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Educational programmes used in teaching nurses mechanical ventilation in adult intensive care units: a scoping review

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EDUCATIONAL PROGRAMMES USED IN TEACHING NURSES MECHANICAL VENTILATION IN ADULT INTENSIVE CARE UNITS: A SCOPING REVIEW

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A dissertation submitted to the Centre for Health Science Education, Faculty of Health Sciences, the University of the Witwatersrand in fulfilment of the requirements for the degree of Master of Science in Medicine in Health Sciences Education.

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Dissertation Abstract

Introduction

Mechanical ventilation is a common form of life support intervention and nurses are the key personnel in providing safe and specialized care to these patients. Their education determines whether patients receive optimal quality care and attain the best possible outcomes.

Purpose

To identify the available evidence on invasive mechanical ventilation educational programmes developed for teaching all nurses working in adult intensive care units; regardless of their level of qualification or years of experience. It includes the content taught and the method of instruction used.

Methods

Due to the breadth of the review topic, a scoping review methodology was considered appropriate and guided by The Joanna Briggs Institute (JBI) Scoping Review methodology. Eligibility criteria using the PCC framework, and relevant keywords and phrases originating from these criteria were used to search five databases in July and August 2022 (PubMed, EBSCO CINAHL, Wiley Online, Scopus and ProQuest). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines were used to report the results.

Results

Nine studies fulfilled the inclusion criteria for full review. Four studies were relevant to invasive mechanical ventilation; two studies were specifically related to ventilator-associated pneumonia and one each on weaning, endotracheal tube cuff pressure management and the development of a programme for nurses transitioning into the intensive care unit.

Conclusion

There is limited evidence of comprehensive educational programmes on invasive mechanical ventilation for all nurses working in the intensive care unit.

Keywords

Educational programme; mechanical ventilation; nurses; adult; intensive care units; critical care units.

Declaration

I, Daniele Ruth Davis declare that this Dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science in Medicine in Health Sciences Education at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Signature 

Daniele Ruth Davis

Signed at Woodmead, Johannesburg

On this day 10 February 2023

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Dedication

This dissertation is dedicated to my family. Your encouragement and sacrifice motivated me to pursue my academic goals and strive for excellence in all that I do. I could not have done this without you.

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Abbreviations

ABG: Arterial Blood Gas

ARDS: Acute Respiratory Distress Syndrome

ADDIE: Analysis, Design, Development, Implementation, Evaluation

BWAP: Burns Weaning Assessment Programme

CC: Critical Care

CCE: Critical Care Environment

CCN: Critical Care Nurse/Nursing

CCSSA: Critical Care Society of Southern Africa

CCU: Critical Care Unit/Coronary Care Unit

CE: Continuing Education

CINAHL: The Cumulative Index of Nursing and Allied Health Literature

CNE: Continuing Nursing Education

CPD: Continuing Professional Development

CICU: Coronary Intensive Care Unit

CTICU: Cardiothoracic Intensive Care Unit

EBP: Evidence-Based Practice

ETT: Endotracheal Tube

GICU: General Intensive Care Unit

HCU: High Care Unit

HPS: Human Patient Simulation

IC: Intensive Care

ICE: Intensive Care Environment

ICU: Intensive Care Unit

JBI: Joanna Briggs Institute

LMS: Learner Management System

LOI: Length of Intubation

LOS: Length of Stay

MV: Mechanical Ventilation

NDOH: National Department of Health

NIV: Non-Invasive Ventilation

PCC: Participants, Concept, Context

PLS: Protective Lung Strategies

PollEv: Poll Everywhere

RCTs: Randomised Controlled Trials

RIPPLES: The Recognition in Prior Professional Learning, Experiences, and Skills

RN: Registered Nurse

RT: Respiratory Therapist

S.A: South Africa

SANC: South African Nursing Council

SDLP: Self-Directed Learning Package

USA: United States of America

VAP: Ventilator-Associated Pneumonia

VALI: Ventilator-Associated Lung Injury

VBOS: Ventilator Bundle Observation Schedule

VBQ: Ventilator Bundle Questionnaire

VILI: Ventilator-Induced Lung Injury

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Chapter 1 Introduction

1.1 Background

The South African Nursing Council (SANC) under the provisions of the Nursing Act (2005) (ACT No. 33 of 2005) describe the competencies for a critical care nurse (CCN) specialist (Adult) as, “the care of patients with life-threatening illnesses and injuries and it occurs within a continuum from the scene of initial incident or onset of critical illness such as home through stabilisation, transfer/transportation, emergency and intensive care up to and including transfer to care in lower acuity levels/ step down units. Critical care (CC) is complex care offered either with or without technology by highly skilled clinical practitioners who may be nursing, medical and or paramedical personnel. Nursing personnel are supposed to be assigned on a 1:1 basis with a running or Floor Nurse who is often a team leader.”

Pfrimmer and Roslien (2011) advise that hospitals aim to reduce costs and improve patient outcomes. This has led to intensive care units (ICUs) being identified as areas of opportunity because these units incur the highest costs in healthcare and have the highest mortality rate. This is due to invasive mechanical ventilation (MV) being the principal reason for an adult patient to be admitted to the intensive care unit (ICU). Fenstermacher and Hong (2004) describe MV as an essential life-saving intervention for patients with respiratory failure or with partial or total airway obstruction whereby the patient is unable to maintain an adequate level of oxygenation and ventilation by natural means. Tobin, Laghi and Jubran (2012) explain that as ventilatory failure progresses it increases the patients distress levels and their work of breathing, therefore MV is initiated to alleviate the patient’s distress and reduce the activity of their respiratory muscles. This therapy increases the patient’s risk of developing complications with potential iatrogenic consequences. Minimising the risk of complications impacts the length of intubation (LOI), ventilation duration, length of stay (LOS) in the ICU and hospital, associated care costs, and in-hospital morbidity and mortality rates.

Guilhermino et al (2014) describe the role of the ICU nurse in the care of a patient receiving invasive (MV) to include the assessment, management and clinical-decision-making as either an autonomous responsibility or in collaboration with other healthcare professionals. Nurses are the key personnel in providing these critically ill patients with safe, effective, and specialized care that reduces the risks of major adverse effects and complications (Mamdouh, Mohamed and Abdelatief, 2020). Accurate and timely clinical decision-making demands that nurses have extensive knowledge and skills that are underpinned by an advanced biomedical understanding of the highly sophisticated and complex technology used to support these patients. Their education determines whether these patients receive optimal quality care and attain the best possible outcomes. Perrie et al (2014) state that a nurse should be guided by the ethical code that governs the profession to practice safe and competent nursing care.

Mchunu (2021) on behalf of The SANC (Act no. 33 of 2005) released a position statement (Section 4 (7) government gazette R.767 of 1 October 2014) regarding the allocation of non-specialised nurses to specialised units based on the following, “only a Nurse Specialist can work in the ICU and other areas in the hospital that are resourced with specialised equipment for health care users for specific health conditions; a Nurse Specialist is a Professional nurse who has met the theoretical and practical requirements of a specific postgraduate nursing programme of at least one year in duration and has expert knowledge in a specific practice area or alternatively an experienced Professional nurse may work under the supervision of a registered Nurse Specialist after an 80-hour induction has been completed.”

However, there are nurses working in South African ICUs that are not registered as CCNs (Scribante and Bhagwanjee, 2007; de Beer, Brysiewicz and Bhengu, 2011; Perrie, Schmollgruber, Bruce and Becker, 2014; Malelelo-Ndou, Ramathuba, Netshisaulu, 2019; Botha, 2012; Kubheka, 2019). Due to a shortage of specialist nurses, healthcare facilities are forced to staff these units with non-qualified CCNs which suggests that patients are most likely being managed by non-qualified CCNs (Scribante and Bhagwanjee, 2007). Education on MV is not part of the undergraduate nursing curriculum. Therefore, non-qualified CCNs enter this

environment without the required knowledge and skills to clinically manage these patients or operate the technology used to support their recovery. Their education is mainly from in-service education or on-the-job learning or self-teaching (Guilhermino et al, 2014; Murugiah et al, 2021; Hassan and Wahsheh, 2016). Variations in the skill mix compromise the patient's safety and directly impact their recovery.

1.2 Statement of the problem

The continuous advancements in the field of MV and the technology used necessitate the design and development of educational programmes on invasive MV to meet the needs of any nurse who works in ICU regardless of their professional educational background, level of qualification or years of experience. Knowledge is of utmost importance to ensure the delivery of safe and effective nursing practice. Both novice and experienced nurses in ICU require ongoing education to maintain their competencies and stay current with the rapid advances in this field.

The limited focus on MV educational programmes for nurses working in the ICU in the field of research and the rapid advances in the field of MV that demand nurses have the required skills and knowledge to manage these patients led to the primary question for this review to determine, ‘What type of mechanical ventilation programmes are used to teach nurses working in adult intensive care units, about the care and management of patients receiving invasive mechanical ventilatory support?’ This question was purposely broad, to encapsulate the scope and extent of the literature relating to the core topic.

To maintain focus and guide the direction and coherence of the included studies incorporating the establishment of a structured approach for data extraction and analysis, the following study objectives were constructed:

1. Document the basic and advanced mechanical ventilation programmes for educating nurses working in adult intensive care units about the care of a patient receiving invasive ventilatory support, and
2. To describe the content taught and the method of instruction used.

An understanding of how these studies are being conducted is important for two main reasons to inform future research, specifically in the design and development of new educational programmes on MV, and to report and discuss the opportunities of new educational strategies and approaches to ensuring that knowledge can effectively be transferred into clinical practice.

This scoping review comprises five sections namely an introduction, a literature review, the methodology, the results and the discussion. Each section is included as a chapter and are briefly described below.

Chapter 1: Introduction and background

This chapter introduces the subject matter.

Chapter 2: Literature Review

This chapter outlines a review of the academic literature related to the clinical and technical complexities of ICUs and the need for nurses working in these units to have advanced knowledge and skill sets to manage MV patients. The shortage of nurses worldwide has forced hospitals to staff these units with nurses that often don't have a postgraduate qualification in CC. Therefore, it is important to determine what educational programmes are available to all nurses working in these units regardless of their qualifications or experience to manage patients who require highly invasive, life-saving interventions.

Chapter 3: Methodology

This chapter provides a justification for the selection of a scoping review methodology to underpin this research, and describes all steps of the review, from eligibility criteria, types of sources, search strategy and information sources, selection of sources of evidence, data charting process, and analysis of the results.

Chapter 4: Results

This chapter contains the search results, article selection and inclusion process, characteristics of the included articles, the discussion and the key findings relating to the scoping review programme.

Chapter 5: Discussion

This chapter answers the review question and cohesively summarises the evidence described in the included studies by aligning it to the broader context of current academic literature. The summary of the main results includes an overview of concepts, themes, and types of evidence available, linking it to the review question and objectives. It discusses the limitations of the scoping review process and provides a general interpretation of the results in alignment with the review question, objectives, and the potential implications and/or next steps.

Chapter 2 Literature Review

2.1 Literature Review

This chapter provides an overview of the broader literature related to mechanical ventilation.

2.1.1 The intensive care environment

The SANC (Act no. 33 of 2005) defines Intensive Care (IC) as an environment in a hospital comprising several units that are staffed with specialised nurses and advanced equipment that is not routinely available in other hospital wards. The equipment and medical resources are essential for the monitoring and treatment of patients who are at risk of or have sustained acutely life-threatening single or multiple organ system failure. This could be as a result of a disease or injury with life-threatening conditions. These patients require close monitoring of their respiratory, cardiac, and metabolic status which includes the use of medication and equipment to try to maintain normal bodily functions (Marshall et al, 2017; Mathivah, 2002).

2.1.2 Mechanical ventilation

Smith and Nielsen (1999) state that adult patients are admitted to the ICU when they require advanced respiratory support and/or support for two or more organ systems. MV is a common life support intervention involving complex medical devices that are used in these settings. It assists or replaces spontaneous breathing in patients who are unable to protect their airway and/ or maintain physiological breathing. Adult patients require the insertion of an artificial airway. The endotracheal tube (ETT) or tracheostomy is adjoined to a breathing circuit which is then connected to the ventilator. Walter, Corbridge and Singer (2018) describe the artificial airway as a means to facilitate the delivery of mechanical breaths, protect the airway, allowing for suctioning of secretions, and to support select procedures including bronchoscopy.

Invasive MV is an essential life-saving technique and the principal reason an adult patient is admitted to the ICU. Approximately 80% of patients admitted to the ICU

require MV (Asmar et al, 2020; Ghafoor et al, 2022). Patients who only require supplemental oxygen or non-invasive ventilation (NIV) or mask ventilation are usually not admitted to an ICU but rather to a high care unit (HCU). NIV or mask ventilation alleviates some of the physiological effects of respiratory failure by reducing the work of breathing and reversing hypoxia. Providing adequate oxygenation and ventilation to normalise arterial blood gas (ABG) levels and correct acid-base imbalances is the primary goal whilst the underlying disease process that is causing the respiratory failure is reversed (Chlan, Tracy and Grossbach, 2011; Esteban et al, 2000; Grundgeiger et al, 2010; Lynch-Smith et al, 2016). A recent study describes how decades of research, progress and clinical monitoring have expanded the focus from just normalising ABG levels to including minimising ventilator-induced lung injury (VILI) whilst maintaining adequate gaseous exchange (Pham, Brochard and Slutsky, 2017).

2.1.3 Complications associated with invasive mechanical ventilation

It is an important lifesaving intervention for critically ill patients, but MV comes with potential iatrogenic consequences. Sound scientific knowledge and evidence should inform clinical decision-making (Jordan et al, 2022). Extensive knowledge and skills are required for timely and accurate decision-making. This is crucial to ensuring safe, best-practice care and reducing the risks of major adverse effects and complications (Guilhermino, Inder and Sundin, 2018; Asmar et al, 2020; Ghafoor et al, 2022; Pham, Brochard and Slutsky, 2017).

Complications associated with MV include ventilator-associated pneumonia (VAP), VILI, acute respiratory distress syndrome (ARDS), patient-ventilator asynchrony, ETT complications, and diaphragm atrophy. Prolonged MV increases the patient's risk of developing complications and is also associated with increased LOI, LOS, associated care costs, and rates of in-hospital morbidity and mortality. Many of these complications can be minimised and this has become a focus area of current research (Elliott and Elliott, 2018; Bloos et al, 2009; Guilhermino, Inder and Sundin, 2018).

2.1.4 The intensive care unit

The ICU is characterised as a high-tech, fast-paced, stressful environment due to the higher patient acuity coupled with rapid advancements in both healthcare and technology. Patient admissions are mostly the consequence of trauma. Other reasons are due to medical conditions, infectious diseases, post-surgical complications (elective), and obstetric conditions (de Beer, Brysiewicz and Bhengu, 2011; Mathivah, 2002). These patients may have prolonged hospital stays or be admitted for 24-hour monitoring or post-operative observation and support for up to three days. Adult patients may have co-existing illnesses or co- morbidities which make invasive MV more challenging and require a superior level of knowledge in physiology and the ability to recognize and avert early warning signs. As stated by Hassan and Wahsheh (2016, p. 125) “The application of knowledge to the care of critically ill patients is a hallmark of professional nursing practice”.

2.1.5 Critical care nursing

The high complexity of care inherent in this environment demands the skills and knowledge of a registered CCN to mitigate the risk of adverse events and errors. These patients are at high risk for developing infections and factors associated with increased morbidity and mortality; and necessitate continuous surveillance and bedside care. Nurses require high-level cognitive, emotional and interpersonal skills to manage and care for a MV patient (Goldsworthy, 2016). ICUs are staffed with non-qualified CCNs (Scribante and Bhagwanjee, 2007; de Beer, Brysiewicz and Bhengu, 2011; Perrie, Schmollgruber, Bruce and Becker, 2014; Malelelo-Ndou, Ramathuba, Netshisaulu, 2019; Botha, 2012; Kubheka, 2019). This is most likely attributed to the fact that we have a shortage of CCNs in South Africa (S.A) and healthcare facilities are forced to consider organizational changes in the provision of health care delivery.

The findings from the last audit conducted by the Critical Care Society of Southern Africa (CCSSA) disclosed that the employed nurse-to-functional ICU bed ratio and trained CCNs was below the international norm. These findings stated that the nurse-to-bed ratio was more than 5:1 and that only 25.6% of nurses were qualified in CC. It

is recommended that ICU patients should have a nurse-to-patient ratio of 1:1 and at least 50% of the nurses working in ICU should be qualified CCNs (de Beer, Brysiewicz, Bhengu, 2011; Joynt et al, 2019; Scribante and Bhagwanjee, 2007).

Using non-qualified CCNs to complete the required staff complement puts the patient's safety at risk as these nurses have not been formally educated in MV and lack the required technical skills to operate the sophisticated equipment (Perrie et al, 2014). The implications of this leads to these nurses entering the ICU environment ill-equipped with the means to only increase their knowledge through on-the-job learning. Their lack of knowledge indicates they are assigned responsibility in advance of acquiring competency. Non-structured and informal teaching and learning does not guarantee that nurses have acquired the specific or required knowledge or skill competencies to guide their clinical decision-making.

The essential elements and practices in the care of MV patients include the following but are not limited to the ventilator and circuit-related care, modes of ventilation; interpretation of waveforms; lung pressures and compliance, lung protective ventilation; monitoring of fluid balance, tracheal suctioning; ETT cuff pressure management; oral care; eye care; patient positioning; patient-ventilator synchrony; humidification; collection and interpretation of ABGs; sedation; weaning protocols and early mobilisation. Preceding the development of a new online educational programme on infection prevention, a knowledge assessment was administered to ICU nurses in 22 countries across Europe on evidence-based guidelines for preventing VAP, which is a common complication of MV. The results yielded an average score of 45.1% (Labeau et al, 2008). These results provide important information for the development of educational programmes that can address the identified gaps in knowledge and competencies.

Extensive research has been conducted on the knowledge levels and practices of nurses working in the ICU that are managing MV patients. The results of these studies conclude that these nurses do not have the desired level of knowledge and require mandated education and training regardless of their level of education or

years of experience (Khaleghi et al, 2019; Saritas, Kaya and Dolanbay, 2019; Melo et al, 2014). A study in Palestine reported that 43.6% of CCNs had not received any specialised training or education on MV and lacked adequate levels of knowledge regarding protective lung strategies (PLS) for MV patients. This emphasises the need for the provision of educational programmes to increase the knowledge levels of nurses to prevent associated complications and optimise the efficacy of PLS (Asmar et al, 2020). Nursing practice can be improved with regular teaching sessions and structured programmes.

An inexperienced nurse who is unfamiliar with the technology and interpretations of the patient's values might not be able to identify early warning signs to alert a more experienced nurse to assist. Nurses supervising inexperienced nurses may have their own patients to manage and depending on the unit's occupancy and the acuity of these patients, they may not always be available to provide immediate support. This puts the patient's safety at risk unnecessarily.

Participants from a study by Gohery and Meaney (2013) concurred that as they transitioned from the clinical ward environment to the CCU they only approached staff they knew would assist and support them. This suggests that targeted education and support could ease the transition process and assist them in developing adequate skills and knowledge to increase their level of self-efficacy and competence. The recovery or the demise of a critically ill patient is directly influenced by the nurses knowledge and experience (Botha, 2012).

In Australia, the management of MV patients is learnt through on-the-job continuing education (CE) or beyond the graduate level (Guilhermino, Inder and Kuzmiuk, 2014). MV management is not included in the undergraduate nursing curriculum. Due to this, it is imperative that knowledge on invasive MV is provided through CE in the ICU. Even though Australian and New Zealand standards mandate that 50% of the nursing staff in ICUs must hold a postgraduate qualification, both the experienced and the less experienced nurses in this study were in favour of regular refresher courses (Guilhermino et al, 2014).

