "all of the above." For the definitive treatment of MH, 93% correctly chose Ryanodex, and 86% correctly chose Dantrolene. Additionally, 86% correctly identified RYR1 as the receptor associated with MH. Most participants (86%) knew the location of the MH cart in their facility. Confidence in recognizing MH signs and symptoms was somewhat agreed upon by 71%, while 86% somewhat agreed they knew the steps to take if a patient exhibited MH symptoms, with only 14% strongly agreeing. A significant 86% believed simulation could improve confidence and short-term clinical and

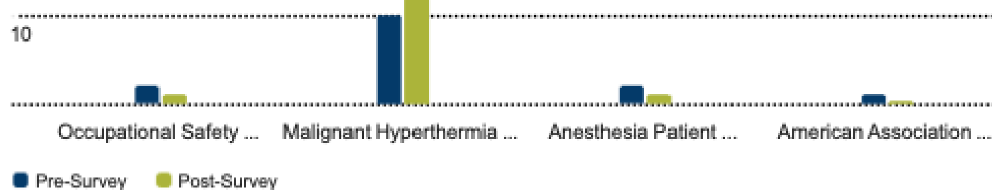
interdisciplinary teamwork skills. All participants believed simulation training would enhance their ability to recognize and treat MH, with 79% strongly agreeing and 21% somewhat agreeing. Furthermore, all participants agreed that simulation training fosters learning more than web-based training, with 64% strongly agreeing and 36% somewhat agreeing.

Posttest Survey Results

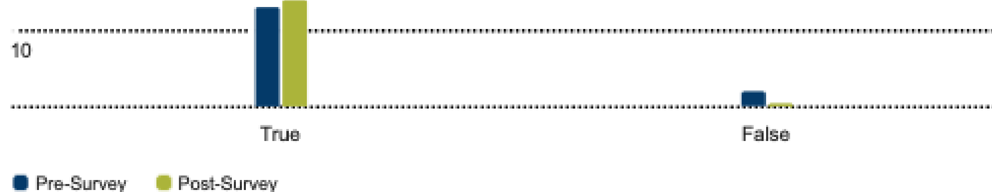
Following the intervention, 92% correctly identified MHAUS as the responsible organization for MH management recommendations. For MH signs and symptoms, 92% correctly identified muscle contraction, and 100% correctly identified tachycardia and masseter rigidity. All participants believed that simulation could improve confidence and lead to short-term improvements in clinical and interdisciplinary teamwork skills. When asked which diagnoses mimic MH, 77% correctly chose “all of the above.” For definitive treatment, 100% correctly selected both Ryanodex and Dantrolene, and 100% correctly identified the RYR1 receptor. Confidence in recognizing MH signs and symptoms was high, with 77% strongly agreeing and 23% somewhat agreeing. Furthermore, 100% agreed they knew the steps to take if a patient exhibited MH symptoms, with 85% strongly agreeing. All participants believed simulation training would improve their ability to recognize and treat MH and agreed that simulation fosters learning more than web-based training.

Figure 2. Questions 8-10 Responses

Q8 - Which organization is responsible for recommendations related to the management of malignant hyperthermia?



Q9 - Simulation can improve participant confidence and lead to short-term improvement of clinical skills and interdisciplinary teamwork skills.



Q10 - Signs and symptoms of MH include: (select all that apply)

