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An exploration of ventilation-associated events prevention practices in Australian adult intensive care units

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Abstract

Background: Ventilator-associated events (VAE) are hospital-acquired complications of mechanical ventilation, which can increase hospital length of stay, costs and morbidity and mortality risks in the intensive care unit (ICU). VAE affect up to 25% of mechanically ventilated patients in Australia. Evidence-based guidelines are used to decrease harm and improve quality of care. The aim of this mixed methods study was to explore nurses' knowledge of VAE prevention across Australia and to evaluate the implementation of evidence-based guidelines in two intensive care units of contrasting size and case mix, in the state of Victoria.

Design: An explanatory sequential design was used. In Phase One, two data collection methods were used: a cross-sectional online survey of intensive care nurses across Australia (*n* = 294) and a three-month prospective medical records review of mechanically ventilated patients (*n* = 96). Data were analysed using descriptive and inferential statistics. In Phase Two, individual, semi-structured interviews were conducted with nurses (*n* = 16) and doctors (*n* = 4) exploring facilitators and barriers to the implementation of evidence-based guidelines to prevent VAE. The interview findings were thematically analysed using the Braun and Clarke method (2006) and were integrated with the Phase One results.

Results: The nurses' median knowledge score of the evidence-based guidelines for VAE prevention was 6/10 (IQR: 5-7). There was a significant positive association between knowledge score and completion of postgraduate qualification (*p* = 0.014).

The participants' experience did not influence their knowledge score or self-reported adherence to the implementation of evidence-based guidelines to prevent VAE. There were inconsistencies in the implementation of the evidence-based guidelines to prevent VAE. The overall bundle adherence rate over the three days of mechanical ventilation was 88.3%. The adherence rate increased with the number of mechanical ventilation days. The elements of the guidelines to which participants most adhered were the use of peptic ulcer and deep vein thrombosis prophylaxis. There was a statistically significant difference in the mean APACHE III score of patients with head-of-bed elevation and those without, on Day 3 (p = <0.001) and on Day 4 (p = 0.007) of mechanical ventilation. The higher the APACHE III score, the lower the likelihood of head-of-bed elevation on Days 3 and 4. There were no significant differences in adherence to the remaining evidence-based guidelines and patients' APACHE III mean scores. There were four major themes identified that influenced the implementation of evidence-based guidelines to prevent VAE: 'tailored approach to evidence-based guidelines'; 'use of evidence-based guidelines to underpin practice'; 'impact of resources on care provision' and 'inadequate training and knowledge of the evidence-based guidelines.'

The participants acknowledged the importance of evidence-based guidelines to prevent VAE; however, their knowledge and experience did not significantly influence their implementation of the guidelines. Organisational factors, such as inadequate staffing and equipment, influenced the implementation of evidence-based guidelines to prevent VAE. The adherence rates were dependent upon adequate staffing, equipment and unit culture. Inadequate equipment, such as a lack of oral care products, was one of the factors that led to missed care in mechanically ventilated

patients. Some participants reported that preventative care was given a lower priority than immediate life-saving interventions in their units.

Conclusion: There is a need for consistency in the implementation of evidence-based guidelines and the development of educational packages which focus on VAE prevention. Increasing awareness of VAE prevention by auditing the implementation of evidence-based guidelines is recommended. Surveillance of VAE in Australian ICUs should be seriously considered, to enhance the prioritisation and implementation of evidence-based guidelines.

Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature : 

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List of Abbreviations

ACCCN: Australian College of Critical Care Nurses

ACT: Australian Capital Territory

AIHW: Australian Institute of Health Welfare

ANUM: Associate Nurse Unit Manager

AHPRA: Australian Health Practitioner Regulation Agency

ARDS: Acute Respiratory Distress Syndrome

APACHE: Acute Physiology and Chronic Health Evaluation

CCRN: Critical Care Registered Nurse

CDCP: Centre for Disease Control and Prevention

CLABSI: Central Lines-Associated Bloodstream Infections

CNEs: Clinical Nurse Educators

CNS: Clinical Nurse Specialist

CPR: Cardiopulmonary Resuscitation

DVT: Deep Vein Thrombosis

ETT: Endotracheal Tube

FASTHUGS: Feeding, Analgesia, Sedation, Thromboembolic prophylaxis, Head-of-bed elevation, Stress ulcer prophylaxis, Glucose control and Spontaneous breathing trial

HAI: Hospital-associated Infections

HoBE: Head-of-bed elevation

HREC: Human Research Ethics Committee

ICC: Intercostal Catheter

ICU: Intensive Care Unit

ICU A: Pseudonym name for an intensive care unit

ICU B: Pseudonym name for an intensive care unit

IHI: Institute for Healthcare Improvement

IVAC: Infection-related Ventilator Associated Complications

NAS: Nursing Activities Score

NHMRC: National Health and Medical Research Council

NUM: Nurse Unit Manager

NSQHS: National Safety and Quality Health Service Standard

NSW: New South Wales

NT: Northern Territory

MUHREC: Monash University Human Research Ethics Committee

PVAP: Possible Ventilator-associated Pneumonia

RASS: Richmond Agitation Sedation Scale

RN: Registered Nurse

USA: United States of America

VAC: Ventilator-associated Condition

VAE: Ventilator-associated Event

VAP: Ventilator-associated Pneumonia

VIC: Victoria

RN: Registered Nurse

SA: South Australia

TAS: Tasmania

TISS: Therapeutic Intervention Scoring System

TSPP: Transition to Specialist Practice Program

WA: Western Australia

WHO: World Health Organisation

Glossary of Terms

Access Nurse:

Access nurse is also known as Team Leader or Admission and Discharge nurse. Access nurses are additional to bedside nurses, clinical coordinators, unit managers, educators, and non-nursing support staff. The role of these nurses is to help and support bedside nurses. They should hold a postgraduate qualification in intensive care nursing (Australian College of Critical Care Nurses [ACCCN], 2016).

Acute Physiology & Chronic Health Evaluation (APACHE III):

A system used to measure the severity of sickness and the likelihood of hospital death from physiological assessment and observations gathered in the first 24 hours of admission; APACHE III scores range from 0 to 299, and higher scores are associated with severe sickness and likelihood of death in hospital (Keegan, Gali, Findlay, et al. 2009). APACHE III is an improved version of APACHE II. It is known for its “improved statistical power, ability to predict individual patient outcome” (Bouch & Thompson, 2008, p. 183).

Associate Nurse Unit Manager (ANUM):

A Registered Nurse, with postgraduate qualifications in intensive care nursing, who is appointed and works within the guidelines and practices established by the Nurse Unit Manager, assisting with the overall clinical and administrative management in the ICU.

Bundle:

A set of evidence-based guidelines grouped in an attempt to achieve the best patient care or outcome (Dellinger, Townsend, Marik, Raghunathan, & Bloomstone, 2013).

Clinical Nurse Educator (CNE):

A Registered Nurse appointed to teach clinical and theoretical skills in intensive care nursing. This person is responsible for the continuous education of nursing staff in the ICU.

Clinical Nurse Specialist (CNS):

The CNS is a promotional position for an advanced Registered Nurse with postgraduate qualifications in intensive care nursing who has been working in ICU for more than a year. The CNS will have advanced clinical nursing knowledge, skills and experience in intensive care nursing (ACCCN, 2016; Cashin et al., 2015).

Critical Care Registered Nurse (CCRN):

A Critical Care Registered Nurse (CCRN) is a Registered Nurse who has postgraduate qualifications in intensive care nursing and does not have a special role, such as CNS, ANUM or CNE.

Guideline:

Clinical practice guidelines are systematically developed statements that assist clinicians to optimise recommended patient care, as informed by relevant evidence for specific circumstances (Australian Commission on Safety and Quality in Health Care [ACSQHC], 2017).

Level 1 ICU:

Provides mechanical ventilation and cardiovascular monitoring for at least 24 hours to patients who require cardio-respiratory support, then transfer to a Level 2 or 3 ICU (Australian Institute of Health & Welfare, [AIHW], 2018).

Level 2 ICU:

Provides high standard intensive care to surgical and medical patients, including complex multi-organ life support, for several days. The Level 2 ICU has five to 10 beds (AIHW, 2018).

Level 3 ICU:

A tertiary referral unit, which provides comprehensive, highest level of care where patients can be supported for an indefinite period. Specialised care, such as cardiothoracic care and neurology, is provided in addition to the more general type of care provided to medical and surgical patients. The Level 3 ICU has more than 15 beds (AIHW, 2018).

Nurse Unit Manager:

The Nurse Unit Manager is responsible for nursing management in the ICU, with particular attention to resources, hospital/health service policy and environmental safety, including inter-departmental and intra-departmental liaison.

Policy:

A set of principles or guidelines that reflect the organisation's values on a subject. All procedures and protocols are linked to a policy statement (ACSQHC, 2017).

Procedure:

A procedure consists of a “set of instructions to make policies and protocols operational, which are specific to an organisation” (ACSQHC, 2017, p.74).

Registered Nurse (RN):

A Registered Nurse (RN) is a person who has “completed prescribed preparation education, demonstrates competence to practice” and is registered with the Australian Health Practitioner Regulation Agency (AHPRA) and the Nursing and Midwifery Board of Australia (NMBA) to practice as a nurse in the Australian health system (Nursing and Midwifery Board of Australia [NMBA], 2020, p. 6)

Specialist Role:

A specialist role is either a promotional or an appointed role undertaken by a Registered Nurse with postgraduate qualifications and advanced skills in intensive care nursing.

Chapter One – Background

1.1 Introduction

Intensive care units (ICUs) are distinct, self-contained units, which provide care for critically ill patients with life-threatening conditions. Patients are admitted to ICU for treatment of failing organs, constant monitoring or frequent nursing care (AIHW, 2018). Nearly half (42%) of all patients admitted to the ICU require mechanical ventilation as life-support treatment, occupying 71% of ICU beds (Department of Health Victoria, 2014). Mechanical ventilation is a crucial and lifesaving therapy for patients with critical illness and respiratory failure (Aitken, Marshall, & Chaboyer, 2015). However, patients are prone to complications, such as ventilator-associated events (VAE), if they are mechanically ventilated for more than 48 hours (Centre for Disease Control and Prevention [CDCP], 2018).

VAE are life-threatening, healthcare-acquired complications of mechanical ventilation, which can increase the mechanical ventilation period and increase the hospital length of stay, leading to increased hospital costs and increased risk of disability and mortality in the ICU (Klompas, 2019; Klompas, Kleinman, & Murphy, 2014; VICNISS Healthcare Associated Infection Surveillance, 2017). VAE affect up to 15 percent of mechanically ventilated patients (Institute for Healthcare Improvement [IHI], 2018), with an estimated mortality rate of 31 to 35 percent (Magill et al., 2016; Wunsch et al., 2010), and are reported to be higher in older people (>65 years) compared to those in the younger age groups (Blot, Poelaert, & Kollef, 2014).

Ventilator-associated events is a general term referring to a group of conditions which result in a significant and sustained deterioration of oxygenation; defined as a greater than 20 percent increase in the daily minimum fraction of inspired oxygen or an increase of at least three centimetres in the daily minimum positive end-expiratory pressure (PEEP) to maintain oxygenation (CDCP, 2018). These include infectious conditions, such as ventilator-associated pneumonia (VAP) and sepsis, and non-infectious conditions, such as barotrauma, pulmonary oedema, pulmonary embolism and Acute Respiratory Distress Syndrome (ARDS) (CDCP, 2018). Patients are prone to complications, such as VAE, if they are mechanically ventilated for more than 48 hours. However, mechanical ventilation is a crucial lifesaving therapy for patients with critical illness and respiratory failure (Aitken, Marshall, & Chaboyer, 2015).

The Institute of Healthcare Improvement (IHI) (2012) recommended the use of the grouped evidence based practice to reduce the risk of VAE in mechanically ventilated patients. There is a variety of evidence on VAE prevention (such as head of bed elevation), which has been adopted by several health services (Klompas et al., 2015; Labeau et al., 2008; Sedwick, Lance-Smith, Nardi, & Reeder, 2012). Despite focused efforts for more than a decade to reduce morbidity and mortality among ventilated patients, VAE remains a significant health care challenge (Sousa, Ferrito, & Paiva, 2018). In Australia, VAE have been reported to be higher than in other countries (IHI, 2018), with up to a quarter of mechanically ventilated patients affected (Government of South Australia Health, 2019).

In this study, nurses' knowledge of VAE prevention was explored across Australia and the implementation of the ventilation bundle was explored in two ICUs in the state of

Victoria, Australia. In this chapter, the author presents the background to the thesis related to how intensive care is organised in Australia, evidence-based guidelines to prevent VAE in adult ICU, surveillance of mechanical ventilation complications, the ventilation bundle, the research aims and questions, the significance and scope of the study, the theoretical framework and the thesis structure.

1.2 Characteristics of Australian intensive care units (ICUs)

Australian ICUs are classified into five categories according to the level of services, the number of beds and staffing requirements (AIHW, 2018). The five types of ICUs are adult ICU Level 3, adult ICU Level 2, adult ICU Level 1, paediatric ICU and neonatal ICU. Most of the ICUs admit both critically ill patients and high-dependency patients (AIHW, 2018).

A Level 1 adult ICU provides immediate short-term care and multisystem life support for at least 24 hours before transfer to a Level 2 or 3 ICU. It should have an established consultation, referral and transfer policy to a Level 2 or 3 ICU (AIHW, 2018).

A Level 2 adult ICU has at least five beds and provides complex multi-organ failure support for several days or a more extended period in regional areas. It should be capable of delivering mechanical ventilation, renal support and invasive cardiac monitoring (AIHW, 2018).

A Level 3 adult ICU is a tertiary referral unit which offers comprehensive, multisystem support. It should have at least eight beds and may range up to more than 50 beds and should support academic education and research (Victoria State Government, 2018). It should have extensive pathology and clinical services to facilitate the referral role. The Level 3 adult ICU also supports mechanical ventilation, renal support services and invasive cardiovascular monitoring for critically ill patients for an indefinite period (AIHW, 2018).

In Australia, in 2019, there were 191 ICUs with a total of 2378 beds (Litton et al., 2020). There were 161,000 admissions to ICUs in Australian public and private hospitals in 2017-18, which represents 12.8 million hours of intensive care (AIHW, 2019). In Victoria, there has been an increase in the number of ICU admissions over the past ten years. An increase of 25 percent in admissions was reported from 16,329 in 2001-02 to 20,483 in 2010-11. The increase in ICU admissions was mostly a result of ageing and the growing population in Victoria (Department of Health Victoria, 2014). The increase in the elderly population admitted in ICU has been reported worldwide (median age 65 years) (Guidet et al., 2018). The risk of adverse events is higher in older people with cognitive impairment (Suman Ahmed, Leurent, & Sampson, 2014); an ICU admission is acknowledged to result in cognitive impairment in some older patients (Ahmed, Leurent & Sampson, 2014) and ICU population is increasingly older with more comorbidities (Wunsch et al., 2010) hence some of the ICU population are at greater risk of adverse events.

Most patients admitted to Australian ICUs have an assessment undertaken of their Acute Physiology, Age, Chronic Health Evaluation III (APACHE III) score in the first

24 hours of admission (Paul, Bailey, Lint, & Pilcher, 2012). The APACHE III score is used to measure the severity of patient sickness and to predict the risk of hospital mortality. The APACHE III score ranges from 0 to 299; a higher score is associated with a higher risk of hospital death (Paul et al., 2012).

There are multidisciplinary teams caring for critically ill patients in ICU; the majority of these staff members are nurses and doctors. It is vital to have medical and nursing staff with expertise to support the management of the critically ill patient in ICU. Effective interprofessional collaboration between nurses and doctors supports timely care delivery and improved patient outcomes in ICU (Reeves, Nelson, & Zwarenstein, 2008; Rose, 2011).

1.2.1 Nursing staff in the adult ICU

The intensive care nurse is essential in the ICU, for the safe delivery of vigilant nursing care to unstable patients with life-threatening conditions (ACCCN, 2016; McGahan, Kucharski & Coyer, 2012). Only nurses registered with the Australian Health Practitioner Regulation Agency (AHPRA) who have completed the required education and shown competency to practice are eligible for employment in an Australian ICU (NMBA, 2020). Most intensive care units in Australia have in-house educational programs for all novice intensive care nurses (Madhuvu, Plummer, & Morphet, 2018). The in-house programs are called Transition to Specialty Practice Programs (TSPPs). The TSPP in an ICU is an introductory educational program to intensive care nursing, which intends to equip the registered nurse with the knowledge and skills to work in an ICU before they seek postgraduate qualifications (Madhuvu et al., 2018).

The responsibility to support a registered nurse to seek an intensive care nursing qualification rests with the employing organisation (ACCCN, 2016; College of Intensive Care Medicine of Australia and New Zealand [CICMANZ], 2011).

