

Improvement Of The Competence And Confidence Of Critical Care Nurses In Critical Care Units In Saudi Arabia In Care Of Patients On ECMO Machine Through Educational Interventions And Its Impact On Mortality Rates Of Patients Placed ECMO Machines

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Capstone Project submitted for the Master of advanced nurse practitioner

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Date of Submission: 23-03-2020

Date of Acceptance: 14-04-2020

I. Introduction

This paper is a proposal concerning the use of educational interventions to improve the competence and confidence of intensive care unit (ICU) nurses and coronary care unit (CCU) nurses at critical care units in Saudi Arabia in care of patients on Extra Corporeal Membrane Oxygenation (ECMO) machine, also known as extracorporeal life support (ECLS). The importance of this project is that a significant proportion of patients who are placed on ECMO machines often die (Kimet *al.*, 2018). Part of the reasons why patients placed on ECMO have higher than average rates of mortality is the result of the lack of expertise and experience among staff concerning the use of ECMO machines. National Institute for Health and Clinical Excellence (Kimet *al.*, 2018) state that the lack of competence in the use of ECMO machines is that they are not used often enough for staff to gain adequate competence and confidence.

The first adult survivor after being placed on ECMO was placed on the machine in 1972 (Vuylsteke *et al.*, 2017). Barbaro *et al.*, (2015) state that ECMO machines have reduced mortality rates among adults and children suffering from varied ailments and who need cardiovascular support. Shimizu and Ogura state that only 30% of surgical patients and 38% of medical patients survive weaning from ECMO machines (2016). This is a problem which justifies the investigation of the mortality rates of patients placed on ECMO in Saudi Arabia. Since the rates of mortality among patients placed on ECMO in Saudi Arabia are not known, an objective of this study is to evaluate the mortality rates of patients placed on ECMO in the facility in the previous years so that these can be compared with the mortality rates after the completion of the training intervention which will enable the demonstration of whether the intervention was effective or not. Various tactics can be used to lower the mortality rates among these patients which can be staff training and education. The mortality rates of patients placed on ECMO in Saudi Arabia are unknown. Kim *et al.*, (2018) established that mortality rates among ECMO patients can be as high as 91.3% while at the same time stating that staff training/education can reduce the mortality rates among ECMO patients from 91.3% to 66.7% within a year. This is how significantly the above proposal can help in reducing the mortality rate. In this study, the prevailing rates of mortality among patients placed on ECMO will be studied to provide a baseline for comparison with the mortality rates of patients placed on ECMO after the implementation of the intervention. The purpose of this paper is to propose the use of education for nurses working in CCU and ICU areas as a way of improving the competence and confidence levels of nurses and thus ultimately reduces the mortality rate (the prevailing rates in the region will be identified during the pre-test phase of the study. Presently data concerning the mortality rates of patients on ECMO doesn't exist with regards to Saudi Arabia) of patients placed on extra corporeal membrane oxygenation (ECMO). The rates in the United Arab Emirates are unknown. This is why the rates of mortality among patients on ECMO in the UAE have not been mentioned and the statistics used belong to other countries. The rates of mortality among UAE patients on ECMO can only be established during the pre-test phase of this study as proposed. Based on the study cited, the intervention is expected to be as effective in reducing the mortality. The evaluation of the effectiveness of the intervention will be carried out using the pre-test post-test method. The

mortality rates of patients managed using ECMO will be assessed before and after the intervention (training of staff).

Background

The ECMO Machine

ECMO is a network used for the support of patients whose lungs and hearts are unable to function (American Thoracic Society). Firstenberg, Byrnesand Hejal(2015) state that the ECMO machine is associated with higher survival rates for patients suffering from cardiac and pulmonary failure in comparison to other ventilator management strategies available.

The principle for ECMO is similar to that of the cardiopulmonary bypass machine. The extracorporeal membrane oxygenator is connected to the body of the patient through two cannulas. One cannula carries blood in need of detoxification (colored blue in the picture) from peripheral veins such as the femoral vein, internal jugular vein, or the subclavian vein (Firstenberg, ByrnesandHejal, 2015). Another cannula returns blood to the body after the removal of carbon dioxide, addition of oxygen, and warming (colored red) through the right atrium or through a major artery such as the femoral artery or the axillary artery (Firstenberg, ByrnesandHejal, 2015; Dell Children's, 2019).

The Setting of ECMO Machine Use

The use of the ECMO machine is often advised when patients' lung and hearts stop functioning optimally as a result of underlying diseases or injuries (American Thoracic Society., no date). The primary setting for the use of the ECMO machine is the intensive care unit of a health facility (ICU) (American Thoracic Society, no date; Monaco *et al.*, 2018). Monaco *et al.* (2018) state that ECMO is often used as a last effort in the management of severe cases of cardiac and respiratory failure.

Makdisiand Wang (2015) state that only staff with sufficient training and experience in the initiation, maintenance and weaning from ECMO systems should manage patients who are on the machine. Daly (2017) states that the management of patients using ECMO should only be carried out by specialists who are particularly trained to operate the machinery under the supervision of a physician. Additionally, ECMO specialists are derived from a range of healthcare professions including, but not limited to, medicine and nursing (Daly, 2017). O'Connor and Smith (2018) state that a registered nurse (RN) with sufficient experience as well as individuals drawn from other healthcare professions are considered ECMO specialists by traditional standards. Registered nurses working in facilities whereby the ECMO machine is frequently used are considered to have sufficient exposure to confer competence in the manipulation of the ECMO machine as well as the management of patients who are using these machines (O'Connorand Smith, 2018).Fehr *et al.* (2016) demonstrated that ECMO specialists with more than one-year experience were more likely to score better in comparison to those whose experience constituted of less than one year's work with ECMO. The exposure comes from the fact that these nurses frequently use the ECMO machines and are, therefore, more competent in comparison to nurses who only use the ECMO machines occasionally. The meaning is that staff who use ECMO regularly are better at using the machine in comparison to staff who only use the machine occasionally in the sense that practice makes a man perfect. In spite of the wide range of staff available for the operation of ECMO machines and the management of patients under these machines, Ruppel and Funk (2018) states that nurses are the intended end-users of most of the technologies that are found in the intensive care units which include ECMO machines.

