EFFECTIVENESS OF MALIGNANT HYPERTHERMIA SIMULATION TRAINING AND EDUCATIONAL POWERPOINT ON CONFIDENCE, KNOWLEDGE, AND COMMUNICATION SKILLS IN CRITICAL CARE NURSES

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Dedications

I would like to express my gratitude to my family and friends for the unwavering support they have provided me throughout the past three years. I am immensely grateful for my husband and our four children who have showered me with endless love and encouragement while I was away, working hard to achieve my goal of earning a Doctorate in Nursing Practice degree. I am also thankful for our parents who have been there at every turn, providing their support and stepping in to help whenever needed. I am grateful for the amazing nurse anesthetists that I have met who have mentored me and encouraged me even on my hardest days.

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Abstract

Background: Malignant hyperthermia (MH) is a high acuity low occurrence event. It is classified as an autosomal dominant inherited skeletal muscle disorder, caused by the improper release of calcium from the sarcoplasmic reticulum. When the acute events of malignant hyperthermia are left untreated, the mortality rate is 80-90%. Outside of the operating room, MH is rarely observed but can occur to a patient for 24 hours after transfer from the operating room. **Purpose:** The purpose of this Doctor of Nursing Practice (DNP) project was to evaluate the effectiveness of an educational presentation and MH simulation on intensive critical care (ICU) registered nurse's (RN) confidence, knowledge, and role clarity while managing an MH crisis at a large regional hospital. **Methods:** The Awareness to Adherence model and Johns Hopkins Evidence-Based Practice model provided guidance for implementation. Critical care registered nurses were invited to a PowerPoint presentation accompanied by an interactive MH simulation performed by the PI. A mixed-methods, quality improvement design using a pre-and post-test survey was used to collect data. **Results:** A mixed-methods quality improvement design was used to measure ICU RNs' confidence, knowledge, and role clarity before and after MH education and simulation. Sixteen ICU RNs participated in the project. Descriptive statistics were utilized to analyze data from the sixteen paired pre- and post-test surveys. Preintervention 13% agreed or strongly agreed they knew the initial treatment for MH, post-intervention this increased to 100%, and 94% stated that they could calculate and reconstitute dantrolene following education and simulation. **Conclusion:** This project showed that the interventions were successful in enhancing individuals' confidence and knowledge of MH management, which in turn can reduce the morbidity and mortality of patients during an MH crisis. The results of the project suggested that simulation training is an effective tool to improve confidence, knowledge,

and role clarity in an MH crisis while preparing for life-threatening emergencies in a safe and controlled environment. *Key Words*: malignant hyperthermia, education, simulation, nurse confidence, knowledge, role clarity

Background and Significance

Malignant hyperthermia (MH) is a high acuity low occurrence event. It is classified as an autosomal dominant inherited skeletal muscle disorder, caused by the improper release of calcium from the sarcoplasmic reticulum. The onset of symptoms has been reported to occur within minutes of exposure to the triggering agents to several hours later, and the progression of life-threatening features is also variable (Hopkins et al., 2021). Clinical features of MH include tachycardia, masseter muscle rigidity, increased carbon dioxide levels (ETCO2), and fever. The most reliable feature is an unexplained increase in the ETCO2 levels and tachypnea. Signs and symptoms of MH can mimic other clinical conditions, so early recognition and prompt treatment are vital to decrease morbidity and mortality (Rosenbaum & Rosenberg, 2022).

Treatment is started after the recognition of signs and symptoms and after the elimination of differential diagnosis. When the acute events of malignant hyperthermia are left untreated, the mortality rate is 80-90% (Hopkins et al., 2021). As mentioned, MH is a rare occurrence event with a high mortality rate. Outside of the operating room, MH is rarely observed but can occur to a patient after transfer from the operating room. Research shows that the triggering anesthetic agents can lead to MH several hours after exposure, occurring after the patient has left the operating room and is in a surgical intensive care unit (Hopkins et al., 2021).

The importance of MH simulations, education, and knowledge in critical care can lead to improved patient outcomes. Treatment should be initiated as soon as signs and symptoms are suspected and recognized. Simulation-based training allows healthcare providers to participate in

the treatment of real-life scenarios in a controlled environment. This type of training is effective because it allows for the training of skills in situations that occur infrequently, like MH. This allows team members to practice response times, effective treatment options, clear provider roles, and effective communication skills. Simulations can be repeated multiple times, with a magnitude of scenarios, due to the nature of training (Lei & Palm, 2022). The most effective way to treat an event like MH is to ensure proper training with the use of simulations and educational PowerPoints in the critical care setting.