A study in Ireland reported that CC areas employed nurses with no CC experience due to staff shortages. This results in a nurse transitioning from the ward to a CCE with insufficient knowledge and skills to integrate technology with patient care delivery. In such highly technological environments, inexperienced nurses tend to prioritise technology over patient care because they are fearful of the equipment due to end-user inexperience and lack of training on the medical devices inherent in these units (Gohery and Meaney, 2013).

In Pakistan, more than 90% of critical care units (CCUs) are managed by untrained CCNs and approximately 28% to 35% of patients develop irreversible complications due to unsatisfactory nursing practices (Ghafoor et al, 2022). A deeper understanding of the essential care practices of MV patients and the associated complications may assist nurses to recognize patients' early warning signs and allow for targeted interventions. The emergent evidence implies that the lack of adequate nurse staffing and poor skill mix have a negative impact on the quality of patient care and outcomes and therefore educational programmes are fundamental to safe and effective practice (Chamberlain et al, 2018).

The findings from a multistate, cross-sectional study of hospitals in the United States of America (USA) reported a strong correlation between nurse staffing, education and the quality of work environments and mortality post common surgical procedures. This suggests that a CCE that is staffed with knowledgeable and educated nurses may improve patient outcomes. If variations in the level of qualifications impact the required standard of care and patient outcomes, then nursing education has the potential to improve patient outcomes and lower the rate of mortality (Kelly et al, 2014).

2.1.6 Continuing Education

Continuing professional development (CPD) for all levels of nurses working in the ICU is essential, to remain up to date with changes in evidence-based practice (EBP) and technological advancements. The advances in the technology of medical devices

are rapid and mandate nurses to continuously build and maintain their knowledge and skills for optimal patient care and safety. However, selecting the right content to achieve individual goals may be challenging due to the varying levels of knowledge, skill and clinical experience (Guilhermino et al, 2014).

A study in Johannesburg, S.A. (Perrie et al, 2014) revealed an average knowledge score of 47.6% for ICU nurses that work in selected care areas that use protocol-directed care. These knowledge deficits can impact nurses' decision-making skills to comply with or implement protocol-directed care especially if there is incongruence in the steps of different protocols being used (Perrie et al, 2014). This indicates that evidenced-based guidelines, protocols and care bundles still require nurses to have an in-depth understanding and advanced level of foundational knowledge to improve awareness, avert potential complications and direct targeted nursing interventions.

By committing to lifelong learning nurses are exposed to current advances in nursing practice which enables the acquisition of new skills, to remain current and improve their professional performance. In a study by Al-Majid et al, (2012), most nurses reported that they were in favour of continuing nursing education (CNE) and believed it would improve their nursing practice, impact patient outcomes, enhance their competencies and keep them up to date with advances in nursing. Besides acquiring and retaining knowledge, CE aids in developing cognitive abilities and evaluation skills. This assists nurses in the promotion of self-reflection and supports the delivery of safe practice and optimal patient care and outcomes (Guilhermino et al, 2018).

In-service training is provided by the suppliers of medical devices when new equipment is installed but their training is restricted to the use of their equipment only. The nomenclature used in MV is not standardized and each brand has different names for its modes of ventilation and associated adjuncts. In addition, the manufacturers regularly update the nomenclature when new modes or features are released. This can cause confusion in ICUs due to the lack of standardization resulting in multiple brands and varying models (Chatburn et al, 2012). Disposables and consumables sold with the equipment are only tested by the manufacturer of the

brand. In units with multiple brands, lack of education can lead to potential errors and put the patient at risk as the disposables and consumables have not been tested on another brand's equipment and are therefore deemed unsafe to use.

2.1.7 Technology

The literature provided by the suppliers of the equipment provides a 'textbook' patient, which is acceptable if the patient is receiving only mandatory ventilation and there is no spontaneous effort by the patient. However, when the ventilator is only providing assisted ventilation, there needs to be synchrony between the support of the ventilator and the efforts of the patient to minimize any damage to the patient's lungs. It is crucial that the nurse can interpret the waveforms and understand the modes and settings of the ventilator and how it interacts with the patient regardless of the brand or model to aid in the optimal recovery of the patient. Due to the complexity of invasive MV and that there is no standard nomenclature across manufacturers, all nurses regardless of their level of qualification, or years of experience require CE to mitigate risk and optimize patient outcomes by developing the skills and knowledge required for identifying early warning signs and how to troubleshoot problems (Windsor, 2005).

2.1.8 Educational programmes on mechanical ventilation for nurses working in the ICU

Educational programmes on MV for nurses working in the ICU are an under-researched topic although the need for educational programmes is recommended in almost all studies involving the assessment of nurses' knowledge in MV. Education on MV is necessary to meet the needs of these nurses working in ICU regardless of their different stages of professional development. This scoping review aimed to identify all the available literature relating to programmes that have been developed on invasive MV relevant for any nurse who works in the ICU regardless of their background, level of qualification, or experience. This review will detail what educational programmes are available including the topics and content covered, and the design and teaching methods used in the delivery of these programmes.

Chapter 3 Methodology

Scoping reviews are used to map and scope a body of literature on a particular topic and explore the types of available evidence in a given field, as well as providing an opportunity to identify key concepts, theories, sources of evidence and gaps in research. (Arksey and O'Malley, 2005). Researchers conducting scoping reviews may address one or all of these aims. The main reason for this type of review is to address a broad topic that can include different study designs and methods or to explore an area that has not been reviewed comprehensively before. This contrasts with systematic reviews which assess the quality of included studies whereas scoping reviews do not include a quality appraisal of the evidence (Munn et al, 2018).

The framework was initially created by Arksey and O'Malley (2005) and has been influential for researchers conducting scoping reviews. This framework was later updated and expanded upon by Levac, Colquhoun and O'Brien (2010) providing researchers with more explicit detail regarding the purpose and indications for conducting scoping reviews and what occurs at the various stages of the review process to increase both the clarity and rigour of the review process. Both of these frameworks have been instrumental in the development of the Joanna Briggs Institute (JBI) approach to the conduct of scoping reviews.

3.1 Methods

The methodological approach selected for this study was a scoping review. Following the methodological recommendations from the JBI and the PRISMA-ScR guidelines for reporting, an *a priori* review protocol was developed. In accordance with the JBI methodology for scoping reviews the following methods were employed: develop the title, objectives and review question; determine the eligibility criteria; develop the literature search strategy; extract and present the results and discuss the findings, limitations of the review, draw conclusions and discuss the implications for practice and further research (Peters et al, 2017). An *a priori* review protocol was developed based on these steps and outlined the eligibility criteria, search strategy, study selection and data extraction for this review. The protocol is available in Appendix I.

3.2 Eligibility Criteria

For this review, the eligibility criteria are described using the Participants, Concept and Context (PCC) framework (Aromataris and Munn, 2020). A preliminary search of the literature assisted in developing the PCC framework to inform this review, where a range of different sub-categories of MV, method of instruction, and varying content of educational programmes were identified. The intention of this PCC framework was to capture the diversity of the literature in this area of research and the extent of the literature on MV educational programmes available to all nurses working in the ICU.

3.2.1 Participants

For this review, a nurse was defined as any nurse working in the ICU, who manages adult patients receiving invasive mechanical ventilatory support. There were no restrictions based on age or other demographic aspects. Studies that used mixed groups of participants such as registered nurses and respiratory therapists or nurses and physicians were included if the study and intervention included specific relevance to nurses and their role in managing MV patients.

3.2.2 Concept

The concept of interest was educational programmes on invasive MV, specifically on what had been taught and how it was taught. It included the objectives of the programme and/or study detail, content of the programme, key concepts or related topics, and the instruction method of the programme. This review excluded any educational programmes regarding NIV or mask ventilation as this type of treatment is not usually offered in an ICU but rather in the HCU.

3.2.3 Context

The context of this review was limited to the ICU because mechanical ventilators are usually not used in general wards. The emergency department and the operating theatre were also excluded from the settings as the ventilation of these patients is

short-term and nurses are not the primary caregivers. Mechanical ventilators used in these settings usually ventilate the patient via a transport ventilator or an anaesthetic machine and these devices do not offer the same functions, modes and adjuncts and disposables or consumables as a mechanical ventilator that is positioned in an ICU. In CCEs, nurses provide continuous bedside monitoring and management of these patients and most patients who are admitted to the ICU require invasive mechanical ventilatory support. MV can be either short-term or long term which increases the patients' risks of adverse effects and or complications associated with the intervention. The study focus was aimed at the adult patient range as the care and management of these patients differs from that of paediatric and neonatal patients.

3.2.4 Types of Sources

Only papers published in English from 2011 to 2022, when the search was conducted, were eligible for inclusion in this review. The language restriction was due to the cost and time involved in translating non-English studies. The search commenced in 2011 as this is when positive pressure mechanical ventilators, as we know them today, were operational and available from all manufacturers. There were no limitations relating to study design or approach to data analysis.

3.3 Search Strategy and Information Sources

An initial limited search of PubMed was conducted to locate articles on this topic, followed by an analysis of the text words contained in the titles, abstracts, and index terms. This led to the development of a search strategy for PubMed. The refined search string was then adapted to the other databases during July and August of 2022.

The review process followed the PRISMA-ScR ("PRISMA extensions for scoping reviews"). The five databases searched were PubMed, EBSCO CINAHL, Wiley Online, Scopus and ProQuest for both published and unpublished literature and gray literature. The Cumulative Index of Nursing and Allied Health Literature (CINAHL) was searched via EBSCO Host. The other four databases were searched using the

University of the Witwatersrand libguides, electronic resources, databases A-Z via Innopac. The search for unpublished studies and gray literature included ProQuest. The search was carried out with the support of a librarian. The full search strategies of the above-listed databases are shown in Appendix 4.

3.4 Selection of Sources of Evidence

After searching, all identified records were collated and uploaded into a Microsoft Excel spreadsheet (Version 2209; Build 15629.20208) and duplicates were removed. Titles and abstracts of the identified studies were scrutinized in relation to the review question and objectives by the reviewer. A co-reviewer provided input into the generated list of titles produced from the search and consensus was reached on which papers should be downloaded for full-text review. Thereafter, a list of studies for potential inclusion was developed.

Thereafter, the full-text papers were retrieved, read and assessed against the inclusion criteria. A final decision was made on whether to include or exclude the retrieved papers. The studies that were excluded following the full-text review are detailed in Table 4.1.

The emphasis was on educational programmes for teaching nurses, and the appropriate management of adult patients receiving invasive MV support in an ICU, utilising any study design. The reference lists of all included papers were screened for additional potential studies.

3.5 Data extraction

Data extraction was conducted by the researcher and undertaken using a charting table developed for the review objectives. A co-reviewer provided guidance into the structure of the data extraction charting table. Extracted data from the papers that met the selection criteria are presented in the following chapter. Two articles were analysed using the data charting tool and following discussion with the co-reviewer,

no further changes were made. The charting table details the authors, year of publication, country of origin, study details and characteristics, population size and setting, study design and method, instructional methods, content and assessment of the invasive MV educational programmes, results and key findings that were relevant to the question and objective of this review.

3.6 Ethics

As this research study was a review of information that is accessible in the public domain, an ethics clearance waiver was received from the University of the Witwatersrand Human Research Ethics Committee (Medical) reference number: W-CBP- 211115-01 (Appendix 2).

3.7 Data charting process

The reviewer with input from a co-reviewer designed a data extraction tool (Appendix 3) based on the main aspects of the review question. The extracted data included specific details about the PCC, topic investigated, study designs and methods, instructional methods used and content covered and key findings that related to the review question. The reviewer created a spreadsheet on Excel (Version 2209; Build 15629.20208). This allowed for the comparison of specific aspects in multiple records and facilitated the organisation and visualisation of data prior to analysis.

3.8 Analysis and writing of results

The interpretation of the results was guided by the review question and objective. The high degree of variability in approaches to the study deigns and methods used, as well as topics investigated, posed a challenge in the presentation of results in a meaningful way. The first step taken was to divide the approaches into study design, methods and topics investigated into categories. Approaches to study design included cross-sectional, randomised controlled trials (RCTs), quasi-experimental, observational, systematic reviews and instructional design model. The methods included pre-test and post-test designs, frequency of repeated measurement time

points and a survey. The categorisation of the topics investigated were divided into the following final categories: Educational programmes for nurses transitioning into ICU; patient-ventilator synchrony, MV educational programmes for ICU nurses, ETT cuff pressure management, weaning and VAP.

In this chapter the methods followed for this review have been described. The findings are described in the following chapter.

Chapter 4 Results

Following the JBI Manual of Evidence Synthesis (2020), this chapter presents the results yielded from the research conducted for this review. The results indicate how many sources of evidence were identified and the selection process. The results are accompanied by a narrative description of the search decision process and include the source of evidence identification and inclusion decision flowchart adapted from the PRISMA 2020 flow diagram (Figure 4.1). The flow chart clearly details the review decision process, indicating the results from the search, removal of duplicate citations, source selection, full retrieval and identification of new studies via other methods.

The narrative summary describes the aims or purposes of the reviewed sources, concepts adopted and results that relate to the review question. The results are classified under the main conceptual categories such as distribution of papers across geographical locations, the profile of the participants and setting characteristics, study backgrounds and associated aims, study designs and methods, content covered, types of interventions, duration, results and key findings and how they relate to the question of this review.

4.1 Search results and article selection and inclusion process

The results of the literature search and the subsequent screening process undertaken during this scoping review are presented in Figure 4.1. A total of 415 papers were found during the database search and divided accordingly; PubMed 4, EBSCO_CINAHL Complete 108, Wiley Online 17, Scopus 31 and ProQuest 255. A total of 14 duplicates were removed, leaving 401 titles and abstracts to screen. An additional 373 were classified as irrelevant after examining the title and abstract. This left 28 articles, of which 20 did not meet the inclusion criteria and were therefore excluded. The 20 excluded papers and the reasons for their exclusion are presented in Table 4.1. Eight papers were identified as eligible for inclusion. A hand search of the reference lists of the eight included studies was conducted. One additional study was found eligible for inclusion. The included systematic review (Guilhermino,

Inder and Sundin, 2018) reference list was checked for additional articles for inclusion. Two studies listed were duplicates whilst the remaining studies were either not related to educational programmes on MV; were not in the ICU setting or were earlier studies that did not meet the inclusion criteria of this review. In conclusion, the screening stage resulted in nine eligible articles for data extraction.

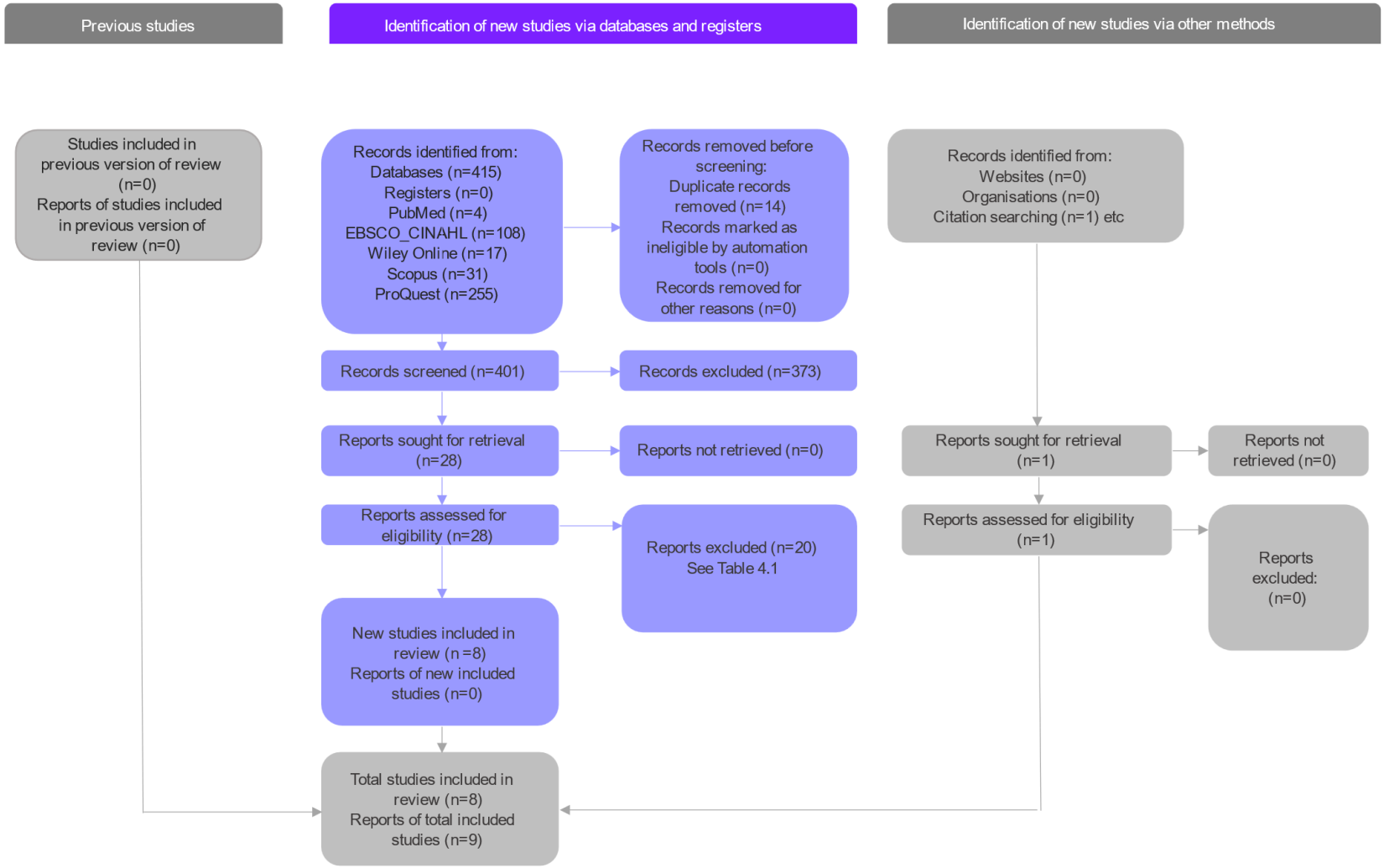


Figure 4.1: Search results and article selection and inclusion process

Page et al (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, 372:71 doi:10.1136 /bmj. n71

Table 4.1 Studies excluded following full-text review (n=20)

Authors	Reasons for exclusion
Asmar, I.T., Alrajoub, B.M., Almahmoud, O.H., Nakhleh, D.N., Makharzeh, S.I. and Falaneh, Y.M. Critical Care Nurse Quarterly, 2020, 43(3), 274-285.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Kydonaki, K., Huby, G., Tocher, J. and Aitken, L.M. The Journal of Clinical Nursing, 2016, 25(3-4), 434–444.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Perez, D., Murphy, G., Wilkes, L. and Peters, K. J The Journal of Clinical Nursing, 2021, 30(11-12), 1706-1718.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Cavalcante, J.G.T., e Silva, R.D., de Souza, H.C.M. and Nelson de Moraes, H.L. The Journal of Intensive Critical Care Nursing, 2015, 31(3), 179-86.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Li, J., Zhan, Q. Y. and Wang, C. The Journal of Respiratory Care, 2016, 61(9), 1224-31.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Guttormson, J.L., Bremer, K.L. and Jones, R.M. The Journal of Intensive Critical Care Nursing, 2015, 31(3), 179-86.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Wagner, B.V., Alves, E.F., Brey, C., Waldrigues, M.C. and Caveião, C. The Journal of Nursing UFPE online. Recife, 2015, 9(5), 7902-9.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Roberts, M., Bortolotto, S.J., Weyant, R.A., Jock, L., LaLonde, T. and Henderson, A. Dimensions of Critical Care Nursing, 2019, 38(4), 201-212.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Kelly, D.M., Kutney-Lee, A., McHugh, M.D., Sloane, D.M. and H. Aiken, L.H. The Journal of Critical Care Medicine, 2014, 42, 1089-1095.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Grap, M.J., Munro, C.L., Wetzel, P.A., Best, A.M., Ketchum, J.M., Hamilton, V.A., Arief, N.Y., Pickler, R. and Sessler, C.N. The American Journal of Critical Care, 2012, 21(3), e53–e64.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Nilsen, M., Sereika, S.M., Hoffman, L.A., Barnato, A., Donovan, H. and Happ, M.B. Research in Gerontological Nursing, 2014, 7(3), 113–125.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Randen, I., Lerdal, A and Bjørk, I.T. Nursing in Critical Care. The British Association of Critical Care Nurses, 2013, 18(4), 176-186.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Soh, K.L., Soh, K.G., Japar, S., Raman, R.A. and Davidson, P.M. The Journal of Clinical Nursing, 2011, 20(5-6), 733-42.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Lian, J.X. The Journal of Nursing, 2013, 43(6), 46-52.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation delivered to nurses.