The Significance of the Problem

The provision of training or education for critical care nurses concerning ECMO is an opportunity for healthcare facilities. Ruppel and Funk (2018) allege that little attention is paid to how nurses interact with medical technologies in spite of the fact that they are the target users for health technologies especially in the intensive care units. Nurses rarely ever receive training concerning the use of the various technologies available at their workplaces (Ruppel and Funk, 2018). Presently, it is unknown if the nurses working within critical care units in Saudi Arabia receive adequate training concerning the use of various medical technologies. This study will establish the competence and confidence of the critical care nurses in particular with regards to using ECMO and establish and seek to fill the gaps in knowledge and skills identified.

Often, health technologies are introduced to the nursing workplace with little consideration of the workflow. The result is that nurses improvise to adapt the technologies into their workplaces in ways that may be inefficient or ineffective. The result is that the quality of care in healthcare facilities is compromised (Ruppel and Funk, 2018).

Another challenge in the preparation of staff for ECMO especially in small facilities is the relatively low numbers of patients needing ECMO and their high mortality rate. The National Institute for Health and Clinical Excellence (Kim *et al.*, 2018), states that the lack of experience in dealing with ECMO is a factor in the unacceptably high mortality rates associated with the sporadic need and use of ECMO. Bartlett (2016) states that the mortality rate for patients who have been placed under ECMO in the last five years has been 40% whereas

Kim *et al.* (2018) refer to the mortality rate associated with ECMO as being “high”. Fehr *et al.* (2016) terms the occurrence of acute events requiring ECMO as unpredictable and infrequent and claim that 25% of the patients placed under ECMO die. Weems *et al.* (2017) states that less than 3000 cases of ECMO usage are reported every year and that complications are observed “frequently”. Moll *et al.* (2016) report that the staff at Emory University Hospital suspected that few of the minimal numbers of patients placed on EMOC survived but that part of the reason for the high mortality among patients placed on EMOC was inadequate formal training of the nurses in the management of EMOC. Weems *et al.* (2017) propose that ECMO is a high risk and low yield therapy with few clinical opportunities for practicing and maintaining the skills necessary for reproducible care for other patients in the future. The result is that healthcare workers, including critical care workers may be reluctant to train or oblivious to the opportunities and benefits associated with ECMO training. Nevertheless and Bartlett (2016) predicts an increase in the number of patients requiring ECMO machines in the near future. Monaco *et al.* (2018) also predict a higher frequency of the employment of ECMO outside critical care units. The result of an increase in the usage of ECMO will be an increased demand for nurses who are specifically trained to handle ECMO circuits and ECMO patients.

The significance of training nurses in the management of ECMO machines as well as patients who are being treated with such technologies is that nurses have the closest and most frequent contact with patients even in critical care (Fehr *et al.*, 2016). Bartlett (2016) states that in the future, the role of critical care nurses in the management of ECMO circuits as well as patients under the circuit will be the responsibility of the critical care bedside nurse. These facts highlight the importance of the competence of critical care nurses in the circuitry of ECMO as well as the management of patients placed under ECMO in critical care areas. The proximity of nurses to patients especially in the critical care unit necessitate the investigation of ways through which critical care nurses can optimize their contribution towards the wellness of patients in critical care areas. Aldisiet *al.*, (2017) state that apart from percussionists, nurses spend a significant amount of time supervising patients who are on ECMO machines. The advantage of training nurses over other professionals in the management of patients on ECMO as well as ECMO circuits is that while nurses and other professionals may have the same skills and knowledge sets concerning the subject, only nurses are in close proximity to the patients, especially in the critical care units, for 24 hours every day (Daly, 2017).

The complexity of the ECMO machines and the conditions of patients who are put on these machines also justifies the evaluation of the effectiveness of training and education initiatives for critical care nurses concerning ECMO. Daly (2017) states that the nurse manning an ECMO station in the critical care unit must be competent enough to understand the circuit of the ECMO system as well as the physiological indicators of the wellness of the patient who is receiving care under the ECMO machine. Daly (2017) states that two personnel are often involved in the management of patients supported on ECMO; a perfusionist for the circuits and acritical care nurse for the patient. Nevertheless, the management of the circuits is not beyond the scope of the ECMO specialist nurse. Daly (2017) states that nurses in the critical care unit should know how to titrate blood and sweep gas flows in case of emergencies arising when patients are on ECMO.

Purpose of the Study

The purpose of this proposal is to study the effects of an educational/training program on the improvement of the competence and confidence of critical care nurses in care of patients on ECMO machine and its impact on mortality rates of patients placed on ECMO machines.

Research Question

Can an educational/training program improve the competence and confidence of critical care nurses at critical care units in Saudi Arabia in care of patients on ECMO machine through educational interventions? Plus, its impact on mortality rates of patients placed on ECMO machines.

Research Aims/Objectives

The parameters of this study which include confidence, competence, mortality, knowledge and skills levels are achievable. Various tools may be used to evaluate the confidence levels of nurses. Cummings and Connelly (2016), used the “Student Satisfaction and Self Confidence in Learning and Educational Practices Questionnaire (Jeffries, 2012, Cummings and Connelly, 2016)” to evaluate confidence levels. Forbes, Mohebbi and Duke (2017) designed an instrument for the measurement of confidence among nurses and state that the instrument is rigorously designed and validated and can, therefore, be used for the evaluation of the confidence among nurses in other settings. Competence can also be reliably and validly tested. Thomas, Chung and Holt (2019) and Chen *et al.* (2017) used task-based activities to evaluate the competence of nurses. Flinkman *et al.*, (2017) state that the Nurse Competence Scale is the most popular instrument for the measurement of the competence of various aspects of nurses as professionals throughout their careers. Ameh *et al.* (2016) have evaluated the knowledge of nurses using a series of 40 closed ended questions and their skills

through structured scenario-based assessments and objective structured clinical examinations for the evaluation of the skills (OSCEs).