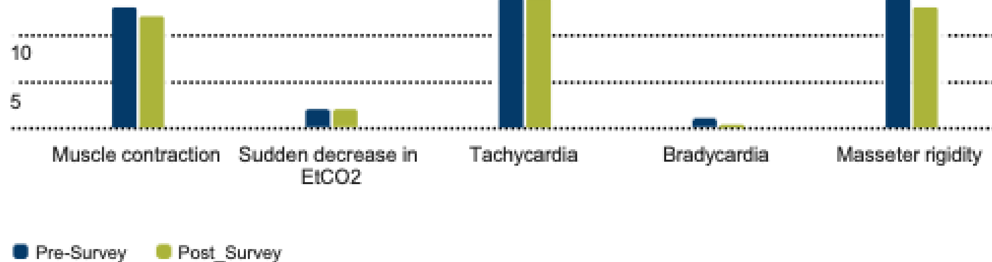
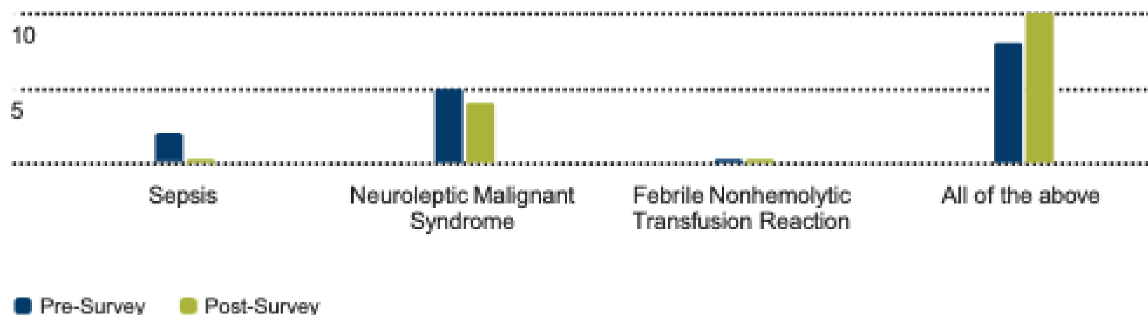
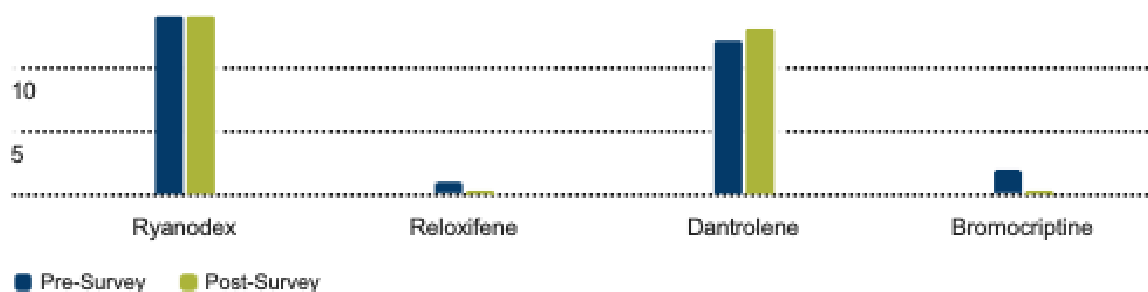


Figure 3. Questions 11-13 Responses





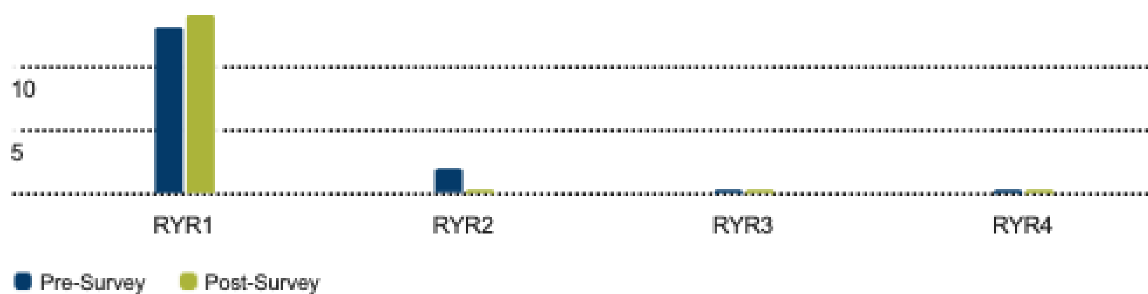
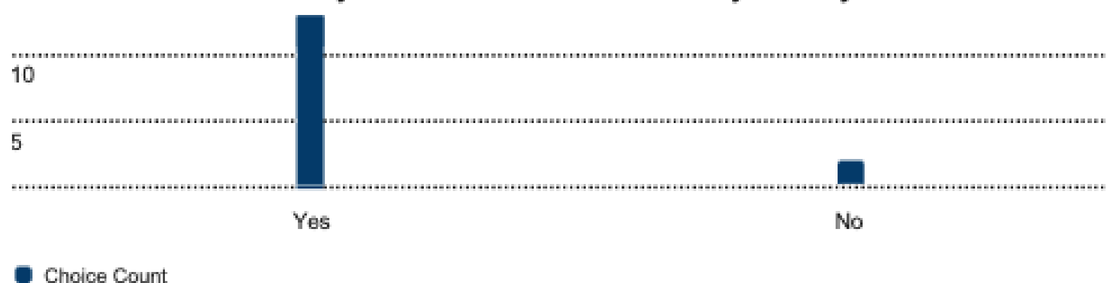
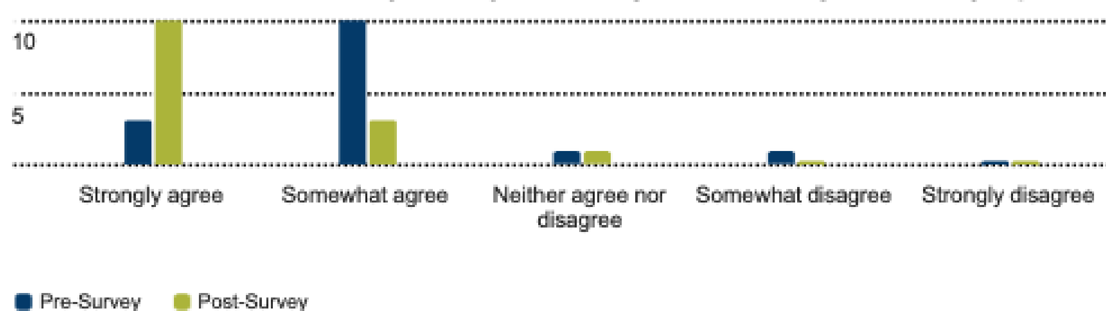