Purpose

The purpose of this Doctor of Nursing Practice (DNP) project was to evaluate current training methods regarding MH treatment in the ICU. Protocols were evaluated to look for up-to-date information on the treatment of an MH patient. This project measured the usefulness of a PowerPoint presentation and accompanying simulation-based training on MH recognition and treatment in the ICU. Critical care nurses were assessed for improved confidence, knowledge, and role clarity regarding MH by utilizing pre-and post-test surveys, in addition to the educational materials.

Literature Review

A literature search was conducted using CINAHL, PubMed, and Medline, for the years 2017 to 2023. The literature review used the Boolean phrases: “malignant hyperthermia”, “nurses”, “critical care”, “simulation”, “treatment”, “nurse confidence”, and “education”. Peer-reviewed articles, retrospective cohort studies, cross-sectional studies, and professional journals were included in the synthesis. Non-peer-reviewed articles, blogs, and nonrelevant studies were excluded. A total of 16 articles were reviewed with a focus on simulation and education of critical care nurses, nurses’ confidence, increase in knowledge, and role clarity related to prompt

recognition of malignant hyperthermia, and patient management in the ICU.

Malignant Hyperthermia

Malignant hyperthermia is caused by a genetic mutation and affects a patient when exposed to anesthesia drugs, triggering a low occurrence, high acuity medical emergency. The exposure causes a cascade of events leading to a hypermetabolic skeletal muscle disorder. MH is triggered when a susceptible person receives inhaled volatile anesthetics or the depolarizing muscle relaxant succinylcholine, which are typically administered in the operating room.

The onset of MH is usually rapid following receipt of triggering agents usually during general anesthesia. The most frequent signs and symptoms include hyperthermia up to 107 degrees Fahrenheit, muscle rigidity, increased ETCO2, and tachycardia, and when left untreated, these can lead to death. MH can be deadly without treatment. The most important factors in decreasing mortality and morbidity are prompt treatment with dantrolene and supportive measures, so prompt treatment is crucial (Hopkins et al., 2021). Appropriate training for critical care nurses can expedite diagnosis and treatment and decrease MH mortality.

MH can present up to 1 week after receiving triggering agents in the operating room, such as when the patient is in the ICU. These types of cases are recognized as delayed onset MH. Despite the infrequency of MH cases, prompt treatment and management of these patients leads to increased chances of survival. Mortality can be as high as 80% when not recognized and treated properly (Min et al., 2021). Differential diagnosis is more difficult in cases of delayed MH, as it typically occurs within 10 to 60 minutes of initiation of the triggering agents. A delayed diagnosis and treatment are more likely to occur in the ICU since the onset of MH is rare in this setting. There are cases reported to have a delayed onset of symptoms as far out as one week after exposure to the anesthetic agents. (Min et al., 2021). The rapid progression of MH

increases the mortality by 1% after every 20 minutes that dantrolene administration is delayed (Gallegos & Hennen, 2022). Without prompt treatment, MH can progress to multiple organ failure, respiratory distress, hemodynamic instability, and death. A coordinated team response is empirical to the patient's survival. Appropriate training by critical care nurses institutes a substantial decrease in MH mortality, which can be improved with exposure to simulation-based training. Simulations provide an environment for continuous education for healthcare workers, particularly in rare events like MH (Edwards et al., 2023).

With the increased mortality risk related to delayed treatment, healthcare providers and critical care staff require regular training to produce timely recognition and intervention. Their knowledge of the symptoms of MH, barriers, and treatment protocols is crucial to treating an MH crisis and preventing the progression to death.

Simulation Training

Simulation training is effective for high-acuity situations and exposes healthcare providers to life-like scenarios, in a controlled and interactive environment. Exposure to simulation training provides the ability to duplicate complex patient situations and improves staff's skills, knowledge, communication, and confidence. Simulation training equips providers with the ability to develop their knowledge and confidence and to establish clear roles and responsibilities in high-acuity events, such as MH (Corinne et al., 2019). This type of training serves as a critical tool to add to continuing clinical education (Corinne et al., 2019). Thorough education must highlight the causes of MH, recognition, treatment interventions, and location of the MH-specific cart (Gallegos & Henning, 2022).

Simulation improves critical decision-making and communication skills when compared to traditional education. This type of training bridges the gap between healthcare theory and

practice, leading to improved patient outcomes (Kourkourikos et al., 2021). This is particularly beneficial in high acuity, low occurrence events such as MH, leading to improved nursing knowledge, confidence, and perceived patient outcomes. Parsons et al. (2019) conducted a quality improvement project looking at the effects of an MH simulation on knowledge and interventions. The surveys collected showed an increase in knowledge and clinician's confidence related to an MH crisis because of the simulation. Another study by Al Gharibi & Arulappan (2020) evaluated the effects of simulation-based training and found that this type of training, both low and high fidelity, produced positive outcomes for knowledge, confidence, and participation in both nursing students and practicing nurses.