- To determine the confidence levels among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, before the administration of an educational/training program
- To determine the competence levels among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, before the administration of an educational/training program
- To determine the mortality levels of patients placed on ECMO machines for two months before the administration of an educational/training course at critical care units in Saudi Arabia. The rate of death among patients on ECMO is one of the indicators of the effectiveness of the ECMO training program since one of the anticipated gains from the program is a reduction in the mortality rates of patients placed on ECMO for two months. As mentioned earlier, the mortality rates of patients placed on ECMO in Saudi Arabia are not known. Further, the success of the intervention proposed is pegged on the successful reduction of mortality rates among ECMO patients in Saudi Arabia. Therefore, this study will have a pre-test, post-test type of design whereby the mortality rates of patients placed on ECMO will be evaluated before and after the training intervention. A comparison of the mortality rates of ECMO patients in the 6 months before the intervention will be compared to the mortality rates in the same time following the intervention.
- To determine the knowledge levels among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, before the administration of an educational/training program
- To determine the skill levels among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, before the administration of an educational/training program
- To create an educational/training course for ECMO for critical care nurses at critical care units in Saudi Arabia
- To administer an educational/training course for ECMO for critical care nurses at critical care units in Saudi Arabia, after the administration of an educational/training program
- To determine the confidence levels among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, after the administration of an educational/training program
- To determine the competence levels among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, after the administration of an educational/training program
- To determine the knowledge levels among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, after the administration of an educational/training program
- To determine the skill levels among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, after the administration of an educational/training program
- To determine the mortality levels of patients placed on ECMO machines after the administration of an educational/training course at critical care units in Saudi Arabia

II. Literature Review

Basis for Educational/Training Program for Critical Care Nurses Concerning ECMO

Simulation Training

Simulations are the most popular modality of delivering training concerning the management ECMO machines and patients placed on these machines. Forty-six% of the ECMO coordinators at Extracorporeal Life Support Organization sites in the United States used ECMO simulation programs. Armenia *et al.* (2018) states that the use of high-fidelity simulations for teams working in various areas within health facilities including acute areas such as the critical care units are feasible and effective methods of improving their knowledge and skills concerning varied clinical phenomena whereas Brum *et al.* (2015) recommend simulation training for the management of ECMO emergencies. Therefore, simulations are preferred as a modality of training critical care nurses managing ECMO patients. Armenia *et al.* (2018), however, allege that little evidence demonstrates the impact of simulation training on patient outcomes. The implication is that the mortality rates of patients on ECMO should not be expected to change as a result of the training program. However, Armenia *et al.*, (2018), does not provide any alternatives to simulation-based training. On the contrary, Fouilloux *et al.*, (2019) states that simulation training is the core of training concerning ECMO and that the use of simulations is the gold standard in medical and paramedical education. Without the availability of an alternative for simulation-based training for nurses, this project proposal prefers to utilize simulation-based training. The use of simulations is further justified by the responses from healthcare workers who have participated in ECMO simulation trainings. Just like (Hackmann *et al.*, 2017, Fehr *et al.*, 2016) created eight simulations of emergency scenarios which may be encountered in the critical care units requiring ECMO and according to the participants, these simulations are close enough to actual scenarios which are encountered in ECMO emergencies. The implication is that the use

of simulations of emergency scenarios is an acceptable method of delivering education concerning the use of ECMO.

It is preferable that the training exercise is designed by nurses with some form of expertise in ECMO management. Brum *et al.*, (2015) utilized clinical and critical care unit experts to develop the course content. Fouilloux *et al.*, (2019) used an ECMO Specialist Course Committee for the development and execution of the training course. For the sake of this project, the researchers will be involved in the design of the program in spite of their relative naiveté in relation to the subject.

Content of the Simulation Training Exercise

Some topics in the simulation training exercises are more popular than others and now we shall have a look at the various literature findings and how do they compare with one another. Weemset *al.*, (2017) determined that the most popular simulations involved pump failure, the failure of the oxygenator, and the rupture of circuits while the training exercise by Brum *et al.*, (2015) comprised of the practical demonstration of the use of ECMO machines with reference to the ECMO circuit, console components, the effects of circuit interactions, and the possible sources of complications among others. Notably, the patient factor in the successful management of ECMO patients is not addressed. The management of patients on ECMO is just as important in the successful weaning of these patients off these machines as the correct assemblage and troubleshooting of issues concerning ECMO machines. Whereas (Hackmannet *al.*, 2017) training program comprised of management of ECMO circuits, the physiology of ECMO, the identification and management of common ECMO emergencies as well as simulations (using water circuits), ICU models.

Some weaknesses have also been noted among ICU workers in reference to the use of ECMO machines. (Fehr *et al.*, 2016) established that the ECMO specialists were most competent in scenarios which involved hemodilution and that they were least competent with scenarios which comprised of air entrainment. The implication is that the majority of workers in the ICU require more training with reference to air entrapment as opposed to hemodilution. Simulations can be combined with theoretical instructions. (Brumet *al.*, 2015), delivered both theoretical and practical training concerning the operation of ECMO machines. This is the justification for theoretical and practical exercises in this project proposal.

Nature of ECMO Simulator

It was explored that the impact of the design and implementation of a modular ECMO simulator and preferred to use a modular ECMO simulator which had thermochromic ink and an instructor/clinician interface as opposed to using actual ECMO circuits. The justification is that in spite of the fact that actual ECMO circuits are realistic, the use of expensive disposable equipment such as oxygenation membranes for training purposes is wasteful. It further laments the lack of oxygenation color differentials, and manual circuit adjustments and injections in the use of actual ECMO machines for training purposes and hoped to re-create a functional ECMO circuit which is functional, affordable, reusable, and extensible for training purposes. In the simulator created by (Aldisiet *al.*, 2017), oxygenation is visually simulated by the heating of thermochromic ink which results in the change of color between dark and light red. The availability of an interface which enables the manual adjustment of parameters wirelessly is representative of the ECMO machine itself. The simulation also comprised of visual and audio representations of mechanical complications which may be encountered in the course of the use of ECMO machines such as access line shattering and mechanical vibrators. (Aldisiet *al.*, 2017) state that the use of the ECMO simulation system they created can facilitate the cheaper training of ECMO specialists.