The ICU nursing staff in Victoria, Australia consist of a Nurse Unit Manager (NUM), an Associate Nurse Unit manager (ANUM), a Clinical Nurse Educator (CNE), a Clinical Nurse Specialist (CNS), a Registered Nurse with critical care qualification (CCRN), a Registered Nurse without critical care qualification (RN), graduate RNs on rotation and RNs transitioning into critical care nursing practice (ACCCN, 2016). An Access Nurse is also known as the team leader or admission and discharge nurse and holds a postgraduate qualification in intensive care nursing. Access nurses are additional to bedside nurses, clinical coordinators, unit managers, educators, and non-nursing support staff (ACCCN, 2016; CICMANZ, 2011).

The Australian College of Critical Care (ACCCN) is an organisation which represents ICU nurses in Australia; in 2003, it recommended that all RNs working in an ICU complete a postgraduate qualification in intensive care nursing provided by a higher education institute (ACCCN, 2016; Australian and New Zealand Intensive Care Society [ANZICS], 2015; CICMANZ, 2011). It is now a requirement by the Department of Health's accreditation board that each Australian ICU have a minimum of 50% of ICU nursing staff as qualified intensive care nurses; preferably, 75% (Australian Government Department of Health, 2010; ANZICS, 2015; CICMANZ, 2011). Nurses' knowledge, or qualifications, is one of the factors which influences patient outcomes (ACCCN, 2016; Aiken et al., 2014). ICUs with qualified intensive care nurses comprising less than 50 percent of their nursing staff are required by the Department

of Health to have an access nurse (1 access nurse per every 4 ICU patients) to support and assist the bedside nurse (ACCCN, 2016; CICMANZ, 2011). According to Benner's Novice to Expert model, an access nurse will be the expert (critical care trained with experience in ICU) in intensive care nursing (Benner, 1984). The nurse-patient allocation in Australian ICUs is a 1:1 nurse-patient ratio for all intensive care patients, while the high-dependency nurse-patient ratio is 1:2 plus an access nurse (ACCCN, 2016; CICMANZ, 2011).

1.3 Surveillance of mechanical ventilation complications

Surveillance is an information-based activity, where data on healthcare-associated infections (HAIs) are collected, analysed, interpreted and reported to the Department of Health using specific guidelines (VICNISS Healthcare Associated Infection Surveillance, 2018). According to the Australian Commission on Safety and Quality in Health Care (ACSQHC), "surveillance programs enable hospitals to monitor the outcomes of current practice and provide timely feedback to clinicians to ensure practice improvement and better patient outcomes" (ACSQHC, 2019, para 2). In Victoria, the surveillance of preventable HAI is controlled by the Department of Health and Human Services Victoria. The surveillance data in Victoria is reported to VICNISS Healthcare Associated Infection Surveillance, which is a government-funded organisation aiming to decrease the incidence of HAI (VICNISS Healthcare Associated Infection Surveillance, 2018). VICNISS sends quarterly aggregated reports of infection rates and processes, to help decrease infections in specific hospitals (VICNISS Healthcare Associated Infection Surveillance, 2018).

In healthcare systems, surveillance is an essential component of quality patient care and a crucial component of effective infection prevention, whereby healthcare practice is assessed against specific standards. Surveillance of certain HAIs, such as Central Line-Associated Bloodstream Infections (CLABSI), is mandated in the state of Victoria by the Department of Health and Human Services Victoria (VICNISS Healthcare Associated Infection Surveillance, 2018). However, VAE surveillance remains optional in Australian ICUs.

The surveillance of mechanical ventilation complications has been controversial, internationally, as a result of subjectivity in the surveillance criteria (CDCP, 2018; Klompas, 2013). The subjectivity of ventilator-associated pneumonia (VAP) surveillance criteria has left room for disagreement among clinicians, which has led to lack of consensus on the concept and diagnosis of VAP in Australia and New Zealand (Richards & Russo, 2007). Consequently, in a comparative prospective study analysing VAP rates using a consensus checklist against medical assessment in 10 ICUs in Australia and New Zealand, VAP rates ranged from 25.9% to 26.7% per 1000 mechanical ventilation days, respectively (Elliott et al., 2015). According to Elliot and colleagues, there were no significant differences noted between the two assessments (Elliott et al., 2015) and VAP rates were comparable to those reported worldwide. Ventilator-associated pneumonia is reported to be the most common HAI (Sousa et al., 2018). Despite this, the lack of consensus on the diagnosis of VAP may have contributed to limited Australian research in this area.

1.3.1 Characteristics of VAE

In 2012, the CDCP convened leaders of different professional societies to develop an objective set of metrics for the surveillance of VAE. The surveillance has since shifted from VAP to VAE, to demonstrate the progressive persistent chest radiographical abnormal findings within 48 hours of mechanical ventilation in ICU patients (CDCP, 2018; Klompas, 2013). The surveillance of VAE include changes in ventilator settings, fever or altered mental status in elderly patients and changes in respiratory secretions, dyspnoea, worsening in oxygenation regardless of other potential causes (CDCP, 2018; Klompas, 2013). VAE has broadened the preventative focus. VAE surveillance consist of surveillance focused on:

1. ventilator-associated condition (VAC), indicated by the onset of increased oxygen requirements or a need for increased positive end-expiratory pressure following two or more days of mechanical ventilation, the cause of hypoxemia is not considered;
2. infection-related ventilator-associated complications (IVAC), indicated by hyperthermia or hypothermia or elevated or low white blood cell count in the setting of three days of mechanical ventilation and worsening of oxygenation; and antibiotics are used for a minimum of four days and
3. possible ventilator-associated pneumonia (PVAP), indicated by the setting of the above and the presence of a laboratory positive culture of respiratory aspirates or purulent secretions or a positive test of a pleural specimen (CDCP, 2018).

VAE surveillance is not to be used as a clinical diagnosis in the clinical management of patients, as most cases of VAC are associated with the following four conditions: pneumonia, ARDS, pulmonary oedema and atelectasis (CDCP, 2018). In a large retrospective study of 1320 patients in 11 North American ICUs, Muscedere et al., 2013 reported that both VAC and IVAC were associated with significantly prolonged mechanical ventilation, hospital days, and in-hospital mortality. The patients who met the criteria for VAC also met characteristics of IVAC definition (Muscedere et al., 2013). In an editorial article, Raoof and Baumann (2014), claimed that the VAE surveillance tool should be used with caution until further multicentre clinical trials authenticate the definition of VAC from IVAC.

The main route for acquiring a VAE is through oropharyngeal colonisation by endogenous flora or pathogens acquired exogenously from the ICU environment, especially via the hands of healthcare workers and contaminated equipment (Kalanuria, Zai, & Mirski, 2014). Micro-aspiration of subglottic secretions, due to an underinflated endotracheal cuff, has been related to mechanical ventilation complications (Blot et al., 2014). The stomach is another potential site of colonisation and reservoir of nosocomial gram-negative bacilli. The most common aerobic gram-negative bacilli which can cause ventilation infections include Pseudomonas aeruginosa, Staphylococcus aureus (methicillin-sensitive and methicillin-resistant) and Acinetobacter species (Blot et al., 2014; Koulenti et al., 2009). Interventions to prevent VAE aim to avoid micro-aspiration and colonisation of the upper respiratory airways and the gastrointestinal tract with pathogens (Blot et al., 2014; Hellyer, Ewan, Wilson, & Simpson, 2016). Healthcare organisations developed bundles in response to new surveillance of VAE (Klompas, 2019; Raoof & Baumann, 2014).

1.4 Evidence-based guidelines to prevent VAE

There are various evidence-based guidelines for the prevention of VAE in the ICU (Klompas et al., 2015; Sedwick, Lance-Smith, Nardi, & Reeder, 2012). When a set of evidence-based guidelines are grouped in an attempt to achieve the best patient care or outcome, it is called a bundle, such as the IHI ventilation bundle or Feeding, Analgesia, Sedation, Thromboembolic prophylaxis, Head of bed elevation, stress Ulcer prophylaxis, Glucose control and Spontaneous breathing trial (FASTHUGS) (Dellinger, Townsend, Marik, Raghunathan, & Bloomstone, 2013). The use of bundles aims to promote consistency in the reliance on evidence-based guidelines and the use of a multidisciplinary approach. The bundles help with continuity of care, better care delivery and better patient outcomes, if all elements of the bundle are implemented (IHI, 2017). Bundles have been reported to be effective but require skills and adaptive change strategies, which might include the use of new products or an education package on the new skill set (Dawson & Endacott, 2011). The bundle also requires regular review and updates according to the latest evidence to ensure practice is current (Dellinger et al., 2013). Care bundles, in general, facilitate audit and feedback which can influence healthcare professionals' bedside behaviours (Dellinger et al., 2013). Audit is the “direct observation or monitoring of healthcare personnel adherence to job-specific infection prevention measure” (CDCP, 2019, para. 4). The data from audits can be used to motivate healthcare professionals, highlighting what they are doing well and areas for improvement (Dawson & Endacott, 2011).

The ventilation bundle was developed by the IHI in conjunction with other organisations through the consensus of a multidisciplinary team (IHI, 2012).

The first ventilation bundle established in 2001 consisted of four structured, evidence-based elements: "Head of the Bed Elevation (HoBE) 30 and 45 degrees, daily sedation interruption and assessment of readiness to extubate, peptic ulcer prophylaxis and Deep Vein Thrombosis (DVT) prophylaxis" (IHI, 2001, p. 3). The ventilation bundle elements were adapted differently by organisations. Some organisations used FASTHUGS in the prevention of mechanical ventilation complications (Vincent, 2005). FASTHUGS includes four elements of the IHI ventilation bundle. In 2010, a fifth element, “daily oral care with chlorhexidine”, was added to the IHI ventilation bundle following evaluation of evidence and its use in Scotland (IHI, 2012). The bundle was tested in 13 ICUs in the United States of America (USA) and demonstrated a 61% decrease in VAP rates with greater than 95% compliance with the bundle (IHI, 2012). The IHI ventilation bundle focuses on the prevention of specific complications of mechanical ventilation, such as VAP, sepsis, barotrauma, pulmonary oedema, pulmonary embolism and ARDS (IHI, 2018; Klompas, 2013).

The implementation of care bundles requires effective communication, to explain the importance of the change, the components of the care bundle and the benefits of the new care bundle (Fulbrook & Mooney, 2003). Borgert et al. (2015), in a systematic review of strategies used to implement care bundles in the ICU, concluded that there were three most commonly used strategies: education, reminders, and audit with feedback. Policy and procedures have been reported to promote efficiency, safety and consistencies in delivery to patients (Klompas et al., 2015; Vincent, 2005).

Some studies have reported the effectiveness of pre-implementation educational sessions on care bundle implementation (Okgün Alcan, Demir Korkmaz, & Uyar, 2016; Sachetti et al., 2014). Most of the educational sessions reported were didactic. Didactic teaching facilitates the delivery of a large volume of content to large numbers using minimal resources. However, didactic teaching alone does not have a significant influence on learner behaviour (Emde, 2003; Forsetlund et al., 2009).

The IHI recommended adherence with the ventilation bundle be measured using an "all or none" approach (IHI, 2012). The all or none approach of measurement emphasises the use of all bundle elements; when all elements of the bundle are either implemented or marked as contraindicated, the bundle should be marked as complete (IHI, 2012). Measuring adherence with each element is essential for identifying areas of weakness which require improvement to reach compliance with the ventilation bundle and improve the quality of patient care (IHI, 2012).

The IHI recommended approaching VAE prevention as a multidisciplinary initiative, by having a representative of every discipline in the initiation team, as the bundle is a multidisciplinary tool, which requires nurses, doctors and the rest of healthcare professionals for its successful implementation (Goutier et al., 2014; IHI, 2012). Engaging the multidisciplinary team is vital to facilitate opportunities for collaborated holistic patient care (Goutier et al., 2014). This demonstrates that bundles can drive improvement in the reliability of care and patient outcomes; which is aligned with the Donabedian Structure, Process, Outcome framework that assumes the care given to a patient influences their outcome (Donabedian, 2003).

The challenges of care bundles are poor uptake or poor adherence by healthcare professionals (Rello et al., 2002). Poor knowledge of evidence-based practice to prevent mechanical ventilation complications has been reported as a challenge internationally (Blot et al., 2007).

1.5 Research aims and questions

The overall aim of this study is to explore nurses' knowledge of VAE prevention across Australia and evaluate the implementation of evidence-based guidelines to prevent VAE in adult intensive care units in Victoria, Australia.

Specifically, the aims of this study were to:

1. examine intensive care nurses' knowledge and self-reported adherence to evidence-based guidelines to prevent VAE;
2. evaluate the use of the evidence-based guidelines to prevent VAE by healthcare professionals in two ICUs in different healthcare services; and
3. explore facilitators and barriers to the implementation of evidence-based guidelines to prevent VAE.

1.5.1 Research questions

1. What is Australian intensive care nurses' knowledge and self-reported adherence to evidence-based guidelines to prevent VAE?

    a) What areas of VAE prevention strategies generate the highest and lowest knowledge scores for intensive care nurses?

    b) Are there differences in knowledge scores across different types of ICUs?

    c) What are the self-reported adherence rates to VAE prevention strategies?

d) What are the highly adhered to elements of the evidence-based guidelines?

2. How are evidence-based guidelines implemented to prevent VAE in two ICUs?

a) What elements of the evidence-based guidelines are used in the two ICUs?

b) What are the adherence rates with the evidence-based guidelines?

c) What variations are there in implementation between the two sites?

3. What are the facilitators and barriers to evidence-based guidelines adherence?

a) What are nurses' and doctors' perceived barriers to the use of evidence-based guidelines?

b) Do barriers and facilitators to VAE prevention guidelines differ at the individual patient and ICU levels?

c) What recommendations do nurses and doctors offer for future implementation of VAE strategies?

The study was conducted in two phases using an online survey of intensive care nurses (*n* = 294) and medical record review (*n* = 96) (Phase 1). After analysis of the Phase 1 results, interview questions for Phase 2 were formulated. Interviews were conducted with intensive care nurses and doctors (*n* = 20) in two ICUs.

1.6 Significance of the study

In Australia, the prevalence of VAE is approximately 25% (Government of South Australia Health, 2019), which is similar to the rates reported worldwide (Klompas et al., 2015; Klompas, Kleinman & Murphy, 2014; Magill et al., 2016; Rello et al., 2012). However, the surveillance and reporting of VAE in some Australian States remain optional (VICNISS, 2018).

The implementation of evidence-based guidelines to prevent VAE is understudied in Australian ICUs and there is a paucity of qualitative data on the use of evidence-based guidelines to prevent VAE.

This study will examine nurses' knowledge and will evaluate nurses' and doctors' adherence to evidence-based guidelines to prevent VAE. As the implementation of evidence-based guidelines requires a multidisciplinary approach, both nurses and doctors were included in this study. The potential significance of this study is in the identification of factors which limit the implementation of evidence-based guidelines to prevent VAE and of recommendations for improving VAE preventative care in Australian ICUs. The results of this study will fill the gap in research in clinical practice. VAE can prolong the mechanical ventilation period and increase intensive care and hospital length of stay (Klompas, 2019; Klompas et al., 2014), which increases the burden on the family and healthcare system. Knowing more about VAE prevention and recommendations for practice improvement has potential benefits for patient recovery, family wellbeing and healthcare costs.

In summary, a study of the implementation of evidence-based guidelines to prevent VAE is essential for several reasons. Firstly, knowing the depth of nurses' knowledge of the evidence-based guidelines to prevent VAE can inform intensive care educators, managers and educational institutions to best support the prevention of mechanical ventilation complications. It might also influence the curriculum and professional development courses in the ICU.

Secondly, the evaluation of the use of evidence-based guidelines can contribute to the knowledge of the quality and safety of mechanically ventilated patients and help health services develop quality improvement initiatives. Thirdly, the understanding of the factors which influence the implementation of evidence-based guidelines can help health services to evaluate current practices and develop strategies to minimise barriers and improve processes. Fourthly, this study will contribute to the body of knowledge, validate findings from other countries and inform practitioners and patients of VAE prevention in Australian ICUs. The findings will also identify potential areas for future research, to improve the prevention of VAE in ICUs.

1.7 Scope of the study

In this study, nurse's knowledge was surveyed, a review of the medical records of patients receiving mechanical ventilation was undertaken and interviews were conducted with nurses and doctors to identify facilitators and barriers to the implementation of evidence-based practice to prevent VAE. Included in the study were nurses and doctors currently working in an adult ICU for more than six months, as they were considered to have adequate experience in caring for mechanically ventilated patients. Level 1 ICUs were excluded from the study, as they do not provide care to ventilated patients for more than 24hours. Paediatric and neonatal ICUs were also excluded because the ventilation bundle was recommended for adult mechanically ventilated patients (CDCP, 2018).