Mehta, R.S. CONNECT: The World of Critical Care Nursing, 2014, 9(2), 43-43.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Madhuvu, A., Endacott, R., Plummer, V. and Morphet, J. The Journal of Intensive Critical Care Nursing, 2020, 59, 102827.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Guilhermino, M.C., Inder, K.J., Sundin, D. and Kuzmiuk, L. The Journal of Continuing Education in Nursing, 2014, 45(5), 225-232.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Kaddoura, M.A. The Journal of Continuing Education in Nursing, 2013, 44(11), 488-95.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Pfrimmer, D.M. and Roslien, J.J. The Journal of Continuing Education in Nursing, 2011, 42(8), 342-3.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.
Goherya, P. and Meaney, T. The Journal of Intensive and Critical Care Nursing, 2013, 29, 321-328.	The study does not relate to the research question as it is not based on an educational programme on mechanical ventilation for nurses.

4.2 Characteristics of included articles

Table 4.2: Characteristics of included studies (n=9)

Author(s), year of publication, country of origin	Guilhermino, M.C., Inder, K.J., Sundin, D., Kuzmiuk, L. 2013, Australia
Study aims / purpose of study	How intensive care unit nurses perceived current education provided on MV, including a self-directed learning package and a competency programme; identify other important topics and forms of education, and determine factors associated with the completion of educational programmes on invasive MV.
Participants details / Sampling / sample size	Total number of registered nurses in the study hospital ICU (n = 160) Number of nurses who returned the survey (n = 83)
Concept	Components of the CE: 1. Educator-assisted orientation: 2. Bedside orientation 3. Adult Ventilation Management Self-Directed Learning Package (SDLP) 4. Recognition in Prior Professional Learning, Experiences, and Skills programme (RIPPLES) 5. In-service session
Context	22-bed, level 3 ICU within a 550-bed regional tertiary referral hospital in New South Wales (adult, paediatric and cardiothoracic intensive care, including high dependency services).
Design and Methods	**Design:** Descriptive cross-sectional survey. **Method:** A self-administered, 30-item semi-structured, printed survey.
Instructional methods and content covered	1.Educator-assisted orientation: • Assessment of knowledge and skills on invasive mechanical ventilation for nurses new to the intensive care unit environment • Orientation to ventilators, location of consumables, and intranet resources (learning packages, guidelines and procedures, competency programme) • Practical hands-on teaching session • Assembly of ventilators • Initial settings and modes 2.Bedside orientation: • Demonstration of respiratory physical assessment: • Auscultation, inspection, signs of respiratory distress • Indications, modes and complications of invasive ventilation

	• Airway security, the position of the endotracheal tube, cuff pressure • Documentation • Demonstration of the airway safety equipment and placement • Discussion of respiratory interventions: • patient positioning • endotracheal tube suctioning • blood gas interpretation • humidification and nebulisers 3. Adult Ventilation Management Self-Directed Learning Package (SDLP): • Airway management • Invasive ventilation indications and contraindications • Description of the role of the intensive care unit nurse • Ventilation modes and other settings • Intubation equipment and medications • Nursing care, communication with the patient and ventilation documentation • Weaning methods and extubation 4.Recognition in Prior Professional Learning, Experiences, and Skills programme (RIPPLES) – care of a ventilated patient in intensive care: • Ventilation objectives • Servo-i ventilator • Evita 4 ventilator • Intubation objectives • Intubation skills • Tracheostomy objectives • Tracheostomy percutaneous insertion • Tracheostomy tube change • Intercostal catheter management objectives • Intercostal catheter removal skills 5. In-service session
Results	The majority had not received education on MV prior to working in the ICU. The self-directed learning package and competency programme were perceived to be valuable and beneficial. Hands-on-practice was perceived as the most important form of education and ventilator settings as the most important topic.
Key findings that relate to the scoping review question	Registered nurses are commencing their ICU experience with limited knowledge of invasive MV. Education provided within the ICU workplace becomes fundamental to safe and effective practice. Regardless of the level of ICU experience, the ICU nurses perceive continuing education as a positive. This may influence the type of continuing education on invasive MV provided to ICU nurses in the future. These findings may support future recommendations to improve continuing education on invasive MV.

Author(s), year of publication, country of origin	Lynch-Smith, D., Thompson, C.L., Pickering, R.G. and Wan, J.Y. 2016, America
Study aims/purpose of the study	To evaluate the effects of education on patient-ventilator synchrony on the clinicians' level of knowledge and patients' mean duration of mechanical ventilation.
Participants details / Sampling / sample size	Registered nurses (n = 17)
Concept	A lecture was presented to nurses in the critical care classrooms and critical care units providing information on patient-ventilator synchrony and asynchrony.
Context	Intensive care unit
Design and Methods	**Design:** A prospective quasi-experimental study. **Method:** Pre-test and post-test. Both tests were the same except for the ordering of questions. The content included questions on determinants and phases of patient-ventilator synchrony and causes and management of patient-ventilator asynchrony and basic waveform analysis.
Instructional methods, content covered and assessment	A 1-hour lecture was given at 7 different times in the critical care classroom, the respiratory care department classroom, and the critical care unit. The educational presentation consisted of a 54-slide PowerPoint presentation that included definitions of patient-ventilator synchrony and asynchrony; basic mechanical ventilation waveforms and interpretations; synchronous and asynchronous waveforms and interpretations; strategies to improve triggering, flow, and rate asynchronies; measures of oxygenation and ventilation; and ventilator setup and adjustments. A pre-test was administered before the 1-hour lecture and after the lecture a closed-book post-test was administered.
Results	Test scores increased significantly after the lectures. The mean overall scores were 10.3 (SD, 3.2) before the lecture and 15.9 (SD, 3.6) after the lecture. The mean increase in post-test scores compared with pre-test scores was 5.6 (SD, 2.9) points ($P < .001$), for a mean improvement of 71% (SD, 69%; $P < .001$).
Key findings that relate to the scoping review question	The post-test scores indicated an increase in the knowledge scores of the nurses. The education on patient-ventilator synchrony and asynchrony had a significant and positive effect on the nurse's level of knowledge.

Author(s), year of publication, country of origin	Jansson, M.M., Ala-Kokko, T.I., Ohtonen, P.P., Meriläinen, M.H., Syrjälä, H.P., Kyngäs, H.A. 2014, Finland
Study aims / purpose of study	To evaluate the effectiveness of human patient simulation (HPS) education in the nursing management of patients requiring mechanical ventilation.
Participants details / Sampling / sample size	Critical care nurses randomly selected to participate: Control group (n=20); Intervention group (n=20) All study procedures completed: Control group (n=10); Intervention group (13)
Concept	The HPS educational programme began with a brief bedside introduction and hands-on explanation of the simulation process (briefing, simulated scenario, and debriefing) and use of the HPS mannequin. In the brief scenario, participants were asked to engage in all of the essential nursing interventions to prevent VAP in a patient being enterally fed and requiring MV with an artificial airway, starting from respiratory management.
Context	A single academic centre in a 22-bed, adult mixed medical-surgical ICU.
Design and Methods	**Design:** A single-centre, prospective, parallel, randomized controlled trial with repeated measurements. **Method:** The effectiveness of the HPS education was evaluated through the validated Ventilator Bundle Questionnaire and Ventilator Bundle Observation Schedule at baseline and repeated twice after the clinical and simulation settings.
Instructional methods, content covered and assessment	A brief bedside introduction (20 minutes), giving a hands-on explanation of the simulation process and use of the HPS mannequin. During the 10-minute scenario, participants were asked to engage in all the essential nursing interventions to prevent VAP in a patient being enterally fed and requiring mechanical ventilation with an artificial airway, starting from respiratory management. During the simulations, the software of the HPS mannequin was programmed to cough and change vital signs (e.g., heart and respiratory rates, blood and airway pressures, and peripheral oxygen saturation). Participants had access to all necessary equipment used in the ICU environment (e.g., patient monitors, respirator, oxygen, endotracheal suctioning device, and oral care equipment) and could ask the facilitator questions. Only the intervention group received verbal feedback and participated in a 60-minute structured debriefing based on the effectiveness of the VBs. During the debriefing, participants could ask questions and engage in discussion with the simulation educators. The measurements were completed three times for both groups. After the baseline measurement, the intervention group underwent HPS education. Then the measurements were performed similarly for the intervention and control groups. The initial post-intervention measurements (3 months after the intervention) were conducted in the simulation environment (follow-up I), and the final post-intervention measurements (6 months after the intervention) were made during the morning shift (7 AM-3 PM) in clinical practice (follow-up II). Participants were evaluated while managing adult patients requiring mechanical ventilation using a direct, structured, non-participatory method of observation, which is a purposeful data collection method, particularly for recording participant behaviour. Participant knowledge and skills in adhering to VBs were evaluated through the validated 49-item multiple-choice Ventilator Bundle Questionnaire (VBQ) and 86-item Ventilator Bundle Observation Schedule (VBOS). The content of the VBQ and VBOS consisted of a list of pharmacologic and non-pharmacologic nurse-led interventions aimed at preventing VAP: intubation and mechanical ventilation and prevention of airway colonization.
Results	The average skill scores (VBOS) increased significantly after HPS education in the final post-intervention observation.
Key findings that relate to the scoping review question	HPS education significantly improved skills among critical care nurses in managing patients requiring mechanical ventilation and persisted at the 6-month follow-up.

Author(s), year of publication, country of origin	Al-Faouri, I.G., AbuAlRub, R.F. and Jumah, D.M. 2013, Jordan
Study aims / purpose of study	To determine the effect of educational interventions for nurses on the success of weaning trials, ventilation period, and reintubation incidence for mechanically ventilated patients.
Participants details / Sampling / sample size	Registered nurses who provide direct care to patients in the critical care units. Patients: Convenience sample n=135; historical control group (n=65) and post-intervention group (n=70); adults ventilated >24 hr
Concept	The educational interventions on the BWAP were held to train nurses on how to assess patients' readiness for weaning from mechanical dependency and to detect any uncorrected factors before initiating weaning trials.
Context	504-bed university hospital, three ICUs with 30 beds in total (general, coronary and cardiothoracic)
Design and Methods	**Design:** A non-equivalent group, pre-test–post-test (quasi-experimental) design. **Method:** In-service education; bedside education and hands-on application.
Instructional methods, content covered and assessment	The Burns Weaning Assessment Protocol (BWAP) is a 26-factor scoring instrument that was used to decrease variability in managing patients on mechanical ventilators. The instrument consists of three subscales; a general assessment, a respiratory assessment, and ABGs results. The response on each item of these subscales is yes, no, or not assessed. The cut-off point for the instrument is 50. Over 50, is a predictor of successful weaning. Less than 50, is a predictor of unsuccessful weaning. Prior to the educational sessions of the experimental group, data were collected from a convenience sample of patients' charts of the control group (historical group). The experimental group were educated and trained on the BWAP items over one month through in-service education, bedside education, and hands-on applications. Data collection and monitoring were performed by one of the researchers and two trained nurses from each unit. The participants completed a form for each of the recruited patients which included the Burns Weaning Assessment tool, demographic data of patients, number of reintubations, the ventilation period, and the successful weaning.
Results	The interventions had a positive impact on failed trials and reintubation occurrence, which are essential for patient safety.
Key findings that relate to the scoping review question	A significant reduction in failed trials and reintubation post-intervention indicated that the education provided on the published weaning protocol was effective and is recommended as a guide for nurses to use in the management and weaning of patients from mechanical ventilation.

Author(s), year of publication, country of origin	Guilhermino MC, Inder KJ, Sundin D. 2018, Australia
Study aims / purpose of study	A systematic review to determine whether CE programmes on invasive MV involving ICU nurses are effective in improving patient outcomes.
Participants details / Sampling / sample size	ICU nurses. Twelve studies met the inclusion criteria for full review: 11 pre- and post-intervention observational and 1 quasi-experimental design.
Concept	Continuing education programmes on invasive mechanical ventilation that are effective in improving patient outcomes.
Context	Intensive care
Design and Methods	**Design:** Systematic review. **Method:** Five electronic databases were searched from 2001 to 2016. The following keywords were used: mechanical ventilation, nursing, and education.
Instructional methods and content covered	The education programme methods were diverse. In-service education sessions, seminars or lectures were included in seven studies comprising: self-directed learning module/package, in-service education and hands-on education, seminars and lectures, posters, fact sheets and feedback sessions. Four studies included an exam component. The studies provided a clear description of the education context and study setting. However, some studies provided limited detail around the precise nature of the education intervention. For two studies, the intervention was not described Four studies did not specify the method. and materials used to deliver the education programme. Five studies mentioned the education topic covered but did not detail the content. Six studies did not report the duration of the education. All studies lacked detail on how the education intervention was run in practice. There was consistency between the studies with regard to the education focus. Nine studies focused on the prevention of VAP, three studies on the compliance of lung-protective ventilation strategies in patients with ARDS/ALI and one study on a failed weaning trial.
Results	Non-statistically significant results were reported for in-hospital and ICU mortality, re-intubation, and ICU length of stay. Limited evidence of the effectiveness of CE programmes on MV involving nurses in improving patient outcomes exists. Comprehensive CE is required.
Key findings that relate to the scoping review question	High-quality continuing education about mechanical ventilation for ICU nurses may lead to improved patient outcomes, regardless of their level of experience. Comprehensive continuing education is required to improve patient outcomes by using well-defined, structured educational programmes about MV with comprehensive content, including decision-making around ventilation strategies and weaning, in addition to the prevention of ventilator-associated pneumonia.

Author(s), year of publication, country of origin	Murugiah, U.R., Ramoo, V., Jamaluddin, M.F.H., Yahya, A., Baharudin, A.A., Abu, H., Thinagaran, R.R.R. 2021, Malaysia
Study aims/purpose of study	To evaluate the effectiveness of an educational intervention related to ETT cuff pressure management on improving and retaining critical care nurses' knowledge
Participants details / Sampling / sample size	Registered nurses. Total nurses invited N=122 Total nurses volunteered to participate in the study (n=114) The total amount of nurses who completed the study (n=112)
Concept	An educational intervention to enhance nurses' knowledge and skills in relation to cuff pressure management was delivered over 3 months.
Context	24-bed adult general intensive care unit at a teaching hospital
Design and Methods	**Design:** Quasi-experimental single-group pre-and post-test design. Knowledge assessment was done at baseline and 3 and 9 months after the educational intervention. **Method:** A theoretical session, hand-outs and hands-on practice. A 12-item self-administered questionnaire pre-and post-intervention was used to assess their knowledge.
Instructional methods, content covered and assessment	A total of 12 continuous formal educational sessions were delivered over 3 months. As a continuing educational activity, all the nurses in the unit had to attend at least one of the educational sessions. The content was based on an extensive literature review, international guidelines, and experts' input. The topics included characteristics of ETT, cuff pressure limits, complications of under and over-inflation, cuff pressure measurement methods, patient management, and nursing interventions related to ETT cuff management. Methods of measuring cuff pressure and calibration using a hand-held gauge manometer were taught through demonstration. Each session was attended by 8 to 13 nurses and lasted approximately 45 minutes to an hour. Hand-outs of the teaching material including endotracheal cuff management guidelines were given to the nurses at the end of the session. Nurses had hands-on practice throughout the study period. They were required to monitor and record cuff pressure every 6 hours as part of the patient care procedure. Trained senior nurses including the main researcher checked and coached the nurses during the first month after the educational intervention.
Results	There was significant knowledge acquisition following the educational intervention including significant knowledge retention at 3- and 9 months post-intervention. It was suggested that these results could be due to the hands-on practice and implementation of compulsory 6-hourly monitoring of cuff pressure as part of patient care.
Key findings that relate to the scoping review question	Nurses' knowledge needs to be assessed regularly to identify their learning needs. Ongoing educational programmes with current updates are necessary to enhance understanding and knowledge retention. Re-enforcement, monitoring and assessment are recommended. Awareness of their responsibilities should be imparted to all nurses from the beginning of their careers.

Author(s), year of publication, country of origin	Hassan, Z.M. and Wahsheh, M.A. 2016, Jordan
Study aims/purpose of study	To identify the level of nurses' knowledge of ventilator-associated pneumonia and prevention measures before an educational programme, identify the level of nurses' knowledge on ventilator-associated pneumonia and prevention post an educational programme and identify the reasons for not applying ventilator-associated pneumonia prevention measures among nurses in Jordan.
Participants details / Sampling / sample size	Nurses working in ICUs. Total nurses (N=595) Pre-testing (n=595) Post-testing (n=480)
Concept	The educational intervention was created to improve and retain critical care nurses' knowledge in ETT cuff pressure management. The current study was carried out over three phases: (a) pre-intervention, (b) educational and (c) post-intervention.
Context	ICUs in public and private hospitals in Jordan; 28 hospitals (8 from the Ministry of Health and 20 hospitals from the private sector).
Design and Methods	**Design:** Pre- and post-intervention observational study **Method:** A self-administered questionnaire comprising: Part 1: Socio-Demographic and Background Data, and Part 2: 20 items of VAP knowledge questionnaire that covered the following domains: pathophysiology (four questions), risk factors (three questions) and preventive measures of ventilator-associated pneumonia (13 questions).
Instructional methods, content covered and assessment	In the pre-intervention phase, pre-test knowledge levels were assessed by self-report. The pre-test was conducted and thereafter participants were encouraged to attend a one-day educational programme. In the educational phase, VAP evidence-based strategies were introduced to participants. A variety of educational methods were used including PowerPoint lectures, videos, printed materials, posters and electronic materials. Seven modules about ventilator-associated pneumonia and preventive measures were presented in one educational day consisting of 2 hr of lectures followed by 3 hr of small group discussions. The educational programme contained seven modules that covered several topics including orientation to nosocomial infection control, VAP pathophysiology, VAP aetiology and contributing factors, VAP assessment, VAP prevention measures, hand hygiene and basic principles of patient positioning. For two months following the educational programme, the participants were not exposed to any kind of intervention. Thereafter, their knowledge was reassessed using a post-test.
Results	More than three-quarters of nurses had a low knowledge level regarding pathophysiology, risk factors and ventilator-associated pneumonia preventative measures. This could be attributed to the fact that ICUs lack in-service training. The post-test results improved for three domains. The positive results obtained supported the CDC's recommendations to reinforce training to improve adherence to VAP preventive strategies.
Key findings that relate to the scoping review question	Continuing education has been shown to be more credible and effective than textbooks or other written literature and should be mandatory for all staff providing care in the critical care unit. Hospital and nursing administrators should be actively involved in educational programmes and in assuring support for continuing education.