Duration of Educational/Training Program for Critical Care Nurses Concerning ECMO

Different researchers expedite the ECMO training exercises variously. Brum *et al.* (2015) designed, implemented, and evaluated the effects of a one-day training simulation for ECMO. Some researchers prefer to execute the training and assessment programs for a longer duration of time. (Fouilloux *et al.*, 2019) used high fidelity simulation for the training of critical care nurses who look after patients on ECMO machines and executed seven sessions in a period of two years, each consisting of two days of academic, and hands-on simulation training. (Hackmannet *al.*, 2017) demonstrated the importance of continuous training and evaluation of cardiothoracic intensive care unit nurses (CTICU) concerning ECMO circuits as well as revalidation every six months. Nevertheless, due to time limitations, it is preferred that the training intervention for this research proposal is undertaken in six days.

Evaluation and Outcomes of ECMO Training

The success of training efforts with reference to ECMO training is dependent on several factors. Successful simulation training is positively associated with the access to a simulation center, the management of more than 20 patients annually by a facility using ECMO, the presence of a pediatric cardiothoracic intensive

care unit (Weems *et al.*, 2017). For a facility to effectively conduct a training exercise concerning ECMO, the institution must have a simulation center, a pediatric cardiothoracic intensive care unit, and must cater to than 20 patients annually via ECMO.

Various methods have been used for the evaluation of the effectiveness of the ECMO training programs. In the course of training, nurses were subjected to written examinations. Brum *et al.* (2015) after the delivery of the training sessions, used a knowledge-based test to determine the achievement of the course objectives. Fehr *et al.* (2016) on the other hand, chose to focus on the execution of critical actions as well as global performance (Fehr *et al.*, 2016).

Effects of Educational/Training Interventions Concerning ECMO: Confidence, Competence

The use of training/educational interventions is a proven tactic in the improvement of the confidence levels of nurses. It was determined that training workers concerning ECMO using simulations increased their confidence levels. The respondents for this study included students specializing in perfusion courses and non-perfusion courses. The students were exposed to five tasks whose objectives were to establish their competence in the management and prevention of adverse events for patients who were being managed with ECMO. The parameters observed include the amount of time it took to complete every task, the number of mistakes made, and references made to the protocols in the course of the exercise. (Thomas, Chung and Holt, 2019) established that the time taken to complete the tasks decreased with every subsequent trial the students made and a reduction in the mistakes made as well. Thus, concluded that the increased levels of confidence expressed by both perfusion and non-perfusion students in the process of ECMO management were critical to the promotion of the safety of patients undergoing ECMO management in addition to the improvement of skills, the ability to employ interventions rapidly, and the occurrence of fewer errors.

(Labi and Alinier, 2017) also promotes the use of training, specifically simulation training, as a method of reducing anxiety among staff operating ECMO and increasing their confidence levels. It was stated that simulation training, in comparison to other training and educational modalities, confers several advantages such as the improvement of technical skills e.g. the placement of cannulas besides non-technical skills, effective communication between the team members, effective working of all individuals in a group, shared decision making as well as leadership skills. When they will be trained on these machines, it will give them the confidence to handle critical situations and they won't panic. (Labib and Alinier, (2017) state that ultimately, simulation training for individuals working with ECMO results in the improved confidence for the workers as well as reduction of anxiety when they approach ECMO patients and circuits.

(Cummings and Connelly, 2016) studied the relationship between simulation studies and confidence among student nurses. (Cummings and Connelly, 2016) evaluated the satisfaction, confidence and education practice levels in relation to simulation activities in the course of their academic preparation. The respondents for the study were junior and senior nursing students and the tool used was the "Student Satisfaction and Self Confidence in Learning and Educational Practices Questionnaire (Jeffries, 2012). (Cummings and Connelly, 2016) established that repeated simulation exercises for nursing students can lead to an increase in their confidence levels as well as their participation in active learning.

(Ortiz, 2016) evaluated the mechanisms through which nurses acquire confidence in clinical settings by following newly graduated nurses a state that the development of professional confidence is essential for nurses for purposes of navigating the complex setting which is today's hospital settings. It should be noted that the places where critical care nurses operate are considered the most complex settings within healthcare facilities. He carried out face to face interviews which comprised of 12 participants to understand the processes through which they developed professional confidence. Also, established that communication, making mistakes, divorcing themselves from the academic to the practical setting, independence, building professional relationships, and gaining experience were critical in the acquisition of confidence. He gives the conclusion by stating that the development of confidence is a complex process which involves both positive and negative experiences during the duration of one year.

The tools for the evaluation of confidence among nurses are few and far in between. (Nguyen *et al.*, 2017) studied the evaluation of confidence among nurse educators and states that confidence is associated with successful transitions as well as the development of role confidence. No tool currently exists for the evaluation of confidence and used a multi-phase and multi-setting survey design to test an instrument which they designed to evaluate confidence. The instrument is rigorously designed and validated and can, therefore, be used for the evaluation of the confidence among nurses in other settings (Nguyen *et al.*, 2017). This test may be used for the evaluation among nurses working in the critical care units with ECMO machines.

(Chen *et al.*, 2017) evaluated the impact of an interactive situated as well as a simulated teaching program on novice nurse practitioners on their clinical competence and confidence among other parameters. The study respondents were 31 newly graduated nurse practitioners who were placed into interactive situated and simulated teaching (ISST) and non-ISST groups (Chen *et al.*, 2017). Also, gave the ISST group six follow up

and interactive face-to-face support session for a duration of three months subsequent to the standard orientation training course. The ISST group was noted to have superior nursing competence, lower levels of stress, an increase in professional confidence and competence in comparison to the non-ISST group (Chen *et al.*, 2017). So, it was concluded that the exposure of new nurses to further training opportunities can result in an increase in their competence and confidence levels in the beginning of their careers. (Hackmann *et al.*, 2017) states that simulation exercises are instrumental in the reduction of mortality and the increase in competence of nurses managing patients under ECMO. After a simulation exercise, Brum *et al.* (2015) deemed 57% of the participants to be competent.

All these findings and statements support the proposal that simulation trainings and education can lead to competitive nurses and help a lot in reducing their anxiety levels. Also supporting the argument that confidence levels do get increased.

Conceptual Framework: Jean Watson's Theory of Human Caring/Caring Science Jean Watson's theory of human caring/ caring science is preferred for this project.