1.8 Theoretical framework

This study focuses on evaluating the implementation of evidence-based guidelines to prevent VAE. The evidence from previous studies has highlighted that factors related to ICU characteristics, healthcare professional education, and implementation of evidence-based guidelines are associated with the rates of VAE (Blot, Koulenti, & Labeau, 2017; Labeau et al., 2008; Rello et al., 2002). The use of a theoretical framework helps to define research goals and methodological choices and connect to current literature (Collins & Stockton, 2018). Donabedian's model of Structure, Process and Outcome was used as a theoretical framework for this study (Donabedian, 2003). It examines nurses' knowledge, evaluates adherence of nurses and doctors and explores the barriers and facilitators to the implementation of evidence-based practice to prevent VAE.

According to Donabedian (2003), the structure of care is the setting where care is taking place and includes organisational characteristics and human resources, such as ICU level of service and healthcare professionals' education and experience in intensive care practice. The process of care encompasses the activities undertaken by healthcare professionals to provide care (Donabedian, 2003). The process includes use of VAE evidence-based guidelines, implementation strategies, protocols and surveillance of VAE. The structural factors influence processes within an organisation and processes can also influence structure (Donabedian, 2003). However, the outcome is dependent upon both structure and process (Donabedian, 2003). Figure 1.1, below, illustrates the Donabedian model as applied in this study (Donabedian, 2003).

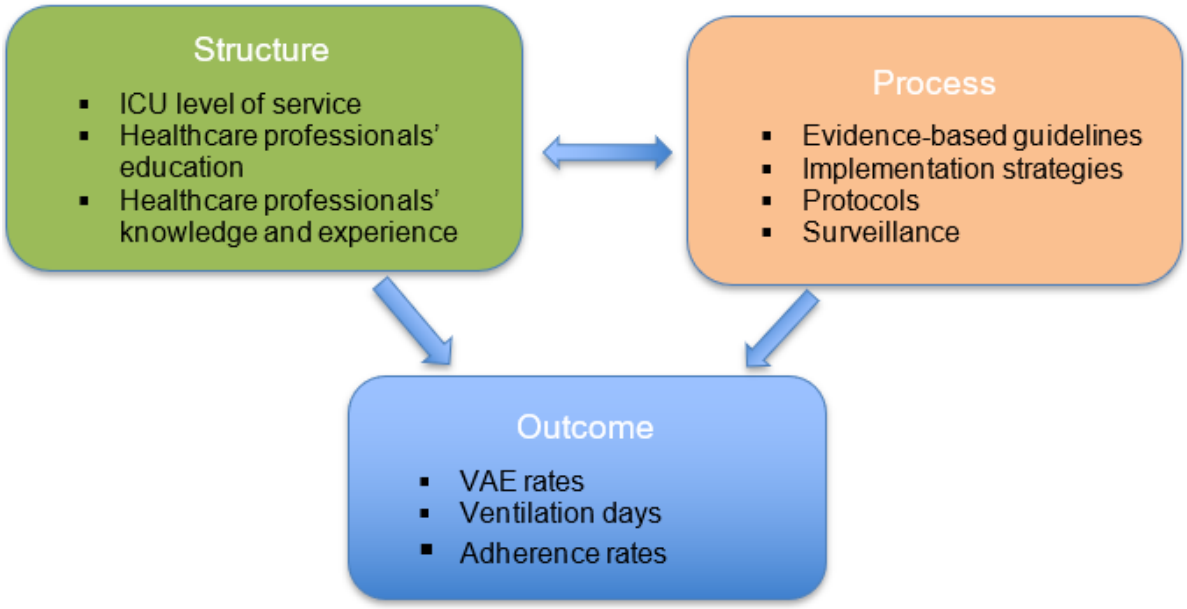

Figure 1.1 Donabedian model applied to evaluate the evidence-based guidelines to prevent VAE

In this situation, healthcare professionals' education and experience (structure) will influence how they implement evidence-based guidelines (process), and the processes will influence the patient outcome. The outcome of care is the component which highlights the efficiency and reliability of a healthcare service. The efficiency and reliability of a healthcare service can be assessed by patient outcomes, which includes patient's prognosis following interventions (Donabedian, 2003). Outcome indicators are the VAE rates, ventilation days and adherence rates to evidence-based guidelines. The outcomes can act as quality indicators of care provided in an organisation. Outcome helps to provide a better assessment of care provided compared to the other two elements in the model (Coyle & Battles, 1999; Donabedian, 2003). However, a large number of cases is required to support the results (Donabedian, 2003).

1.9 Thesis structure

This thesis is presented in eight chapters. Chapter One has introduced the study and provided the background and classification of ICUs and intensive care nursing in Australia. As the focus of the study was on VAE in the ICU, surveillance of VAE in the ICU was discussed and the evidence-based guidelines to prevent VAE were described. The aims and potential significance of the study were presented. Finally, the theoretical framework underpinning the study was discussed and a justification for undertaking the research was provided.

Chapter Two presents a narrative of VAE prevalence and evidence-based guidelines used in VAE prevention. The following aspects are discussed: evidence-based guidelines for VAE prevention, pre- and post-intervention VAE rates and nurses' knowledge of and barriers to the implementation of evidence-based guidelines to prevent VAE in the ICU. The structure, process and outcome factors were identified throughout the review. The limitations of the outcome measures are also discussed.

Chapter Three presents the explanatory sequential research design that was used in this study. The research design is discussed and justified. A critique of the methods used for recruitment and data collection is included. This is followed by a description of the application of the theoretical framework in this study. The research setting and sample, the sampling process and the design of instruments used for the research are presented. A discussion of the ethical considerations of the study, data quality and data analysis are also presented.

The results of the study are presented in Chapters Four, Five and Six. Chapter Four presents the description and analysis of the results of the online survey conducted in two ICUs in Victoria, Australia. The description of the results consists of demographic characteristics and nurses' knowledge of and self-reported adherence to evidence-based guidelines for VAE prevention. The data were analysed using Statistical Package for the Social Sciences version 25 (SPSS V25).

Chapter Five presents the results of the evaluation of the implementation of evidence-based guidelines for VAE prevention, through a document review undertaken in two ICUs in Victoria. The results of reviewed medical records are presented.

Chapter Six presents data collected in Phase Two of this study. The data consist of the findings of semi-structured interviews conducted in two ICUs in Victoria. The qualitative findings are interpreted.

In Chapter Seven, the findings of the study are discussed in relation to existing studies of intensive care nurses' knowledge of the evidence-based guidelines to prevent VAE, nurses' adherence rates to the guidelines and facilitators and barriers to the implementation of the guidelines. This Chapter represents the interpretation phase of the mixed methods study; the findings of Phase One and Phase Two are integrated.

Chapter Eight presents the conclusions, implications, and recommendations arising from the study results, including the strengths and limitations of the study.

1.10 Chapter summary

Mechanical ventilation is an essential, and life-saving measure in patients with life-threatening conditions in the ICU. However, mechanically ventilated patients are at risk of developing VAE as a complication of this aspect of their care. The implementation of evidence-based guidelines to prevent VAE helps to reduce the risk of mechanical ventilation complications.

The main aim of this study was to explore nurses' knowledge of VAE prevention across Australia and evaluate the use of evidence-based guidelines to prevent VAE in ICUs in Victoria, Australia. In the following chapter, peer-reviewed articles on VAE are examined and critiqued.

Chapter Two – Narrative Literature Review

2.1 Introduction

In this chapter, a review and critique of the available literature on evidence-based guidelines to prevent VAE in adult ICUs will be presented. The three questions for this review are:

1) What are the evidence-based guidelines used to prevent VAE?

2) What are the adherence rates, facilitators and barriers to the implementation of evidence-based guidelines to prevent VAE?

3) What are the structure, process, and outcome factors, which influenced the implementation of evidence-based guidelines?

A narrative literature review is a critical and objective analysis of the current knowledge on a topic of interest, that provides a summary based on previously published research (Green, Johnson, & Adams, 2006; Ferrari, 2015). It helps to focus on the context of the current research. A narrative literature was selected to identify, summarise and seek gaps in the literature that need to be addressed (Ferrari, 2015). This literature review is presented in six sections. The first section illustrates the search strategy, which includes a PRISMA flow chart and a table of studies used for this review. The second section presents the five themes which were identified during the literature review: 1) evidence-based guidelines used to prevent VAE, including the IHI ventilation bundle, 2) surveillance of VAE, 3) clinical audits, 4) educational intervention and adherence rates, and 5) nurses' knowledge of evidence-based guidelines to

prevent VAE. The structure, process and outcome factors will be identified throughout the review, indicated by the text in italics and the inter-relationships will be explained, according to Donabedian (2003).

2.2 Search strategy

A search of the electronic databases, CINAHL plus, Medline, EMBASE via OVID and Scopus, and the search engine, Google Scholar, was undertaken to answer the aims of the review. Grey literature and citation tracking were also used to supplement the search. The terms, *ventilator-associated events* and *ventilator-associated pneumonia*, are sometimes used interchangeably so both were included in the keywords. The following keywords were used: ventilator-associated pneumonia OR VAP OR ventilator-associated events OR VAE AND ventilation bundle OR VAP bundle OR evidence-based guidelines OR preventative measures OR implementation strategies AND intensive care unit OR ICU OR critical care unit OR CCU, AND outcome OR adherence OR compliance OR education OR experience OR professional development.

The search was conducted from 15 March 2018 to July 2018. The initial search of the databases resulted in 3,506 articles. The search was limited to articles published after 2001, as the first coordinated attempt to prevent VAP was published in 2001 (IHI, 2012). The search was also limited to peer reviewed articles (quantitative, qualitative, and systematic reviews). Only articles written in English language and available in full-text directly related to ventilator-associated pneumonia (VAP) or VAE were included.

Some of the articles were excluded if they examined VAP/VAE in specialty areas other than the adult ICU. The number of articles was reduced to 98 after screening titles. The 98 abstracts were reviewed next, of which 77 were excluded, as they focused on other specialties, such as paediatrics, or they did not address evidence-based guidelines (see Figure 2.1 PRISMA flow chart).

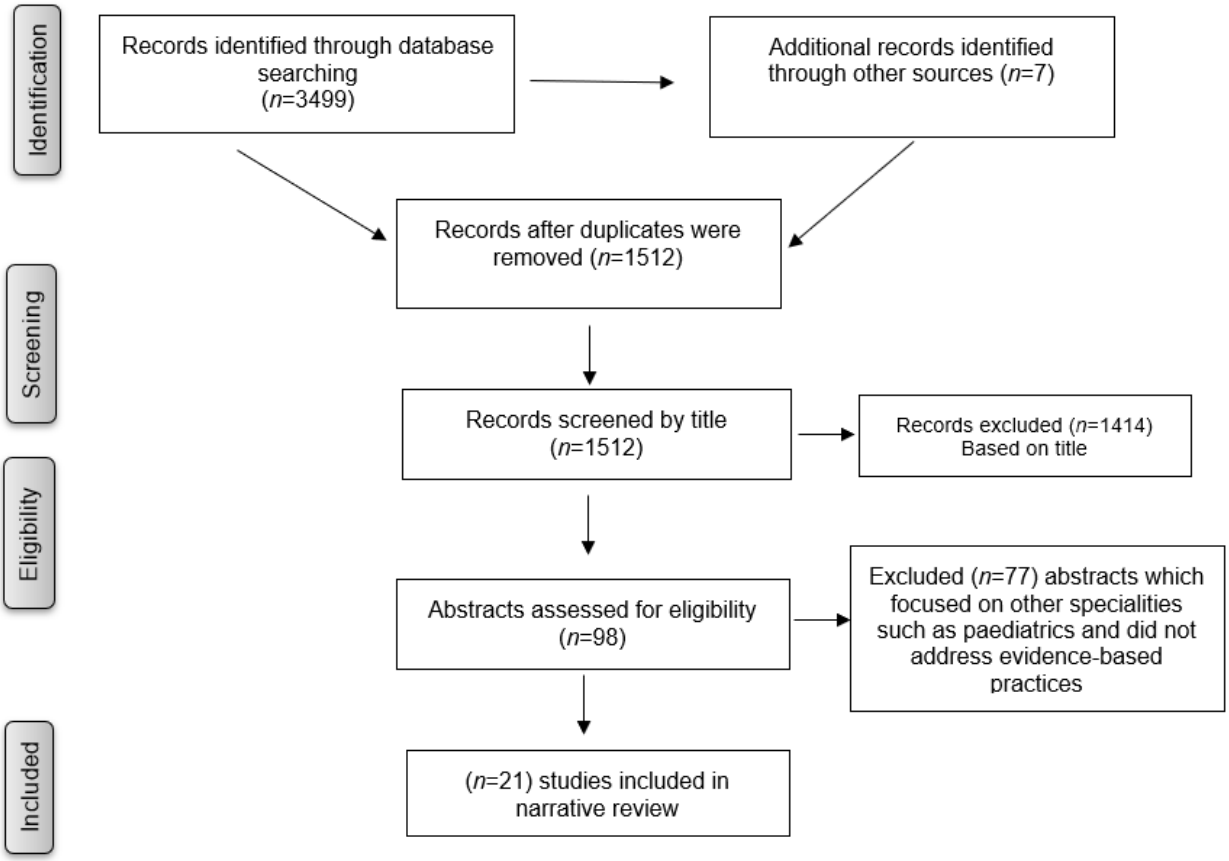

Figure 2.1 PRISMA flow chart of literature review search strategy

The remaining 21 full-text articles were reviewed and relevant material on VAE was extracted from each paper (see Table 2.1). The 21 articles are mostly from Europe (10) and the United States of America (USA) (6). Many of the articles are primary research papers: 10 articles are cross-sectional surveys, seven are observational studies, one is an interventional study, one is a randomised clinical trial, and two are systematic reviews. The five themes identified in the 21 articles reviewed are: evidence-based guidelines for prevention of VAE, surveillance of VAE, clinical practice audit, educational intervention and adherence rates, and nurses' knowledge of evidence-based guidelines to prevent VAE. The next section will discuss the evidence-based guidelines to prevent VAE.

Table 2.1 Articles included in the literature review

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Aloush (2017) Jordan	To investigate factors which influence nurses' VAP guidelines compliance: education or no education.	Randomised clinical trial. Over 6months.	120 nurses.	There was no difference between nurses who had education and those who did not.	Education does not influence compliance but addressing factors such as workload will have an impact.	Compliance before educational intervention was not measured.
Al-Dorzi et al. (2012) Saudi Arabia	To evaluate the impact of an active VAP surveillance program.	Quantitative. Observational. Over 6 years.	2812 patients.	Decrease in VAP rates over the years of surveillance.	There was reduction in VAP rates with active surveillance, reporting and use of evidence-based preventative strategies.	Single hospital.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Al-Tawfiq et al. (2010) Saudi Arabia	To evaluate the effects of a VAP bundle on ICU patients.	Quantitative. Observational. Pre and post intervention.	Not reported.	Implementation of VAP bundle helped to reduce VAP rates from 9.3 to 2.2 per 1000 ventilation days over 2 years.	Significant reduction in VAP rates and potential cost cuts.	Single hospital.
Borgert et al. (2015) Netherlands	To determine which strategies are used to implement care bundles.	Systematic review.	47 studies.	Adherence is influenced by multiple factors, such as education, audits.	The three strategies used most were education, reminders, and audit and feedback.	Could not compare strategies,