Author(s), year of publication, country of origin	Goldsworthy, S. 2016, Canada
Study aims/purpose of study	To describe the unique challenges and opportunities in preparing nurses to transition into the intensive care environment in relation to mechanical ventilation.
Participants details / Sampling / sample size	Critical care nurses. A convenience sample of critical care nurses from hospitals in central Canada who had attended a professional development programme that consisted of simulation and practicum components, and a comparison group that consisted of a random sample of Canadian critical care nurses obtained from the professional licensure registry in the same province (n = 363).
Concept	A professional development programme that consisted of a self-paced CC certificate programme, a simulation intervention component and mechanical ventilation education integration.
Context	Critical care
Design and Methods	**Design:** A longitudinal quasi-experimental design. **Method:** Self-paced certificate programme; 6 online theory courses and a simulation component.
Instructional methods, content covered and assessment	Professional Development Intervention: The professional development intervention was a 324-hour self-paced CC certificate programme offered over a maximum of a 1-year period. The programme included the following 3 components: (a) 6 instructor-facilitated online learning modules offered in an asynchronous format, (b) an onsite instructor-facilitated 39-hour high fidelity simulation course held over 2 weekends, and (c) a preceptored practicum over ten 12-hour shifts in an adult critical care unit. This professional development intervention is intended to prepare registered nurses for the critical care practice setting. This programme was composed of 3 discrete training modalities, with a distinct sequencing model of interactive online learning followed by an intensive simulation laboratory course and finally a practicum component. Before the simulation component, all nurse participants had successfully completed 6 online theory courses. The 6 online courses included an introduction to online learning, and 5 critical care theory courses focusing on the following topic areas: advanced pathophysiology, cardiac, respiratory, neurologic, and gastrointestinal/endocrine/ renal. The respiratory course included foundational topics related to the care of the mechanically ventilated patient, such as oxygen therapy, arterial blood gas analysis, mechanical ventilation modes, nursing management at the bedside, weaning, and pharmacology related to mechanical ventilation. The simulation component of the intervention included 39 hours of simulated critical care cases conducted within the simulation laboratory. Participation in the cases included 3 preparation stations that included arrhythmia/12-lead electrocardiograph interpretation, management of mechanical ventilation and hemodynamic monitoring management (ie, arterial lines and pulmonary artery catheters). After completing the preparation stations, each student participated in 9 critical care cases that consisted of patients experiencing respiratory distress/acute respiratory failure, septic shock, hypovolemic shock, myocardial infarction, abdominal aortic aneurysm repair, hemodynamic instability, end-of-life care (mock family conference), acute renal failure, and head injury/trauma. Each case was delivered via a predetermined template that included learning objectives, pre-test questions, an initial patient phase, an evolving patient phase, and a conclusion phase. The case was followed by guided debriefing and post-test questions. The duration of each case was 60 minutes and included 10 minutes for a pre-brief and review of the learning objectives, a 20-minute case, 30 minutes for debriefing and a post-intervention quiz. The evaluation and testing of the students were completed by instructors via competency-based checklists.

	Mechanical Ventilation Education Integration: Mechanical ventilation was integrated into case-based simulations and followed international best practices for simulation. Specifically, the cases including mechanical ventilation learning followed a 3-pronged approach of pre-briefing, simulation activity, and debriefing. Pre-briefing is designed to provide an orientation and a context to the case by preparing students through a series of activities. Initially, students completed an 8-month online theory component that included the care of mechanically ventilated patients. Indications for ventilation, nursing care, complications, modes, and troubleshooting alarms were among the topics covered in the online course. Once the nurses arrived for the 2 weekends of simulation (39 hours in total), they were assigned specific roles and worked in groups of 3 to 5 to care for the "patient." The approach to teaching care of the mechanically ventilated patient incorporated a scaffolding approach designed to build confidence and competence by starting with less complex skills and cases (ie, acute respiratory distress case, mechanical ventilation skill station focusing on trouble-shooting alarms and arterial blood gas review) and progressing to more complex, or major cases such as acute respiratory distress syndrome. All participants had an opportunity to repeat the cases on the second weekend. During each simulation major case, participants were evaluated based on specific competency checklists. Once the simulation was complete each small group participated in a debriefing of the simulation.
Results	Professional development that includes simulation may be an effective strategy for increasing confidence and allows the nurse to practice in a 'safe' environment where no harm will occur to a patient while the nurse is learning new high-risk competencies. Professional development opportunities should be provided to all ICU nurses on an ongoing basis and consideration should be given to the most effective educational strategy (ie, simulation).
Key findings that relate to the scoping review question	In planning professional development opportunities for nurses transitioning to critical care and for existing ICU nurses; nurse educators need to give attention to competencies nurses report they are the least confident in and consider designing orientations and critical care programmes that will enhance practice opportunities by providing intensive case-based simulation scenarios. Simulation provides the opportunity to create realistic settings for learning, such skills as caring for mechanically ventilated patients. Simulation has been shown to be superior to other educational methods in improving performance and the transfer/application of learning in the practice setting.

Author(s), year of publication, country of origin	Jordan, P., Iwu-Jaja, C., Mokoka, E., Kearns, I., Oamen, B., de Lange, S. Schutte, L. and Naidoo, V. 2022, South Africa
Study aims/purpose of study	To describe the development of the training programme for South African professional nurses on how to manage critically ill COVID-19 patients in intensive care units and repurposed general wards.
Participants details / Sampling / sample size	Professional nurses working in ICU. No sample size as this study describes the development of a training programme.
Concept	Development of a training programme for South African professional nurses on how to manage critically ill Covid-19 patients in intensive care units and repurposed general wards. The educational programme was delivered via a digital platform, namely Zoom which allowed for interaction via PollEv, chat functions, and questions and answers functionality. This programme comprised six modules with one module that was dedicated to the management principles of the ventilated patient in the ICU.
Context	Intensive care units and repurposed general wards
Design and Methods	**Design:** an educational instructional systems design model; The ADDIE. The five phases comprise analysis, design, development, implementation, and evaluation. **Method:** A case-based study approach and blended learning were used to deliver the six modules. The content was delivered via a digital platform, Zoom.
Instructional methods, content covered and assessment	A blended learning and multifaceted approach were used for the delivery of the programme. To disseminate knowledge widely and provide easy access for professional nurses who are working in a fast-paced and complex healthcare setting, a multifaceted approach was used. This approach included the use of live Zoom sessions, Poll Everywhere (PollEv), enabling interaction via, chat functions, questions, and answers functionality immediately to participants. Case studies and additional learning materials in the form of published validated clinical guidelines, protocols, pocket cards and algorithms were used to enhance and reinforce the training. As part of mentoring and support to be given to these nurses, a training manual was developed, which included the training material, the case studies as well as assessment questions and answers, of which hard copies were posted to the participants. A self-learning library file, which could be accessed via the learning management system, and allows the professional nurses to refer to definitions, glossary lists, clinical practice guidelines and frequently asked questions was developed in support of the training. Six modules were delivered over 4 hours per session, with a specific timeslot allocated to each module as determined by the group and based on the depth and scope of the content per module. The six modules covered the following content: Module 1: origin, aetiology, and presentation of COVID-19; Module 2: infection control principles in the management of patients infected with COVID-19; Module 3: Management approach of a patient confirmed with COVID-19 Infection; Module 4: Management principles of the ventilated patient in the ICU; COVID-19 patient; Module 5: Psychosocial health in the time of COVID-19; Module 6: aspects of palliative care, dying and death, and COVID-19Two training sessions over two consecutive days were done per province. PowerPoint presentations were developed for each module and incorporated the best available evidence for reference. Six supplemental video tutorials were provided as an additional tool to the PowerPoint presentations. The content of the videos, which aligned with modules 3 and 4 included the following: intubation basics, basic ventilator settings, lung protective ventilation, and prone positioning used in acute respiratory distress syndrome (ARDS) and arterial line basics. The programme was uploaded to a Learner Management System (LMS). The delivery options were set up in terms of who enrolled, assessments done, pass marks for assessments, and the feedback provided.

Results	Feedback surveys evaluated the programme delivery and content. Participants indicated that the programme assisted them in having more confidence in managing critically ill COVID-19 patients, and alleviated anxiety in dealing with the pandemic.
Key findings that relate to the scoping review question	The training programme was necessary to cross-train professional nurses to manage critically ill COVID-19 patients and included the following mechanical ventilation topics: intubation basics, basic ventilator settings, lung protective ventilation, prone positioning used in acute respiratory distress syndrome (ARDS) and arterial line basics. The strength of the programme was in the online delivery methodology and multiphase approach, which allowed for a countrywide reach.

4.2.1 Distribution of papers by geographical location

The geographic locations of the included articles are presented in Figure 4.2. Australia (Guilhermino, et al, 2014; Guilhermino, Inder, Sundin, 2018) and Jordan (Al-Faouri, AbuAlRub and Jumah, 2013; Hassan and Wahsheh, 2016) had the highest number of studies with two each (22.22%) followed by America (Lynch-Smith et al, 2016), Canada (Goldsworthy, 2016), Finland (Jansson, et al, 2014), Malaysia (Murugiah, et al, 2021) and South Africa (Jordan, et al, 2022) making up the remainder with one paper each.

The publication dates of the included papers ranged from 2013 to 2022. One study was published in 2013 (Al-Faouri, AbuAlRub and Jumah, 2013); two studies were published in 2014 (Guilhermino, et al, 2014; Jansson, et al, 2014); three in 2016 (Hassan and Wahsheh, 2016; Lynch-Smith et al, 2016; Goldsworthy, 2016) and the remaining three were published in 2018 (Guilhermino, Inder, Sundin, 2018), 2021 (Murugiah, et al, 2021) and 2022 (Jordan, et al, 2022).

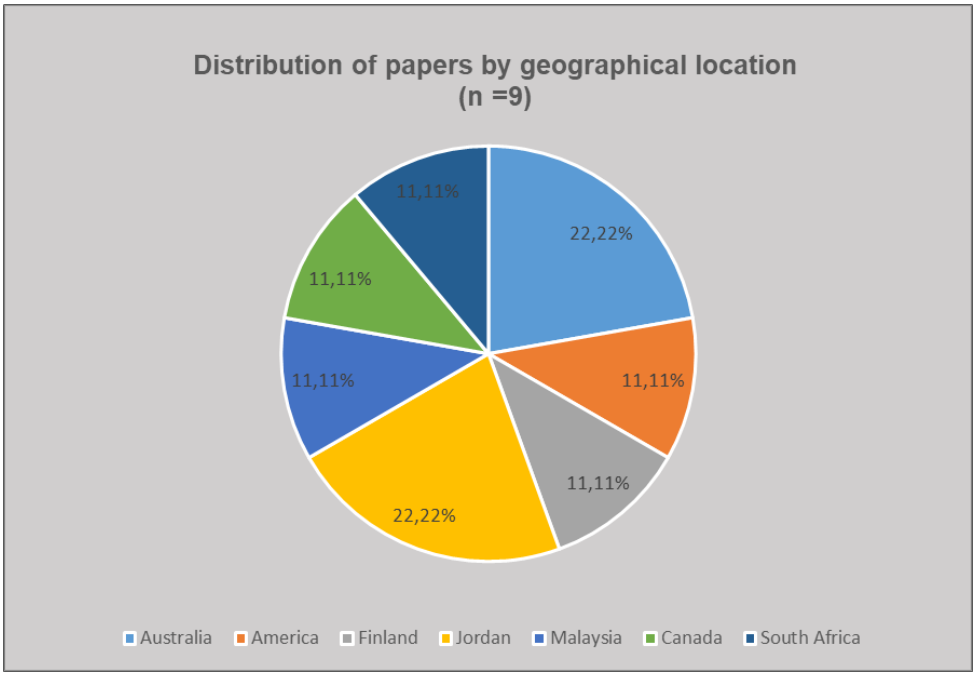


Figure 4.2: Distribution of papers by geographical location (n=9)

4.2.2 Profile of the participants

Three of the nine studies involved registered nurses, (Lynch-Smith et al, 2016; Al-Faouri, AbuAlRub and Jumah, 2013; Murugiah et al, 2021) four of the studies targeted ICU nurses (Guilhermino et al, 2014; Jansson et al, 2014; Guilhermino, Inder and Sundin, 2018; Goldsworthy, 2016), one study referred to professional nurses (Jordan et al, 2022) and another to nurses working in the ICU with differing levels of education (Hassan and Wahsheh, 2016).

Out of the nine studies, three studies had mixed groups of participants (Lynch-Smith et al, 2016; Al-Faouri, AbuAlRub and Jumah, 2013; Guilhermino, Inder and Sundin, 2018). One study included registered nurses (RNs) and respiratory therapists (RTs) (Lynch-Smith et al, 2016), whilst the other study focused on RNs and physicians (Al-Faouri, AbuAlRub and Jumah, 2013). Both these studies were included as the educational intervention for nurses was separate from the other participant groups. The systematic review by Guilhermino, Inder and Sundin (2018) reported that out of the twelve included studies in their systematic review, only four studies targeted only ICU nurses, whilst the remainder were mixed participants. The studies of mixed participants in the systematic review included: three studies who targeted nurses and RTs; four included nurses and medical officers and one study included nurses, medical officers and allied health professionals (Guilhermino, Inder and Sundin, 2018). This study was still included as ICU nurses were the target audience for the MV educational programmes and any study whereby the education programme was applied exclusively to physicians or RTs, where no ICU nurses were involved was excluded (Guilhermino, Inder and Sundin, 2018).

The sample sizes were only mentioned in six of the studies and the number of nurses who partook in the studies ranged from 17 to 595 (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Jansson et al, 2014; Murugiah et al, 2021; Hassan and Wahsheh, 2016; Goldsworthy, 2016). Al-Faouri, AbuAlRub and Jumah (2013) did not state the number of nurse participants included in the experimental group. Their study sought to determine the impact of an educational intervention for nurses on MV patients' outcomes and only the number of patients was specified for both the historical control

group and experimental group (Al-Faouri, AbuAlRub and Jumah, 2013). Guilhermino, Inder and Sundin (2018) stated that the systematic review they conducted included ICU nurses as participants in all of the studies but only four out of the 12 studies included the number of nurses involved, which ranged from 18 to 635. The last study was the development of a training programme for professional nurses transitioning into the ICU or repurposed general wards (Jordan et al, 2022). Their study discussed the development of their programme and conducted a pilot study in one of the South African provinces, but the number of participants was not recorded. This study was still included as it met the eligibility criteria in terms of the sample population, concept and context (Jordan et al, 2022).

4.2.3 Setting characteristics

The participating ICUs ranged from university or teaching-affiliated hospitals (Lynch-Smith et al., 2016; Al-Faouri, AbuAlRub and Jumah, 2013; Murugiah et al, 2021) an academic centre (Jansson et al, 2014) to regional tertiary referral hospitals (Guilhermino et al, 2014) and community or regional hospitals and included hospitals in both the public and private sectors (Hassan and Wahsheh, 2016). One study stated that the participating ICUs were mainly in university or teaching-affiliated hospitals, excepting for a small number that were situated in community or regional settings (Guilhermino, Inder and Sundin, 2018). Goldsworthy (2016) did not report the type of hospitals and only referred to hospitals in central Canada. One study focused on both ICUs and repurposed general wards used to manage critically ill patients during the Covid-19 pandemic (Jordan et al, 2022).

The ICU specialities were not mentioned in all nine studies but were based predominantly in the medical ICU (Lynch-Smith et al, 2016) and medical-surgical ICUs (Jansson et al, 2014; Murugiah et al, 2021), mixed ICUs, general ICUs (GICU), coronary care units (CCU), coronary ICUs (CICU) and cardiothoracic ICUs (CTICU) (Al-Faouri, AbuAlRub and Jumah, 2013). Only one study referred to an ICU offering high dependency services as well as having a mixed patient age range, but the details of the study were not focused specifically on the paediatric patient range or high-dependency services (Guilhermino, et al, 2014). Hospitals often only have one

general ICU and beds are then allocated to different patient ranges if the need arises. If they do not have an HCU and only an ICU, then beds will be allocated to meet the acuity of these patients. Three studies did not report the type of ICU speciality (Guilhermino, Inder and Sundin, 2018; Goldsworthy, 2016; Jordan et al, 2022).

The number of beds was mentioned in five studies and ranged from six to 86 (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Jansson, et al, 2014; Al-Faouri, AbuAlRub and Jumah, 2013; Guilhermino, Inder and Sundin, 2018; Murugiah et al, 2021)

4.2.4 Study backgrounds and associated aims

Although the objective of this review was to identify the available evidence on MV programmes for educating nurses working in adult ICUs about the care of a patient receiving invasive mechanical ventilatory support; it is important to note that the search yielded four studies whereby the focus was predominantly narrowed to an isolated component of MV rather than looking at the comprehensive care of MV patients (Jansson et al, 2014; Al-Faouri, AbuAlRub & Jumah, 2013; Murugiah et al, 2021; Hassan & Wahsheh, 2016). Weaning (Al-Faouri, AbuAlRub & Jumah, 2013) and ETT cuff pressure management (Murugiah et al, 2021) are subcategories of MV patient management and VAP (Jansson et al, 2014; Hassan and Wahsheh, 2016) is a commonly associated complication of MV.

The results of the search revealed MV to be a broad topic and educational programmes on invasive MV for nurses working in ICU could be divided into these subcategories of patient management and did not focus on the holistic care of an MV patient from intubation to extubation. Figure 4.3 provides an overview of the research topics in the selected studies for this review. VAP (Jansson et al., 2014; Hassan and Wahsheh, 2016); educational programmes for nurses transitioning into ICU (Goldsworthy, 2016; Jordan et al, 2022) and MV educational programmes for ICU nurses (Guilhermino et al, 2014; Guilhermino, Inder and Sundin, 2018) each represented 22% of the range of topics covered, whilst the remaining three studies

(Lynch-Smith et al, 2016; Al-Faouri, AbuAlRub & Jumah, 2013; Murugiah et al, 2021) represented 11% each of the total studies.

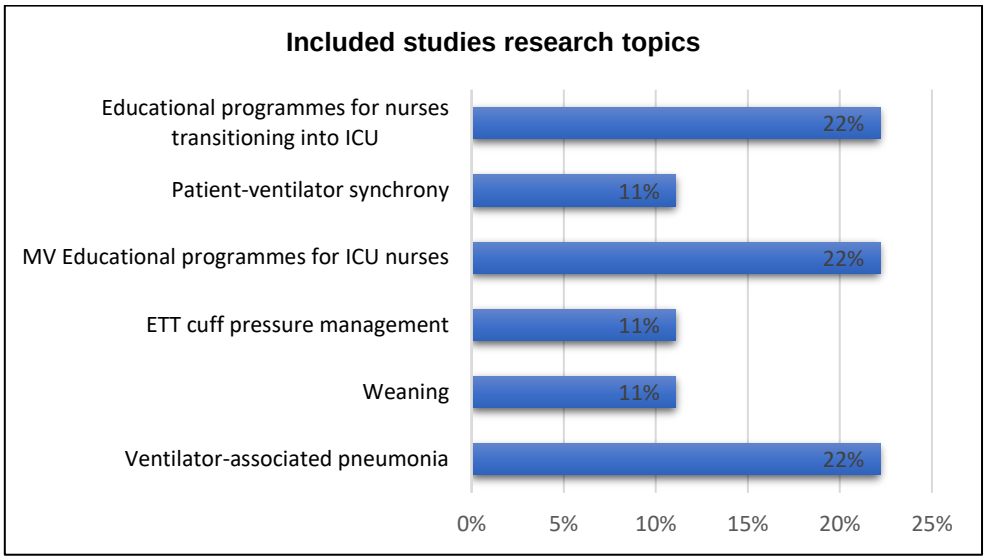


Figure 4.3: Included studies research topics (N=9)

Four studies identified the need to evaluate the effectiveness of an educational programme relating to MV (Jansson et al, 2014; Hassan and Wahsheh, 2016; Al-Faouri, AbuAlRub and Jumah, 2013; Murugiah et al, 2021). Of the four studies, two studies focused on the prevention of VAP (Jansson et al, 2014; Hassan and Wahsheh, 2016) whilst the other two concentrated on weaning Al-Faouri, AbuAlRub and Jumah, 2013) and ETT cuff pressure management (Murugiah et al, 2021).