Clinical Confidence

Theoretical knowledge transitions to practical knowledge with repeated exposure to simulation training. Nurses are provided with a safe training environment to practice and develop their skills in this type of controlled environment, and this leads to improved practice and decision-making skills (Al Gharibi & Arulappan, 2021). Simulation provides active learning and participation, and this leads to improved knowledge and confidence. Repeated exposure to simulation training further improves the nurse's confidence, as this gives opportunities to target areas for improvement. Confidence improves with the ability to make accurate clinical judgments during times of crisis and emergency, and simulation training has been shown to provide this environment. Increased self-confidence positively impacts patient care and leads to better patient outcomes (Sharour et al., 2021.) The ability to work as a team is also improved with simulation-based training and improved knowledge, as healthcare workers can share their knowledge and teach one another vital skills and information (Alrashidi et al., 2023). Enhanced clinical confidence can lead to improved patient outcomes. Guerrero et al. (2022) found an

enhancement in nurses' confidence and motivation, as well as a reduction in participant's anxiety related to emergency responsiveness.

More confident healthcare providers tend to offer better quality care and exhibit higher job satisfaction and retention rates (Kim et al., 2020).

Knowledge

Improvement in knowledge occurs with simulation training, as participants can add to their knowledge base with repeated training sessions. This type of training allows for debriefing sessions and the ability to continue practicing in a safe environment until skills and knowledge have increased (Alanazi et al., 2017). **A n**urse's knowledge of the signs and symptoms of an MH patient improves with proper training and with repeated exposure to simulation training. As clinical confidence and skills increase, so does learning. The inclusion of simulation-based training closes the gap that nurses feel between concept theories and actual practice (Koukourikos et al., 2021). Reading about a clinical concept and experiencing it first-hand have different effects. Simulation exposes healthcare providers to real-life scenarios, such as MH, in a controlled environment.

With low-frequency events like MH, the type of simulation training that would be most effective is the Rapid Cycle Deliberate Practice (Peng & Shertzer, 2022). In this format, learners repetitiously perform simulations and participate in micro-debriefing periods to assist in real-time improvements and diverge knowledge attrition. Mejia et al. (2018) did a prospective, randomized study with two groups. They studied the effects of MH simulation training compared to computer-based case studies and found that participants had increased knowledge of the simulation training versus the computer-based method. This allows for high-fidelity training in the simulation environment and improves skills and knowledge that are then refined further in

the training environment.

Roles and Responsibilities

Individuals with complex health needs require effective communication and understanding from their healthcare team. The process of role clarification involves healthcare professionals developing a clear understanding of their roles as well as the roles of their colleagues. This understanding is crucial in achieving the best possible patient outcomes, as it improves care coordination and allows professionals to balance autonomy with interdependence. However, when responsibilities are ambiguous, it can lead to conflicts, tension, service duplications or gaps, and underutilization of professional expertise. Role clarification is an increasingly recognized collaborative tool, and students pursuing a healthcare career should develop this skill to ensure they are well-prepared for their future roles in the healthcare system.

According to recent literature, the process of negotiating and clarifying roles is essential for hospital teams. Studies suggest that collaborative experiences, open communication, having designated change champions, and work environments that value mutual respect, interdisciplinary collaboration, and patient-centered approaches can all facilitate role clarification (Sibbald et al., 2018). Understanding each team member's role is crucial for effective teamwork as it promotes trust and mutual respect. When everyone has a clear understanding of the roles and responsibilities of their colleagues, it leads to better role clarity and optimal utilization of all professional roles. This, in turn, leads to improved patient outcomes and better cost-effectiveness for the health system. Hence, role clarity is a critical factor in designing effective team training interventions (Kilpatrick et al., 2020).

Gaps

Although rare in ICUs, MH poses a significant challenge due to the lack of research in

this area. While there are limited studies on MH recognition and treatment in this setting, existing research suggests that simulation-based training is an effective approach to training healthcare professionals. However, few studies have examined the long-term outcomes of high fidelity or crisis simulation education, with most focusing on nursing and medical students, as well as anesthesia providers. Therefore, additional research is needed to evaluate crisis management training through simulation methods, including the assessment of confidence, knowledge, and communication skills related to this type of training.