Figure 4. Questions 14-16 Responses





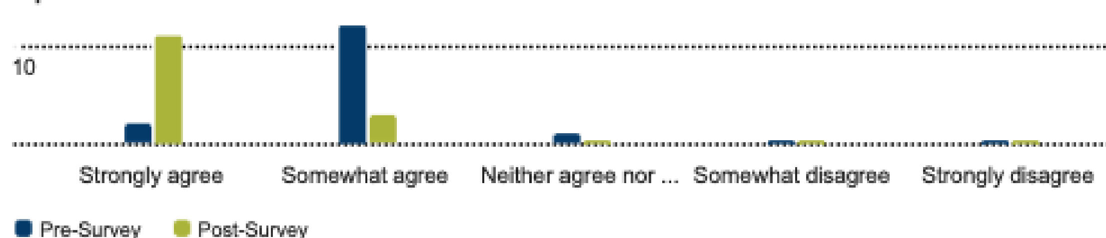
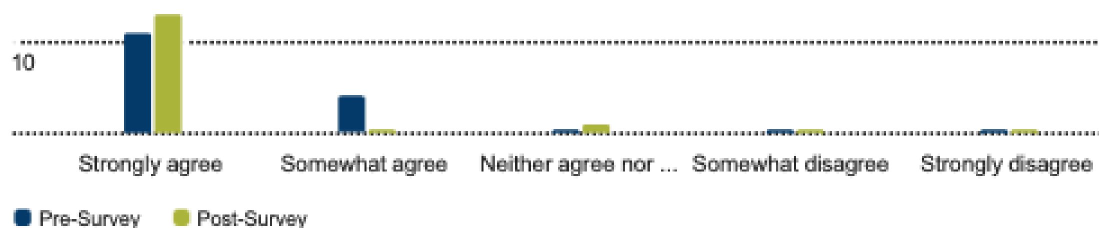
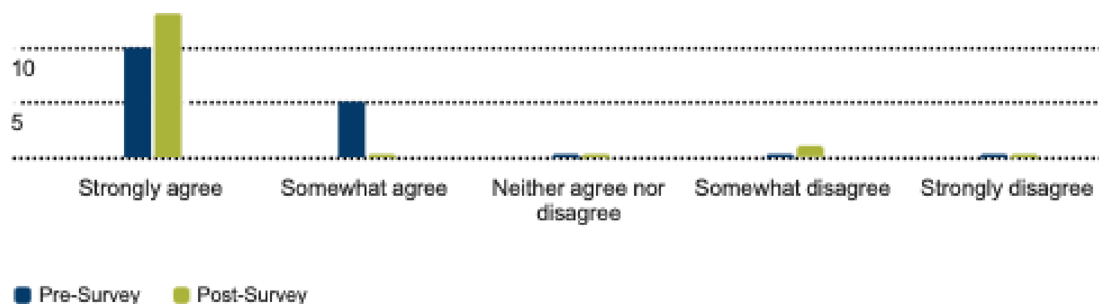


Figure 5. Questions 17-18 Responses

Q17 - I believe simulation training would improve my ability to recognize and treat MH.



Q18 - Simulation training fosters learning more than web-based training.



Interpretation

The pretest survey revealed a strong baseline understanding among participants regarding MH management, signs, symptoms, and treatment. The majority correctly identified key elements such as the responsible organization (MHAUS), symptoms such as muscle contraction, tachycardia, and masseter rigidity, and treatments like Ryanodex and Dantrolene. However, there were notable gaps, particularly in identifying all conditions mimicking MH and in complete confidence in managing MH scenarios.

Posttest results demonstrated significant improvements in knowledge and confidence across all surveyed areas. Nearly all participants correctly answered questions related to MH management, symptoms, and treatment. Confidence in recognizing and responding to MH symptoms increased markedly, with all participants expressing

confidence post-intervention, and a substantial increase in those who strongly agreed they knew the appropriate steps to take. The unanimous belief in the effectiveness of simulation training over web-based training and its role in enhancing clinical skills and teamwork underscores the value of hands-on, practical training methods in improving competency and preparedness for MH crises.

Despite the overall positive outcomes, the data showed no statistically significant relationship between years of experience as a CRNA and confidence in recognizing MH symptoms, as indicated by the chi-square test (X2 (4, $N = 14$) = 7.47, $p = 0.113$). This suggests that the improvements observed were likely due to the intervention itself rather than the participants' prior experience.

Discussion

This quality improvement project demonstrated a strong positive association with several key outcomes, including improved knowledge, increased confidence, and enhanced preparedness in recognizing and managing MH. There are significant associations between the implemented interventions and the observed outcomes in the recognition and management of MH among anesthesia providers. Additionally, several contextual elements, such as participant demographics and professional backgrounds, have seemed to influence these observed associations.