Two studies focused on VAP, a common complication associated with MV and is known to be one of the most prevalent causes of nosocomial infections in the ICU with the highest mortality rate (Hassan and Wahsheh, 2016). The importance of this research topic is the reported low knowledge levels and lack of adherence to evidence-based guidelines for prevention. There are preventative measures that can be taken to reduce the occurrence of this infection but require awareness, education and adherence (Jansson et al, 2014 & Hassan and Wahsheh, 2016).

Unsuccessful weaning trials result in an increase in reintubation, prolonged ventilation duration and an increase in associated costs. Al-Faouri, AbuAlRub and Jumah (2013) state that their aim was to determine the effect of an educational programme for nurses to share in the decision-making process about weaning using protocol-directed care to avoid complications that are associated with the wrong weaning estimation. Prior to the intervention, physicians had been solely responsible for the weaning management process.

All invasive MV patients have an ETT or a tracheostomy to facilitate ventilatory support. As nurses play a key role in the management of the patients ETT cuff pressure, it is crucial to improve their knowledge and ensure optimal patient safety. The study on ETT cuff pressure management suggests that knowledge shapes practice and to ensure safe practice, knowledge of ETT cuff management is essential (Murugiah et al, 2021).

One study explored the ICU nurses perceptions of the current education provided on MV, including a self-directed learning package (SDLP) and a competency-based programme (Guilhermino et al, 2014). A second study aimed to determine whether CE programmes on invasive MV for ICU nurses was effective in improving patient outcomes (Guilhermino, Inder and Sundin, 2018).

Lynch-Smith et al (2016) conducted a pilot study to determine if educating CCNs and RTs on patient-ventilator synchrony and asynchrony would have an effect on their level of knowledge. The hypothesis was that education would increase their knowledge scores. Lynch-Smith et al (2016) provided a different educational intervention for nurses and RTs. Only the intervention related to nurses was included in this scoping review.

Two studies focused on nurses transitioning into the intensive care environment (ICE) (Goldsworthy, 2016; Jordan et al, 2022). Goldsworthy (2016) claimed that a nurse transitioning into the CCE requires critical thinking skills and specialised

knowledge to manage the acuity of the patients in these settings. Novice nurses have to successfully apply their knowledge into the practice setting. Goldsworthy (2016) described the challenges and opportunities these nurses encounter as they prepare to transition into the ICE in relation to MV.

The Covid-19 pandemic emphasised the need for the expansion of the ICUs and highlighted a need to address the existing shortage of ICU staff resources by upskilling professional nurses. A training programme was designed and developed preceding a request received from the National Department of Health (NDOH) in response to the Covid-19 pandemic to upskill professional nurses in the care of critically ill patients with Covid-19 in the ICUs and repurposed general wards in S.A during the pandemic (Jordan et al, 2022).

4.2.5 Study designs

The type of study designs used is represented in Figure 4.4. Four studies used a quasi-experimental design (Lynch-Smith et al, 2016; Al-Faouri, AbuAlRub and Jumah, 2013; Murugiah et al, 2021; Goldsworthy, 2016). One was a prospective study utilising a pre and post-test design (Lynch-Smith et al, 2016); the second was a non-equivalent study and used a control (historical) and experimental group whereby data were collected via a convenience sample of patients' charts before starting the educational sessions for the experimental group (Al-Faouri, AbuAlRub and Jumah, 2013); the third was a single group pre and post-test intervention design with nurses' knowledge assessed at three different time points (Murugiah et al, 2021) and the fourth was a longitudinal study involving an intervention group of novice ICU nurses and a comparison group consisting of experienced ICU nurses to test the effects of a professional development intervention on CCNs' intent to stay and the relationship between general self-efficacy and CC self-efficacy. Transfer of learning was also explored (Goldsworthy, 2016).

The remaining studies varied from a cross-sectional design with a self-administered and semi-structured survey (Guilhermino et al, 2014); to a prospective, parallel, RCT

with repeated measurements commencing at baseline and again at three- and six months post-intervention (Jansson et al, 2014); a systematic review across five electronic databases (Guilhermino, Inder and Sundin, 2018); a pre-and post-intervention observational study (Hassan and Wahsheh, 2016) and an educational instructional design model used to guide the development of a new educational programme (Jordan et al, 2022). Five of the studies (Lynch-Smith et al, 2016; Jansson et al, 2014; Al-Faouri, AbuAlRub and Jumah, 2013; Murugiah et al, 2021; Hassan and Wahsheh, 2016) aimed to evaluate the effects of the educational programme by means of a pre and post-test.

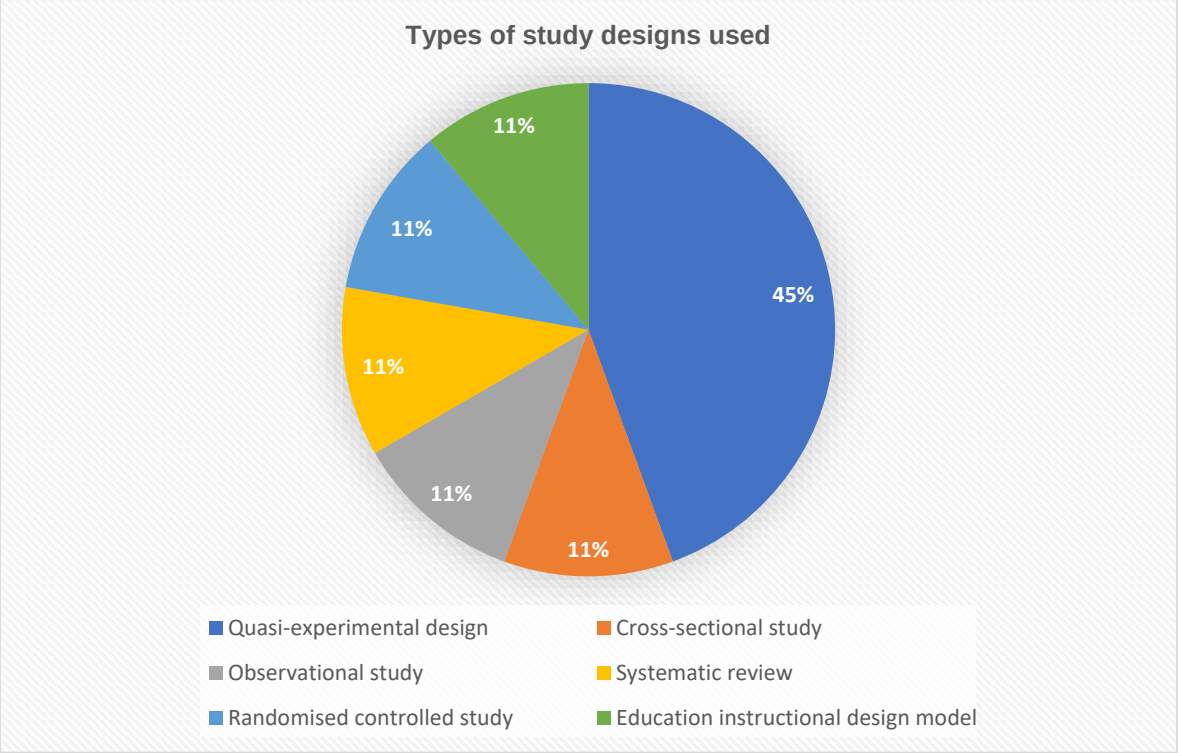


Figure 4.4: Types of study designs used (n=9)

4.2.6 Instructional Methods

As depicted in Figure 4.5 the studies used a multifaceted mixed approach in terms of instructional methods. Demonstration, practical's, hands-on applications, bedside education and a competency-based programme were mentioned in six of the studies (Guilhermino et al, 2014; Jansson et al, 2014; Al-Faouri, AbuAlRub and Jumah, 2013; Guilhermino, Inder and Sundin, 2018; Murugiah et al, 2021; Goldsworthy,

2016); seven studies reported the use of posters, fact sheets, videos, printed materials, hand-outs, electronic materials and a self-directed learning package (SDLP) (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Guilhermino, Inder and Sundin, 2018; Murugiah et al, 2021; Hassan and Wahsheh, 2016; Goldsworthy, 2016; Jordan et al, 2022); eight studies used in-service education; orientations, lectures (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Jansson et al, 2014; Al-Faouri, AbuAlRub and Jumah, 2013; Guilhermino, Inder and Sundin, 2018; Murugiah et al, 2021; Hassan and Wahsheh, 2016; Goldsworthy, 2016); two studies included an online course (Goldsworthy, 2016; Jordan et al, 2022); five studies included scenario-based, simulations and a case study (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Jansson et al, 2014; Goldsworthy, 2016; Jordan et al, 2022); and the remaining methods of seminars, discussions, coaching and feedback were mentioned across six studies (Guilhermino et al, 2014; Jansson et al, 2014; Guilhermino, Inder and Sundin, 2018; Murugiah et al, 2021; Hassan and Wahsheh, 2016; Goldsworthy, 2016).

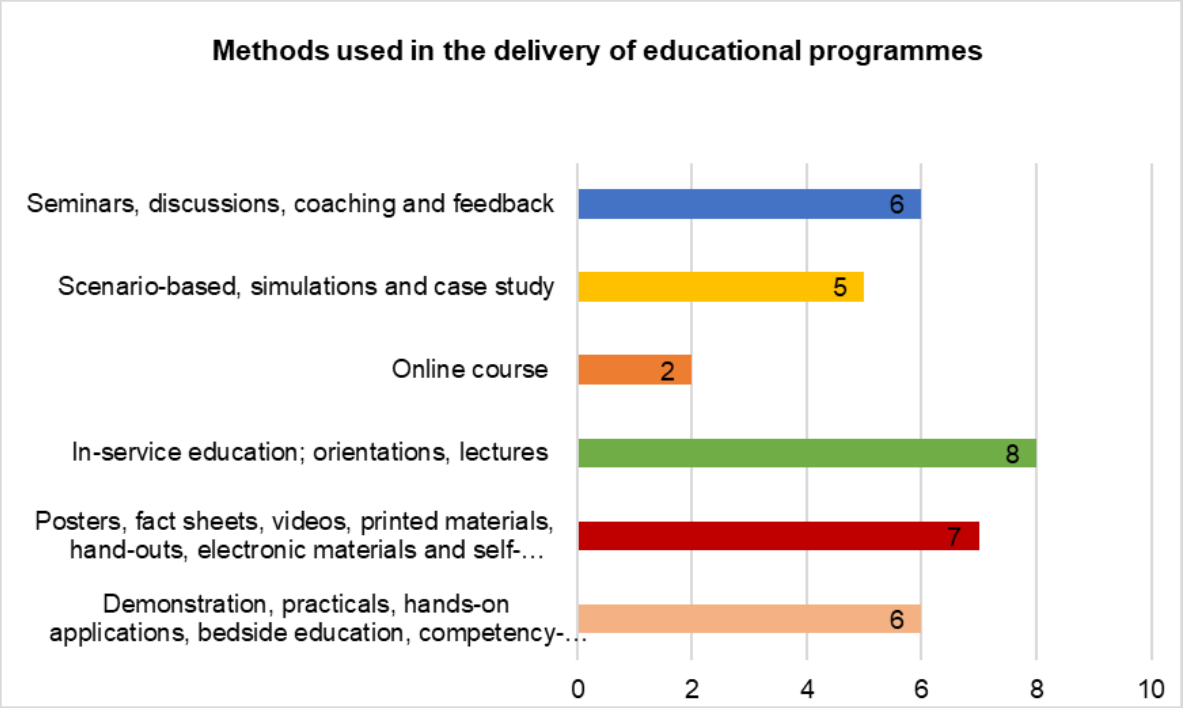


Figure 4.5: Range of instructional methods used (n=9)

4.2.7 Content of the educational programmes

The content across the nine included studies included the following main themes as detailed in Table 4.3. and highlight the broadness of MV and the depth of education that is required by nurses to care for these critically ill patients (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Jansson et al, 2014; Al-Faouri, AbuAlRub and Jumah, 2013; Guilhermino, Inder and Sundin, 2018; Murugiah et al, 2021; Hassan and Wahsheh, 2016; Goldsworthy, 2016; Jordan et al, 2022). The themes were identified based on the topics detailed in each of the educational programmes that were connected and integrated under one main subject.

Table 4.3 Themes and Content

Main Themes	Content
Orientation to ventilators	Orientation to ventilators, location of consumables, and intranet resources; ventilator assembly and setup and adjustments; assembly of ventilators, initial settings and modes and common ventilator trouble shooting.
Respiratory assessment and interventions	Assessment, management, measures of oxygenation and ventilation and documentation. Interventions including patient positioning, ETT suctioning, blood gas interpretation, humidification and nebulisers.
Artificial airways	Intubation objectives and skills (ETT and tracheostomy), airway safety equipment and placement; airway security position of the ETT; cuff pressure limits; suctioning; complications of under-and-over-inflation; measurement methods of cuff pressure; ETT cuff management guidelines; monitoring and recording of cuff pressure; ETT patient management; nursing interventions related to the ETT.
Patient-ventilator synchrony and asynchrony	Definitions; basic mechanical ventilation waveforms and interpretations; synchronous and asynchronous waveforms and interpretations; strategies to improve triggering, flow, and rate asynchronies
Complications of MV	VAP: orientation to nosocomial infections; pathophysiology; aetiology and contributing factors; assessment; prevention measures; hand hygiene; basic principles of patient positioning; pharmacologic and non-pharmacologic nurse-led interventions aimed at preventing VAP including intubation and prevention of airway colonization. Complications, and troubleshooting alarms
Management of MV patients	Ventilation objectives, specific brand and model of ventilators, intercostal catheter management objectives and removal skills, International guidelines and best practices in the care of MV patients; Ventilator Bundle
Weaning	Burns Weaning Assessment Protocol (BWAP) scoring instrument

4.2.8 Duration of the educational programmes

The duration of the educational programmes varied across the types of methods of instruction used. Not all studies detailed the duration of each educational method used. Guilhermino et al (2014) included a competency-based programme as a method to evaluate clinical practice whereby learners were required to demonstrate sufficient knowledge or skill on a topic. The duration of this component was not stated. Al-Faouri, AbuAlRub and Jumah (2013) only reported that the nurses in the experimental group attended the educational sessions on the BWAP items which comprised in-service and bedside education and hands-on applications over a one-month period. Guilhermino, Inder and Sundin (2018) stated that the educational programmes included in their research varied in duration from one to three months, and two studies repeated the programme: once after 6 months in one study and every 6 months for two years in the second one.

Guilhermino et al (2014) reported that in the first week of employment, nurses were provided with an educator-assisted orientation and an assisted bedside orientation whereby the new starter, novice or experienced nurse, worked in partnership with senior ICU nurses over a two-day period. Jansson et al (2014) described a 20-minute bedside introduction with a hands-on explanation of the simulation process and the use of the human patient simulation (HPS) mannequin as an orientation to the instructional method that was used for the educational programme.

Lectures varied between 45 minutes and two hours (Lynch-Smith et al, 2016; Murugiah et al, 2021). One lecture was given seven different times (Lynch-Smith et al, 2016) and another study delivered 12 formal educational sessions over a three-month period. Jordan et al (2022) used a case study and blended learning approach. Jordan et al (2022) detailed their online sessions' training content to be delivered over four hours per session, with a specific timeslot allocated to each module. This course was supplemented with six video tutorials aligned to modules 3 and 4 of the programme covering respiratory management and MV principles. The programme also included two training sessions over two consecutive days (Jordan et al, 2022). Goldsworthy (2016) detailed an intervention focused on professional development

that included a 324-hour self-paced critical care certificate programme that had to be completed within a year. Within this programme's content were six online courses that had to be completed. One was an introduction to online learning and five were dedicated to critical care theory. The online theory component had to be completed within eight months.

Jansson et al (2014) reported that the intervention group was provided with verbal feedback in addition to a 60-minute structured debriefing centred on the effectiveness of the ventilator bundles (VBs). Another study held small group discussions for three hours each (Hassan and Wahsheh, 2016). Goldsworthy (2016) stated that 39 hours of simulated critical care cases were included in the simulation component of the intervention. This included three preparation stations and thereafter they participated in nine critical care cases. Each case was 60 minutes in duration and included 10 minutes for a pre-brief and review of the set learning objectives; a 20-minute case, and 30 minutes for guided debriefing followed by a post-intervention quiz.

Murugiah et al (2021) made provision for hands-on practice throughout the study period. As part of the patient care procedure, participants monitored and recorded cuff pressure every six hours. The first month post-intervention the participants received coaching by the senior nurses and the main researcher. Goldsworthy (2018) included a preceptorship practicum over 10–12-hour shifts in an adult CCU.

Hassan and Wahsheh (2016) used a variety of educational methods including printed materials, posters, electronic materials and videos. Flow charts, posters and fact sheets were created and displayed in the ICUs using educational points from the modules that were summarized into acronyms. This was to reinforce the information in the study module. Guilhermino et al (2014) reported that nurses who were unable to answer a question demonstrating sufficient knowledge and/or skill in the competency-based programme were provided with supplementary resources and educational materials or the opportunity of individual tutoring.

4.3 Discussion

The aim of this scoping review was to identify the available evidence on MV programmes for educating nurses working in adult ICUs about the care of a patient receiving invasive ventilatory support. The objectives of the review were to:

1. Document the basic and advanced mechanical ventilation programmes for educating nurses working in adult intensive care units about the care of a patient receiving invasive ventilatory support, and
2. To describe the content taught and the method of instruction used.

Nine studies were eligible for inclusion and all related to educational programmes for nurses working in adult ICUs on invasive MV, but four studies were related to a specific component of MV namely weaning, VAP, and ETT cuff pressure management (Jansson et al, 2014; Al-Faouri, AbuAlRub and Jumah, 2013; Murugiah et al, 2021; Hassan and Wahsheh 2016). Weaning, VAP and ETT cuff pressure management are topics of interest in current research and although they are related to invasive MV, the lack of comprehensive educational programmes on invasive MV dedicated to the care and management of a MV adult patient from intubation to extubation emphasises an evidence-practice gap.

The study participants and sample sizes varied across all nine studies. The participants were a mix of registered nurses with varying levels of education (Hassan and Wahsheh, 2016); nurses described as working in ICU (Murugiah et al, 2021); professional nurses (Jordan et al, 2022); critical care nurses both novice and experienced (Guilhermino et al, 2014; Goldsworthy, 2016) and one study that referred to critical care nurses (Jansson et al, 2014). Three studies referred to mixed groups of participants but only the educational interventions portion specific to nurses working in ICU are reported in this scoping review (Lynch-Smith et al, 2016; Al-Faouri, AbuAlRub and Jumah, 2013; Guilhermino, Inder and Sundin, 2018).

None of the nine studies makes any reference to basic or advanced MV educational programmes even though there is a varying skill mix in the ICU with regard to both

qualification levels and years of experience. Although this scoping review was for any level of nurse working in the adult ICU, it is important to note the diverse range of education levels described in the eligible studies and how this necessitates demand for increased and structured CE for all nurses working in the ICU. Increasing their knowledge and skills has the potential to improve patient outcomes (Guilhermino, Inder and Sundin, 2018).

Guilhermino et al (2014) reported that 63% of the nurses had not received education before working in the ICU; only 61% had postgraduate qualifications; 35% had not received invasive MV education prior to commencing as an ICU nurse and 22% had only received hospital education. Jansson et al (2014) had only one participant with a master's degree in both their study groups. In the intervention group, 9.8% and 8.6% in the control group had experience in the current ICU. Although the studies reported the nurses having varying levels of education, none of the studies designed their educational programmes according to the mix of qualifications or years of experience of their sample population.

Murugiah et al (2021) stated that 79% of the nurses had obtained only a diploma in basic nursing education. In terms of their prior education relating to ETT cuff management, approximately 50% had only received input sessions during their basic nursing training and 85% through informal bedside education. Besides the lack of knowledge and skills impacting the nurse's performance and patient safety, educators are providing educational programmes designed as a one size fits all approach. The level and experience of the nurses partaking in these studies should be accounted for. This will aid in building and expanding existing foundational knowledge and making the educational programme valuable for all participants. Comprehensive CE is required but the type of CE will be influenced by the level of qualification and experience of the nurses' (Guilhermino, Inder and Sundin, 2018). This necessitates CE programmes to be designed accordingly to meet the diverse needs of all nurses working in the ICU.