Theoretical Framework

The Awareness to Adherence model was used as the theoretical framework for this project. This model helps to implement up-to-date evidence-based practice guidelines and standards into clinical practice (Fleming et al., 2020). Several steps to this model need to be accomplished so these guidelines can be put into practice. Team members need to first be made aware of any new evidence and accompanying practice recommendations. Next, compliance with these practice recommendations is critical. Third, following thorough education, evidence-based practice changes must be carried out. Finally, observance of the most recent evidence-based practice should be implemented into everyday practice.

Team members were given a pre-test survey before the simulation of a patient experiencing malignant hyperthermia, or MH. The survey assessed the need for nurses to receive MH education in the ICU. Next, they were presented with an educational PowerPoint followed by an MH simulation. The PowerPoint and simulation gave detailed information about the pathophysiology of MH, as well as common signs and symptoms. The simulation exposed the nurses to a real-life MH emergency and assisted in guiding the nurses during prompt recognition and accurate treatment of an MH patient. Staff were encouraged to work together to identify the

diagnosis given the most common signs and symptoms. After the differential diagnosis, they located their unit's protocol book containing the checklist of treatments and the nearest MH cart containing the medication dantrolene. Diagnosis, treatment time, communication skills, and roles were identified during the initial simulation.

After the informative presentation and simulation, team members were given the opportunity to discuss and familiarize themselves with the MH cart and supplies. Emphasis was placed on the importance of a collaborative approach to timely identification and treatment, as well as the crucial role of critical care nurses. Through pre- and post-test surveys, the PI evaluated the effectiveness of the PowerPoint presentation and MH simulation in improving the knowledge, confidence, and role clarity of nurses concerning MH.

This project examined the ICU nurse's knowledge and understanding of the recognition and treatment of an MH patient in the ICU. Current MH policies and protocols were also evaluated to ensure accurate and up-to-date training took place. The intervention included an educational presentation and the simulation of an MH crisis. Surveys will be handed out in the pre and post-intervention phases and will assess for improved knowledge, confidence, and communication skills in MH.

Methods

Design

A mixed-methods quality improvement approach was employed in this project design. A pre-and post-test survey was created, and the efficacy of an educational MH simulation was evaluated for enhancement to ICU RNs' confidence, knowledge, and clear provider roles. The principal investigator (PI) was a student registered nurse anesthetist (SRNA). The project's goals were to identify the outcomes of simulation on MH recognition and management to improve ICU

nurse's confidence, knowledge, and communication skills. The project participants consisted of ICU RNs employed at the selected regional medical center. The MH simulation consisted of a scripted crisis depicted by the PI applying up to date MHAUS protocols and recommended emergency equipment. Prior to application, the scripted MH crisis simulation was appraised for correctness by the facility's MH educator as well as the clinical coordinator. The surveys were administered to measure the healthcare team's collective confidence and knowledge around the management of an MH crisis.

This project consisted of three stages of implementation: (1) design of the informational PowerPoint and MH simulation script, (2) development of the surveys, and (3) evaluation of the presentation and simulation using the surveys developed by the PI.

Evidence-Based Practice Model

The Johns Hopkins Evidence-Based Practice (EBP) model was used to assist with the creation and application of this project. This model utilizes a three-step process to create steps to help explain how evidence and current research can be carried out in clinical practice. The three fundamental steps are: practice questions, evidence, and translation (Johns Hopkins Medicine, 2019). The framework explains how this project focuses on using current research to develop an educational simulation to mimic an MH patient and the impact it has on ICU nurses' confidence and knowledge in the management of a patient suffering from an MH crisis.

The first step in this model necessitates the formation of a practice question by identifying the problem, establishing a team, and delegating roles (Johns Hopkins, 2019). This project assessed MH and the effects of simulation training on ICU nurse's confidence, knowledge, and communication skills. PI, critical care nurse manager, and the University of North Carolina at Greensboro (UNCG) faculty advisor comprised the project team.

The second step of the model consisted of reviewing current literature and relative data. This involved reviewing the MH protocols in the ICU and reviewing the content for up-to-date data. The final step involved collecting evidence, and then using it to create an attainable action plan to be employed in clinical practice. The data collected from the linked surveys was analyzed to explain the efficacy of simulation training and the impact on knowledge, confidence, and communication skills. Research shows an improvement in knowledge, confidence, and communication skills when nurses are exposed to real-life scenarios utilized in simulations (Meija et al., 2018). Each step of the model served as a guideline to create an educational PowerPoint presentation and MH crisis simulation, and their effects on nurses' confidence, knowledge, and communication skills in managing an MH emergency.

Permissions

Written approval to conduct this DNP project at the designated regional medical center was obtained from the nurse manager of the ICU. The nurse manager served as the point of contact for implementing this project. Institutional Review Board (IRB) approval was obtained from UNCG and the facility before implementation.