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Blot et al. (2007) Belgium	To examine nurses' knowledge of VAP preventative measures.	Quantitative, Questionnaire,	638 nurses.	The knowledge level was higher in experienced nurses than novice nurses.	Overall poor knowledge of VAP prevention.	Self-reported.
Darawad et al. (2018) Jordan	To assess nurses' adherence to VAP guidelines.	Quantitative. Survey.	224 nurses.	VAP guidelines adherence rate of 50 to 70%	Continuing education about VAP preventative guidelines would increase adherence and patient outcome.	Self-reported.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Jansson et al. (2013) Finland	To explore ICU nurses' knowledge of, adherence to, and barriers to prevention of VAP.	Quantitative. Multiple-choice questionnaire.	101 nurses.	84% adherence rate. Barriers to adherence were inadequate resources, skills, knowledge and guidance.	There is need for ongoing education and effective implementation strategies.	Self-reported. Single hospital.
Jordan et al. (2014b) Croatia	To explore knowledge, attitudes and oral care practices in ICU.	Quantitative. Cross-sectional survey.	241 nurses	Nurses lack of VAP knowledge and preventive practices but positive attitude towards oral care.	Insufficient VAP knowledge by ICU nurses.	Self-reported.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Kaier et al. (2014) Germany	To analyse effects of the availability of VAP guidelines to compliance.	Quantitative. Questionnaire.	1730 critical care physicians from 77 different countries.	Higher compliance rates with VAP guidelines and VAP surveillance.	Availability of written VAP guidelines and surveillance systems has a positive association with compliance for preventative measures.	Self-reported.
Kaynar et al. (2007) United States	To understand practices of and adherence to evidence-based guidelines among respiratory therapist and registered nurses	Cross-sectional questionnaire.	278 Overall 172 Respiratory therapists 106 Registered nurses	All participants frequently practice evidence-based guidelines.	Respiratory therapists and registered nurses encounter barriers in practice, such as costs, poor availability of resources and patient discomfort.	Self-reported.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Klompas et al. (2015) United States	To investigate preventability of VAE by using evidence-based guidelines.	Quantitative, multicentre, prospective clinical trial.	5164 Patients	No change in the VAE rates but decrease in the risk per episode of mechanical ventilation.	Positive results with spontaneous breathing trials and awakening which is associated with decreased VAE rates.	Lack of randomisation.
Lin et al. (2014) Taiwan	To investigate nurse's knowledge of VAP prevention guidelines.	Quantitative survey.	133 nurses	Nurses without ICU qualification lacked knowledge of VAP prevention.	Inadequate knowledge of VAP prevention guidelines. Educating nurses is important.	Self-reported.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Malouf-Todaro et al. (2013) United States	To determine whether embedding VAP checklist in the existing health records will increase completeness.	Quantitative checklist.	137 pre- and 504 post-health records.	Increase in nursing documentation compliance.	Use of checklists improves the quality of patient care.	Single clinical setting.
Muscedere et al. (2008) Canada	To develop evidence-based guidelines for the prevention of VAP. Study covered articles from 1980 to 2006.	Systematic review.	Not reported	Consensus on VAP prevention practices.	Recommended evidence-based practices to prevent VAP.	Number of articles used was not reported though the study was well referenced.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Okgün Alcan et al. (2016) Turkey	To investigate the effects of using care bundle on VAP rates.	Quasi-experimental, pre-observation, educational intervention and post observation over 6 months.	128 nurses.	VAP rates significantly decreased post education on ventilation bundle.	Nurse education as an implementation strategy for VAP bundle increased compliance and decreased VAP rates.	Results might be biased, as the nurses knew they were being observed post education.
Parisi et al. (2016) Greece	To evaluate the effects of education and ventilation bundles on the rates of VAP.	Quantitative. Observational.	362 patients.	Decrease in VAP rates from 21.6 to 11.6 per 1000 ventilation days.	Implementation of ventilation bundle and education helped to reduce VAP incidences.	Hawthorne effect.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Rello et al. (2002) Spain	To review barriers to physicians' adherence to evidence-based guidelines.	Quantitative questionnaire.	110 ICU physicians.	Barriers were poor resources, cost and not agreeing with the interpretation of clinical trial results.	Non-adherence was not influenced by the availability of evidence.	Self-reported.
Ricart et al. (2003) Spain	To review barriers to VAP guidelines adherence.	Quantitative, descriptive survey.	51 nurses.	Barriers were more patient-related, such as patient discomfort and side effects.	Nurses identified patient-centred as well as guideline-related barriers.	Small number of nurses. Self-reported.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Sachetti et al. (2014) Brazil	To assess adherence to the ventilation bundle in ICU.	Quantitative checklist.	198 Nurses	Ventilation bundle adherence increased.	Educational intervention increased bundle adherence but did not decrease VAP rates.	Short duration of the educational intervention.
Sedwick et al. (2012) United States	To develop and implement a ventilator bundle and care practices to reduce VAE.	Quantitative, observational, prospective study.	4709 ventilation days.	Increase in adherence with the use of ventilation bundle.	Strict audits on the use of ventilation bundle enhanced accountability and improved patient outcome.	Hawthorne effect.

Author, Year & Country	Aim	Method	Sample	Results	Conclusions	Limitations
Yeganeh et al. (2016) Iran	To assess intensive care nurses' knowledge of evidence-based guidelines for VAE.	Quantitative, cross-sectional survey.	219 intensive care nurses.	Inadequate knowledge of VAE prevention guidelines.	Knowledge is good, but it does not reflect practice.	Self-reported

2.3 Evidence-based guidelines to prevent VAE

Several evidence-based practices *(process)* were used to prevent VAE in the ICU, including those contained in the IHI ventilation bundle. In a systematic review, several randomised clinical trial results reported the effectiveness of evidence-based practices for the prevention of VAE (Muscedere et al., 2008). Muscedere and colleagues developed evidence-based strategies for the prevention of VAP using a group of multidisciplinary experts in critical care; the group consisted of 20 medical consultants, four infectious disease specialist, three intensive care nurses, an infection control nurse, an ICU pharmacist and an ICU respiratory therapist (Muscedere et al., 2008). The studies used in the development of evidence-based strategies were systematic reviews and randomised clinical trials results. Each trial was critically appraised, using levels of evidence and consensus methods leading to agreed recommended strategies (Muscedere et al., 2008). The following strategies have been recommended to prevent or decrease VAE rates in ICU according to several clinical trial findings, critical appraisal and ranking of evidence. The drafted strategies were also externally reviewed by five critical care professional boards and two expert international reviewers, adding rigor to the process (Muscedere et al., 2008). The recommended strategies are grouped into physical, positional and pharmacological strategies, as follows:

1. Physical strategies

- The oral route for endotracheal intubation
- Use of endotracheal tubes with an extra lumen for subglottic secretions drainage
- Spontaneous breathing trials and spontaneous awakening trials

- The use of new ventilator circuits for every new patient
- Use of heat and moisture exchangers
- Use of closed suction systems
- Use of sterile gloves
- Changing the suction system for every new patient, daily or when clinically indicated

2. Positional strategies

- Use of kinetic beds
- Head of bed elevation 30 to 45 degrees.

3. Pharmacological strategies

- Daily oral decontamination with chlorhexidine
- Use of peptic ulcer prophylaxis
- Use of DVT prophylaxis

Using one or all of the elements of evidence-based guidelines (*processes of care*) had positive effects on the reduction of VAE rates *(outcome)* in ICU (Muscedere et al., 2008), hence, use of the ventilation bundle was recommended (IHI, 2012; Muscedere et al., 2008).

2.3.1 Outcome of the use of evidence-based guidelines

In a multicentre, prospective, interventional study by Klompas et al. (2015), a protocol was developed and implemented to prevent VAE. The protocol had two elements: daily spontaneous awakening trials and spontaneous breathing trials.

The nurses and respiratory therapists worked collaboratively to assess and implement daily spontaneous awakening trials and spontaneous breathing. Patients were screened daily by nurses and a respiratory therapist for spontaneous awakening trials and spontaneous breathing. The nurses and respiratory therapist were trained to screen the patients using a consensus protocol (Klompas et al., 2015). Spontaneous awakening meant stopping all sedatives and, in cases where there was no analgesia requirement, stopping narcotics. The two elements were used for about 18 months in 12 ICUs and combined data were reported. A significant decrease in VAE risk per episode of mechanical ventilation was reported (odds ratio 0.63; 95%, confidence interval 0.42-0.97) (Klompas et al., 2015). The daily implementation of spontaneous awakening trials and spontaneous breathing trials *(process)* also facilitated a significant decrease in mechanical ventilation days *(outcome)* (mean 2.4 days) (95% CI, 1.7-3.1 days) (p = 0.03) and a significant decrease in patients' length of stay in hospital by three days (95% CI, 1.6 – 4.3 days) (p <0.0001) (Klompas et al., 2015).

Klompas et al. (2015) confirm previous findings of a prospective observational study by Sedwick, Lance-Smith, Nardi and Reeder (2012). A significant decrease in VAE rates was reported following the implementation of ventilation bundle clinical audits. The cases of VAE decreased from 9.47 cases per 1000 days to 1.9 cases per 1000 days, which meant there was a decrease in mechanical ventilation days and patient length of stay in hospital (Sedwick et al., 2012). However, the Hawthorne effect might have influenced the findings of the observational study; although, this was not acknowledged as a potential limitation by the authors.

2.4 Surveillance of VAE and use of evidence-based guidelines

Surveillance of VAE (section 1.3) increases hospital staff awareness of the prevalence of mechanical ventilation complications (Al-Dorzi et al., 2012). Use of evidence-based guidelines to prevent VAE and its surveillance led to a significant decrease ($p = 0.003$) (19.1 to 6.3 per 1,000 ventilator-days) of VAE incidence (Al-Dorzi et al., 2012). Al-Dorzi et al. (2012) reported an increase in ventilation bundle (a group of evidence-based practice) adherence from 49% pre surveillance to 99% at 18 months of continuous active monitoring. A few studies concluded that surveillance of ventilation infections in ICU is essential as a clinical indicator and should be included in organisational policies (Al-Dorzi et al., 2012; Al-Tawfiq & Abed, 2010; Kaier et al., 2014). Studies which were conducted pre- and post-implementation of a ventilation bundle reported a significant decrease of VAE incidence ($p < 0.001$) (9.3 to 2.5 episodes per 1, 000 ventilator days), thereby a reduction in the likelihood of developing VAE (Al-Tawfiq & Abed, 2010).

The two studies (Al-Dorzi et al., 2012; Al-Tawfiq & Abed, 2010) demonstrated a significant decrease in ventilation days, regardless of pre-intervention rates, which indicates the importance of surveillance and the use of evidence-based guidelines in the prevention of VAE. The studies were conducted over an extended period and showed a significant reduction in the number of ventilation days, indicating a higher adherence rate to practice over time. It is hard to prevent a VAE without knowing its prevalence or incidence. The method used to report surveillance data back to the clinicians was unclear. Surveillance of VAE, with feedback to healthcare professionals delivering care, should be embedded into regular practice in the ICU.

2.5 Clinical practice audit

Auditing the use of evidence-based guidelines in ICU is essential to increase adherence and reduce VAE prevalence (Malouf-Todaro, Barker, Jupiter, Tipton, & Peace, 2013; Sedwick et al., 2012). In a quality improvement study, the introduction and use of a ventilation bundle checklist improved adherence and documentation of care, from 3.7% pre- to 92.1% (p=<0.001) post-introduction (Malouf-Todaro et al., 2013). High bundle adherence was significantly associated with decreased VAE rates, from 4.34 episodes per 1000 ventilation days to zero over seven months (Malouf-Todaro et al., 2013). This shows that the processes of care influenced VAE rates *(outcome)*. The adherence was measured using the 'all or none' approach, however, the study was conducted in one clinical setting, which limits generalisability of the findings to other settings.

In a prospective study, the use of a modified IHI ventilation bundle in one ICU was enhanced by clinical chart audits, random observations and real-time feedback on a daily basis (Sedwick et al., 2012). Real-time feedback on a modified ventilation bundle helped the practitioners to address any outstanding issues. Real-time feedback also made practitioners accountable for their practice, thereby improving adherence (Sedwick et al., 2012).

The adherence of intensive care physicians and nurses *(structure)* to evidence-based guidelines for VAE prevention in the ICU was studied in 22 countries using a survey (Rello et al., 2002). The evidence-based guidelines, which included the elements of the 2001 IHI ventilation bundle *(processes)*, were used.

The self-reported physicians' non-adherence rate was 37% overall *(outcome)*. Reasons for physicians' non-adherence ranged from disagreement with clinical trial results (35%), poor resources (31.3%), cost (16.9%), miscellaneous (9.7%), nursing convenience (3.7%), fear of adverse events (2.2%) and patient comfort (0.8%) (Rello et al., 2002). Grouping and naming different miscellaneous reasons would give a better understanding of the other reasons for non-adherence. In a separate survey study, the non-adherence of nurses to evidence-based guidelines was lower than that of the physicians (22.3%). The nurses' reasons for non-adherence were unavailability of resources (37%), miscellaneous (21.9%), patient discomfort (8.2%), disagreement with the interpretation of a clinical trial (7.8%) and fear of side effects (5.8%) (Ricart, Lorente, Diaz, Kollef, & Rello, 2003). Similar reasons for non-adherence have been reported by Kaynar et al. (2007).

The nurses were more concerned with patient comfort and fear of adverse events; their barriers were more patient-related (p <0.05) compared to the physicians who reported practice-related barriers, such as cost and disagreements with trial results, as main reasons for non-adherence (Rello et al., 2002; Ricart et al., 2003). The difference in the reasons for non-adherence highlights the importance of collaborative care in designing clinical practice protocols (Ricart et al., 2003). There were other miscellaneous non-adherence reasons for nurses (21.9%), which occurred at double the rate of physicians' (9.7%). Adherence rates *(outcome)* could be higher if both nurses and physicians *(structure)* were to agree on the evidence-based guidelines *(processes)* to be implemented. The data were gathered using a questionnaire. However, interviews might be the best method to explore the different reasons for non-adherence.

In an online questionnaire study conducted in 77 different countries, nurses who worked in organisations that had protocols on VAE evidence-based guidelines reported better adherence rates than those without protocols (Kaier et al., 2014). The availability of written standards of care and VAE surveillance were reported to have a positive association with self-reported adherence to evidence-based guidelines by both nurses and doctors in ICU (p <0.01) (Kaier et al., 2014). Clinical practice audit should be considered as part of a continuous improvement plan for VAE prevention; although, a smaller study conducted in 2003 reported that the policies and protocols had minimum impact on changing bedside behaviour, while educational interventions improved practice behaviour (Ricart et al., 2003).

2.6 Educational intervention and adherence rates

Education *(structure)* was highlighted by a few studies as a critical element for the implementation of and adherence *(process)* to evidence-based guidelines for VAE prevention, such as the IHI ventilation bundle, (Blot, Labeau, Vandijck, Aken, & Claes, 2007; Ricart et al., 2003; Sachetti et al., 2014). Three studies reported on the impact of an educational intervention on adherence to evidence-based guidelines to prevent VAE (see Table 2.2). This shows that education (*structure)* can directly influence adherence rates *(outcome)* as per the Donabedian (2003) model. However, different methods to measure adherence were used; some used an 'all or none' and element-by-element approach while some used only an element-by-element approach.

Table 2.2 Educational intervention and implementation of VAE evidence-based guidelines

Study and setting	Education intervention	Participants and Design	Results
Aloush (2017) Jordan	four, 2-hour face-to-face sessions	59 registered nurses in the experimental group and 43 in the control group. randomised control trial, post-test	non-significant moderate increase in adherence (*p*=0.15), mean compliance score of 14.1.
Okgün Alcan et al. (2016) Turkey	11 face-to-face educational sessions and self-directed learning	128 patients quasi-experimental pre, during and post education	significant increase in adherence rate to 89.8% *(p*=0.001).
Sachetti et al. (2014) Brazil	two days of face-to-face lectures	198 beds were assessed an observational and cross-sectional	increase in adherence rate to 66.7%. *p*-value not reported.

In an observational study by Okgün Alcan et al. (2016), the educational intervention consisted of 11 face-to-face, compulsory sessions, where all attendees were given written material for self-directed learning. Posters were displayed in the unit to increase awareness of the elements of the ventilation bundle (Okgün Alcan et al., 2016). Adherence was recorded daily for each ventilation bundle element, using 'yes' when the task was performed or 'no' if not performed. The overall bundle adherence was accomplished if all elements were performed (Okgün Alcan et al., 2016). Nurses' adherence rate to evidence-based guidelines increased from 10.8% (*n* = 152) pre educational intervention to 89.8% (*n* = 1324) post education, which was a statistically significant improvement ($p < 0.05$) (Okgün Alcan et al., 2016). However, the significant increase in adherence rate might be due to real time feedback given when they were non-compliant during the implementation stage.

The eleven compulsory educational sessions were not explained, and it was not clear whether they were full days or one-hour sessions, which limits implementation of the study intervention in other ICUs.

In a study by Sachetti et al. (2014) a two-day educational intervention that consisted of face-to-face lectures enhanced adherence to practice from 50.3% pre- to 66.7% post-intervention. The adherence rate was reported to be slightly higher (55.4%) in the morning shift than the night shift (54%) (Sachetti et al., 2014), although no cases had all elements compliant. However, statistical significance (p = 0.001) was reported in the following elements of the evidence-based guidelines: bed head position, cuff pressure, oral hygiene and fluid in ventilator circuits (Sachetti et al., 2014). The increase in adherence rates illustrate the importance of education as a facilitator to adherence. However, the prevalence of VAE was similar at pre- and post-intervention periods, 28.5 and 27.1/1000 patients per day, respectively, which was statistically insignificant (p = 0.389) (Sachetti et al., 2014). The insignificant results might be due to the fact that none of their studied case adhered to all elements, compared to Okgün Alcan et al. (2016) who used the ‘all or none’ approach to measure adherence.