Seven studies mentioned the sample size which ranged from 17 to 595 (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Jansson et al, 2014; Guilhermino, Inder, Sundin, 2018; Murugiah et al, 2021; Hassan and Wahsheh, 2016; Goldsworthy, 2016). Lynch-Smith et al (2016) acknowledged the lack of power analysis to estimate an adequate sample size. Al-Faouri, AbuAlRub and Jumah (2013) reported the number of patients but not the denominator of nurses who were used in determining the effect of the educational intervention on the experimental group. The accessible population was a convenience sample of patients currently on MV in the GICU, CICU and CCU in a single centre. As stated by Loiselle et al (2007, cited in Al-Faouri, AbuAlRub & Jumah, 2013, 2205-2214) the recruited sample, which was a convenience, nonrandomised one, and the historical control group was considered a co-intervention bias. To control bias, the study could have utilised a concurrent control and experimental group. Guilhermino, Inder and Sundin (2018) reported in their systematic review that less than half of the included studies reported the number of nurses involved and seven of their included studies did not report the number of participants receiving the educational intervention. Based on the lack of this information, the results could not be compared statistically between the two groups.

Five studies had a response rate that ranged from 92% to 52% (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Jansson et al, 2014; Murugiah et al, 2021; Hassan and Wahsheh, 2016) and three studies did not report (Al-Faouri, AbuAlRub and Jumah, 2013; Goldsworthy, 2016; Jordan et al, 2022).

Four studies (Guilhermino et al, 2014; Lynch-Smith et al, 2016; Jansson et al, 2014; Murugiah et al, 2021) were conducted in single centres and the findings may not be generalizable particularly across ICUs internationally. One study was in a university hospital but across three different ICU specialities (Al-Faouri, AbuAlRub and Jumah, 2013) another across multiple public and private hospitals in Jordan (Hassan and Wahsheh, 2016) and one across central Canada (Goldsworthy, 2016). The other two studies comprised a systematic review of twelve included studies (Guilhermino, Inder and Sundin, 2018) and the development of an educational programme (Jordan et al, 2022).

Five studies used a pre and post-test design (Lynch-Smith et al, 2016; Jansson et al, 2014; Al-Faouri, AbuAlRub and Jumah, 2013; Murugiah et al, 2021; Hassan and Wahsheh, 2016). These studies varied in the number of measurements, the method of measurement, the frequency and the time-lapse following the educational intervention. The intervals recorded for post-intervention measurement ranged from immediate with no further follow-up and one study with repeated measurements up until 9 months (Murugiah et al, 2021).

Lynch-Smith et al (2016) administered a closed-book pre-test before delivering a 1-hour lecture followed immediately by a closed-booked post-test. The questions used were the same for both tests except for the ordering of the questions. To control bias, different questions for each test with equivalent constructs would have benefitted the study. Murugiah et al (2021) used the same multiple-choice questionnaire during the preliminary and post-educational intervention phases. Even though it was validated, and the test-retest reliability indicated a good reliability coefficient, utilising the same questionnaire at all measurement points suggests the possibility of recall bias. Although the study focused on knowledge acquisition, it could have been strengthened if observations were included in the post-intervention measurement points and done to determine the actual practice as an outcome of learning.

Al-Faouri, AbuAlRub and Jumah (2013) used a historical control group of patient data (n=65) that physicians had managed and an experimental group (n=70) of patients currently being ventilated. The nurse participants completed a form for each recruited patient, and these were matched according to specific criteria between both groups. The outcome was measured by the number of successful weaning trials, the occurrence of reintubation and the reduction in ventilation period post-intervention in comparison to the historical control group. Using a historical control group suggests bias and the outcomes did not show any significant difference in the score of the ventilation period.

Hassan and Wahsheh (2016) utilised a pre and post-test observational study of a single group and assessed baseline knowledge levels by self-report. This method

suggests the following limitations of recall bias, acquiescence bias, social desirability and floaters respondents. The pre-test was followed by a one-day educational intervention by voluntary participation and a post-test done two months later. The time lapse between the educational intervention and the post-test poses a threat to internal validity due to other variables potentially impacting the results of the post-test (Hassan & Wahsheh, 2016 & Jansson et al, 2014). This study had no measure of the transfer of learning into clinical practice and no additional follow-up to assess knowledge retention or to measure a change in behaviour (Hassan and Wahsheh, 2016).

Goldsworthy (2016) used a convenience sample of novice ICU nurses in central Canada and a comparison group of experienced CCNs from the professional licensure registry within the same province and integrated MV into case-based simulations. A pre-determined template was created and used for each case that included the learning objectives, pre-test questions, an initial patient phase, an evolving patient phase, and a conclusion phase. On completion of each case, guided debriefing was facilitated followed by post-test questions. The pre-and post-test questions were structured differently, and participants were evaluated using a validated specific competency checklist. The strength of this design and method is in the competency checklist that a team of CC experts had created and then trialled over a 5-year period prior to being used in this study (Goldsworthy, 2016).

Jansson et al (2014) conducted a single-centre, prospective, parallel, RCT with a control and an intervention group. Both groups were measured at baseline, 3 months and 6 months post-intervention. The participant's knowledge was assessed using a validated multiple-choice Ventilator Bundle Questionnaire (VBQ) and their skills were evaluated using a Ventilator Bundle Observation Schedule (VBOS). Jansson et al (2014) reported that in other studies, the intervention and control groups are usually from different units but in this study, both groups worked in the same unit. However, RCTs are known to reduce bias and be an effective measure to determine the cause-and-effect relationship between an intervention and an outcome (Hariton and Locascio, 2018).

Guilhermino et al (2014) used a cross-sectional design that included a self-administered and semi-structured printed survey, a SDLP and a competency-based programme. The methods were not validated. The survey questions had several limitations in terms of recall bias, acquiescence response bias, central tendency bias, and social desirability bias. The survey could have been strengthened if the questions had been piloted.

The methods in the educational programmes were diverse and covered a broad range consisting of orientations and pre-briefings, in-service education, bedside education, demonstrations, hands-on applications, simulations, lectures, videos, hand-outs, interactive online programmes, electronic materials, SDLPs, posters, feedback, debriefings, case studies and blended learning. Guilhermino et al (2014) survey results indicated that all of the participants agreed that hands-on practice was very important/important, followed by 93% indicating a workshop/course. Only 51% of the ICU nurses in the same study reported that the education delivered met their individual learning styles. This suggests that varying individual learning styles and educational strategies should be considered before programme delivery (Guilhermino et al, 2014 & Goldsworthy, 2016). Radha and VijayaNarayanan (2019) address the need for educators to adopt dynamic and advanced technology, use multi-effective teaching strategies and tailor learning activities accordingly to combat the dynamic learning of the learner.

There are numerous teaching strategies that can be adopted to improve learning. Two studies (Jansson et al, 2014; Goldsworthy, 2016) used an advanced new technology that is gaining traction in nursing education namely HPS and high-fidelity simulation. The one study (Jansson et al, 2014) only used a brief bedside introduction, a brief scenario, a simulation component and a debriefing. However, Goldsworthy (2016) focused on a professional development intervention that in addition to the simulation component included a self-paced CC certificate programme that incorporated instructor-facilitated online learning; an onsite instructor-facilitated simulation course and a preceptorship practicum in the CCU. Jansson et al (2014) evaluated the effectiveness of HPS education in the nursing management of patients

requiring invasive MV. Although it was directed more towards the nursing interventions used in the prevention of VAP, the HPS study (Jansson et al, 2014) revealed a significant transfer of learned skills to clinical practice with the average skill score (VBOS) in the baseline measurement being 47.8% of the total score which increased to 60% of the total score in the final post-intervention observation; but the educational programme had no influence on factual knowledge. According to Jansson et al (2014), the low impact on knowledge skills could have been attributed to their sample size or late measurements. The methods used in the delivery of this educational programme do not describe any form of theoretical sessions, hand-outs, or printed or online resource materials to supplement the simulation method of delivery (Jansson, et al, 2014). This programme could improve knowledge levels by adding components and utilising additional methods to supplement the simulation component as detailed in Goldsworthy, (2016). It is important to select appropriate teaching strategies in nursing education and combining HPS education with additional forms of traditional education methods by offering a more blended learning approach may have yielded different results such as an increase in factual knowledge.

Jordan et al (2022) designed an educational programme that resulted in the acquisition and application of knowledge and skills through a multifaceted approach. Using new models of clinical education may improve educational outputs. This programme used an online platform (Zoom) that provided a flexible, accessible and cost-effective approach to delivering education to a vast number of participants around the country. They identified the potential technical and/or internet connection stability challenges by deciding to develop additional materials as hard copies and online materials to reinforce knowledge to be accessible to all participants.

The study (Jordan et al, 2022) methods of instruction included PowerPoint presentations; video tutorials; an assessment method of Poll Everywhere (PollEv) questions to test participants' knowledge prior to each module presentation; short questions and quizzes on completion of each module to test participants' knowledge on the learning outcomes and case studies. A case study and the PollEv inclusion

formed part of a formative and flexible assessment method that consisted of a self-directed component to facilitate adult learning. Case studies are a well-used method to bridge the gap between theory and practice and this method provides active learning through cases that are based on actual events to identify problems that can occur in clinical practice. Jordan et al (2022) addressed the question of whether knowledge can be transferred into clinical practice by all participants having to provide a portfolio of evidence to determine if the training was successfully transferred into clinical practice upon completion of the educational programme. The instructional model described each phase of the design including the steps and the application of each phase.

Lynch-Smith et al (2016) delivered a one-hour lecture using PowerPoint on patient-ventilator synchrony and asynchrony. Lectures are generally an effective method to deliver a substantial amount of information to a large number of students. Lectures are often combined with other techniques making it a more effective and appealing method of instruction. Lynch-Smith et al (2016) reported that all participants scores on the post-tests were higher than the scores on the pre-tests. The results for nurses, mean overall scores were 10.3 (SD, 3.2) before the lecture and 15.9 (SD, 3.6) after the lecture. Patient-ventilator asynchronies are a common occurrence in MV, and nurses need to be educated on this topic as they are the key personnel in identifying and managing patient-ventilator asynchronies as they provide 24/7 bedside monitoring of the patient. This educational programme (Lynch-Smith et al, 2016) could be further developed by including direct observations of participants' clinical inspection and waveform interpretation at the bedside to determine if the knowledge gained transfers into clinical practice.

The study on the BWAP (Al-Faouri, AbuAlRub and Jumah, 2013) educated and trained nurses on the scoring instrument over a one-month period via in-service and bedside education and hands-on application. Three studies (Hassan and Wahsheh, 2016; Al-Faouri, AbuAlRub and Jumah, 2013; Guilhermino et al, 2014) used a mix of traditional and experiential learning approaches. One study (Guilhermino et al, 2014) reported the participants preferred hands-on-practice which could be due to learners

favouring activities and experiences that are more learner-centred rather than the traditional approaches that are more instructor centred.

The content across the nine studies is limited. Only two studies were comprehensive in reporting the objectives, teaching modules, time allocation, assessment method and intended learning outcomes (Goldsworthy, 2016; Jordan et al, 2022). One study identified the five components of the education delivered to the nurses with the content covered under each core component (Guilhermino et al, 2014). Two studies mentioned modes of ventilation but did not list which modes of ventilation were covered (Guilhermino et al, 2014; Goldsworthy, 2016). Ventilator setup and settings were mentioned in several studies but only one study detailed the model of the ventilator (Guilhermino et al, 2014). This impacts the learning of ventilator setup, settings, modes and parameters and values as all brands of ventilators are different and the nomenclature for modes is not standardised. The majority also lacked specifics on how the educational programme was delivered. Educators need to consider the content and the learners' individual learning styles when designing programmes and use this information to guide them in choosing the most appropriate learning environment, methods of instruction, the type of technology, instructional materials, assessment tools and type of feedback delivery.

Al-Faouri, AbuAlRub & Jumah (2013) stated that their study would advance the performance of nurses working in ICU, improve quality of care and mitigate further harm to patients, but did not include the importance and effect on patient safety, increased risk of complications and associated costs with increased ventilation duration. The study objectives included the reduction of the ventilation duration which the educational intervention did not achieve. MV is complex and the acuity of patients in the ICU makes it difficult for a single protocol to encompass all factors that may impact its application. Protocols do not replace decision-making but increasing knowledge levels are important as it guides decision-making (Perrie et al, 2014). A comprehensive MV management programme that includes indications, guidelines, protocols and specifications is essential. CE programmes designed and updated with the latest evidence-based guidelines will assist in adherence and effective implementation of protocols in the CCUs (Al-Faouri, AbuAlRub & Jumah, 2013).

The educational programme by Lynch-Smith et al (2016) thoroughly detailed the content related to patient-ventilator asynchrony which included definitions of patient-ventilator synchrony and asynchrony; basic mechanical waveforms and interpretations; synchronous and asynchronous waveforms and interpretations; strategies to improve triggering, flow, and rate asynchronies; measures of oxygen and ventilation; and ventilator setup and adjustments. Although the results of the educational programme improved knowledge levels significantly, there was a minimal significant difference (p=0.54) in the mean duration of ventilation duration post-lecture (Lynch-Smith et al, 2016). Increased knowledge levels should positively impact patient outcomes.

The study by Goldsworthy (2016), provides a comprehensive list of all the educational interventions, the content and the duration of each component, offering a mix of interactive learning strategies such as simulation in addition to lectures, online learning, continuous feedback and debriefings (Duff, 2010; Wax et al, 2006; Zhang, 2014 as cited in Guilhermino, Inder and Sundin, 2018) mention that these are effective educational approaches for improving clinical performance, behaviour change and sustainability. Goldsworthy (2016) states that case-based simulation scenarios give participants the opportunity to practice high-risk/low-frequency skills in a safe but ‘real-life’ practice setting. The findings of this study report that regular professional development opportunities using the most effective educational strategy should be provided to all nurses working in the ICU.

Jordan et al (2022) designed a training programme using the Analysis, Design, Development, Implementation and Evaluation (ADDIE) instructional design model and describes the identified learning objectives, modules and teaching methods for the programme. This was only reported in one other study by Goldsworthy (2016). This training programme was designed to enhance the knowledge of nurses in the management of critically ill patients in the ICU and repurposed wards in response to the Covid-19 pandemic. Module 3 and 4 of the training programme was dedicated to respiratory management and MV principles. The multifaceted approach is a feasible and practical approach to upskill and empower nurses across a vast geographical

area and this presents the opportunity to deliver earlier interventions to improve knowledge (Jordan et al, 2022).

Guilhermino et al (2014) state that most RNs only register for a postgraduate course after commencing employment in the ICU. This emphasizes the need for high-quality educational programmes to close the knowledge gap between newly acquired knowledge and competent practice. Goldsworthy (2016) notes that a compressed classroom format to provide theory is part of the traditional model of CC education for nurses transitioning into the ICU, followed by a practicum training. To meet the educational needs of nurses, Goldsworthy (2016) designed a new critical care training programme composed of three distinct training modalities with a well-defined sequencing model. This comprised interactive online learning followed by an intensive simulation laboratory course and a practicum component. This educational strategy described by Goldsworthy (2016) is intended to improve knowledge, competency, and judgment in order to provide safe and effective care.

The rapid advancements in technology and the evolving demands of patients in the ICU have led to challenges in ensuring that nurses working in ICU are adequately trained. Traditional educational models do not bridge the gap between knowledge acquisition, retention and transfer of learning into clinical practice. Radha and VijayaNarayanan (2019) propose that nurse educators be inspired to rethink historically instructor-centred programme designs and embrace new ideologies that promote a stronger focus on student-centred learning. Educators need to design educational programmes that are responsive to the current needs of the workforce and ongoing education would assist with identifying possible gaps for new learning opportunities. Education should provide opportunities for active learning that fosters critical thinking, analysis, and problem-solving abilities as advocated by Radha and VijayaNarayanan (2019).

4.4 Key findings relating to the scoping review programme

Jordan et al (2022) indicate that nursing education needs to address the challenges

of limited resources and be responsive to the changing needs and the development of nurses working in the ICU. Guilhermino et al (2014) reported that 47% of the participants were not CC-qualified but working in the ICU. Jansson et al (2014) had only 1 participant with a master's degree. Murugiah et al (2021) stated that 79% of the nurse participants were trained at the diploma level and received on-the-job training on ICU practices from trained preceptors during their three-month induction period in the ICU, and 21% had a post-basic education in ICU nursing. According to Hassan and Wahsheh (2016), 80% of the nurse participants had a bachelor's degree in nursing; 59% learnt about VAP through self-teaching prior to the intervention, and 59% had only one to three years of experience.

Therefore, education in the workplace is central to safe and effective practice but should be responsive to the varying skill mix in qualification and experience. Part of this review's objective was to identify basic and advanced educational programmes on MV for all nurses working in ICU. As the review did not identify educational programmes dedicated to varying levels of qualifications and experience, this suggests that there is a gap to inform future research.

CE is necessary for all levels of nurses working in the ICU and CE programmes should be designed to enhance participants' knowledge and skills (Guilhermino et al, 2014). However, Jansson et al (2014) highlight, that besides increasing knowledge levels, nurses must be able to apply their learnings in clinical practice. In addition, comprehensive ongoing CE programmes for nurses are required on invasive MV to improve patient outcomes (Guilhermino, Inder, Sundin, 2018).

As stated by Murugiah et al (2021) the importance of advanced education programmes is to dispel misconceptions and to instil a knowledge shift that may enhance more effective and safer clinical practice through better awareness. Continuous education is required to develop competency in all aspects of the ICU. ICU nurses must have advanced and up-to-date knowledge and skills for the complex illnesses and treatment procedures that are common in this environment.

According to Hassan and Wahsheh (2016) hospitals and nursing managers should be actively involved and supportive in ensuring educational programmes are designed and delivered to maintain standards and ensure quality patient care delivery and improved patient outcomes are met. Protocols do need to be developed based on current evidence-based guidelines. Likewise, there should be continuous investigations and updating of protocols, guidelines and management of MV patients (Al-Faouri, AbuAlRub & Jumah, 2013).

Goldsworthy (2016) describes traditional orientations for new CCNs are described as a theoretical and clinical component. Training must be effective in order for skills and competencies to be transferred into clinical practice. Different educational strategies and approaches should be explored, and individual learning styles taken into consideration when designing new programmes. Goldsworthy (2016) did this by using a scaffolding approach with the intent to build confidence and competence in teaching MV care to nurses. Nurses transitioning into the CC speciality need to acquire the competencies including promoting self-reflection and developing clinical reasoning and evaluation skills to support safe practice in the ICU. This necessitates additional preparation that extends far beyond the undergraduate level (Guilhermino et al, 2014; Guilhermino, Inder and Sundin, 2018; Goldsworthy, 2016).

This chapter has detailed the populations, educational interventions and contexts of the nine papers included in this review. Whilst the findings of this review yielded limited evidence on invasive MV educational programmes regarding the care and management of the MV patient for all nurses working in adult ICUs, there are several educational interventions involving nursing practice such as oral care, sedation, early mobility, weaning protocols, patient positioning and physical restraints. In addition, there is a vast amount of studies focusing on associated complications of invasive MV such as VAP and VILI. However, a comprehensive invasive MV programme covering all these aspects of the care and management of a MV patient has the potential to reduce the risk of complications, LOI, LOS and in-hospital morbidity and mortality.