There was a noticeable increase in correct responses related to the signs and symptoms of MH, the correct use of Ryanodex and dantrolene, and the identification of the RYR1 receptor post-training. Pre-training results show that 71% correctly identified MHAUS, 93% identified muscle contraction, and 93% identified masseter rigidity. Post-training results showed that 92% correctly identified MHAUS, and 100% identified

masseter rigidity. There was a noteworthy improvement in confidence levels regarding the ability to recognize and manage MH symptoms. Pre-training illustrated that 71% agreed with the statement, “I am confident in my ability to recognize MH signs and symptoms,” and afterward, it increased to 77%. After the training, almost all (92%) participants agreed that simulation training would improve their ability to recognize and treat MH and foster learning more effectively than web-based training; this increased from 73% to 66%, respectively. This training not only provided knowledge but also enhanced the participants’ readiness to run MH cases.

Comparing these findings to other publications shows parallel thoughts. For example, LaCerra et al.[12] showed that HFPS can be viewed as a significant instructional approach that can play a role in nurturing nursing competence when considering competence as the combination of knowledge, performance, psychomotor skills, and clinical solving. In addition, Fischer[18] revealed that when compared to traditional teaching methods, high-fidelity simulator-based instruction in coronary angiography significantly enhances students’ comprehension of coronary artery anatomy, spatial awareness, and the ability to interpret real clinical cases. Further, simulator-based instruction has the potential to enhance clinical competencies.

Most participants were between the ages of 31 and 40 and had varying levels of experience, with a significant portion being new graduates. New graduates made up 47% of the participants; 33% had 1-2 years of experience, and a smaller number of participants had over 10 years of experience. The findings suggest that the new graduates with less than 1 year of CRNA experience and those with 1-2 years of experience are early adopters of simulation and benefited greatly from the simulation training, as

indicated by the marked improvement in their knowledge and confidence levels. This points to the importance of early and ongoing simulation training in developing clinical competence as an anesthesia provider.

Limitations

Before the intervention, participants already showed a strong belief in the efficacy of simulation training over web-based training. This prior belief likely contributed to the engagement and positive outcomes observed. As mentioned, most of the participants are new in their CRNA experience and just out of school, where simulation training was more than likely utilized.

A problem was encountered during the survey distribution. The bounced emails represented a challenge in reaching the entire target audience, potentially biasing the results due to the exclusion of some alumni. These bounced emails contributed to missing data, reducing the number of potential respondents to 152 people.

Discussion of the Results with Implications for Advanced Practice Nursing

The results of this project can have significant implications for advanced practice nursing across various domains, including education, practice, administration, and leadership. Positive outcomes from the project can influence advanced practice education by highlighting the importance of in-situ simulation training in program curricula. Further, it could emphasize the benefits of ongoing training and continuing education programs. Within the domain of clinical practice, the results could improve patient outcomes and patient safety. Advanced practice nurses, especially CRNAs, can apply these learned skills to recognize and address MH, promptly reducing adverse events. Further, this project will encourage interdisciplinary collaboration among healthcare

professionals, emphasizing the importance of effective communication and teamwork in managing critical events like MH.

Conclusions

The findings of this project underscore the critical importance of simulation-based training in enhancing the knowledge and confidence of healthcare professionals in managing MH. Post-intervention results demonstrated significant improvements in participants' ability to identify MH signs and symptoms, correctly respond with appropriate treatments, and confidently manage MH scenarios.

Given that MH is a high-impact, low-frequency (HILF) event, it is essential to prioritize ongoing research and training to ensure healthcare teams remain prepared for such emergencies. Future research should explore the long-term retention of skills and knowledge gained through simulation training and examine the benefits of interdisciplinary simulations, which can further enhance teamwork and response effectiveness. Hospitals should consider implementing systems to ensure a sufficient supply of Dantrolene is available for at least 24 hours post-rescue, as current supplies are often inadequate for extended treatment needs.

By fostering an interdisciplinary approach to simulated learning and addressing logistical challenges in MH management, healthcare institutions can improve patient outcomes and ensure a higher standard of care in the face of these rare but critical events.

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Appendix A: Letter of Support

Nicole Wertheim College of Nursing & Health Sciences
FLORIDA INTERNATIONAL UNIVERSITY

January 22, 2024

Valerie Diaz, DNP, CRNA, PMHNP-BC, APRN, CNE, CHSE, CAPT, NC, USN
Clinical Assistant Professor
Department of Nurse
Anesthesiology
Nicole Wertheim College of Nursing & Health
Sciences Florida International University

Dr. Valerie Diaz,

Thank you for inviting FIU Alumni to participate in the Doctor of Nursing Practice (DNP) project conducted by Jessica Mulet entitled "The Effect of Simulation-Based Training vs. Web-Based Education on Anesthesia Provider Confidence in the Perioperative Management of Malignant Hyperthermia" in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthesiology at Florida International University. I have granted the student permission to conduct the project using our alumni providers.