In a randomised clinical trial by Aloush (2017), 120 participants were allocated into two groups: experimental and control. The participants in the experimental group went through an intensive ventilation bundle education course while the control group had no additional education. The educational course consisted of four two-hour face-to-face sessions. The two groups were observed in practice following the educational program.

The mean adherence score for the experimental group was 14.1 ± 4.4, compared to 12.8 ±3.7 for the control group, but the difference was not statistically significant (p = 0.15) (Aloush, 2017). The size and variation in numbers of the participants due to dropouts might have resulted in a Type II error. The participants also knew that they were being observed, which might have led to the Hawthorne effect. However, participants who worked in units where the nurse-to-patient ratio was 1:1 demonstrated better adherence than the participants who had a 1:2 patient ratio, with a statistically significant difference (p <0.05) (Aloush, 2017). This suggests that there are other factors that influence adherence to evidence-based guidelines, other than nurses' knowledge or education.

In the study conducted by Aloush (2017), workload appeared to be one of the confounding factors that influenced adherence to practice. There were other self-reported barriers to adherence to evidence-based guidelines, notably poor time management, knowledge of skills, workload and policies (Jansson, Ala-Kokko, Ylipalosaari, Syrjälä, & Kyngäs, 2013). This shows that structural factors can directly influence the outcome of care, as per the Donabedian (2003) model. Therefore, addressing structural factors related to adherence, other than education, is also essential.

2.7 Nurses' knowledge of VAE evidence-based guidelines

Using a validated multiple-choice questionnaire, nurses' knowledge *(structure)* of VAE evidence-based guidelines in ICU was evaluated by several studies as being poor overall (Blot et al., 2007; Jansson et al., 2013; Jordan et al., 2014a; H.-L. Lin, Lai, &

Yang, 2014; Yeganeh, Yekta, Farmanbar, Khalili, & Atrkar Roushan, 2016). In Table 2.3 (below) the nurses' overall knowledge score ranged from 41% to 66% in five studies. According to Blot et al. (2007), nurses' years of experience were significantly associated with a higher knowledge level (p <0.001). Lin and colleagues confirmed the findings of Blot et al. (2007) using the same questionnaire by Labeau, Vandijck, Claes, Van Aken, and Blot, (2007); the higher the level of education in the ICU, the higher the level of knowledge in VAE prevention, a relationship that was statistically significant (p = 0.032) (H.-L. Lin et al., 2014).

Nurses' knowledge is not a proxy measure for practice, although, it is one element that might influence behaviour change and it might be a barrier to adherence to evidence-based guidelines (H.-L. Lin et al., 2014; Yeganeh et al., 2016). Two studies concluded that intensive education at the implementation stage of evidence-based guidelines was important to enhance adherence (Blot et al., 2007; Okgün Alcan et al., 2016). An understanding of ventilation infections and the ventilation bundle would support better practice and adherence to evidence-based guidelines (Blot et al., 2007).

Table 2.3 Nurses' knowledge of VAE prevention practices

Study	Participants	Instrument	Post graduate qualification in critical care %	Overall knowledge score %
Blot et al. (2007) Belgium	638 critical care nurses, 76% with >1year ICU experience	survey[1]	68%	41.2%
Jansson et al. (2013) Finland	101 critical care nurses 85.2% with ICU experience	survey[1]	not reported	59.9%
Jordan et al. (2014a) Croatia	241 critical care nurses	survey[1, 2]	not reported	65.7%
Lin et al. (2014) Taiwan	133 critical care nurses, with an average of 4.1years ICU experience	survey[1]	not reported, 87.2% had ICU working license	65.6%
Yeganeh et al. (2016) Iran	219 intensive care nurses, the majority with 1-5years ICU experience	survey[1]	41.1%	51.4%

1. Labeau et al. (2007)
2. Ricart et al. (2003)

2.8 Structure, Process and Outcome

There were factors identified in the review of the literature, which help to explain the structure, process and outcome as per Donabedian's (2003) model. In a few studies nurses' level of education, workload, patient ratios *(structure)* influenced their knowledge of VAE prevention strategies and its implementation (Blot et al., 2007; Ricart et al., 2003; Sachetti et al., 2004). The following factors were identified as the process: implementation of and adherence to VAE guidelines (Klompas et al., 2015; Sedwick et al., 2012), auditing (Malouf-Todaro et al., 2013) and surveillance (Al-Dorzi

et al., 2012). The outcome factors were adherence rates (Klompas et al., 2015; Sedwick et al., 2012), VAE rates (Al-Dorzi et al., 2012; Al-Tawafiq & Abed, 2010) and ventilation days (Al-Dorzi et al., 2012; Al-Tawafiq & Abed, 2010; Malouf-Todaro et al., 2013). According to the literature reviewed, there is clear link between structure, process, and outcome as per Donabedian's (2003) model.

2.9 Limitations of the narrative literature review

There were a few limitations identified while reviewing the literature related to VAE in ICU. Most of the studies used a self-reported questionnaire to collect data. A few studies were single-site studies, which limits the generalisation of results (Al-Dorzi et al., 2012; Al-Tawfiq & Abed, 2010; Malouf-Todaro, et al., 2013). Some of the pre- and post-observational or interventional studies might have triggered the Hawthorne effect, resulting in positive results post-intervention (Malouf-Todaro, et al., 2013; Okgün Alcan et al., 2016; Sedwick et al., 2012). Most authors agreed that evidence-based practices helped to reduce VAE, despite the limitations described.

2.10 Chapter summary

Evidence-based guidelines for VAE prevention help reduce the prevalence of VAE in ICU. The four most used implementation strategies to enhance adherence to evidence-based guidelines were education, auditing with feedback, use of protocols and VAE surveillance. Auditing with feedback was done internally and provided real-time feedback compared to surveillance. Increased adherence to evidence-based guidelines led to a decrease in ventilation days and, thereby, a decrease in VAE rates

in the ICU. However, all the studies reviewed reported overall poor nurses' knowledge of evidence-based guidelines for VAE prevention. Most of the studies reviewed were quantitative and quasi-experimental, and they concluded that evidence-based guidelines reduce VAE rates. The structure, process and outcome factors were identified in this review.

There have been no Australian studies examining nurses' knowledge of VAE prevention and how Australian nurses compare with international nurses. No Australian studies have examined professional adherence to evidence-based guidelines to prevent VAE in mechanically ventilated patients. There are a variety of evidence-based practices for VAE prevention adopted by different countries.

The evidence-based practices that have been adopted, implemented and evaluated in Australian ICUs are minimal. Understanding the factors that influence the implementation of evidence-based guidelines could help health services to evaluate current practices and develop strategies to minimise the barriers and improve the processes to implementation. Therefore, assessing Australian intensive care nurses' level of knowledge and adherence to evidence-based guidelines using mixed methods would appear to be important, as most of the studies on VAE are quantitative or quasi-experimental. In the next chapter, the research design and methods are discussed.

Chapter Three - Research Design

3.1 Introduction

In the previous chapter, studies exploring evidence-based guidelines to prevent VAE in the adult ICU were critiqued and conclusions were drawn about the content of those studies, including its limitations. This study aims to explore nurses' knowledge of VAE prevention across Australia and evaluate implementation of evidence-based guidelines in two intensive care units in Victoria, Australia.

The study aims were addressed through three research questions, i) examine intensive care nurses' knowledge of and self-reported adherence to evidence-based guidelines to prevent VAE, ii) evaluate the use of the evidence-based guidelines to prevent VAE by healthcare professionals, and iii) explore facilitators and barriers to the implementation of evidence-based guidelines to prevent VAE in the adult ICU.

In this study a mixed methods approach was used; quantitative and qualitative research designs were used to answer the research questions. The data were collected in two phases, as per the explanatory sequential mixed methods design (Creswell & Plano Clark, 2018). This chapter includes a critique of the mixed methods approach, including its philosophical background, strengths, and weaknesses, and provides justification of the mixed methods design along with an outline of the theoretical framework applied to this study.

An audit trail is provided of decisions made regarding the research setting, population sample, recruitment, instruments used, data analysis and ethical considerations. The chapter concludes with a rationale for the integration of Phase 1 and Phase 2 data.

3.2 The mixed methods approach

A mixed methods approach is a combination of two or more different approaches to data collection and analysis. Mixed methods research commonly consists of quantitative and qualitative approaches to aid the breadth and depth of knowledge and understanding of the study topic (Creswell & Plano Clark, 2018; Johnson, Onwuegbuzie, & Turner, 2007; Teddlie & Tashakkori, 2009).

3.2.1 Philosophical background

Mixed methods approaches were existing in the 20th century, although they became more popular following the 'paradigm war' of the 1980s (Teddlie & Tashakkori, 2009). The war or debate of methodologies developed from the stance that research can either be quantitative or qualitative and cannot be both (Johnson & Onwuegbuzie, 2004).

However, a few authors suggested that mixed methods bridge the gap between quantitative and qualitative approaches, suggesting this as a third paradigm (Creswell, 2003; Creswell & Plano Clark, 2007; Johnson & Onwuegbuzie, 2004; Teddlie & Tashakkori, 2009). Mixed methods approaches are called the 'third methodological movement', the third research paradigm (Johnson & Onwuegbuzie, 2004) and 'the

third research community' (Tashakkori & Teddlie, 2003; Teddlie & Tashakkori, 2009), in view of quantitative and qualitative methodologies being the first two movements in social and behavioural sciences (Teddlie & Tashakkori, 2009).

A worldview is the philosophical assumptions that researchers bring to a study (Creswell & Plano Clark, 2018). There are four worldviews used in mixed methods research: postpositivist, constructivist, transformative and pragmatist (Creswell & Plano Clark, 2018). Postpositivist research is mostly associated with quantitative approaches. It reflects the view that truth is singular and requires acceptance or rejection of the hypothesis. In contrast, constructivist research is based on the premise that there are multiple perspectives to be sought from participants, and is often associated with qualitative approaches (Creswell & Plano Clark, 2018). Transformative research focuses on the underprivileged, pursuing social justice and human rights. It recognises that there are various perspectives based on the social and cultural perspectives of individuals (Creswell & Plano Clark, 2018). The main focus of pragmatism is on the consequences of research, dwelling more on answering the question than the ways of data gathering, and focusing more on the best option which suits the real-world problem or practice (Creswell & Plano Clark, 2018).

Mixed methods research can be based on any of the four world views (see Table 3.1) using two different ways of quantitative data collection and analysis or two different ways of qualitative approach or both quantitative and qualitative approaches (Creswell & Plano Clark, 2018). Mixed methods research should be placed within the worldview that best addresses the research question.

Table 3.1 Four worldviews used in mixed methods research

Worldview	Postpositivist (Quantitative)	Constructivist (Qualitative)	Transformative (Quantitative and Qualitative)	Pragmatist (Quantitative and Qualitative)
Epistemology	Determination	Understanding	Political and activist	Consequences of action
Strategy of Inquiry	Reductionism	Multiple participants meanings	Empowerment, human rights, social justice oriented	Problem centred
Strategy of Researcher	Empirical observation and measurement	Social and historical construction	Collaborative	Pluralistic
Result	Theory verification	Theory generation	Change, emancipatory oriented	Real-world practice oriented

Adapted from Creswell and Plano Clark, (2018)

Pragmatism is seen as the 'best' worldview for mixed methods research (Creswell and Plano Clark, 2018) as it posits that there are multiple paradigm approaches, which allow the researcher to move between postpositivist to constructivist approaches. The flexibility in mixed methods design is important, for example, allowing the researcher to move from a survey to interviews to build a deeper understanding of the research question. The researcher's ability to use knowledge gained through one method for data collection to inform another method promotes transferability of results in a study (Creswell & Plano Clark, 2018). Mixed methods research also facilitates both inductive and deductive reasoning. Inductive reasoning is the finding of patterns and themes in the data while deductive reasoning uses a pre-determined theoretical framework (Creswell & Plano Clark, 2018; Teddlie & Tashakkori, 2009).

3.2.2 Mixed methods design

The mixed methods designs, names and approaches have evolved, and some were eliminated from 2003 to 2018 (Creswell & Plano Clark, 2018); however, there is no

agreement on the names and approaches used by mixed methods authors (Teddlie & Tashakkori, 2009). The design names previously focused on the 'timing' of data collection, emphasising timing over method; for example, 'sequential explanatory' emphasises the timing of data collection over the qualitative method (Creswell & Plano Clark, 2018). Over the past years, researchers realised that timing was a difficult concept to follow in research design and that what the researcher aims to achieve by mixing the two data sets is the most appropriate concept. Therefore, the names of the designs have changed and, now, they begin with the intent of the design, such as explain, explore or converge (Creswell & Plano Clark, 2018). The sequence of the study became the second word in the design name. The changes are illustrated in the table below. Table 3.2 illustrates the decrease in the number of mixed methods designs in 2018. Some of the designs, such as embedded design, have been eliminated from the core designs but can be used to intersect or add complexity in mixed methods experimental studies (Creswell & Plano Clark, 2018).

Table 3.2 Changing typologies of mixed methods research designs

Creswell et al. (2003)	Creswell & Plano Clark (2007)	Creswell & Plano Clark (2011)	Creswell & Plano Clark (2018)
Sequential explanatory	Explanatory design	Explanatory sequential design	Explanatory sequential design
Sequential exploratory	Exploratory design	Exploratory sequential design	Exploratory sequential design
Sequential transformative		Transformative design	
Concurrent triangulation	Triangulation design	Convergent parallel design	Convergent design
Concurrent nested	Embedded design	Embedded design	
Concurrent transformative		Transformative design	
		Multiphase design	

(Creswell & Plano Clark, 2018, p. 59)

There are three core designs in mixed methods research: convergent design, explanatory sequential design, and exploratory sequential design, as illustrated in Table 3.2 above (Creswell & Plano Clark, 2018). The designs have specific guidelines of how and when the data are collected, reported and mixed. The selection of each design depends on the research question, aim and what is already known about the research study (Creswell & Plano Clark, 2018).

The convergent design, which is also known as the concurrent or parallel design (Creswell & Plano Clark, 2018) and also referred to as triangulation (Teddlie & Tashakkori, 2009), is the most commonly used (Creswell & Plano Clark, 2018). The researcher collects data at the same time, using two methods, and analyses the two datasets together. The two datasets can have equal or unequal emphasis; however, the overall intent is to converge the results (Creswell & Plano Clark, 2018). The researcher combines and compares the two datasets, in an attempt to obtain a comprehensive meaning of the problem, or uses one dataset to explain a second dataset (Creswell & Plano Clark, 2018; Teddlie & Tashakkori, 2009).

The exploratory sequential design has two distinct phases (Creswell & Plano Clark, 2018). The qualitative methods are used first to explore the problem and the quantitative methods follow to assess the extent of qualitative results on a larger scale. This design is usually used to examine the generalisability of findings of the qualitative phase to a larger quantitative sample. The exploratory sequential design is usually used to develop an instrument or to confirm the choice of instrument to be used for the quantitative study; qualitative data are gathered and analysed before the quantitative

phase begins. The results of the first phase (qualitative) inform the second phase (quantitative) of data collection (Creswell & Plano Clark, 2018).

The explanatory sequential design has two distinct phases: quantitative and qualitative (see Figure 3.1). It starts with collecting and analysing quantitative data followed by qualitative data collection and analysis, which helps to explain the quantitative results (Creswell & Plano Clark, 2018).

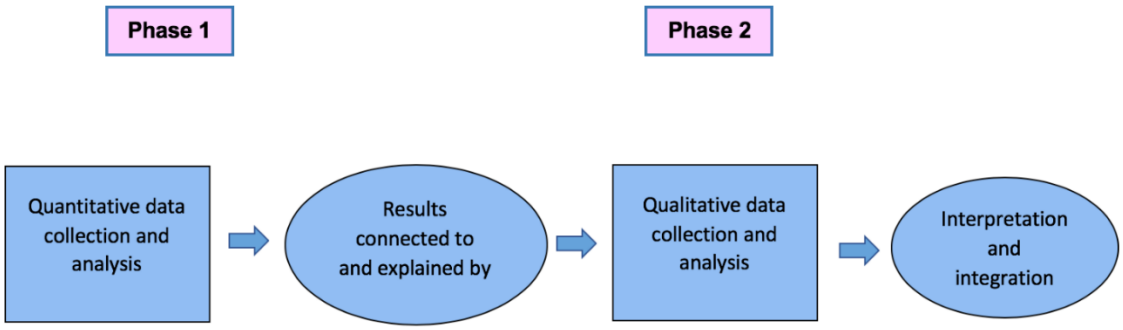

Figure 3.1 Explanatory sequential design (Creswell & Plano Clark, 2018)

The first step in the process is to design, implement and analyse an initial quantitative phase of the study, Phase 1. The second step is to analyse the results and see which results can be used to design the instrument (semi-structured questions) for the qualitative phase, Phase 2. The third step is collecting and analysing qualitative results (Creswell & Plano Clark, 2018). The final step is the integration and interpretation of the results and finding connections which explain the findings of the quantitative phase (Creswell & Plano Clark, 2011, 2018).