The focus of Watson's theory are human relations and the nursing paradigm. This theory proposes that human beings cannot be viewed as objects during nursing processes and attempts to find a balance between health and disease states among human beings. Instead, the patient should be viewed as a sum of himself/herself, the environment, their experiences, and their biological constitution (Yeter, 2015). Watson proposes that the patient should be viewed as a whole and not as a component of the individual parts which make him/her up. The theory characterizes the environment as a place which is comfortable, beautiful, and peaceful (Lukaose, 2011. Watson, 2009, 2007, Yeter, 2015). Caring is considered an ethical requirement which is characterized by the unity between the mind, the body, and the soul (Yeter, 2015). According to Watson's theory, nursing is a humanitarian science which comprises of "personal, scientific, ethical, and aesthetic" elements (Yeter, 2015). This "person" subject of this proposal is the nurse.

The justification/rationale for the selection of Jean Watson's theory of human caring/caring sciences in this proposal is that the nursing profession is based on the care of other human beings. By training the nurses to be competent concerning the use of ECMO, the nurse will be creating an environment which is comfortable, beautiful, and peaceful. Nursing is a humanitarian science which comprises of "personal, scientific, ethical, and aesthetic" elements (Yeter, 2015). The nurse as a person will ensure that he or she is competent as a person by gaining the scientific and ethical principles necessary for the management of patients on ECMO. The nurse's competence in the management of patients placed under ECMO as well as the management of ECMO circuits entails the scientific aspect of this project. The ethical aspect is highlighted by the fact that nurses have a moral duty to preserve the lives of their patients (Yeter, 2015).

Watson's theory of human caring focuses on people and accepts them with their integral peculiarities without ignoring the fact that people are composed of minds, bodies, and spirits which are enmeshed (Jesse, 2006; Fawcett, 2005; (Watson and Foster, 2003; Rafael, 2000). Love is the most important nursing resource in the course of the healing of patients. Nursing is a process characterized by the caring of one human being for another and comprises of healing processes, the creation and maintenance of interpersonal relationships, caring moments, and awareness of healing (Watson, 2012, Yeter, 2015).

Watson's theory of human caring comprises of ten curative factors which are ample guidelines in the clinical implementation of the theory. The first curative factor addresses the humanistic-altruistic system of values and urges the practice of loving kindness/compassion for the nurse and for other people (Yeter, 2015). The second curative factor urges for the enabling of faith and hope and advises nurses to be authentic, and to respect the diverse belief systems and subjective world of self/other in the nursing process. The third curative factor addresses the generation of sensitivity to the nurse and to other people and involves the identification of one's spiritual practices. The fourth curative factor is the creation and sustenance of a helping and trusting relationship in the care of other people. The expression of positive and negative feelings by allowing their expression and authentically listening to such feelings is the fifth curative factor. The utilization of innovating solutions in the process of caring which involve the full use of self in the establishment of artistic methods of caring for patients. The seventh curative factor addresses transpersonal teaching-learning which involves staying within each other's frames of reference and progressing towards a health-healing-wellness coaching model. The eighth curative factor concerns the creation of an environment that is protective and supportive of mental, social, and spiritual wellness through physical and non-physical means. The ninth curative factor concerns human needs assistance and proposes that the basic needs of patients should be upheld at all times. Existential-phenomenological-spiritual forces are the substance of the tenth curative factor. The tenth curative factor advises nurses to retain space for mysterious and unknown forces in the healing process of their patients (Yeter, 2015).

In the course of offering nursing services to patients, nurses should demonstrate loving kindness, the enabling of faith and hope, the cultivation of sensitivity to self and others, the development of trusting human

care relationships, the expression of positive and negative feelings, the initiation of problem solving-caring process, transpersonal teaching-learning, the creation of a supportive environment, human needs assistance, and existential-phenomenological-spiritual forces. Nurses practicing in the critical care units should be careful to extend a loving and kind hand to their colleagues and to the patients. One of the ways through which nurses can apply this curative factor clinically is by ensuring that they are well trained concerning the care of patients placed on ECMO as well as their colleagues. Nurses who are inadequately trained may be a danger to themselves, their colleagues, and their patients. Undergoing training concerning ECMO procedures is therefore, an act of love and kindness for themselves, their colleagues, as well as their patients(Watson, 2012).

Table 1: Caring Moments/occasions and associated research caritas processes

Caring Moments/Occasion	Research Caritas Processes
Transpersonal teaching-learning	The determination of the confidence levels, confidence levels, knowledge levels, among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, before the administration of an educational/training program. The creation and administration of an educational/training course for ECMO for critical care nurses at critical care units in Saudi Arabia
Creative problem-solving caring process and Transpersonal teaching-learning	The creation and administration of an educational/training course for ECMO for critical care nurses at critical care units in Saudi Arabia
Expression of positive and negative feelings	The determination of the confidence levels, confidence levels, knowledge levels, among critical care nurses at critical care units in Saudi Arabia, concerning ECMO, before the administration of an educational/training program.
Supportive, protective, and/or corrective mental, social, spiritual environment.	The identification of the right venue, tools, materials, required for the training exercise
Existential-phenomenological-Spiritual forces	The acknowledgement that the research project may perform exceedingly poorly or better than conceptualized. When a nurse is confident and competent in using the machine, he or she is free to care for the person beneath it.

Research Design/Methodology

Plan-Do-Study-Act Cycle

The Plan-Do-Study-Act Cycle, usually abbreviated as the “PDSA” cycle, a four-step tool used for the management of change within organizations (Donnelly and Kirk, 2015). The purpose of the planning stage is to establish the goals, and objectives of the project as well as the strategies which will be used to actualize the set goals and objectives (Donnelly and Kirk, 2015). In the case of the study of the competence and confidence of critical care nurses in care of patients on ECMO machine, the objective is to establish if the training of nurses in the critical care units increase their confidence and competence in the management of patients who have been placed in ECMO machines.