Chapter 5: Summary, recommendations and conclusion

5.1 Summary

Nurses frequently commence work in the CCE without the appropriate knowledge and skills to competently care for patients requiring invasive MV (Lynch-Smith et al, 2016; Jansson et al, 2014; Murugiah et al, 2021; Hassan and Wahsheh, 2016). These studies found that both qualified and non-qualified CCNs demonstrated poor knowledge levels in the pre-test and/ or baseline measurements. These pre-test scores indicate that there is a need for the provision of rigorously well-designed effective CE programmes for all nurses in ICU on a regular basis.

This review yielded limited studies that focused predominantly on MV educational programmes and none of the nine studies referred to basic or advanced programmes despite the varying skill mix. There is not a one-size fits all approach to CNE in the CCE. CE plays an important role for both qualified and non-qualified ICU nurses for the acquisition and maintenance of knowledge. Advanced and ongoing education is required to build and improve competency, particularly in all aspects of fundamental ICU care (Perrie et al, 2014). Educational programmes need to be updated regularly with the latest evidence-based guidelines and repeated assessments and evaluations utilised to identify learning gaps and guide specific competencies that need to be addressed.

Hospitals invest significantly in educational programmes with the expectation of maximizing their return on investment. For education to translate into a meaningful return on investment for the hospital, education must be effective for the transfer of knowledge and skills into clinical practice (Goldsworthy, 2016). In addition, hospitals and nursing educators need to be more actively involved in developing educational programmes and supporting CE (Jansson et al, 2016).

Although educational programmes in this review were delivered using a variety of different instructional methods, educators need to examine their educational strategies by looking at the advantages and disadvantages of the instructional

methods and the challenges they pose to both the educator and the learner including the type of content that needs to be delivered. Factors that impact the design and effectiveness of educational programmes include time constraints, workflow, patient safety, complex communication tasks and large volumes of information, disruption of clinical activities, clinical workloads, team dynamics, varying education levels and backgrounds, accessibility, and cost-effectiveness. This review suggests that there is no standardised approach to teaching invasive MV which could be attributed to a variety of factors such as variable CCEs, differences in practice across geographic locations, accessibility and feasibility.

5.2 Limitations

This review only included nine studies from nurses working in adult ICUs. The results may have differed if the study was expanded to include all patient ranges.

5.3 Strengths of the review

This review found limited evidence of educational programmes on invasive MV for all nurses working in the adult ICU. Educational programmes are fundamental in building foundational knowledge and advanced clinical reasoning skills that enhance confidence, impact performance and promote the delivery of safe, effective quality care. Advanced knowledge and skills may be effective in reducing MV-associated complications, LOI, LOS, failed weaning trials and in-hospital mortality (Guilhermino, Inder and Sundin, 2018). To improve patient outcomes, nurse educators need to design CNE that can be effective in improving patient outcomes.

This review provides a comprehensive map of what educational programmes on MV are available to all nurses working in the adult ICU. However, despite the limited evidence on educational programmes that cover the broad topic of MV, this review has summarised and mapped the diverse range of topics investigated, approaches to study designs and methods used; approaches to data analysis and the type of data collected in this area of research. As the focus in this area of research over the last decade has been predominantly on isolated components of MV or complications

associated with MV, this review has highlighted the importance of further research to be conducted into educational programmes on MV for all nurses working in an adult ICU. Newer models of educational strategies and technologies used in the instructional design of nursing education programmes have been described and discussed. The use of varying instructional methods and materials and their impact on the learning experience have been detailed.

5.4 Conclusion

Not all nurses working in the ICU are CC qualified or have received formal education on MV (Guilhermino et al, 2014). Low knowledge scores reflect the fact that nurses need specialised education and qualifications in ICU for nurses to stay abreast of current changes, besides ensuring safe and effective practice, knowledge retention and improving patient outcomes (Guilhermino, Inder and Sundin, 2018; Murugiah et al, 2021). Education is required to bridge the gap between newly acquired knowledge and competent practice.

Ongoing CE should be customised in response to nurses' educational needs, their level of qualification, years of experience and their preferred learning styles. As knowledge may diminish over time, periodic assessments of knowledge and skills is fundamental to ensuring knowledge acquisition, retention and transfer of knowledge into clinical practice. This will facilitate the identification of knowledge deficits to aid the timeous delivery of refresher courses (Murugiah et al, 2021).

Newer models of learning, educational strategies and technology should be explored when designing a robust programme that combines theoretical knowledge with interactive learning activities and experiential learning approaches to promote a behaviour change (Duff, 2010; Wax et al, 2006; Zhang, 2014 as cited in Guilhermino, Inder and Sundin, 2018).

5.5 Recommendations

This review recommends that a multilevel experiential training programme be developed that targets all nurses working in adult ICUs that is systematic, comprehensive, demand-oriented and has the potential to improve clinical learning and competence. Historically, CC programmes were designed with a theoretical component followed by a practicum (Goldsworthy, 2016). As described by Xie et al (2020) traditional speciality educational programmes for ICU nurses have several shortcomings, whereas a combined approach involving experiential learning and speciality programmes would be more effective in orienting ICU nurses into clinical practice. According to Murray (2018) simulations, role-playing, clinical experiences, case studies, problem or inquiry-based learning, and concept mapping are examples of active pedagogical strategies that engage students in the learning process. It has been widely used in various fields of nursing education around the world. (Xie et al, 2020).

With the emergence of new instructional design models, innovative educational strategies and approaches and the advancement of technology, it is recommended that educational programmes be designed using a multifaceted approach to teaching methods with a distinct sequencing. It is suggested that programmes should incorporate an interactive theoretical component to build a solid foundation delivered online or face-to-face, simulation learning including case-based strategies followed by an intensive practicum (Goldsworthy, 2016).

Simulation learning is a fairly new educational strategy that has recently been adopted in nursing education that is used to facilitate learning in the clinical environment (Kaddoura, 2010). It represents a new paradigm in nursing education to maintain standards of practice, evaluate competency, reduce errors and complications and improve patient outcomes. Simulation learning combines face-to-face instruction and interactive learning experiences with discussions and hands-on practice. This concurs with Kaddoura (2010) who suggests that nurses prefer to learn in person, through discussions and interactive experiences. This is in accordance with Radha and VijayaNarayanan (2019) who state that interactive methods are

needed in teaching evidence-based practice. The advantage of creating active learning activities and experiences is to help learners apply their learnings in their work environment, which results in increased engagement and a more meaningful learning experience (Murray, 2018). In addition, Xu (2016) recommends a debriefing session is conducted after simulation learning to improve critical thinking and clinical reasoning.

Case-based strategies foster learner interaction, problem-solving, and collaborative learning through the provision of realistic situations. They can be used in the classroom, online, in simulation laboratories, at the bedside or in a test (Pilcher, 2018). Online learning has become very popular in the aftermath of the Covid-19 pandemic. The pandemic raised the demand for upskilling nurses and provided an opportunity to explore alternative methods for the delivery of educational programmes. Online increases accessibility, it is more cost-effective and it increases the audience reach by the number of participants and the ability to expand across vast geographical areas. Online can be offered as a self-paced programme or as an instructor-led interactive learning experience. Interactive online programmes bring the classroom to the learner and assist with increasing engagement through discussions and group work. Self-paced programmes alleviate time constraints and empower the learners to take control of their own learning.

Blended learning approaches are beneficial to accommodate diverse individual learning styles and the delivery of different types of content. Instructional materials such as flow charts, videos, printed materials, posters and electronic materials to supplement learning activities are valuable; and educators can influence learning by providing materials to reinforce information, clarify abstract concepts and simplify complex messaging. As described by Mesue (2018) instructional materials are the vehicles used to help articulate the information in alternative ways and facilitate learning reinforcement.

There is a need for comprehensive educational programmes to be developed that covers the breadth of knowledge required in the nursing care and management of a

MV patient from intubation to extubation and includes the following: anatomy and physiology; respiratory diseases; the common indications for invasive MV; principles of MV; intubation objectives, skills, airway safety equipment, placement, changes and management; respiratory interventions including patient positioning, suctioning, ABG interpretation and analysis and humidification and nebulisation; orientation to the brand and model of the ventilator including the nomenclature used; assembly and testing of the ventilator, consumables and disposables and frequency of changes; initial settings including parameters and recorded values; alarms, modes of ventilation and adjuncts; nursing management at the bedside; common ventilator troubleshooting; understanding waveform analysis and interpretation; pharmacology related to MV; x-ray interpretation; identification and management of patient-ventilator asynchrony; intercostal catheter management objectives and removal skills, understanding common complications associated with invasive MV and strategies to manage these complications; oral care and eye care and indications for weaning, the weaning process, methods, and extubation. In addition to this content, Joyce, Berg and Bittner (2017) suggest that the CCE provides additional opportunities for acquiring knowledge and skills including technical skills such as central line placement and ultrasonography, as well as non-technical skills such as teamwork, communication, and leadership which are equally important.

Regular evaluation and assessment of nurses' knowledge and skills are recommended. Validated competency checklists that are developed by critical care nurse experts can be used to evaluate the nurses and enable the early identification of areas that require further education. As suggested by Aase et al (2022) it is critical to encourage students to contextually reflect on their clinical learning experiences, including the establishment of clearer guidelines for formal assessment discussions, which may be both necessary and important for exploring untapped learning opportunities. It is recommended that nurse educators find ways to increase collaboration with learners to improve feedback methods, critical reflection and clinical learning.

Specialised training benefits not only the nurse's own professional development but the patient, the hospital and the healthcare system. Furthermore, nurses' self-evaluation of their educational needs throughout their professional careers, should be taken into consideration and educational programmes adapted to each professional stage. ICU nurses value CNE because it aids their professional development and complements their experience (Santana-Padilla, Bernat-Adell and Santana-Cabrera, 2022). CE must appropriately prepare and maintain the competencies of all nurses working in the ICU by focusing on patient safety which has a symbiotic relationship with improved patient outcomes and the effectiveness of the CCN professional. To maintain its dynamic quality, nursing education must embrace innovation and modern teaching and learning methods (Radha and VijayaNarayanan, 2019).

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Appendices

Appendix 1: *A Priori* Protocol

Appendix 2: Ethics Clearance Certificate

Appendix 3: Data Extraction Tool

Appendix 4: Search Strategy

Appendix 5: PRISMA for Scoping Reviews Checklist

Appendix 1: *A Priori* Protocol

Protocol

Research Title: Educational programmes used in the teaching of invasive mechanical ventilation to nurses working in adult intensive care units: a scoping review

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Synopsis of Research

Review question: What types of educational mechanical ventilation programmes are used to teach nurses working in adult intensive care units, about the care and management of patients receiving invasive mechanical ventilatory support?

Objective

The objective of this scoping review is to identify the available evidence on mechanical ventilation programmes for educating nurses working in adult intensive care units about the care of a patient receiving invasive ventilatory support, including the content taught and the method of instruction used.

Introduction

MV is a common form of life support intervention and nurses are the key element in providing safe, effective, and specialized care to these critically ill patients. Their education determines whether these patients receive optimal quality patient care and the best possible outcomes. This scoping review serves to determine what programmes have been developed and implemented on invasive MV, to develop an appropriate educational programme that is relevant for teaching all nurses who work in adult ICUs regardless of their level of qualification or years of experience.

Inclusion Criteria

This scoping review will consider studies that include only nurses with the emphasis on invasive MV educational programmes used for teaching nurses working in adult ICUs. Only English studies from 2011 will be considered.

Methods

The databases to be searched include PubMed, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Scopus and Wiley Online Library. The search for unpublished and gray literature will include ProQuest. Searching will follow a 3-step process. Results will be presented in tabular or diagrammatic form, together with a narrative summary.

Key Words

Educational programme; invasive mechanical ventilation; nurses; adult intensive care units; critical care.

Student Name: Daniele Davis

Title: Educational programmes used in the teaching of invasive mechanical ventilation to nurses working in adult intensive care units: a scoping review

Introduction

The South African Nursing Council (SANC) defines Intensive Care (IC) as an environment consisting of several units within a hospital staffed with specialised nurses and equipped with advanced technology that is not routinely available in other hospital wards. The equipment and medical resources are essential for the monitoring, care, and treatment of patients who have sustained or are at risk of sustaining acutely life-threatening single or multiple organ system failure due to disease or injury with life- threatening conditions. These patients require close monitoring of their respiratory, cardiac, and metabolic status which includes the use of medication and equipment to try to maintain normal bodily functions (Marshall et al., 2017; Mathivah, 2002)

Patients are admitted to an adult ICU for advanced respiratory support and/or for support of two or more organ systems (Smith and Nielsen, 1999). Patients who only require supplemental oxygen or non-invasive (NIV) or mask ventilation are usually not admitted to an ICU but rather to a high-care unit. NIV or mask ventilation alleviates some of the physiological effects of respiratory failure reducing the work of breathing and reversing hypoxia.

Mechanical Ventilation (MV) is a common life support intervention used for patients requiring IC. Invasive MV is an essential life support intervention in the treatment of respiratory failure and the most common reason for admission of an adult patient to the ICU. It provides artificial respiration through mechanical means to assist or replace spontaneous breathing in patients who are unable to maintain and protect their airway and/ or physiological breathing. Adult patients require the insertion of an

artificial airway and are connected to the ventilator by a breathing circuit that is adjoined to either an endotracheal tube or tracheostomy. The primary goal is to normalise arterial blood gas levels and acid-base imbalances by providing adequate oxygenation and ventilation (Chlan, Tracy and Grossbach, 2011; Esteban et al., 2000; Grundgeiger, et al., 2010).

In the adult ICU, there is a high complexity of care coupled with advancements in both healthcare and technology. This is because patient admissions are mostly the consequence of trauma. Other reasons are due to medical conditions, infectious diseases, post-surgical complications (elective), and obstetric conditions (de Beer, Brysiewicz and Bhengu, 2011; Mathivah, 2002). These patients may have prolonged hospital stays or be admitted for 24-hour monitoring or post-operative observation and support for up to three days. Adult patients may have co-existing illnesses or co-morbidities which make invasive MV more challenging and requires a superior level of knowledge in physiology and the ability to recognize and avert early warning signs.

The acuity of patients inherent in this environment demand the skills and knowledge of a registered Critical Care Nurse (CCN}, of which we have a shortage of in South Africa. The last audit undertaken by the Critical Care Society of Southern Africa (CCSSA) revealed that the employed nurse to functional ICU bed ratio and trained CCNs were below the international norm. These findings stated that the nurse-to-bed ratio was more than 5:1 and that only 25.6% of nurses were trained in CC. ICU patients should have a nurse-to-patient ratio of 1:1 and at least 50% of the nurses should be CCNs (de Beer, et al., 2011; Joynt, et. al., 2019; Scribante and Bhagwanjee, 2007).

Using non-qualified CCNs to complete the required staff complement puts the patient's safety at risk as these nurses have not been formally trained in MV and lack the required technical skills to operate the sophisticated equipment (Perrie et. al., 2014). As such, these nurses begin their ICU experience with limited knowledge of MV and gain most of their knowledge through on-the-job learning. Managing patients under the supervision of a more experienced nurse increases patient risk due to their inexperience with the technology and level of patient care to identify early warning

signs to avert complications. Therefore, the knowledge and experience of the nurse can also determine the recovery or the demise of the critically ill patient (Botha, 2012).

There is growing evidence that inadequate nurse staffing and poor skill mix have a negative impact on the quality of patient care and outcomes and therefore educational programmes are fundamental to safe and effective practice (Chamberlain et. al., 2018). Advancements in the technology of medical devices are rapid and it is essential for nurses to build and maintain their knowledge and skills for optimal patient care and safety. However, continuing professional development for all levels of nurses working in ICU is essential, to remain up to date with evidence-based literature and technological advancements. Nurses do receive in-service training by the suppliers when new equipment is installed but their training is restricted to the use of the equipment only.

The nomenclature used in MV is not standardized and each brand has different names for the modes of ventilation and their adjuncts. In addition, the manufacturers have also updated the nomenclature as they release new modes or features. This can cause confusion in ICUs where there is no standardization and there are multiple brands and varying models (Chatburn et. al., 2012). Disposables and consumables sold with this equipment is only tested by the manufacturer of the brand. In units with multiple brands, this can cause confusion and put the patient at risk as the disposables and consumables have not been tested on another brand’s equipment and therefore not deemed safe to use.

The literature provided by the suppliers of the equipment provides a 'textbook' patient, which is acceptable if the patient is receiving only mandatory ventilation and there is no spontaneous effort by the patient. However, when the ventilator is only providing assisted ventilation, there needs to be synchrony between the support of the ventilator and the efforts of the patient to minimize any damage to the patient's lungs. It is therefore critical that the nurse can interpret the waveforms and

understand the modes and settings of the ventilator and how it interacts with the patient regardless of the brand or model to aid in the recovery of the patient. Knowledge about invasive MV for adult patients is a very broad category and can be broken down into many smaller sub-categories for example, understanding and setting up of the ventilator; setting parameters and values; patient-ventilator synchrony; modes of ventilation; interpretation of waveforms; lung pressures and compliance, lung protective ventilation, weaning protocols; patient positioning; understanding alveolar recruitment and indications, collection and interpretation of arterial blood gases. Due to the complexity of invasive MV and that there is no standard nomenclature across manufacturers, all nurses regardless of their level of qualification, or years of experience require ongoing education to mitigate risk and to optimize patient outcome by developing the skills and knowledge required for identifying early warning signs and how to troubleshoot problems (Windsor, 2005).

MV is a common form of life support intervention and nurses are the key personnel in providing safe, effective, and specialised care to these critically ill patients. Their education determines whether these patients receive optimal quality patient care and the best possible outcomes. This scoping review serves to determine what programmes have been developed and implemented on invasive mechanical ventilation, to develop an appropriate mechanical ventilation educational programme that is relevant for teaching all nurses who work in adult ICUs regardless of their level of qualification or years of experience.

Review Question

What types of educational mechanical ventilation programmes are used to teach nurses working in adult intensive care units, about the care and management of patients receiving invasive mechanical ventilatory support: a scoping review

Objective

The objectives of this scoping review are to provide:

1. a critical review of the basic and advanced educational mechanical ventilation programmes for educating nurses working in adult intensive care units about the care of a patient receiving invasive ventilatory support, and
2. to describe the content taught and the method of instruction used.

Inclusion Criteria

Population

The review will consider studies that include nurses only. Nurses are the key personnel in the care and management of critically ill patients and the technology used to support them in their recovery. For the purpose of this review, a nurse is defined as any nurse working in the ICU, who manages adult patients, receiving invasive mechanical ventilatory support. This includes all adult ICUs and there are no exclusions based on years of experience, levels of qualification, age, or gender.

Concept

The concept of interest in this scoping review is educational mechanical ventilation programmes - what is being taught and how it is being taught. This will include the objectives of the programme or study detail, content of the programme, key concepts or related topics and the format or delivery of the programme.

Context

This review will consider studies that are conducted for nurses working in ICU. Protocols and guidelines for the initiation, settings, and management of invasive MV differ according to the hospital setting, for example, theatre and the emergency unit. For the purpose of this scoping review, only educational programmes that are directed at the management of adult patients receiving invasive MV in an ICU hospital setting will be considered. The ICU hospital setting will include and not be limited to geographic location and/or specific social, cultural, or gender-based interests. The context of this scoping review is not limited to a particular country and or health system.

Types of sources

The source of information is open to allow for the inclusion of all types of evidence. The emphasis is on invasive MV educational programmes used for teaching nurses

working in adult ICUs. All research that was conducted from 2011 onwards will be considered as this was when ventilators as we know them today were operational and available from all manufacturers. The source inclusion by language will be restricted exclusively to English because of the cost and time involved in translating non-English studies.

Methods

The proposed scoping review will be conducted in accordance with the JBI methodology for scoping reviews consisting of the following methods: develop review question and review objective; determine the eligibility criteria; develop the literature search strategy; extract, analyse, discuss the findings; draw conclusions and discuss the implications for practice and further research (Peters et. al., 20_17)

Search Strategy

The search strategy will follow the JBI three-step approach that aims to find both published and unpublished papers. An initial limited search was conducted in PubMed to identify relevant articles on this topic. The text words in the title and abstracts used in the retrieved articles as well as the index terms used to describe the articles were all used to develop a full search strategy (Appendix I). The reference lists of all studies selected for inclusion will be screened for additional studies.