Evidence-based practice's primary aim is to yield the best patient outcomes by selecting interventions supported by the evidence. This proposed quality improvement project seeks to investigate and synthesize the latest evidence regarding simulation-based training to increase providers' confidence in malignant hyperthermia signs and symptoms recognition, and its prompt treatment to improve patient outcomes.

We understand that participation in the study is voluntary and carries no overt risk. Anesthesiology providers are free to participate or withdraw from the study any time. The educational intervention will be conveyed by a 15- minute virtual PowerPoint presentation, with a pretest and posttest questionnaire delivered electronically by a URL link via Qualtrics, an online survey product. Responses to pretest and posttest surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password-encrypted digital cloud, only accessible to the investigators of this study: Jessica Mulet and Dr. Valerie Diaz.

Once the Institutional Review Board's approval is achieved, this scholarly project's execution will abide its tenets and occur over two weeks. Jessica Mulet will not impede hospital performance and will uphold standards of care. We support the participation of our Nurse Anesthesiology alumni in this project and look forward to working with you.

DocuSigned by:
Ann Miller
A086D8685003471...

Ann B. Miller DNP, CRNA, APRN, FAANA

Interim Chair, Department of Nurse
Anesthesiology Nicole Wertheim College of
Nursing & Health Sciences Florida
International University

Appendix B: IRB Approval

Office of Research Integrity
Research Compliance, MARC 430

MEMORANDUM

To:	Dr. Valerie Diaz
CC:	Jessica Mulet
From:	Kourtney Wilson, MS, IRB Coordinator KMW
Date:	January 31, 2024
Protocol Title:	"The Effect of Simulation-Based Training vs. Web-Based Education on Anesthesia Provider Confidence in the Perioperative Management of Malignant Hyperthermia"

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #:	IRB-24-0029	**IRB Exemption Date:**	01/31/24
TOPAZ Reference #:	113999		

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
3) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

KMW

Appendix C: Project Consent

CONSENT TO PARTICIPATE IN A QUALITY IMPROVEMENT PROJECT

The Effect of Simulation-Based Training vs. Web-Based Education on Anesthesia Provider Confidence in the Perioperative Management of Malignant Hyperthermia

SUMMARY INFORMATION
Things you should know about this study:

- **Purpose:** Simulated experience to increase provider's awareness of using simulation-based education to increase Anesthesia provider confidence in the recognition and management of Malignant Hyperthermia signs and symptoms, improve patient outcomes, and improve interdisciplinary communication.
- **Procedures**: If you choose to participate, you will be asked to complete a pretest, watch a voiceover PowerPoint, and then take a posttest.
- **Duration:** This will take about a total of 25 minutes.
- **Risks**: As would be expected in any type of educational intervention, this project will involve minimal risks, which may include mild emotional stress or mild physical discomfort from sitting in a chair for an extended period.
- **Benefits:** The main benefit of this research is the increase in the participants' knowledge of simulation-based education to increase Anesthesia provider confidence in the recognition and management of Malignant Hyperthermia signs and symptoms.
- **Alternatives:** There are no known alternatives available to the participant other than not taking part in this quality improvement project.
- **Participation:** Taking part in this quality improvement project is voluntary.
-

Please carefully read the entire document before consenting to participate.

NUMBER OF STUDY PARTICIPANTS:
If the participant decides to be in this study, they will be one of 10 people in this research study.

PURPOSE OF THE PROJECT

The participant is being asked to be in a quality improvement project. The goal of this project is to increase provider's awareness of using simulation-based education to increase Anesthesia provider confidence in the recognition and management of Malignant Hyperthermia signs and symptoms, improve patient outcomes, and improve interdisciplinary communication. If you decide to participate, you will be 1 of approximately 10 participants.

DURATION OF THE PROJECT
The participation will require about 25 minutes.

PROCEDURES
If the participant agrees to be in the project, PI will ask you to do the following things:
1. Complete an online 10-question pretest survey delivered electronically via Qualtrics, an Online survey product for which the URL link is provided
2. Review the 15-minute educational PowerPoint Module delivered electronically via Qualtrics, an Online survey product for which the URL link is provided.
3. Complete the online 10-question posttest survey delivered electronically via Qualtrics, an Online survey product for which the URL link is provided.

RISKS AND/OR DISCOMFORTS
The main risk or discomfort from this research is minimal. As would be expected in any type of educational intervention, this project will involve minimal risks, which may include mild emotional stress or mild physical discomfort from sitting in a chair for an extended period.

BENEFITS
The following benefits may be associated with participation in this project: An increased participant knowledge of using simulation-based education to increase Anesthesia provider confidence in the recognition and management of Malignant Hyperthermia signs and symptoms.