Sample and Setting

The educational presentation and MH simulation training were conducted in a 30-bed Surgical Intensive Care Unit (SICU) at a large 921-bed regional medical center located in central North Carolina. The target population consisted of ICU nurses employed at this chosen medical center. Exclusion criteria were travel and contracted RNs employed outside of the facility. Participation in this project was strictly voluntary, and participants were able to withdraw their involvement at any time without penalty.

After careful consideration of the ICU's environment, it was determined that the MH

simulation training should be conducted in an unoccupied ICU room. Utilizing the ICU for the simulation facilitated the deployment of skilled staff and emergency gear, thereby heightening the simulation's authenticity.

Implementation

The informational presentation and accompanying simulation training were implemented during a day shift and evening shift staff meeting on two separate days. Before the training, a recruitment speech was given to the potential participants during both staff meetings, which included the purpose of the project, an explanation of the presentation and simulation, and the information included in the surveys. The staff were made aware that any participation was voluntary and informed that there would be no penalty for not participating.

Once the pre-test survey was completed, participants were asked to put their completed surveys into envelopes and return them to the PI, and the educational PowerPoint presentation was presented, followed by the MH simulation. The PowerPoint provided detailed information on the pathophysiology of MH, differential diagnostic criteria, early and late signs and symptoms, interventions to stabilize the patient, and ICU management. During the presentation, facility-based protocols on MH were reviewed. Following the completion of the surveys, the PI and volunteer participants staged the simulation. The participants were assigned various roles, including either the nurse manager or unit nurse secretary, and the PI assumed the role of nurse team leader in each of the simulations performed. The live simulation incorporated an MH scenario from arrival to the ICU, recognition of MH, and patient care. The MH simulation portrayed early and late signs of MH as well as interventions to quickly stabilize the patient.

To create realistic vital signs, the clinical coordinator included the training Zoll monitor in the simulation to depict appropriate vital signs and accompanying cardiovascular changes as

the crisis progressed. Visual cues, such as critical vital signs (ETCO2, blood pressure, increasing temperature) were provided to aid in the simulation fidelity. The MH cart was in the ICU and applicable supplies were used for the training. The simulation also incorporated hands-on tasks, such as retrieving bags of ice, cold fluids, the MH cart, and the code cart from their assigned locations, as well as the overhead call for "Code MH." Necessitating staff to leave the room to retrieve appropriate supplies was an included portion of the PI to simulate a realistic environment and the time it takes to perform each task during a crisis. The MH cart was opened, and step-by-step guidelines were employed to show what an adequate emergency response should include, from early recognition to post-crisis MH management. After the simulation, the ICU nurses were given time to acquaint themselves with the items and equipment located in the MH cart and to debrief.

Data Collection

Procedures

The envelopes containing the pre-test survey were given to potential participants at the start of the staff meetings. Completion of the surveys implied consent to the project. To ensure anonymous collection, the surveys were placed in unmarked envelopes and returned to the PI. Those who chose to participate filled out the survey and placed them in sealed unmarked envelopes, and those who did not choose to participate placed the blank surveys into unmarked envelopes to protect anonymity.

Four weeks after the simulation training, the post-test surveys were distributed to participants. Envelopes with the post-test surveys were placed in the ICU breakroom for participants to fill out in unmarked envelopes. The completed post-test surveys were returned to a lockbox in the breakroom. The surveys were left in the breakroom for two months to improve

the response rate.

No identifying data was collected, to protect the anonymity of the participants. A distinctive identifier was utilized to link the pre-and post-test surveys.

Instruments

This project utilized a pre-and post-test survey that contained questions to measure the participant's confidence, knowledge, and provider roles associated with airway emergencies, cardiac arrest, and MH patients. The questions assessed their ability to recognize MH symptoms, treatment, and management of an MH patient, as well as their roles during these situations. The proper procedure for reconstitution and administration of dantrolene was also assessed in the survey.

The survey assessed recognition of MH signs and symptoms, participant's ability to manage a patient emergency, management, and treatment of an MH patient, and knowledge about reconstituting and administering dantrolene to an MH crisis patient. The scale was a 1 to 5, with 1 being 'strongly disagree' and 5 being 'strongly agree'. Project participants were given the same survey and then asked to rate themselves on these items four weeks after taking part in the simulation and presentation.

Survey questions were categorized into five different types of questions: confidence, MH patient management, role and responsibility, signs and symptom recognition, and simulation-based questions. Questions 1-4 were confidence-related questions. Knowledge of MH management questions and signs and symptom recognition were 3,5,6,7,9,10, and the role and responsibly related questions were #2 and #8. Simulation-based training was evaluated by questions #11 and #12.