In the “do” stage of the PDSA cycle, the strategies for the achievement of the goals and objectives established in the “plan” stage are implemented (Donnelly and Kirk, 2015). Usually, small changes are usually made to establish the effectiveness of the plan before rolling it out throughout the organization (Donnelly and Kirk, 2015). In this particular research project proposal, the strategy to be implemented is the training/education of nurses in the management of patients who have been connected to the ECMO machine.

During the “study” phase of the project, the results of the project implemented are examined for efficacy (Donnelly and Kirk, 2015). The results from the small-scale implementation of the project are measured against the expected results for similarities and differences (Donnelly and Kirk, 2015). In the case of this research project proposal, the results of the educational/training intervention will be measured for their efficacy, or lack thereof, in the enhancement of the confidence and competence of nurses concerning the use of the EMCO machine.

The last stage of the PDSA cycle, the “act” stage, is also sometimes referred to as the “adjust” stage (Donnelly and Kirk, 2015). The reason is that this is the stage where the effectiveness of the project determines whether the project will be rolled out to the entire organization or whether the organizers will go back to the planning phase with the inclusion of the data concerning the mistakes observed in the previous PDSA cycle (Donnelly and Kirk, 2015). In the case of this research project proposal, the act or adjust stage will evaluate the efficacy of the educational/training intervention. In case the educational/training intervention will be rolled out to the rest of the organization in case it is found to have brought the required results which are an improvement in the confidence and competence of critical care nurses concerning the management of the ECMO machine and the patients placed under it. In case the educational/training intervention is found to not be effective in increasing the confidence and competence levels of the critical care nurses, the project managers will go back to the drawing board and alter the project in accordance to the issues identified.

Sampling

The targeted respondents for this research project proposal are all nurses working in the critical care areas. Since the numbers of these nurses are small and the study will focus on only one healthcare facility, non-probability sampling methods will be used. On-probability sampling is that where all the members of a population are not given an equal chance of being participants in the study (Vehovar, Toepoeland Steinmetz, 2016). Purposive sampling, a type of non-probability sampling, will be used for the selection of participants in this research project proposal. In particular, homogeneous purposive sampling will be utilized. Homogeneous purposive sampling is preferred when the desired set of respondents should have similar characteristics (Vehovar, Toepoeland Steinmetz, 2016). In this case, the similarity of the respondents as required by the researchers is that they all work in the critical care areas where they are most likely to encounter ECMO machines as well as patients who are being managed using ECMO machines. These nurses will be drawn from the critical care department of the critical care units in Saudi Arabia. The age, gender, and length of work experience among the nurses selected to be participants in this project will not be considered. The target number of participants for this research project proposal is 40 critical care nurses.

Ethical Considerations

In research in the healthcare industry, four ethical principles, which are universally recognized, should be adhered to. These include the respect for autonomy, beneficence, non-maleficence, and justice (Holloway and Galvin, 2016). Before the commencement of any research project, a nurse must get clearance from the relevant authorities (Holloway and Galvin, 2016). In the case of this research project proposal, the relevant authorities include the academic institution to which the nurse belongs and the institution where the research project will be conducted (critical care units in Saudi Arabia). Ethical clearance for the project will be sought and received in writing.

Autonomy refers to the respect for the participants of the study as individuals in their own capacity (Holloway and Galvin, 2016). The implication is that the study participants should be allowed to participate in the study voluntarily and should also be allowed to leave the study whenever they think it is necessary for them to do so. Also, participants in the study will be enrolled by the signing of a consent form. Beneficence refers to the promotion of the wellbeing of other people (Holloway and Galvin, 2016). In the course of the execution of the study, the wellness of the participants will be upheld at all times. The principle of non-maleficence is often translated to “do no harm” (Holloway and Galvin, 2016). Throughout the duration of this research project, the researchers will carefully ensure that no physical, mental, or emotional harm is encountered by the participants. The principle of justice urges all the participants in a research project to ensure fairness are upheld (Holloway and Galvin, 2016). Fair practices will be the norm in the course of the completion of the research project.

Research Design

The experimental research design, specifically the pretest-posttest design, will be used for this project. Experimental research designs are characterized by the presence of an intervention (Vehovar, Toepoeland Steinmetz, 2016). The pretest-posttest design is preferred in the identification of changes which have occurred as a result of the interventions administered. In the case of this study, the intervention is a training/educational program for ICU and CCU nurses concerning the ECMO machines. The training will have two components, the management of the ECMO circuits and the management of patients who have been placed on the ECMO machines. Prior to, and after the administration of the educational/training intervention, a test will be used to evaluate various parameters of the participants which are the subject of this research project proposal. These parameters which will be investigated include the confidence of nurses concerning ECMO management, their competence, knowledge, and skill levels. The measurement of the mortality rates for patients who have been placed on ECMO before and after the educational/training intervention is also an important indicator of the effectiveness of the educational/training program on the quality of care offered to these patients. From the description of the research design, it is obvious that both quantitative and qualitative methods will be used to gather both qualitative and quantitative data. Qualitative methods are scientific methods which yield numerical data (Vehovar, Toepoeland Steinmetz, 2016). In this study proposal, the quantitative data comprises the evaluation of the mortality rates of patients before and after the administration of the ECMO educational/training program. On the other hand, qualitative methods are those which explore and provide understanding for various phenomena (Vehovar, Toepoeland Steinmetz, 2016). In the case of this study, the phenomena under study is the competence and confidence of nurses with the view of providing an understanding concerning the influence of education on these parameters. These include the skills, knowledge, confidence, and competence of nurses before and after the administration of an ECMO training program.