ALTERNATIVES
There are no known alternatives available to the participant other than not taking part in this project. However, if the participant would like to receive the educational material, it will be provided to them at no cost.

CONFIDENTIALITY
The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, PI might publish, it will not include any information that will make it possible to identify the participant. Records will be stored securely, and only the project team will have access to the records.

PARTICIPATION: Taking part in this quality improvement project is voluntary.

COMPENSATION & COSTS
There is no cost or payment to the participant for receiving the health education and/or for participating in this project.

RIGHT TO DECLINE OR WITHDRAW
Participation in this project is voluntary. The participant is free to participate in the project or withdraw the consent at any time during the project. The participant's withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove the participant without their consent at such time that they feel it is in their best interest.

RESEARCHER CONTACT INFORMATION
If you have any questions about the purpose, procedures, or any other issues relating to this research project, you may contact Jessica Mulet at 786-210-8066 or email jmule009@fiu.edu. You may also contact Dr. Valerie Diaz at 305-348-9027, or email

vdiaz@fiu.edu.

IRB CONTACT INFORMATION
If the participant would like to talk with someone about their rights pertaining to being a subject in this project or about ethical issues with this project, the participant may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT
I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the "consent to participate" button below I am providing my informed consent.

Appendix D: Recruitment Letter

Nicole Wertheim College of Nursing & Health Sciences
FLORIDA INTERNATIONAL UNIVERSITY

The Effect of Simulation-Based Training vs. Web-Based Education on Anesthesia Provider Confidence in the Perioperative Management of Malignant Hyperthermia

Dear FIU Alumni:

I am Jessica Mulet, a student in the Anesthesiology Nursing Program Department of Nurse Anesthesiology at Florida International University. I invite you to participate in my quality improvement project. The goal of this project is to increase healthcare provider awareness of using simulation-based education to increase anesthesia provider confidence in the recognition and management of Malignant Hyperthermia signs and symptoms, improve patient outcomes, and improve interdisciplinary communication. You may participate in this project because you are a FIU alumni perioperative provider.

If you decide to participate in this project, you will be asked to complete and sign a consent form. Next, you will complete a pre-test questionnaire, which is expected to take approximately 5 minutes. You will then be asked to view a 15-minute-long educational presentation online. After completing the educational module, you will be asked to take the post-test questionnaire, which will take approximately 5 minutes. No compensation will be provided.

Remember, this is completely voluntary. You can choose to be in the study or not. If you'd like to participate or have any questions about the study, please email or contact me at 786-210-8066, or jmule009@fiu.edu

Thank you very much.

Sincerely,

Jessica Mulet
786-210-8066 (c)
Jmule009@fiu.edu

Appendix E: Educational Module

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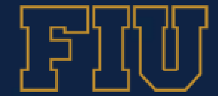
The Effect of Simulation-Based Training vs. Web-Based Education on Anesthesia Provider Confidence in the Perioperative Management of Malignant Hyperthermia

Jessica Mulet
Dr. Valerie Diaz



PICO Question

For anesthesia providers, does semiannual simulation training improve overall perioperative management of malignant hyperthermia (MH) care and provider confidence compared to the sole use of web-based educational training?

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Learning Objectives

FIU

Identify	• Identify the current problem in the treatment of malignant hyperthermia (MH) in the operating room (OR).
Explain	• Explain MH and the signs and symptoms that will first be seen in the OR by anesthesia providers.
Demonstrate	• Demonstrate how simulation of MH management in the OR will be beneficial.
Explain	• Explain what measures are being tracked and the staff's role in this plan.
Understand	• Understand the limitations impeding prompt recognition of MH signs and symptoms

Problem Statement & Identification

Anesthesia providers admit to lack of confidence in recognizing and treating MH, which may lead to:

- Poor patient outcomes
- Increased hospital costs
- Decreased provider confidence and morale.

FIU

- High-impact, low-frequency (HILF) event
- Primary concern:
  - Ability of anesthesia provider
  - Low confidence level
- Limiting factors[1]:
  - Delayed recognition of MH
  - Delayed readiness for administering dantrolene or Ryanodex
  - Inadequate training
- Lack of timely recognition attributed to[2]:
  - Variability in symptom onset
  - Symptoms masked (i.e., beta-blockers, paralytics)
  - Symptoms mimic other processes (i.e., sepsis, NMS, pain, febrile nonhemolytic transfusion reactions

Background of the Problem

- MH is a triggered hypermetabolic state that causes an excessive release of calcium, causing muscle rigidity[2]
- S/S – sudden increase in end-tidal CO_2, hyperthermia, tachycardia, dark urine, ventricular fibrillation, excessive bleeding, severe rhabdomyolysis, and death
  - First signs: hypercarbia, tachycardia, masseter spasm, hyperthermia [3]
  - No single symptom is exclusive to MH, so although rare, remain vigilant.
- Incidence: 1 in 100,000 patients with a mortality rate of 70-80%[1, 2]