3.2.3 Strengths and weaknesses of the mixed methods approach

Mixed methods reflect and reveal different aspects of the reality being studied (Creswell & Plano Clark, 2018). It employs both quantitative and qualitative techniques in data collection and analysis, which helps to overcome the weaknesses of a single approach (Creswell & Plano Clark, 2011; Fetters, Curry, & Creswell, 2013). The weaknesses of a single approach can be minimised by integrating different methods and designs. The combination of two methods in a single analysis may give insight into aspects that may not be achievable without such integration (Creswell & Plano Clark, 2018). The complementarity of the mixed methods approach facilitates a richer understanding of the research problem or research results (Creswell & Plano Clark, 2018; Teddlie & Tashakkori, 2009). It also promotes the integration of data at the analysis stage, which means stronger inferences can be concluded (Creswell & Plano Clark, 2018).

Mixed methods research design requires the researcher to have both quantitative and qualitative training and understanding (Hesse-Biber, 2010). The researcher needs to learn how to effectively apply both methods in a study (Greene, 2008). It can be time consuming and might require extra people at the points of data collection and analysis, resulting in additional costs (Creswell & Plano Clark, 2018; Onwuegbuzie, Johnson, & Collins, 2009; Teddlie & Tashakkori, 2009). Morse (2012) highlighted that the strength of comprehensiveness can also be perceived as a weakness; however further suggested the importance of carefully describing the results of both phases and the relationship between the datasets to demonstrate rigour (Morse, 2012).

3.3 The application of mixed methods for the study

The explanatory sequential mixed methods approach (see Figure 3.1) was used for this study on the basis of the explanations outlined below;

- To examine Australian nurses' knowledge of evidence-based guidelines for VAE prevention in the adult ICU, the use of an online survey was required, to reach as many participants as possible.
- To obtain richer content and seek to understand the current evidence-based guidelines used, a prospective observational study was used. The approach facilitated collection of data on current practice in the ICU.
- To have a deeper understanding of the prevention of VAE in the ICU, interviews were conducted. The lack of qualitative studies made it difficult to determine what was essential to explore in a qualitative design.

Mixed methods can generate understandings that may be missed if only one method is used. It can also enhance the generalisability of the findings and provide comprehensive knowledge to support theory and inform practice (Johnson & Onwuegbuzie, 2004). The explanatory sequential design was considered the most appropriate for this research project. There is paucity of research on VAP or VAE in ICU in Australia, so an approach examining the breadth of VAE was necessary. This design is most suitable when the researcher can identify the crucial variables and includes a valid quantitative instrument to gather the data (Creswell & Plano Clark, 2018); a valid questionnaire has been identified as suitable for this study (Labeau et al., 2007). The explanatory sequential design facilitates the use of quantitative participant characteristics to guide purposive sampling for the qualitative phase (Creswell & Plano Clark, 2018; Teddlie & Tashakkori, 2009).

When using sequential design, consideration must be given to the weight of quantitative and qualitative data collection and methods of analysis. Therefore, in this study, more weight was given to the quantitative phase, and that facilitated data collection from a large sample throughout Australia first. A modified explanatory sequential design was used in this study, in line with the suggested sequence by Creswell and Plano Clark (2018). This study adapted the model by conducting three inter-related studies; two concurrent quantitative studies in Phase 1, then one qualitative study in Phase 2, as illustrated in Figure 3.2. The design was modified to address the study's main aim, which was focused more on quantitative than qualitative approach. The aim of the study was to evaluate nurses' knowledge of and adherence to evidence-based guidelines to prevent VAE.

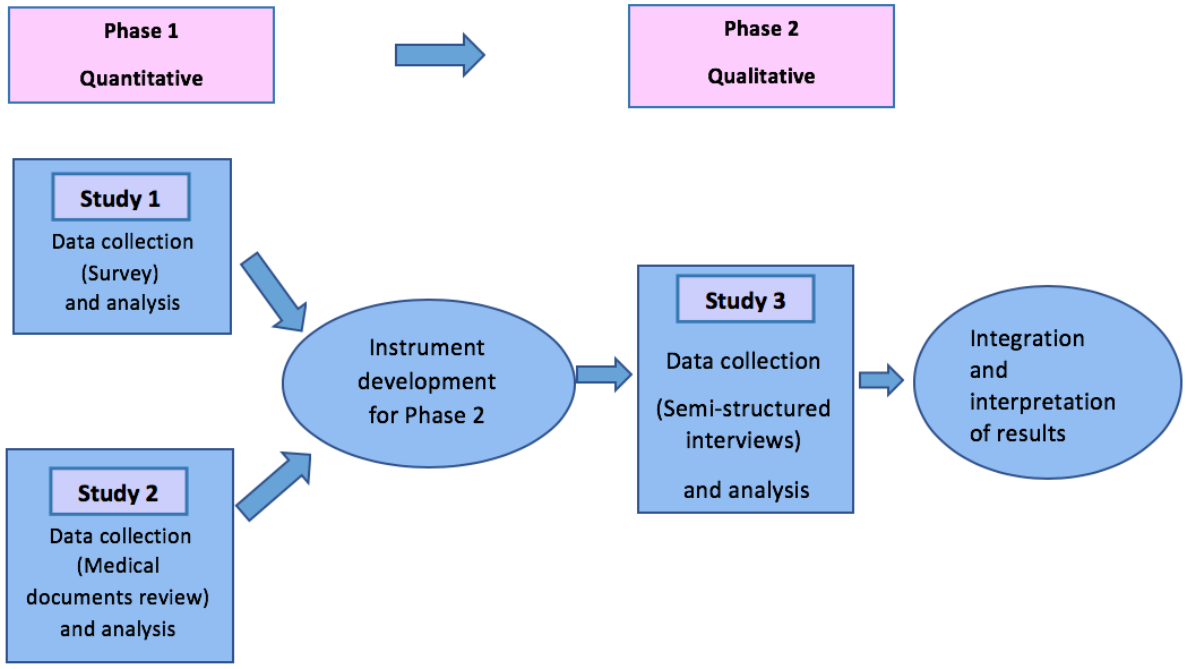

Figure 3.2 Model for this study (Creswell & Plano Clark, 2018)

Study 1 was a survey which provided numerical data for statistical analysis. The statistical analysis of the survey data gave insight to intensive care nurses' characteristics, their knowledge of VAE and their self-reported adherence to evidence-based guidelines for VAE prevention (Research questions in Study 1). Study 2 comprised of a medical records review, comprising patient's progress notes, observation charts, medication charts and FASTHUGS checklist (Research question in Study 2). The review of the medical records provided further details regarding the adherence of healthcare professionals to the evidence-based guidelines. The data gathered in the two quantitative studies informed the data collection for Phase 2, (Study 3) in which semi-structured interviews were conducted to explore facilitators and barriers to evidence-based guidelines adherence (Research questions Study 3).

Integration of the data is essential at each phase of the study to avoid undertaking separate studies on the same topic (Creswell & Plano Clark, 2018). The Study 1 and Study 2 results were combined and interpreted and provided insight into the nurses' knowledge and their practices. The quantitative results guided the development of semi-structured questions for qualitative data collection in Study 3. The qualitative data were collected and analysed independently. However, the final step of this study design was the integration and interpretation of Study 1, Study 2 and Study 3 results.

3.4 Application of the theoretical framework

The theoretical framework used in this study was Donabedian's Structure-Process-Outcome framework (Donabedian, 2003), as discussed in Chapter One (Section 1.8).

Donabedian's (2003) model is used to evaluate the quality of care, which evaluate the three components of the model and also supports measurement for improvement in healthcare services. When evaluating patient care, it is important to measure the structure, process and outcome of care. The Donabedian model has been used extensively to evaluate quality of care in different contexts, such as in emergency department, to examine the effectiveness of nurse practitioner assessment of chest pain (Roche, Gardner, & Lewis, 2015) and, in the ICU, to explore factors related to relocating to a new geographical and structural unit (Lin, Foster, Chaboyer, & Marshall, 2016).

The use of Donabedian's framework and its relationship to the explanatory sequential design of this study is demonstrated in Figure 3.3, below. Phase 1 of the study examined the structures, processes and outcomes. The *structure* was the healthcare professional's characteristics, including their knowledge and education. The implementation of the evidence-based guidelines comprised the *processes* of care. The *outcomes* were the levels of adherence to components of the VAE prevention bundle. Phase 2 of this study identified factors which might affect the interplay between structures, processes and outcomes through exploring experiences of ICU nurses and doctors, their reported facilitators and barriers to implementation of care, and the integration of the results of all the studies.

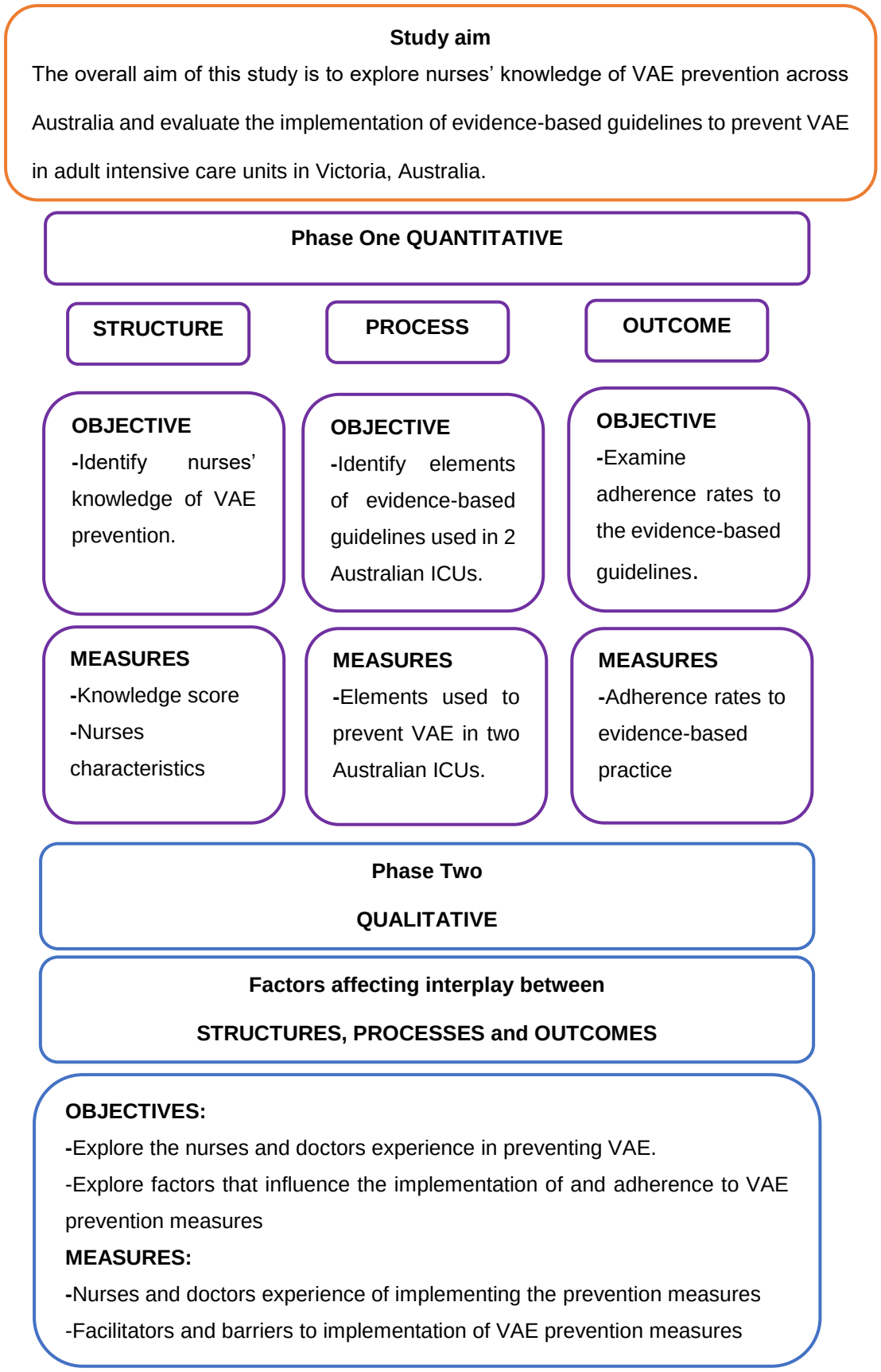

Figure 3.3 The relationship of Donabedian's Structure-Process-Outcome framework (2003) to this study

3.5 Phase 1 Research setting

There were two population settings for Phase 1 of this study: i) ICUs in two hospitals based in large health services in Victoria, Australia (Study 1 and 2) and ii) ICUs in hospitals Australia-wide (Study 1). There are 25 adult ICUs in Victorian public hospitals. There are seven Level 3 ICUs, seven Level 2 ICUs, and 11 Level 1 ICUs that provide both coronary care and intensive care (Department of Health and Human Services Victoria, 2020). The two ICUs (ICU A and B) are managed by two different health services in Victoria. ICU A is a Level 3 ICU and ICU B is a Level 2 ICU. The two ICUs were conveniently selected for participation as they are examples of the two ICU levels in Victoria where patients can be mechanically ventilated for more than 48 hours. The separation of the population settings facilitated comparison of Study 1 and Study 2 results at both Hospital A and B; to see if nurses' knowledge translated to their practice in the prevention of VAE in ICU. The separation of data collection for ICU A and B from data collection Australia-wide was important, as Study 2 and 3 were conducted at the two ICUs only.

An Australian wide intensive care nurses' membership-based organisation, ACCCN was also used to recruit respondents for Study 1. ACCCN is an organisation which represents intensive care nurses in Australia (ACCCN, 2018). It aims to provide and support intensive care nurse's education and to improve knowledge and skills. It also supports nursing research and evidence-based practices. Overall, ACCCN aims to improve the care and outcomes of critically ill patients in the ICU and their families (ACCCN, 2018).

3.6 Phase 1 Quantitative data collection and analysis

The quantitative phase of this research project included two studies. Study 1 was an online survey and Study 2 was a prospective review of care records.

3.6.1 Data collection

Data collection is a procedure of sample selection and data gathering from the participants (Polit & Beck, 2018). This section will discuss the sample, instruments used, recruitment and the data collection procedure for Study 1.

3.6.1.1 Study 1 Sample

Convenience sampling is a form of non-probability sampling and was considered most appropriate for this study (Fink, 2009; Richardson-Tench, Taylor, Kermode, & Roberts, 2011). There were two study populations: nurses working in two ICUs in Victoria and nurses working in ICUs Australia-wide. A convenience sample of registered nurses working in the ICUs were invited to participate in this study. More than 275 registered nurses were working at both sites (ICU A and B). The aim of this study was to recruit 100 nurses from both sites combined. In Australia, there are six States and two Territories. ACCCN has members in all States and Territories. At the time of study recruitment, there were around 800 ACCCN members but the total number of members who had indicated their interest in participating in the research was not known. The aim of this study was to recruit a total of about 400 nurses, in line with previous studies using the same survey instrument; this sample size was found to be sufficient for statistical analysis (Blot et al., 2007).

An appropriate sample size is essential in the quantitative research process as findings can be compromised by inadequate or small sample sizes (Fink, 2009; Polit & Beck, 2006). However, there is no easy equation to establish how large a sample is needed for survey-based research; there is a risk of the data undermining the study's statistical validity if the sample is too small. A large sample more likely demonstrates a representation of the study population (Polit & Beck, 2018). Creswell (2003) suggested that, if the sample is large, there is a minimum potential error that the sample will be different from the represented population. According to Barlett, Kotrlik and Higgins (2001), there is no perfect sample size, considering the margin of error when reporting results is crucial.

The inclusion criteria for participating in this study were registered nurses who were currently working for more than six months in an adult ICU in Australia, thereby with sufficient experience in the ICU environment. Nurses with or without postgraduate qualifications were eligible. Excluded from the study were registered nurses working in a paediatric ICU or neonatal ICU and registered nurses who were only allocated to provide care to non-ventilated patients. These nurses were not anticipated to have the knowledge tested by the survey.

3.6.1.2 Study 1 Data collection instrument

The data collection instrument consisted of two international questionnaires (Aloush, 2017; Labeau et al., 2007). The questionnaires were adapted and used with permission from the developers. The questionnaires have been previously used to evaluate intensive care nurses' knowledge of and adherence to the evidence-based

guidelines (Aloush, 2017; Labeau et al., 2007). The integrated questionnaire consisted of three sections: demographic data, nurses' knowledge of evidence-based guidelines, and three-point scale questions regarding nurses' adherence to evidence-based guidelines (Appendix A). The questionnaire, which consisted of closed questions, facilitated quantitative data collection only and was appropriate for answering the research question. Structured questions with fixed-response items simplify the participant's task and the researcher's analysis (Punch, 2003).