The post-test survey created by the PI was administered four weeks after the intervention.

The post-test survey used identical Likert-scale questions to measure MH management in the ICU. Four additional questions in the post-test survey evaluated the effectiveness of simulation-based training compared to traditional methods, and potential barriers to MH simulation and education.

Data Analysis

Twenty-six critical care nurses completed the pre-test survey, and sixteen critical care nurses completed the post-test survey. This correlates to a 62% completion rate, and ten pre-test surveys were excluded from data analysis, as they were not linked to any post-test surveys. Data from the completed sixteen linked surveys was entered into a Microsoft Excel document and analyzed using descriptive statistics. The data from the surveys was calculated using a percentage of ICU RNs that selected agree or strongly agree with each Likert item. The data from the pre-test and post-test surveys were compared for improvements in confidence, knowledge, and role clarity.

Budget, Time, and Resources

No financial resources were needed to implement this project. This quality improvement project took 55 minutes to implement on two occasions, including the speech, review of survey material and questions, educational information, and simulation. The recruitment speech took 5 minutes, the information sheet was presented and required 5 minutes, the PowerPoint presentation took 10 minutes, and the MH simulation necessitated 25 minutes. Staff was then given 10 minutes to review the cart, ask any clarifying questions, and debrief after the simulation. This process was repeated during a morning staff meeting as well as an evening staff meeting, to recruit participants that worked both night and day shifts.

Results

Likert survey responses were recorded and ranged from strongly disagree (1) to agree and strongly agree (4 or 5). Positive responses were recorded as agree and strongly agree (4 or 5). When evaluating confidence, the pre-test survey revealed that 68.7% of ICU RNs felt confident in their skills during any patient emergency, and 12.5% of ICU RNs felt confident caring for a patient experiencing an MH crisis. The post-test survey revealed an increase in both confidence levels, showing that 81.3% felt confident in their ability to care for a patient experiencing an emergency, and 100% reported confidence in caring for a patient during an MH crisis. When assessing confidence in signs and symptom recognition, the results of the pre-test survey showed that 12.5% of ICU RNs felt confident in recognizing MH, and 100% of ICU RNs reported confidence in the post-test survey. In addition, the survey assessed confidence related to calculating the patient dose of dantrolene. In the pre-test survey, 6.3% were confident in their ability to calculate the appropriate dose, and the post-test survey revealed that after the training, 93.8% of ICU RNs were confident in calculating the correct dose of dantrolene.

The survey included knowledge questions related to MH management, including the initial treatment for MH, reconstitution of dantrolene, and the location of the MH cart. In the pre-test survey, 12.5% of respondents knew the initial treatment for MH, but this increased to 100% in the post-intervention phase. In the pre-test survey, 0% of the ICU RNs reported knowing how to reconstitute dantrolene, and 100% stated they knew how to reconstitute dantrolene in the post-test survey. Additionally, 50% of respondents knew the location of the MH cart in the pre-intervention survey, this increased to 100% in the post-test survey.

The pre and post-test surveys evaluated the roles and responsibilities of providers. Two questions were asked in this section of the survey. The first question examined the role and

responsibility of ICU RNs during a cardiac arrest event. In the pre-test, 81.3% of respondents stated that they knew their role, and this increased slightly to 87.5% in the post-test survey. The second question assessed the respondents' knowledge of their role and responsibility during an MH crisis. In the pre-test survey, only 12.5% knew their role and responsibility, while 87.5% stated that they knew their role and responsibility in the post-test survey.

The results of the project show that there was an improvement in the participants' perception of the effectiveness of simulation training and MH education. In the pre-test survey, 87.5% of participants felt that simulation training was more effective than traditional training using only computer modules, and this number increased to 100% in the post-test survey. Additionally, 87.5% of participants in the pre-test survey felt that simulation training helped them retain learned material, which also increased to 100% in the post-intervention phase. Participants believed that MH education and simulation would improve their knowledge, confidence, and communication skills, with 81.3% in the pre-intervention phase and 93.8% in the post-intervention phase agreeing that MH education and simulation did indeed improve their knowledge, confidence, and communication skills.

Discussion

The results of this DNP project highlight notable enhancements in various aspects of ICU RNs' confidence, knowledge, and role perception following the implementation of simulation training and MH education.