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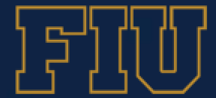
FIU

Summary of Literature

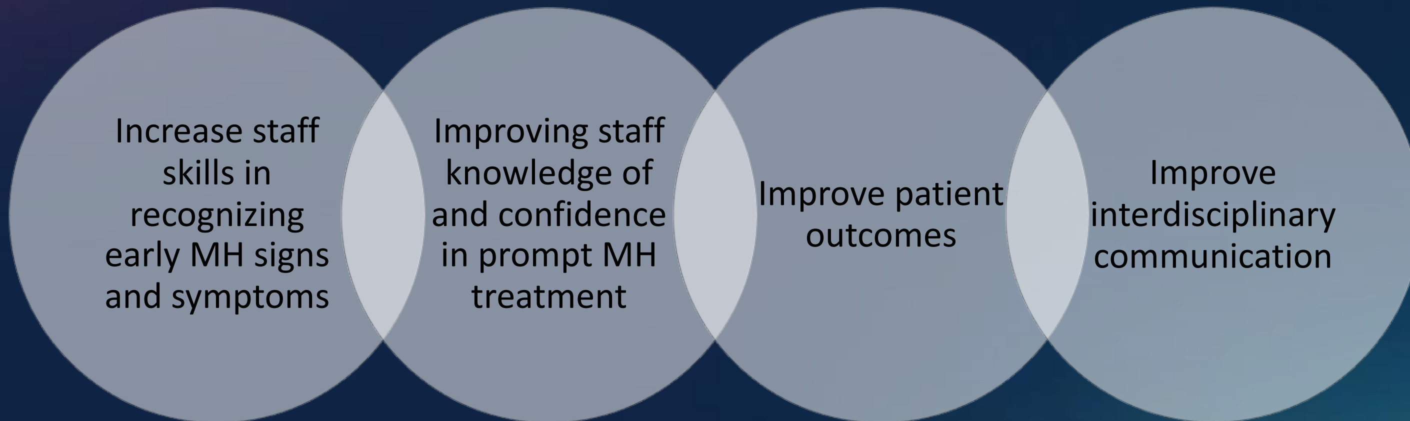
- About 1 in 20 patients experience preventable harm while receiving medical treatment in the hospital.[2]
- Benefits of simulation:
  - Skill development for HILF events, offering practical exposure
  - Safe environment[5]
  - Evaluation and improvement of teamwork, leadership, situational awareness, decision-making skills[4-6]
  - Improves participant confidence[4]
- Simulation-based team training (SBTT) places its emphasis on both individual and team conduct in everyday situations and high-pressure crises, all while giving significant attention to honing decision-making abilities, interpersonal interactions, and effective team leadership.[4]
- Bienstock and Heuer explain that disciplines commonly train within their realm, but rarely is interdisciplinary training completed together.[4]
- Recommendations from Malignant Hyperthermia Association of the United States (MHAUS), Anesthesia Patient Safety Foundation (APSF), and American Association of Nurse Anesthesiology (AANA)

Proposed Solution

- Semiannual in-situ training as a component of the institutional competency-based education for anesthesia providers.
- OR suite designated for simulation of MH event utilizing a high-fidelity mannequin to complete competency-based training.
- Tasks:
  - Simulation of surgical procedure while articulating signs and symptoms as they manifest.
  - Team leader will assign responsibilities and guide treatment
- Following simulation, debriefing will cover:
  - MH signs and symptoms
  - MH treatment and protocols
  - MH cart content and locations
  - Communication techniques



Project Purpose



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Proposed Solution

- Pre-simulation survey:
  - Baseline knowledge of MH
  - Perceived confidence in recognizing MH
  - Preparedness in managing MH
- Simulation
- Post-simulation survey:
  - Same as pre-simulation survey
  - Request for feedback on simulation experience to modify future iterations
- Operational definition for clinical outcomes: a measurement of the time frame from recognition of symptoms, diagnosis of MH, and administration of Dantrolene or Ryanodex.

Take Home Points

- Malignant hyperthermia is a rare but life-threatening complication that can occur during surgery with anesthesia.
- Symptom recognition and treatment must be prompt to improve the chances of survival.[1]
- Diagnosis is often missed because it resembles other issues like neuroleptic malignant syndrome and sepsis.[2]
- Simulation-based training increases confidence in performance, as well as short-term skill enhancement. It also improves interprofessional teamwork, communication, and non-technical human factors. [4-6]
- SBTT places its emphasis on both individual and team conduct in everyday situations and high-pressure crises, all while giving significant attention to honing decision-making abilities, interpersonal interactions, and effective team leadership.[4]
- Semiannual simulation of the recognition and treatment of malignant hyperthermia in the operating room by anesthesia staff will improve patient outcomes.