Section 1 of the questionnaire consisted of demographic variables (independent variables), including age, level of education, years of experience in intensive care and level of the ICU at which they were employed. The demographic data items allowed examination of relationships between the key study variables, nurses' knowledge, adherence to evidence-based guidelines, and demographic factors (Punch, 2003).

Section 2 consisted of the questions designed to test the nurses' knowledge of the evidence-based guidelines of VAE prevention in the ICU. It consisted of nine multiple-choice questions believed to be essential in the prevention of VAE in the ICU (Labeau et al., 2007). The multiple-choice questions invited the participants to choose a single answer. There were four choices by which to respond, and every question included the last option, '*I do not know'*. This option was included to discourage participants from guessing the answers.

Section 3 consisted of items related to nurses' adherence, using a three-point scale. The consisted of 10 questions, which invited participants to respond as follows: i) Done completely and accurately, ii) Not done completely and accurately, and iii) Not done.

There were minor modifications to the questionnaire to reflect contemporary practice. The modifications to the questionnaire were approved by the original author (Labeau et al., 2007). Changes are detailed below, in Table 3.3.

Table 3.3 Changes to the original questionnaire

Section/question	**Original wording** (Labeau et al., 2007)	**Amended wording**
Section 2, Q4 C	It is recommended to change humidifiers every week (or when critically indicated).	It is recommended to change *heated* humidifiers every week (or when clinically indicated).
Section 3, Q10 added	N/A	10. Use of 0.12% chlorhexidine gluconate antiseptic oral rinse (mouthwash) A) 0.12% chlorhexidine gluconate antiseptic oral rinse reduces the risk of VAP B) 0.12% chlorhexidine gluconate antiseptic oral rinse increases the risk of VAP C) 0.12% chlorhexidine gluconate antiseptic oral rinse does not influence the risk of VAP D) I do not know

In Section 2 at Question 4, the word, ‘heated’, was added to the question to differentiate the two methods of humidification used in ICUs (Ahmed, Mahajan, & Nadeem, 2009). In Section 2, Question 10 was added, as the use of chlorhexidine gluconate mouthwash is the fifth IHI ventilation bundle element (IHI, 2017). Section 3 consisted of three-point scaled questions on adherence to evidence-based guidelines; no changes were made.

3.6.1.3 Study 1 Establishing rigour

The authors of the questionnaire tested it for face and content validity, using eight experts with three years of experience in intensive care nursing (Labeau et al., 2007). The questionnaire was revised according to the feedback from the experts and it was sent back to them again and they all agreed with the content and the clarity. The items of the questionnaire were analysed using the survey results of 638 intensive care nurses. The questionnaire was reported to be reliable (Labeau et al., 2007). The questionnaire has since been subjected to further face and content validity when used by different teams (Jansson et al., 2013; Jordan et al., 2014; Lin et al., 2014).

Face validity is a process of checking whether the instrument measures what it is supposed to measure (Punch, 2003). Following the changes described above, the research topic, aims, questions and the questionnaire were given to five experts for face validity. The five experts (two academics and three Clinical Nurse Educators) had knowledge of ICUs and VAE prevention. The experts were asked to read and comment on the relevance of the questionnaire to achieve its aim and objectives. The researcher’s supervisors also checked the questionnaire for face validity. They

recommended moving exclusion questions close to the top of Section 1, to avoid wasting a participant's time if they did not qualify for the study. The questionnaire was sent to the same experts for content validity, using a scale of 1 to 4, to check for content relevance (Polit, Beck, & Owen, 2007). The average scale-level content validity index (S-CVI) was 0.97, based on the experts' rating. The item-level CVI was calculated using the simple rating scale, then averaged across the 19 I-CVIs to calcuate the total S-CVI (Polit et al., 2007). The estimated time to complete the questionnaire was ten minutes.

3.6.1.4 Study 1 Recruitment

Recruitment for the study was initiated via an email sent to the ICU NUM delegate at ICU A and ICU B, to disseminate the invitation to each registered nurse working in the ICU. The invitation email included a survey link to the questions and the participation information sheet, which outlined the research aims, and the details of the primary researcher for further clarification, if needed (see Appendices B and C). This study was conducted over eight weeks, with two reminder emails sent to participants ensuring the maximum opportunity to participate.

The same survey, in an invitational email with the survey link and the participation information sheet, was sent to ACCCN four weeks later. The email was distributed to members who had consented to receive research emails. The study was conducted over eight weeks, with a reminder email sent to all participants. The Australia-wide invitational email was delayed so that data collection in ICU A and ICU B could be commenced first.

There was an overlap of time due to the time constraints of the researcher. However, participants in ICU A and ICU B were asked to use the link sent to them via their employment network email rather than the ACCCN (see Appendix D). The participants were also asked not to complete the survey twice.

3.6.1.5 Study 1 Data collection procedures

A web-based descriptive survey was used to collect the data (Qualtrics, 2018). The skip logic function was used, to enforce the exclusion criteria, and the forced response was used on all knowledge and adherence questions (De Vaus, 2002; Fink, 2009). Survey access was given to the research supervisors who assessed the survey for meaning and functionality. The strengths and weaknesses of using a questionnaire are highlighted in Table 3.4, below. The weaknesses were addressed in this study through the use of a pre-validated questionnaire, which forced responses to all of the questions considered important to answering the research question.

Table 3.4 Strengths and weaknesses of questionnaires

Strengths	Weaknesses
Quick turnaround	Require validation
Considered low cost	Possibility of missing data
Perceived anonymity	Must be short
Easy data analysis for closed questions	Low response rate for online surveys
No interviewer bias	
Moderately high measurement validity as questionnaires are well-constructed and well-tested before use	

(Fink, 2009; Tashakkori & Teddlie, 2003)

3.6.1.6 Study 1 Data quality

As described above, the questionnaire was tested for face and content validity, which gave an assurance that the study collected what was intended. Before the analysis, the data set was checked for errors. The data were cleaned and coded into numerical data (Pallant, 2013).

3.6.2 Study 1 Data analysis

According to Creswell and Plano Clarke (2018), data analysis for the explanatory sequential mixed methods design should be described in a three-step process, comprised of quantitative, qualitative and integration steps. Descriptive statistics were used to report the Study 1 data, with tables and graphs used to illustrate the results. Data were collected using the ten multiple-choice questions that had only one correct answer. Responses to the ten multiple-choice questions were analysed separately, initially, and then aggregated to get a score out of ten for an individual participant, in line with previous users of the survey instruments (Aloush, 2017; Blot et al., 2007). The three-point scale questions were also analysed individually and then combined together.

Inferential statistics were used to explore relationships between variables, and statistical models were created to explore the relationships and differences between the study constructs (Pallant, 2013). Statistical analyses were performed using Statistical Package for Social Sciences (SPSS) v25 (IBM Corporation, 2018). A chi-square test was used to compare categorical measures (Pallant, 2013). The Kolmogorov-Smirnov test revealed a p value of <0.001, indicating that the knowledge

test scores were non-normally distributed. The survey data were unevenly distributed, hence non-parametric tests (chi-square, Mann-Whitney U and Kruskal-Wallis) were used to examine associations and relationships. Mann Whitney U was used to analyse differences in scores between two groups with or without post-graduate qualification, and Kruskall-Wallis test was used to analyse differences between 3 or more groups such as years of ICU experience. Bonferroni correction was applied to the multiple chi-square tests, with the corrected *p*-value of 0.005. In line with previous studies (Labeau et al., 2008; Jansson et al., 2013), linear regression was also used to examine the relationship between demographic data and median scores of the nurses' knowledge of evidence-based guidelines to prevent VAE. A *p*-value of <0.05 was considered statistically significant for all analyses.

3.6.3 Study 2 Data collection

Three months of prospective review of medical records was undertaken in two ICUs in Victoria, Australia. Prospective is a general term for "a study in which data are collected from a starting date until some future time" (Last, 2007, p. 247).

3.6.3.1 Study 2 Sample

All medical records of patients who were mechanically ventilated for more than 48 hours in ICU A and ICU B were prospectively reviewed. The medical records were comprised of patient progress notes, drug charts, observation charts and the FASTHUGS checklist, which were used to record the care provided to mechanically ventilated patients. Contextual data were also collected daily. The contextual data

collected was comprised of the patient case-mix report, daily bed capacity, daily staffing skill mix, and Acute Physiology, Age, Chronic Health Evaluation (APACHE III) score. Relationships were previously established between nursing care and bed occupants and staff skill mix; the two elements had direct impact on patient care in the ICU (Tiruvoipati et al., 2017). Therefore, patient medical records review alone would not have provided enough information required to answer the research questions.

3.6.3.2 Study 2 Data collection instrument

An existing IHI ventilation bundle checklist was used (IHI, 2017). The ventilation bundle was comprised of evidence-based guidelines for VAE prevention. It has been used in several different studies across several different countries, including USA (Klompas et al., 2015), Europe (Blot et al., 2007; Jansson et al., 2013) and Jordan (Aloush, 2017). The ventilation bundle comprised five elements to be checked on the medical records of mechanically ventilated patients:

i) HoBE at 30-45 degrees

ii) daily sedation interruptions and daily assessment of readiness to extubate

iii) peptic ulcer prophylaxis

iv) DVT prophylaxis

v) daily oral care with chlorhexidine

The checklist was used to check the medical and nursing documentation for adherence with the ventilation bundle in ICU A and ICU B (see Appendix E for the checklist). Contextual data were reviewed in their original form and recorded daily on a separate spreadsheet.

3.6.3.3 Study 2 Recruitment

All medical records for patients who were mechanically ventilated for more than 48-hours were included, as patients can only be diagnosed with a VAE condition 48 hours following intubation and ventilation. Excluded from the study were records for patients with tracheostomy and records for patients ventilated for more than five days. Medical records for patients ventilated for more than five days were excluded, as the risk of developing a VAE decreases after day five (American Thoracic Society, 2005).

3.6.3.4 Study 2 Data collection procedures

An online Microsoft program, OneNote was used for data entry during data collection (Microsoft, 2016). OneNote facilitated online data entry, organisation of data and data sharing with the supervisors. The adherence check was conducted on days three, four and five of mechanical ventilation, since the risk of a VAE is highest in the first three to five days of mechanical ventilation and then decreases as the period of mechanical ventilation increases (American Thoracic Society, 2005).

The three days of records per patient facilitated analysis of any trends in practice within the two ICUs. There were incidences when a patient was extubated and three days of records per patient were not collected, data was still used but not for trend analysis. Comments and reasons were noted if the three datasets collected for the patient.

The contextual data such as total number of patients in ICU were accessed online, from the day-to-day management documents on the hospital network database using

the access provided by the NUM. The data were gathered from various sources to provide more information about the unit, which facilitated a better analysis of the medical record data.

The data collection period took place between 22 October 2018 and 23 January 2019 in ICU A. This study was conducted concurrently with Study 1, as they both informed the qualitative Study in Phase 2. The data collection in ICU B started four weeks later (01 December 2018 to 02 March 2019), as the ethics review process experienced delay. Data collection from medical records enables assessment of information that is routinely recorded for patient care without requiring consent from the patient. It requires fewer resources and minimises recall bias. However, some medical records might be incomplete or inadequately documented which leads to missing data (Labeau, 2020). This study was conducted prospectively, and data were gathered from different documented sources. Gathering similar type of data from different sources was an attempt to overcome incomplete documentation.

3.6.3.5 Study 2 Establishing rigour

The checklist was given to three ANUMs and two NUMs who were working in non-participating hospitals, to check for face validity. They recommended splitting element ii) *daily sedative interruptions and daily assessment of readiness to extubate*. The element is joined by the word ‘and’ so the two were separated, as the five managers all agreed that the two require different actions to achieve the objective. It was then altered to reflect recommendations of the face validity review. The data were collected by one person, which helped with consistency. In a spreadsheet, the data were

structured with one participant per row and one variable per column, with no blank rows or columns. No value was given to missing data; this column was left blank.

3.6.4 Study 2 Data analysis

The data were analysed using IBM SPSS, Statistics for Windows (IBM Corporation, 2018). The “all or none approach” was used to measure adherence as per previous studies (Malouf-Todaro, et al., 2013; Sedwick et al., 2012). The data were analysed primarily as an overall bundle adherence per day and adherence over the three days of mechanical ventilation. Adherence with each element of the bundle was also analysed, as it was essential to identify areas of weakness or strength (IHI, 2012; Sachetti et al., 2014).

The data were collated into a single de-identified dataset for analysis and reporting. The data were assessed for normality using the Kolmogorov–Smirnov test before commencing analysis (Pallant, 2013). The data met the assumption of normality, so parametric tests were used to analyse the data. Categorical variables were presented using frequencies, means, and standard deviation. The continuous variables also were presented using means and standard deviations. Univariate comparisons were carried out between the bundle elements using a chi-square test. Other variables included were the difference in adherence mean scores per element and the APACHE III score. The independent t-test was used to compare the mean differences in APACHE III scores. The contextual data recorded in Onenote helped to explain the data collected using the checklist.

3.7 Phase 2 Qualitative data collection and analysis

The research setting for Phase 2 (Study 3) was the same as for Study 2, two ICUs (ICU A and ICU B) in Victoria. Phase 2 of this research comprised of a qualitative study using semi-structured interviews. The interview questions were developed using the Phase 1 results and findings. Semi-structured interviews are essential when a researcher aims to increase understanding of other results (Morse, 2012), helping the researcher to explore a specific issue in-depth and allowing participants to express their thoughts (Morse, 2012).

3.7.1 Phase 2 Data collection

3.7.1.1 Phase 2 Sample

A purposive sample of registered nurses and doctors working in ICU A and ICU B were interviewed for this study. Doctors were included based on literature, which stated the importance of multidisciplinary team in the implementation and adherence with evidence-based guidelines to prevent VAE (see Section 1.3 and 2.5).

According to Creswell & Plano Clark (2018), when using explanatory sequential design, it is recommended to collect data from the same source for Phases 1 and 2, as Phase 2 results give context to Phase 1 results. In Phase 1, Study 2, RN and doctor VAE prevention practices were reviewed through the patient's medical records. The study sample for Phase 2 was a subset of Phase 1, Study 2 (RNs and doctors). It is recommended to use a smaller sample size compared to quantitative as the aim of the explanatory sequential design is not to compare but to collect enough data to draw

meaningful themes that will explain selected quantitative results (Creswell & Plano Clark, 2018). The purposive sample involves a maximum variation in the selection of participants to facilitate diversity in perspectives (Polit & Beck, 2004). The participants were of different experience levels in the ICU (ANUM, CNE, CNS, medical consultants, medical registrars, and RNs), which facilitated diverse views.

3.7.1.2 Phase 2 Development of interview schedule

The interview questions were developed based on the results of Phase 1 studies and the literature review. The questions focused on facilitators and barriers to the use of evidence-based guidelines in the prevention of VAE in the ICU (see interview schedule Appendix F).

3.7.1.3 Phase 2 Recruitment

Advertisement posters with research intentions were displayed on notice boards in the two ICUs to advertise the research project. Information on the poster included the research project title, the aim, and details of how to contact the researcher if they were interested in being part of the study (see Appendix G). An email was also sent to all nurses and doctors in the ICUs, inviting them to contact the researcher if they were interested (see Appendix H). The researcher aimed to recruit participants until data saturation was achieved.

3.7.1.4 Phase 2 Data collection procedure

Before each interview, the researcher explained to the participant the aim of the research, expectations of participants and confidentiality, before seeking consent. The details of the explanation were also provided in the participant explanatory statement, which accompanied the consent form given to the participant prior to the interview (see Appendix I). Each participant was invited to sign a consent form indicating that they understood the purpose of the research and that they were willing to participate. Interviews were conducted at a time suitable to the participant.

Semi-structured interviews were used for data collection. The semi-structured questions comprised of general themes of the research topic, target issues and specific questions, which helped the researcher to remain focused on the study issue. The questions started with “how” and “what” to facilitate spontaneous description from the participant (Charmaz, 2006; Whiting, 2008). The individual interviews and semi-structured questions created an environment that encouraged participants to discuss and explore participants’ experience in an open-ended discussion (Speziale Streubert & Carpenter, 2003). It enabled the researcher to ask guiding questions and allowed uninterrupted responses.