Initially, a considerable proportion of ICU RNs reported modest levels of confidence across several critical areas. The pre-test survey revealed significant gaps, with 68.7% feeling confident in their emergency skills and 12.5% feeling confident in managing MH crises. Early recognition and intervention are critical to reducing morbidity and mortality rates associated with

MH. Failure to diagnose and treat MH promptly can result in a mortality rate of up to 80-90% (Hopkins et al., 2021). However, the post-test survey demonstrated substantial improvements, with 81.3% expressing confidence in managing emergencies and a remarkable 100% reporting confidence in addressing MH crises. Patient care and outcomes can be positively impacted by an increase in self-confidence (Sharour et al., 2021). Enhanced clinical confidence among nurses resulted in improved motivation and reduced anxiety related to emergency responsiveness for participants (Guerrero et al., 2022). Similarly, confidence in recognizing MH symptoms improved from 12.5% pre-training to 100% post-training, while confidence in calculating dantrolene doses increased from 6.3% to 93.8%.

Knowledge about MH management was substantially improved. The pre-test survey identified deficiencies, with limited awareness of initial MH treatment and dantrolene reconstitution, as well as uncertainty of the MH cart location. Thorough education on the causes of MH, recognition, treatment interventions, and location of the MH-specific cart is necessary for recognition and treatment (Gallegos & Henning, 2022). Post-education knowledge increased to 100% on these topics which will improve patient outcomes with appropriate treatment.

The project also evaluated participants' understanding of their roles and responsibilities during critical events. While initial responses indicated some uncertainty, particularly their roles during an MH crisis, post-training surveys demonstrated significant improvements, with the majority reporting clarity in their responsibilities during both cardiac arrests and MH emergencies. Engaging in simulation training assists staff in defining and understanding their specific roles and responsibilities during high-acuity events such as an MH crisis (Corrine et al., 2019). When a team is knowledgeable about their roles, management of crises improves, leading to decreased morbidity and mortality (El Hussein et al., 2022).

Participants' perceptions of simulation training and MH education improved significantly. Pre-intervention, the majority recognized the superiority of simulation over traditional training methods and acknowledged its role in knowledge retention. These sentiments were unanimously endorsed post-intervention. Participants recognized the comprehensive benefits of MH education and simulation, acknowledging enhancements in knowledge, confidence, and communication skills, underscoring the effectiveness of the intervention. Simulation-based training and improved knowledge can also lead to better teamwork among healthcare workers, who can share vital skills and information (Alrashidi et al. 2023). Exposure to simulation training helps staff establish clear roles and responsibilities in high-acuity events like MH (Corrine et al., 2019). This high-fidelity simulation allows for the improvement of skills and knowledge for crisis management.

In conclusion, the findings underscore the efficacy of simulation-based training and targeted education in augmenting ICU RNs' confidence, knowledge, and preparedness in managing critical events, particularly MH crises. The project not only addresses identified deficiencies but also underscores the importance of ongoing education and training initiatives in optimizing patient care and safety within the ICU setting.

After undergoing the simulation and educational PowerPoint, a significant number of critical care nurses reported an increase in confidence, knowledge, and clear understanding of their roles in the context of the MH simulation. Their competency was also improved as they gained more knowledge and confidence in their ability to perform critical tasks and make clinical-based decisions.

Barriers

The project had some limitations due to a small sample size and reduced response rates to

the post-test survey (Appendix B). This project was focused on surgical intensive care nurses, which limited the number of potential participants. Many of the critical care nursing staff were unavailable during the day and evening shift presentations and simulations, which further reduced the sample size. Also, not all participating ICU RNs completed both the pre-test and post-test surveys, leading to a further decrease in the sample size. This could be due to staffing demands or turnover in the unit. The PI originally planned to leave the post-surveys in the lounge for two weeks, but this was extended to two months to increase participation.

The project's data was collected at a single facility and focused on interventions that utilized MH-specific education and simulation training for a case scenario. The training was conducted for one day shift and one evening shift. During the simulation, it was found that the MH cart was missing several critical supplies that were considered necessary for MH management according to the MHAUS guidelines. The absence of these vital emergency supplies made it challenging to simulate the appropriate response scenario. However, this highlighted the significance of crisis simulation training and the need for proper equipment and supplies that are readily available to enhance user experience and identify gaps. The PI was also unable to open the locked refrigerator in the MH cart due to facility policy, adding to response time with the need to retrieve cooled saline from another location.

Future Recommendations

Further research is necessary to determine the impact of this simulation on patient outcomes. Ensuring the nursing team's familiarity with the facility's MH cart location, contents, and utilization during an MH crisis is imperative. Critical care nurses must stay current on the latest guidelines and recommendations from the Malignant Hyperthermia Association of the United States (MHAUS). Comprehensive simulations involving the entire healthcare team

should be conducted, encompassing all facets of crisis management to provide dynamic, hands-on training. Such an approach prioritizes patient safety and ensures the delivery of optimal care.