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3. Gong X. Malignant hyperthermia when dantrolene is not readily available. BMC Anesthesiol. 2021/04/16 2021;21(1):119. doi:10.1186/s12871-021-01328-3
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Appendix F: Pretest and Posttest Questionnaire

Start of Block: FIU Informed Consent

QI Consent

- I consent (1)
- I decline (2)

End of Block: FIU Informed Consent

Start of Block: Thank you for participating! I truly appreciate your time.

Start of Block: Pre-Demographics Questionnaire

Q2 Gender:

- Male (1)
- Female (2)
- Non-binary / third gender (3)
- Prefer not to say (4)

Q3 Age:

- Younger than 20 (1)
- 21-30 (2)
- 31-40 (3)
- 41-50 (4)
- 51-60 (5)
- 61-70 (6)
- Older than 70 (7)

Q4 Ethnicity

- Hispanic or Latino (1)
- Not Hispanic or Latino (2)

Q5 Race

- American Indian or Alaska Native (1)
- Asian (2)
- Black or African American (3)
- Native Hawaiian or Other Pacific Islander (4)
- White (5)
- Other (6)

Q6 Level of Education

- ○ Master of Science in Nursing (1)
- ○ Doctor of Nursing Practice (2)

Q7 Years of experience as a CRNA

- ○ Less than 1 year (1)
- ○ 1-2 years (2)
- ○ 3-5 years (3)
- ○ 6-10 years (4)
- ○ Greater than 10 years (5)

End of Block: Pre-Demographics Questionnaire

Start of Block: Pretest Questionnaire

Q8 Which organization is responsible for recommendations related to the management of malignant hyperthermia?

- ○ Occupational Safety and Health Administration (1)
- ○ Malignant Hyperthermia Association of the United States (2)
- ○ Anesthesia Patient Safety Foundation (3)
- ○ American Association of Nurse Anesthesiology (4)

Q9 Simulation can improve participant confidence and lead to short-term improvement of clinical skills and interdisciplinary teamwork skills.

- ○ True (1)
- ○ False (2)

Q10 Signs and symptoms of MH include: (select all that apply)

- ☐ Muscle contraction (1)
- ☐ Sudden decrease in EtCO2 (2)
- ☐ Tachycardia (3)
- ☐ Bradycardia (4)
- ☐ Masseter rigidity (5)

Q11 What diagnosis does MH mimic?

- ○ Sepsis (1)
- ○ Neuroleptic Malignant Syndrome (2)
- ○ Febrile Nonhemolytic Transfusion Reaction (3)
- ○ All of the above (4)

Q12 What is the definitive treatment of MH? (Select all that apply)

- ▢ Ryanodex (1)
- ▢ Reloxifene (2)
- ▢ Dantrolene (3)
- ▢ Bromocriptine (4)

Q13 Which receptor is implicated in MH?

- ○ RYR1 (1)
- ○ RYR2 (2)
- ○ RYR3 (3)
- ○ RYR4 (4)

Q14 I know where my MH cart is located at my facility.

- ○ Yes (1)
- ○ No (2)

Q15 I am confident in my ability to recognize MH signs and symptoms.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q16 If my patient is exhibiting MH signs and symptoms, I know what steps to take.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q17 I believe simulation training would improve my ability to recognize and treat MH.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q18 Simulation training fosters learning more than web-based training.

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

End of Block: Pretest Questionnaire

Start of Block: Educational Module

Q32 Please watch the educational module below.

Thank you!

End of Block: Educational Module

Start of Block: Posttest Questionnaire

Q1 Which organization is responsible for recommendations related to the management of malignant hyperthermia?

- ○ Occupational Safety and Health Administration (1)
- ○ Malignant Hyperthermia Association of the United States (2)
- ○ Anesthesia Patient Safety Foundation (3)
- ○ American Association of Nurse Anesthesiology (4)

Q2 Simulation can improve participant confidence and lead to short-term improvement of clinical skills and interdisciplinary teamwork skills.

○ True (1)

○ False (2)

Q3 Signs and symptoms of MH include: (select all that apply)

▢ Muscle contraction (1)

▢ Sudden decrease in $EtCO_2$ (2)

▢ Tachycardia (3)

▢ Bradycardia (4)

▢ Masseter rigidity (5)

Q4 What diagnosis does MH mimic?

○ Sepsis (1)

○ Neuroleptic Malignant Syndrome (2)

○ Febrile Nonhemolytic Transfusion Reaction (3)

○ All of the above (4)

Q5 What is the definitive treatment of MH? (Select all that apply)

- Ryanodex (1)
- Reloxifene (2)
- Dantrolene (3)
- Bromocriptine (4)

Q6 Which receptor is implicated in MH?

- RYR1 (1)
- RYR2 (2)
- RYR3 (3)
- RYR4 (4)

Q8 I am confident in my ability to recognize MH signs and symptoms.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q9 If my patient is exhibiting MH signs and symptoms, I know what steps to take.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q10 I believe simulation training would improve my ability to recognize and treat MH.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q11 Simulation training fosters learning more than web-based training.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

End of Block: Posttest Questionnaire