Key Words

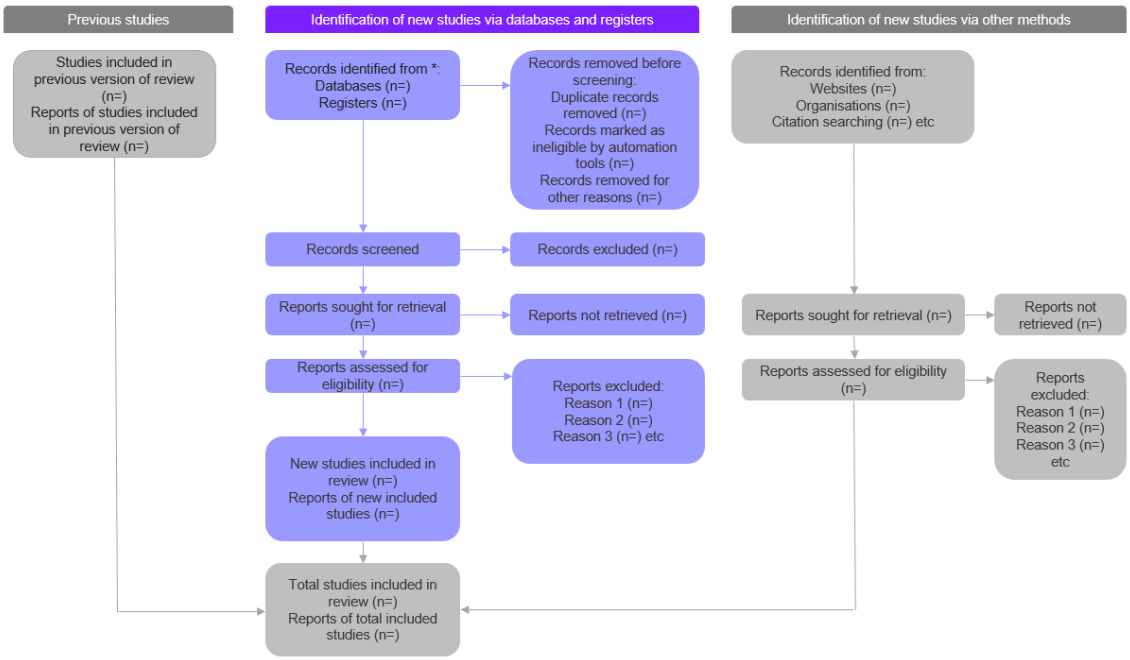
Educational programme; invasive mechanical ventilation; nurses; adult intensive care units; critical care.

Information Sources

The databases to be searched include PubMed, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Scopus and Wiley Online Library. The search for unpublished studies and gray literature will include ProQuest.

Study Selection

Following the search, all identified citations will be collated and uploaded into Endnote and all the references of the identified reports and articles will be searched for additional sources and duplicates will be removed. Thereafter, it will be uploaded into SUMARI. Titles and abstracts will be screened against the inclusion criteria for the review. Studies that meet the inclusion criteria will be retrieved in full. Full text studies that do not meet the inclusion criteria will be excluded and the reasons for exclusion will be provided in the final scoping review report. The results of the search will be reported in full and presented in a PRISMA flow diagram as per the below Table 1.1.



Page et. al., (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, 372:71 doi:10.1136 /bmj. n71

Data Extraction

The data extracted will include specific details about the population, concept, context, study methods, types of educational mechanical ventilation programmes and key findings relevant to the review question. Authors of papers will be contacted to request missing or additional data, where required. A draft data extraction tool

(charting table) is provided in Appendix II. This tool will be modified and revised as necessary during the process of extracting data from each included paper. Modifications will be detailed in the full scoping review. The data to be extracted will include specific details about the population, concept, and context relevant to the review question and objective. The extracted data from the papers that meet the selection criteria will be compiled into a table detailing the following information as outlined in Appendix II.

Data presentation

Extracted data will be presented in diagrammatic or tabular form in a manner that aligns with the objective of this scoping review. The charting table will report on distribution of papers by year of publication, country of origin, study design, research methods and the key findings/outcomes. A narrative summary will accompany the tabulated and/or charted results and will describe how the results relate to the review's objective and question.

Gantt Chart

Task	Sept-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22
Submit final protocol											
Application to change a study title											
Application for an ethics waiver											
Search for information sources											
Study selection											
Data extraction											
Preparation of data presentation and narrative											
Final submission for examination											

Ethics Waiver

An application has been made to the Human Research Ethics Committee for a waiver from ethics clearance of research due to this research study being a review of information that is accessible in the public domain.

Budget

Item	Description	Cost
Printing Costs	Black and white copies @ R1.00 per copy	R3500,00
Purchasing of Articles	R.O.E dependent on source	R4500,00

Appendix 1: Search Strategy

PubMed

Search conducted on 22 May 2021

	Terms			
OR	AND			
	Respiration, Artificial	nurses	Intensive Care Unit	Workshops
	Artificial Respiration		Unit, Intensive Care	Workshop
	Artificial Respirations		ICU Intensive Care Units	Training Programs
	Respirations, Artificial			Program, Training
	Ventilation, Mechanical			Programs, Training
	Mechanical Ventilations			Training Program
	Ventilations, Mechanical			Educational Activities
	Mechanical Ventilation			Activities, Educational
				Activity, Educational
				Educational Activity
				Literacy Programs
				Literacy Program
				Program, Literacy
				Programs, Literacy
				Learning
				Research Support as Topic
				Students
				Teaching
				Training Support
MeSH terms				

History and Search Details

Download Delete

Search	Actions	Details	Query	Results	Time
#12	•••	›	Search: "invasive mechanical ventilation" AND nurses AND " intensive care units"	28	06:37:34
#10	•••	›	Search: "invasive mechanical ventilation" AND nurses AND "adult intensive care unit"s	2	06:37:15
#11	•••	›	Search: "mechanical ventilation" AND nurses AND "adult intensive care unit"s	7	06:35:34
#9	•••	ⓘ ›	Search: "educational program OR educational programme" "invasive mechanical ventilation" nurses "adult intensive care unit"s	1	06:34:06
#8	•••	›	Search: "educational program*" "invasive mechanical ventilation" nurses "adult intensive care unit"s	0	06:33:20
#7	•••	›	Search: "educational program*" "invasive mechanical ventilation" nurses "adult intensive care unit"s - Schema: all	0	06:33:20
#6	•••	ⓘ ›	Search: "educational program* "invasive mechanical ventilation" nurses "adult intensive care unit"s	1	06:32:35
#5	•••	ⓘ ›	Search: What educational programmes have been used to teach invasive mechanical ventilation to nurses working in adult intensive care units?	4	06:30:56

Showing 1 to 8 of 8 entries

Search	Actions	Details	Query	Results	Time
#14	•••	›	Search: ((("Respiration, Artificial"[Mesh]) AND "Nurses"[Mesh]) AND "Intensive Care Units"[Mesh])	66	07:27:25
#13	•••	›	Search: ((("Respiration, Artificial"[Mesh]) AND "Nurses"[Mesh]) AND "Intensive Care Units"[Mesh]) AND "Education"[Mesh] Sort by: Most Recent	13	07:26:32

Additional search conducted on 3 November 2021, to include the term "Critical Care".

Search	Actions	Details	Query	Results	Time
#13	•••	>	Search: **"invasive mechanical ventilation" AND nurses AND "Critical care units"**	0	04:00:49
#12	•••	>	Search: **"invasive mechanical ventilation" AND nurses AND "Critical care units" - Schema: all**	0	04:00:49
#11	•••	>	Search: **"invasive mechanical ventilation" AND nurses AND "Critical care unit"s**	1	03:59:44
#10	•••	>	Search: **"invasive mechanical ventilation" AND nurses AND "adult critical care unit"s**	0	03:58:31
#9	•••	>	Search: **"invasive mechanical ventilation" AND nurses AND "adult critical care unit"s - Schema: all**	0	03:58:31
#8	•••	>	Search: **"mechanical ventilation" AND nurses AND "adult critical care unit"s"**	0	03:57:12
#7	•••	>	Search: **"mechanical ventilation" AND nurses AND "adult critical care unit"s" - Schema: all**	0	03:57:12
#6	•••	>	Search: **"educational program OR educational programme" "invasive mechanical ventilation" nurses "adult critical care unit"s"**	0	03:56:14
#5	•••	>	Search: **"educational program OR educational programme" "invasive mechanical ventilation" nurses "adult critical care unit"s" - Schema: all**	0	03:56:14
#4	•••	>	Search: **"educational program*" "invasive mechanical ventilation" nurses "adult critical care unit"s - Schema: all**	0	03:54:42
#3	•••	>	Search: **"educational program*" "invasive mechanical ventilation" nurses "adult critical care unit"s - Schema: all - Schema: all**	0	03:54:42
#2	•••	>	Search: **"educational program* "invasive mechanical ventilation" nurses "adult critical unit's**	2	03:52:13
#1	•••	>	Search: **What educational programmes have been used to teach invasive mechanical ventilation to nurses working in adult critical care units**	6	03:50:13

History

Download history Clear history

Search	Add to builder	Query	Items found	Time
#3	Add	Search ((("Respiration, Artificial"[MeSH Terms]) AND "Nurses"[MeSH Terms]) AND "Critical Care Units"[MeSH Terms]) AND "Education"[MeSH Terms]	0	04:22:43
#2	Add	Search (("Respiration, Artificial"[MeSH Terms]) AND "Nurses"[MeSH Terms]) AND "Critical Care Units"[MeSH Terms]	0	04:19:57

Appendix II: Data extraction instrument

Author	Year of Publication	Origin or Country of Origin	Aim or Purpose	Study Details	Format or Type of Educational Programme	Key Concepts or Related Topic	Key Findings that relate to the scoping review question

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Appendix 2: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Innovation)

TO: Ms D Davis
Faculty of Health Sciences
Department: Centre for Health Science Education
Medical School
University

E-mail: daniele.davis7504@gmail.com

CC: Supervisor: Professor P McInerney <Patricia.McInerney@wits.ac.za>
and <HREC-Medical.ResearchOffice@wits.ac.za>

FROM: Mr Iain Burns
Human Research Ethics Committee (Medical)
Tel: 011 717 1252

E-mail: Iain.Burns@wits.ac.za

DATE: 15/11/2021

REF: *R14/49*

PROTOCOL NO: W-CBP-211115-01 (This is your ethics application study reference number. Please quote this reference number in all correspondence relating to this study)

PROJECT TITLE: *Educational programmes used in the teaching of invasive mechanical ventilation to nurses working in adult intensive care units: a scoping review*

Please find attached the Ethics Waiver Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to the Government funding of the University.

MSWorks2000\Iain3007\ClearScan\Waiver.wps

Appendix 3: Data Extraction Tool

Article Review Details	
Author(s)	
Year of publication	
Origin / Country of origin	
Inclusion/Exclusion Criteria	
Population / Participants details	
Concept	
Context	
Aims or purpose of the study	
Participants' details, sampling and sample size within the source of evidence	
Design and methods	
Instructional methods, content covered and assessment	
Outcomes	
Key findings that relate to the scoping review question	

Appendix 4: Search Strategy

PubMed

Date searched: 03/07/2022

Set #	Search query	Results retrieved
1	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND "critical care units"[tiab] OR "intensive care units"[tiab] AND nurs*[tiab]	1800
2	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND ("critical care units"[tiab] OR "intensive care units"[tiab]) AND nurs*[tiab]	4

EBSCO_CINAHL

Date searched: 13/07/2022

Set #	Search query	Results retrieved
1	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND ("critical care units"[tiab] OR "intensive care units"[tiab]) AND nurs*[tiab] Filters included: All Adults, English, 2011-2022, Special Interest: Critical Care Subject Major Heading: Respiration Artificial, critical care nursing, nurses	40
2	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND "critical care units"[tiab] OR "intensive care units"[tiab] AND nurs*[tiab] Filters included: All Adults, English, 2011-2022, Subject Major Heading: Respiration Artificial, critical care nursing, nurses *Critical Care Nursing Quarterly *Connect The world of critical care nursing *Critical care nurse *AACN advanced critical care nurse *Australian critical care *Journal of advanced nursing *nursing in critical care *Dimensions of critical care nursing	68

Wiley Online

Date searched: 27/07/2022

Set #	Search query	Results retrieved
1	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND "critical care units"[tiab] OR "intensive care units"[tiab] AND nurs*[tiab] Wiley Online>Nursing, Dentistry & Healthcare>Nursing>Nursing Education & Professional Development>Advanced Search with filter: custom dates 01/2011-07/2022	0
2	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND ("critical care units"[tiab] OR "intensive care units"[tiab]) AND nurs*[tiab] Wiley Online>Nursing, Dentistry & Healthcare>Nursing>Nursing Education & Professional Development>Advanced Search with filter: custom dates 01/2011-07/2022	0
3	nurs* AND "intensive care units" AND "mechanical ventilation" AND educational program* OR "education" Wiley Online>Nursing, Dentistry & Healthcare>Nursing>Nursing Education & Professional Development>Advanced Search with filters: Filter:01/2011>07/2022	1024
4	nurs* AND "intensive care units" AND "mechanical ventilation" AND educational program* OR "education" Wiley Online>Nursing, Dentistry & Healthcare>Nursing>Nursing Education & Professional Development>Advanced Search with filters: Filter: 01/2011>07/2022 and Subject: Nursing & Midwifery	321
5	nurs* AND "intensive care units" AND "mechanical ventilation" AND educational program* OR "education" Wiley Online>Nursing, Dentistry & Healthcare>Nursing>Nursing Education & Professional Development>Advanced Search with filters: "Nursing in Critical Care" and 01/2011>07/2022	79
6	nurs* AND "intensive care units" AND "mechanical ventilation" AND educational program* OR "education" Wiley Online>Nursing, Dentistry & Healthcare>Nursing>Nursing Education & Professional Development>Advanced Search with filters: "Journal of Clinical Nursing" and 01/2011>07/2022	50
7	nurs* AND "intensive care units" AND "mechanical ventilation" AND educational program* OR "education" Wiley Online>Nursing, Dentistry & Healthcare>Nursing>Nursing Education & Professional Development>Advanced Search with filters: "Nursing Open" and 01/2011>07/2022	17

Scopus

Date searched: 01/08/2022

Set #	Search query	Results retrieved
1	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND "critical care units"[tiab] OR "intensive care units"[tiab] AND nurs*[tiab]	0
2	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND ("critical care units"[tiab] OR "intensive care units"[tiab]) AND nurs*[tiab]	0
3	"mechanical ventilation" AND "educational program*" AND "critical care units" OR "intensive care units" AND nurs*	236
4	"mechanical ventilation" AND "educational program*" AND "critical care units" OR "intensive care units" AND nurs* Add date filter: 2011>2022	162
5	"mechanical ventilation" AND "educational program*" AND "critical care units" OR "intensive care units" AND nurs* Add Language Filter: English	152
6	"mechanical ventilation" AND "educational program*" AND "critical care units" OR "intensive care units" AND nurs* Add Subject Area: Nursing	47
7	"mechanical ventilation" AND "educational program*" AND "critical care units" OR "intensive care units" AND nurs* Add Filter Keyword Search: Adult, Critical Care Nursing, Intensive Care Nursing, Artificial Ventilation, Nursing Education, Respiration, Artificial, Mechanical Ventilation, Education, Nursing, Continuing, Education, Nursing,	31

ProQuest Nursing & Allied HCPs

Date searched: 01/08/2022

Set #	Search query	Results retrieved
1	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND "critical care units"[tiab] OR "intensive care units"[tiab] AND nurs*[tiab]	0
2	"mechanical ventilation"[tiab] AND "educational program*"[tiab] AND ("critical care units"[tiab] OR "intensive care units"[tiab]) AND nurs*[tiab]	0
3	(mechanical ventilation) AND (educational program*) OR education AND (critical care units) OR (intensive care units) AND nurs*	181,579
4	(mechanical ventilation) AND (educational program*) OR education AND (critical care units) OR (intensive care units) AND nurs* Filter: Date Range 01012011>01082022	108,433
5	(mechanical ventilation) AND (educational program*) OR education AND (critical care units) OR (intensive care units) AND nurs* Filter: Language - English	107,398
6	(mechanical ventilation) AND (educational program*) OR education AND (critical care units) OR (intensive care units) AND nurs* Filter: Adults, nursing, education, critical care, ventilators, nursing education	21,774
7	(mechanical ventilation) AND (educational program*) OR education AND (critical care units) OR (intensive care units) AND nurs* Filter: MESH - Adult, critical care, education, nursing, continuing, education, nursing, respiration, artificial, critical care nursing, ventilators, mechanical	502
8	(mechanical ventilation) AND (educational program*) OR education AND (critical care units) OR (intensive care units) AND nurs* Filters: Publication Title - NOT (BMC Health Services Research AND Intensive Care Medicine AND The American Surgeon AND Nephrology Nursing Journal AND Workplace Health & Safety AND Nursing Economics AND American Journal of Respiratory and Critical Care Medicine AND BMC Pregnancy and Childbirth AND Demography AND Health Affairs AND Pediatric Nursing AND Physical Therapy AND American Journal of Public Health AND Journal of Gerontological Nursing AND Journal of Immigrant and Minority Health AND American Journal of Pharmaceutical Education AND Community Mental Health Journal AND Journal of Clinical Monitoring and Computing AND Journal of the American College of Cardiology AND Medsurg Nursing AND Nursing Ethics AND Nursing Management (through 2013) AND BMC Women's Health AND CJEM : Journal of the Canadian Association of Emergency Physicians AND Diabetes Care AND Journal of Clinical Anesthesia AND Journal of Emergency Nursing AND Nutrition Journal AND Supportive Care in Cancer AND The American Journal of Emergency Medicine AND Australian Health Review AND Child Welfare AND Clinical Journal of Oncology Nursing AND Dynamics : The Official Journal of the Canadian Association of Nurses AND European Journal of Applied Physiology AND European Journal of Pediatrics AND Expert Review of Pharmacoeconomics & Outcomes Research AND Hospitals & Health Networks AND	

8	Continued: International Psychogeriatrics AND Journal of Applied Behavior Analysis AND Journal of Occupational Rehabilitation AND Journal of Palliative Care AND Journal of Primary Prevention AND Journal of Psychosocial Nursing & Mental Health Services AND Journal of the Medical Library Association AND Medical and Biological Engineering and Computing AND Military Medicine AND Neurotherapeutics AND Orthopaedic Nursing AND Palliative & Supportive Care AND Perspectives in Public Health AND Prehospital and Disaster Medicine AND Quality of Life Research AND The Annals of Otology, Rhinology & Laryngology AND The British Journal of Nutrition AND The New England Journal of Medicine AND Journal of Critical Care AND Contemporary Nurse: a Journal for the Australian Nursing Profession AND Eastern Mediterranean Health Journal AND Canadian Medical Association. Journal AND Nursing History Review AND International Journal of Technology Assessment in Health Care AND JAMA AND Journal of Allied Health AND Journal of Nursing Scholarship) nursing OR education OR critical care OR ventilators OR adults OR nursing education Adult OR Education, Nursing, Continuing OR Education, Nursing OR Respiration, Artificial OR Critical Care Nursing OR Ventilators, Mechanical English	255

Appendix 5: PRISMA for Scoping Reviews Checklist

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	i
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	ii-iii
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	1-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	6-13
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	*A Priori* Protocol: Appendix 1
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	15-16
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	16-17
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix 4
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	17
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	17-18
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	18-19
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	20-21
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	22-24
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	25-36
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	37-49
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	50-62
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	63-64
Limitations	20	Discuss the limitations of the scoping review process.	64
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	65-69
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	N/A

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.