Given the infrequency of encounters with patients experiencing MH, it is essential to recognize the potential rapid deterioration associated with such events in the absence of prompt diagnosis and treatment interventions. To sustain healthcare provider's competency in managing MH patients effectively, the integration of simulations into new ICU RN orientation and annual mandatory MH training is proposed. Simulations should align with current guidelines to uphold patient care standards consistent with best practices. A thorough review of facility policies and MH protocols may unveil areas necessitating improvement, thereby mitigating adverse patient outcomes. The site was informed about missing items from the MH cart and has rectified the situation so that critical items are readily available in an emergency. Ultimately, simulation training serves to enhance decision-making and communication competencies, fostering improved patient outcomes and bridging the theoretical-practical gap inherent in healthcare practice.

Conclusion

The project aims were to evaluate critical care nurses' confidence, knowledge, and role clarity when given an MH PowerPoint presentation and simulation. This project's aims were achieved through a quality improvement initiative focused on simulation training and MH-specific education. ICU RNs received an educational session covering MH pathophysiology, symptom recognition, and treatment, followed by an MH simulation emphasizing early symptom identification and appropriate ICU response. The study showed that the participants' confidence, knowledge, and role clarity improved. Additionally, their attitudes towards simulation training were positive, and barriers to MH management were identified.

Results demonstrated significant improvements in ICU RNs' confidence in caring for MH patients and understanding initial treatment protocols, affirming the efficacy of the combined educational approach. Participants reported increased knowledge in calculating dantrolene dosages, proficiency in dantrolene reconstitution, and MH patient management skills. Identified gaps in training, such as deficiencies in MH cart equipment and centralized supply storage, prompted recommendations for protocol adjustments to align with best practices. The project underscores the importance of continuing education for critical care nurses, advocating for the consistent integration of simulation training in MH crisis education to enhance MH management, improve patient outcomes, and bolster patient safety. These findings support previous research highlighting simulation's positive impact on enhancing clinician confidence in crisis management, recommending the inclusion of yearly training to further enhance providers' proficiency in responding to and managing an MH crisis.

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Appendix A

Malignant Hyperthermia Pre-Test Survey

Part I

1. What is the name of your first pet? _____
2. In what role/capacity do you practice (e.g., RN, NP, PA, MD)? _____
    a. If you are an RN, do you primarily work in the ICU? (yes/no) _____

Part II

1: (strongly disagree); 2: (disagree); 3: (neutral): 4: (agree); 5: (strongly agree)

Questions	**1**	**2**	**3**	**4**	**5**
1. I feel confident with my patient care during an emergency.					
2. I know my role during a cardiac arrest.					
3. I am comfortable recognizing signs and symptoms of MH.					
4. I feel confident that I can care for an MH patient.					
5. I know the initial treatment in MH management.					
6. I am comfortable calculating the dose for dantrolene.					
7. I know how to reconstitute and administer dantrolene.					
8. I know my role and responsibilities during an MH crisis.					
9. I feel that MH specific education, as well as an MH simulation, will improve my knowledge, confidence, and communication skills regarding the care of a patient with MH					
10. I know where the MH cart is.					
11. Simulation training helps me understand better than an educational PowerPoint or training from a computer module alone.					
12. Simulation based training helps me to retain the learned material.					

Appendix B

Malignant Hyperthermia Post-Test Survey

Part II

1. What is the name of your first pet? _____
2. In what role/capacity do you practice (e.g., RN, NP, PA, MD)? _____
    b. If you are an RN, do you primarily work in the ICU? (yes/no) _____

Part II

1: (strongly disagree); 2: (disagree); 3: (neutral): 4: (agree); 5: (strongly agree)

Questions	**1**	**2**	**3**	**4**	**5**
1. I feel confident with my patient care during an emergency.					
2. I know my role during a cardiac arrest.					
3. I am comfortable recognizing signs and symptoms of MH.					
4. I feel confident that I can care for an MH patient.					
5. I know the initial treatment in MH management.					
6. I am comfortable calculating the dose for dantrolene.					
7. I know how to reconstitute and administer dantrolene.					
8. I know my role and responsibilities during an MH crisis.					
9. I feel that MH specific education, as well as an MH simulation, will improve my knowledge, confidence and communication skills regarding the care of a patient with MH					
10. I know where the MH cart is.					
11. Simulation training helps me understand better than an educational PowerPoint or training from a computer module alone.					
12. Simulation based training helps me to retain the learned material.					
13. Barriers to MH treatment: Not enough education about MH					
14. Barriers to MH treatment: I have not been told where the MH cart is located					

15. Barriers to MH treatment: I have not been shown where to locate the MH protocol					
16. Barriers to MH treatment: I have not been shown how to mix dantrolene					
Please list any additional barriers or comments below					