Design of the educational/training intervention

The preferred educational/training intervention is that used by Brum *et al.* (2015). The components of the educational/training intervention will comprise of; theoretical teachings/instructions as well as practical sessions with an ECMO simulator. Case scenarios of the common emergencies in the critical care units while using ECMO circuits will also be presented as part of the training efforts. The teaching and instructions will comprise of an outline of the principles of simulation training as well as the associated human factors as outlined by (Brum *et al.*, 2015). The simulation part of the exercise will take place in a room which is designed to look like the critical care environment. Brum *et al.* (2015) recommends that such a room is equipped with observation charts, clamps, ventilators, monitors as well as a mannequin. The preferred mannequin is the Gaumard Hal 3201 high fidelity mannequin which is fully automated and which enables the mimicking of a wide variety of biological manifestations necessary for ECMO simulations. The possible case scenarios of emergencies which may be encountered in the critical care when using ECMO will be explored. (Brum *et al.*, 2015) demonstrated the various parts of the ECMO machine as well as the effects, possible emergencies, and ways of managing the complications arising with reference to the ECMO machine. In the case of this research project proposal, possible complications affecting patients who have been placed in the ECMO machine as well as ways of managing those emergencies will also be explored. (Brum *et al.*, 2015) executed their ECMO simulation training by having some trainers act out scenarios to demonstrate what was expected of course attendees. The participants were then allowed to participate in one of four ECMO simulation scenarios (Brum *et al.*, 2015). The case scenarios in the case of this research project proposal will be compulsory for all participants. The training exercise will take one week and will involve 40 critical care nurses receiving instructions from five ECMO experts.

Timeline of the Training Exercise

Day 1	Morning	Introduction to the components of the ECMO Machine including assembly of parts (theory)
	Afternoon	Introduction to the components of the ECMO Machine including assembly of parts (practical)
Day 2	Morning	Management of the patient on ECMO machine (theory)
	Afternoon	Management of the patient on ECMO machine (practical)
Day 3	Morning	Identifying and correcting machine errors (theory)
	Afternoon	Identifying and correcting machine errors (practical)
Day 4	Morning	Monitoring and management of patients on ECMO machines (theory)
	Afternoon	Monitoring and management of patients on ECMO machines (practical)
Day 5	Morning	Troubleshooting ECMO machine problems
	Afternoon	Diagnosis and management of complications arising among patients on ECMO
Day 6	Morning	Written evaluation
	Afternoon	Practical evaluation (OSCEs)

Evaluation of the mortality rates of patients before and after the administration of the ECMO educational/training program

The mortality rates of patients who have been placed on ECMO will be taken before and after the execution of the educational/training intervention. Barber *et al.* (2017) states that the mortality rate is a credible indicator of the quality of health services in a population. The specific mortality rate which will be used in the case of this study is the case fatality ratio or rate. The case fatality ratio or rate refers to the deaths of all people with a specific characteristic over a specified period of time (Vehovar, Toepoeland Steinmetz, 2016). However, Fehr *et al.* (2016) states that the use of ECMO is infrequent due to the rarity of events which require the use of the machine. Therefore, those cases of fatality rates will be used that are one year before and after the institution of the educational/training intervention. The fatality rates of patients placed on ECMO in Saudi Arabia are unknown. The rates of death among patients who have been placed on ECMO machines will be obtained from the hospital’s (critical care units in Saudi Arabia) documents and records. The fatality rates of patients placed on ECMO will also be compared to those reported in other literature. The facility rates will be compared with those indicated in the literature.

Evaluation of the knowledge and skills of Critical Care nurses before and after the administration of the ECMO educational/training program

(Amehet *et al.*, 2016) evaluated the knowledge and skills of healthcare workers after the administration of a competency-based training program. The researchers’ model will be used for the evaluation of the knowledge and skills of critical care nurses after the administration of an educational/teaching program. The evaluation of knowledge was conducted using a series of 40 closed ended questions (Amehet *et al.*, 2016). In the case of this project proposal, the knowledge of the participating nurses will be evaluated using closed ended questionnaires as well. These questionnaires will be designed on the basis of the material which was taught in the execution of the training program. The questionnaires testing the knowledge of the participants will be administered before and after the execution of the training program. Amehet *et al.* (2016) used structured scenario-based assessments

and objective structured clinical examinations for the evaluation of the skills of the participating nurses. The skills of the participating nurses will be evaluated using objective structured clinical examinations which will be based on the training material. The objective structured clinical examinations will be administered before and after the administration of the educational/training program.

Evaluation of the confidence rates of Critical Care nurses before and after the administration of the ECMO educational/training program

The tools for the evaluation of confidence among nurses, especially among nurses, are few and far in between. (Nguyen *et al.*, 2017) prepared an instrument for the evaluation of confidence of nurses and recommended it for use in various settings. This tool will be used for the evaluation of the confidence of nurses before and after the education/training.

Evaluation of the competence of Critical Care nurses before and after the administration of the ECMO educational/training program

(Flinkman *et al.* 2017) state that the Nurse Competence Scale is the most popular instrument for the measurement of the competence of various aspects of nurses as professionals throughout their careers. This tool will be used for the evaluation of the competence levels of critical care nurses before and after the institution of the ECMO training. The content validity for the Nurse Competence Scale is 0.83 (Flinkman *et al.*, 2017).

Data Analysis/Evaluation

The data from the research project will be analyzed or evaluated using both quantitative and qualitative methods.

Qualitative Data Evaluation

Qualitative data in this proposal includes the skills, knowledge, confidence, and competence of nurses before and after the administration of an ECMO training program.

Qualitative data will be evaluated using three procedures; data validation, data editing, and data coding. Data validation will be done by investigating for fraud, screening, procedural anomalies and completeness. Fraud is evaluated by determining whether every respondent was evaluated or not. Screening is done by evaluating whether the selection of the respondents was in accordance to the proposed criteria or not. Procedural anomalies are investigated by checking whether the procedures for the collection of data were duly followed. The completeness of the data will be assured by checking if all the respondents responded to all the investigations and procedures or not. Data validation will be carried out on all the respondents since the sample size of the research project is relatively small.

Data editing will be carried out to manage any errors which may have come up in the course of data collection the editing of data will be carried out through basic data checks and checking for outliers which may affect the accuracy of the final results. Data coding will be the final step in the qualitative analysis of the results obtained. Data coding refers to the grouping and assignment of values to the responses obtained from the research project to reveal patterns and outcomes of the study.

Quantitative Data Analysis

Descriptive and Inferential Statistics will be used for the evaluation of quantitative data obtained in the course of executing the research project. In this study proposal, the quantitative data comprises the evaluation of the mortality rates of patients before and after the administration of the ECMO educational/training program.

The mean, of the various categories of data collected will be evaluated to summarize data and show the pattern of the various characteristics of the respondents. The mean of the ages, professional experience by years, and professional experience by the amount of time a nurse has worked in critical care will be evaluated. Other important parameters in the descriptive statistics with regards to this case study include the frequencies and the ranges. A frequency table will be provided. The frequency table is an acceptable form of representation of quantitative data.

Inferential statistics will be utilized for the evaluation of the data collected from this research project. The purpose of inferential statistics is to determine if the results of the research project are generalizable to the entire population or not. In particular, analysis of variance (ANOVA) will be used. ANOVA is a statistical procedure which is used for the evaluation of whether groups involved in a research project have any significant differences. In the case of this project, the two groups involved are the participants before the administration of the educational/training intervention and participants before the administration of the educational/training intervention. If significant variance between the results of the participants before and after the educational intervention are found, it will be concluded that the educational intervention is effective in the modification of the knowledge, skills, competence, and confidence of critical care nurses working with ECMO. Significant

differences in the mortality cases affecting patients who are on EMO in the critical care units will be interpreted to be a manifestation of the effectiveness of the training program.

III. Results

This research will refine, revise, and extend existing knowledge in several ways. To begin with, if this study successfully improves the confidence and competence of critical care nurses concerning the use of ECMO, it will firmly entrench the use of simulations for the training of critical care nurses at critical care units in Saudi Arabia, in the training of nurses. However, the lack of universally accepted tool for the measurement of the confidence and competence of nurses may be an impediment to the objectives of this proposal. To begin with, the tools which are used to measure the competence and confidence of nurses in this study have not been widely used and their application to this study may skew the results and introduce bias. The use of these tools in this study nevertheless is an examination of their validity and reliability in the measurement of confidence and competence of nurses and will influence whether future studies utilize these tools or not. In spite of the minimal utilization of ECMO in healthcare settings, the successful execution of this project will mean that nurses can be routinely trained concerning the use of ECMO. The result of the regular updating of the nurses' skills and knowledge concerning ECMO will result in higher confidence and competence levels of the nurses throughout the year. (Hackmann *et al.*, 2017) demonstrated that patient care as well as patient outcomes improved in the period after the deployment of adequately trained CTICU nurses. (Hackmann *et al.*, 2017) conclude that CTICU nurses are capable of operating the ECMO machinery and thus increasing the availability of trained ECMO personnel in healthcare facilities. Improved patient outcomes are one of the anticipated effects of this training program.

IV. Discussion

The purpose of this research project is to determine if educational/teaching interventions improve the competence and confidence of nurses working with ECMO machines in the critical care units of Military hospital in Saudi Arabia. The majority of studies which have evaluated the fitness of various cadres of workers for work with ECMO machines have used simulations for training. This is the reason why simulations have been used as the intervention in this research project. The majority of papers which have evaluated the outcomes of training for staff operating ECMO have shown that it was associated with mainly positive outcomes. It is hoped that the results of this study, similarly, will be successful in the improvement of the confidence and competence of nurses operating in the critical care areas with regards to ECMO. However, the study of the competence and confidence of nurses regarding ECMO has been wanting. In addition, while a universal tool for the evaluation of nurses' competence exists, no such tools exist for the evaluation of nurses' confidence. It is for this reason that a tool had to be adopted for this study.

In case the results of this study differ from the results of previous studies, it could be the result of several limitations. These limitations include the fact that the acquisition of confidence is a dynamic process which results occurs throughout the first year of practice among new graduate nurses (Ortiz, 2016). The implication is that confidence cannot be conclusively evaluated with a short study period. The distance from the health facility to the city center is yet another factor which could adversely affect the outcomes of the research project. Being relatively far with no means of public transportation, the participants and volunteers may be unwilling to take part in the research. The financial capacity of the researcher and relative inexperience are other factors which may affect the ability to conduct the study to completion. Further, the health facility identified may be unable to meet the research criteria for example by having fewer than anticipated employees in the critical care.

On the other hand, the successful and accurate execution of this research project may be advantageous to the critical care units in Saudi Arabia as well as other players in the healthcare industry. The successful training of healthcare workers in this project implies that the training of healthcare workers can be used as a tool for the management of various issues affecting the outcomes of nursing processes.

V. Conclusion

Extracorporeal membrane oxygenation (ECMO), also known as extracorporeal life support (ECLS), is a network used for the support of patients whose lungs and hearts are unable to function (American Thoracic Society, no date). EMCO has been hailed for saving lives but the death rates for people managed with the machine are still unacceptably high. EMCO is commonly used in critical care areas for patients who have deteriorated severely but who can still be managed adequately. Nurses, in healthcare facilities usually have the highest amount of contact with patients and the majority of patient monitoring devices end up being used by nurses. However, nurses are often inadequately prepared for the use of these machines, including EMCO machines. This research study proposes that the lack of adequate training for nurses concerning the management of EMMCO circuits and patients being managed with EMCO is one of the reasons for the unacceptably high

mortality rates for this demography of patients. This research project proposal suggests that the higher the knowledge, skills, confidence and competence of nurses working in the critical care with EMCO machines, the higher the survival rates of their patients. This study is experimental in design (pretest-posttest) and the results will be processed using qualitative and quantitative methods. This research will refine, revise, and extend existing knowledge in several ways. This study will firmly entrench the use of simulations for the training of critical care nurses at critical care units in Saudi Arabia, in the training of nurse and will influence whether future studies utilize these tools or not. The routine training of nurses concerning the use of ECMO is recommended subject to the success of this project.

Acknowledgement

I would like to express my special thanks of gratitude to Dr: Mary Brigid Martin who has accorded me the opportunity to do hone my research, writing, and critical writing skills by guiding the execution of this paper. The Dublin collaboration with Princess Noura University also deserves a special mention as the completion of this project would have been impossible without their technical support.

Secondly, I would also like to thank my parents and friends who have been instrumental in providing moral, social, and intellectual support even as I took time away to work on the project.

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Jawaher alkhalidi,etal. "Improvement Of The Competence And Confidence Of Critical Care Nurses In Critical Care Units In Saudi Arabia In Care Of Patients On ECMO Machine Through Educational Interventions And Its Impact On Mortality Rates Of Patients Placed Ecmo Machines." *IOSR Journal of Nursing and Health Science (IOSR-JNHS)*, 9(2), 2020, pp. 13-26.