Individual interviews were essential for exploring facilitators and barriers to practice, as participants might not want to talk about such matters in a group environment (Speziale Streubert & Carpenter, 2003). However, the interviews and data analysis are time-consuming and resource intensive (Morse, 2012). The interviewer has to be skilled and able to ask follow-up questions during the interview (Whiting, 2008). There

was also a possibility of interviewer effect, when the participants respond according to how they perceive the interviewer (Diefenbach, 2009). Nevertheless, the number of interviews was increased, asking the same questions to different participants until a pattern emerged, with no new findings were emerging. The researcher conducted two practice interviews before the actual data collection to improve interview techniques and to receive feedback (Roberts, Priest & Traynor, 2006). The interviews were 15 to 41 minutes in duration, which demonstrates the diversity in participants' responses to questions.

Each interview was audio-recorded after obtaining consent from the participant. The researcher also took some notes during the interview to prompt follow-up of some ideas. The data were analysed concurrently with data collection. The researcher conducted interviews until data saturation. Qualitative researchers often use data saturation as a criterion for the number of participants used in a study (Saunders et al., 2018). It is a point in data collection when no new data is gathered in the interviews, when new data repeat what was collected in previous interviews (Saunders et al., 2018).

3.7.2 Phase 2 Qualitative data analysis

The transcribed data were analysed using thematic analysis. Thematic analysis is a qualitative method used for 'identifying, analysing and reporting patterns' (themes) generated from the data (Braun & Clarke, 2006, p.79). The thematic analysis does not rely on the pre-existing theoretical framework as other methods but it can be used with a variety of frameworks, which makes it a more accessible approach (Braun & Clarke,

2006). It is useful when exploring under-researched areas in health service studies because it helps to provide a rich thematic description of the data (Braun & Clarke, 2006). Therefore, the six phases of thematic analysis were used for data analysis in this study (see Table 3.5).

Table 3.5 Phases of thematic analysis

Phase	Description of the process
1. Familiarisation with data	Transcribing data, reading and re-reading the data, noting down initial ideas or short memos.
2. Generating initial codes	Coding interesting features in a systematic way, collating data relevant to each code.
3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes	Checking in the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes	Ongoing analysis to refine themes and the overall story the analysis tells; generating clear definitions and names for each theme.
6. Producing the report	The final analysis: selection of vivid, compelling extracts examples, the final analysis of selected extracts, relating back to the research question and literature, producing a scholarly report of the analysis.

(Braun & Clarke, 2006)

A professional, experienced transcriber transcribed the interviews. The transcripts were checked for accuracy and consistency between files by the researcher and the supervisors, thereby enhancing rigour (Creswell & Plano Clark, 2018, Graineheim & Lundman, 2003). The transcripts were read and verified against the audio files. The data were read and re-read to gain an overall impression. The transcripts were analysed using NVivo, a qualitative data analysis program (QSR International, 2018).

The application of the rules built in NVivo help to increase data reliability (Roberts, Priest & Traynor, 2006). The initial thoughts were recorded as short memos in Nvivo. It is essential to write memo notes as a first step as they would later form broader categories such as codes (Braun & Clarke, 2006). Single words or short notes, that is, meaningful units in line with the aim of the study, were condensed and coded. The coded phrases were extracted and sorted into groups based on similar content. The coded phrases were abstracted into sub-themes, which were further abstracted into themes that link substantial portions of the text together (Braun & Clarke, 2006). The themes were reviewed and refined according to the research questions and aim. The individual transcripts were analysed separately. The data were organised and reported according to healthcare professionals and the main themes which were identified from the interviews. All steps in the analysis and the created subthemes and themes were examined concurrently and independently by the research group, to ensure trustworthiness. The research group consisted of one student (myself), and three supervisors (two Associate Professors and One Professor) employed by Monash University. The supervisors all have massive experience in qualitative research. The supervisors read the transcripts, listened to the audio files and examined the created themes and subthemes. Quotations with pseudonym names were used in presenting the findings to allow the reader to judge the trustworthiness of the interpretations (Anderson, 2010; Braun & Clarke, 2006).

3.7.3 Phase 2 Establishing rigour

Ensuring the quality and rigour of a research project is essential. Rigour is different in quantitative and qualitative data (Creswell & Plano Clark, 2011) but the provision of

quality data, results, and interpretation is the shared aim. This section will discuss the steps taken to analyse the data and maintain rigour. The data were collected using semi-structured interviews, that helped with reliability of the data and shortcomings were recognised. The sample of the qualitative study was purposefully selected to ensure a variety of perspectives from different healthcare professionals. This sampling technique provides provision for findings which can be transferable (Polit & Beck, 2014). The authenticity of the results depends on the sample selection and the ability of the interviewees to express themselves freely (Polit & Beck, 2014). The interviews were recorded; audio files were listened to repeatedly and transcribed. A logbook with notes taken during interviews to direct questioning was maintained throughout the data collection and analysis stages.

According to Polit and Beck (2014), credibility of the data is determined by the manner it is interpreted. The main aspects of credibility are determined by the researchers having extensive involvement in the domain or setting, data source triangulation, and regular peer review (Polit & Beck, 2014). The transcripts were double checked against the audio recordings by the research team. The codes and themes identified were discussed and verified with the research team.

Transferability refers to the extent that the research results can be used in other settings or populations and is indicative of trustworthiness of the research (Graneheim & Lundman, 2004; Liamputtong, 2020). Transferability also relates to various aspects of the study, such as research participants, background and context (Graneheim & Lundman, 2004; Liamputtong, 2020).

Dependability is used to assess trustworthiness of qualitative research. It shows that the data can be used in similar studies in the future, and it has to be confirmed by external reviewers based on assessment of data (Liamputtong, 2020; Roberts, Priest & Traynor, 2006).

3.8 Ethical considerations and study governance

The research was undertaken according to the National Statement on Ethical Conduct in Human Research (2007) (updated 2018) (National Health and Medical Research Council, 2018). This study involved humans and medical records of humans. This study was classified under low-risk human research as low/negligible risk of harm for the participants.

A low/ negligible risk ethics application was submitted to an individual health service ethics committee. The ethics application was approved on the 26/06/2018 (study reference HREC/18/XXX/417) (see Appendix J). The study reference number redacted to protect anonymity of the site. The site-specific research governance approval was also obtained at each site. The research project was also approved by the University Human Research Ethics Committee; Project number 14750 (Appendix K) and ACCCN (see Appendix L).

The ethical matters in connection with reducing research risk were considered before and during data collection and analysis. Five ethical elements were considered in the planning and conduct of the study: i) voluntary participation, ii) confidentiality and anonymity, iii) privacy, iv) informed consent, and v) no harm (De Vaus, 2002).

3.8.1 Voluntary participation

The participants for Study 1 and Study 3 were informed that participating in the study was voluntary. All participants received a participant explanation statement which explained in detail the study project. It also highlighted that the decision to participate or not was not going to jeopardise their employment. Study 1 participants were informed that they could withdraw from the study until the point at which their data could not be identified as theirs. Study 3 participants were told they could withdraw before data were transcribed.

3.8.2 Confidentiality and anonymity

The survey was conducted online, participation was anonymous, and no personal data were collected. The survey database was password protected, accessible to the researchers only. The medical records information was de-identified during data collection. The interviews were conducted face to face, recorded and transcribed. The participants were assured that all the data collected were de-identified, coded, aggregated and saved in a password secured database. The data were de-identified and stored on a password-protected database accessible to the researchers only. All hard copy materials were stored in a locked filing cabinet.

3.8.3 Privacy

For Study 2, nurses' and doctors' confidentiality was maintained. Gaps in care were aggregated and reported weekly to the Nurse in Charge. It was also highlighted to the nurses and doctors that the project was a quality audit, not targeting individual

practice. In Study 3, privacy was maintained; interviews were conducted outside of working hours and away from the workplace in a private hospital office in another building. The participants contacted the researcher to confirm their interest in participating in the study. All the data collected were accessed by the researcher and the researcher supervisors only. The data will be stored for five years, according to Monash University data storage guidelines, on a secure password locked database.

3.8.4 Informed consent

In Phase 1, participants were informed, via the participation explanatory statement, that completing the survey would be regarded as implied consent to participate in the research (De Vaus, 2002). The participants were informed that they could withdraw from completing the survey without an explanation. They were also told that, once they had submitted the survey, they could not withdraw from the study, as it was anonymous.

Consent for the medical records review was waived by the health services, as data reviewed were primarily collected for patient care. An email notification was sent to the nurses and doctors informing them of the study. Consent for all the studies was also obtained from the organisations where the research was conducted.

In Phase 2, participants were given the aims and objectives of the study; they were informed of the risks and benefits of participation. The participants were then able to make an informed decision on whether to participate. The participants interviewed signed written consent, an agreement to participate in the study before the interview.

Participants were also told they could withdraw from the study any time before the data were transcribed.

3.9 Data integration

Integration can occur through linking the methods of data collection and analysis (Creswell & Plano Clark, 2011). Linking of this study occurred in various ways: i) connection between quantitative and qualitative samples, ii) building (quantitative studies informed data collection approach of qualitative study), and iii) merging of quantitative and qualitative datasets together for analysis (Fetters et al., 2013). The data were sequentially integrated by linking the qualitative findings to explain the selected quantitative results (Fetters et al., 2013). The survey and medical records review results helped to identify areas which required further explanation and informed the development of an interview schedule for qualitative data collection. The interview data were analysed independently. The integration of the results was achieved through the adjoining and weaving narrative approach outlined by Creswell & Plano Clark (2018). This approach facilitated the analysis and reporting of quantitative results first, then connecting qualitative findings using key themes.

3.10 Chapter summary

The study methodology and design were discussed in this chapter, including the reasons why the explanatory sequential design was suitable for the study and how it was modified. The reasons why the primary focus was on quantitative data collection were discussed. Phase 2 findings provided the context for Phase 1 data.

The Australia-wide survey of the nurses provided insight to nurses' knowledge of evidence-based guidelines to prevent VAE in the ICU. The two ICUs included in the sample are examples of the range of ICUs in Victoria where patients are mechanically ventilated for more than 48 hours. The appropriate research ethics was approved for all the studies. The data collected for Phase 1 studies were collected concurrently. The Phase 1 data were statistically reported, and the gaps identified in the results guided the Phase 2 data collection. The findings of the Phase 2 study were thematically analysed. Finally, the data for Phase 1 and Phase 2 were integrated. In the next chapter, the results of the online survey, Study 1 Phase 1, will be presented.

Chapter Four – Phase 1, Study 1 Results

A manuscript reporting these findings has been accepted for publication:

Madhuvu, A., Endacott, R., Plummer, V., & Morphet, J. (2020). Nurses' knowledge, experience and self-reported adherence to evidence-based guidelines for prevention of ventilator-associated events: A national online survey. *Intensive & Critical Care Nursing*, 102827. doi:10.1016/j.iccn.2020.102827

4.1 Introduction

An explanatory sequential design was used to explore the nurses' knowledge and adherence to evidence-based guidelines in the prevention of VAE in the ICU. In this chapter, Phase One survey results are reported in four sections: study response rate, demographic data, respondents' knowledge of, and their self-reported adherence to evidence-based guidelines to prevent VAE in the ICU.

The data were collected using three different sources (see Chapter 3, Section 3.5): two ICUs and the ACCCN membership. For ease of reference, the three sources of data collection are referred to as Cohorts A, B and C, respectively. The results are presented alongside each other for comparison purposes where appropriate, and summary data combining the three cohorts are also presented. Descriptive statistics, comparisons and correlations were conducted between dependent and independent variables.

4.2 Response rate

The overall response rate for all three cohorts was 27.3% (294/1075). However, there was a range of response rates from different cohorts, ranging from 23.3% to 45.8%. Response rates for Cohorts A and B were 45.8% (71/155) and 30.8% (37/120), respectively. The response rate from Cohort C was 23.3% (186/800). The total sample represents the number of nurses who received an invitation to participate in the survey; however, some were ineligible and not included in further analysis. Further, not all ACCCN members would have consented to receive research emails, and the total number of the members who consented was not disclosed.

The majority of the respondents answered all questions, distributed as follows: Overall: 95.4%, Cohort A: 95.8%, Cohort B: 91.9%, and Cohort C: 98.4%. Most of the respondents were from New South Wales (NSW) and Victoria (VIC) (see Table 4.1) where the proportion of the population is largest, and there are more ICUs than in the other States/Territories. For each of the remaining States, the number of respondents was less than 10% of the study sample.

Table 4.1 Overall respondents per State (*N* = 288)

Australian States	*n*	% of total sample
Australian Capital Territory (ACT)	11	3.8
New South Wales (NSW)	69	24.0
Northern Territory (NT)	6	2.1
Queensland (QLD)	18	6.3
South Australia (SA)	18	6.3
Tasmania (TAS)	6	2.1
Victoria (VIC)*	*153	53.1
Western Australia (WA)	7	2.4

Note: i) ***Victoria has the largest numbers due to direct hospital recruitment.

ii) Six did not indicate their State, so they were excluded in this table

4.3 Demographic data

Demographic characteristics are summarised in Table 4.2, below. There is variability in denominators as some of the respondents did not answer all the questions; some respondents did not fit in the specific categories such as type of postgraduate qualification.

Table 4.2 Demographic characteristics across the three cohorts (*N* = 294)

Age	Cohort A (*N*=71) *n (%)*	Cohort B (*N*=37) *n (%)*	Cohort C (*N*=186) *n (%)*	Overall Sample (*N*=294) *n (%)*
21-30	15 (21.1)	7 (18.9)	36 (19.4)	58 (19.7)
31-40	34 (47.9)	16 (43.2)	68 (36.5)	118 (40.1)
41-50	20 (28.2)	11 (29.7)	46 (24.7)	77 (26.2)
51+	2 (2.8)	3 (8.1)	36 (19.4)	41 (13.9)
Years experience in ICU	**(*n*=70)**	**(*n*=36)**	**(*n*=184)**	**(*n*=290)**
<1	5 (7.1)	3 (8.3)	6 (3.3)	14 4.8)
1-5	23 (32.9)	14 (38.9)	53 (28.8)	90 (31.0)
>5-10	21 (30.0)	9 (25.0)	43 (23.4)	73 (25.2)
>10	21 (30.0)	10 (27.8)	82 (44.6)	113 (39.0)
Postgraduate qualification	**(*n*=68)**	**(*n*=37)**	**(*n*=184)**	**(*n*=289)**
Yes	48 (70.6)	26 (70.3)	139 (75.5)	213 (73.7)
No	20 (29.4)	11 (29.7)	45 (24.5)	76 (26.3)
Special title in ICU	**(*n*=66)**	**(*n*=37)**	**(*n*=179)**	**(*n*=284)**
Yes	25 (37.9)	12 (32.4)	64 (35.8)	182 (64.1)
No	41 (62.1)	25 (67.6)	115 (64.2)	102 (35.9)
Working in more than one ICU	**(*n*=68)**	**(*n*=37)**	**(*n*=184)**	**(*n*=289)**
Yes	19 (27.9)	6 (16.2)	33 (17.9)	58 (20.1)
No	49 (72.1)	31 (83.8)	151 (82.1)	231 (79.9)
Both	6 (8.8)	2 (5.4)	12 (6.5)	20 (6.9)
Number of beds in ICU	**(*n*=71)**	**(*n*=37)**	**(*n*=184)**	***(*n*=289)**
< 5	-	-	1 (0.5)	*1 (0.5)
5 -15	-	37 (100)	84 (45.7)	*121 (41.9)
> 15	71 (100)	-	99 (53.8)	*167 (57.8)

Note: i) Different denominators as some respondents did not answer all questions,

ii) * Number of participants

4.3.1 Age

The respondents' age ranged from 21 to greater than 50 years. More than a third of the respondents in all cohorts were aged 31-40 years (*n* = 118, 40.1%) and less than 10% were aged 21-25 years. Nearly half (*n* = 35, 49.3%) of the respondents in Cohort A were aged 26-35 years. In Cohort B, more than a third (*n* = 16, 43.2%) were aged 31- 40 years while most age categories for Cohort C respondents were between 10% and 20% except for the range 21-25 years (*n* = 10, 5.4%).

4.3.2 Postgraduate qualification

Nearly three quarters (*n* = 213, 73.7%) of respondents had a postgraduate qualification in intensive care nursing, mostly at the postgraduate certificate level. A small number, less than 5% of the respondents, had other postgraduate qualifications in other nursing specialities.

4.3.3 Years of experience

Most of the respondents (*n* = 186, 64.1%) across all three cohorts, had more than five years of nursing experience in ICU. Every cohort in this study had more than 50% respondents with more than five years of nursing experience in ICU; Cohort A: (*n* = 42, 60%), Cohort B: (*n* = 19, 52.8%) and Cohort C: (*n* = 125, 67.9%). Less than 10% of all the respondents had less than one year of nursing experience across all cohorts.

4.3.4 Nursing titles

The respondents had different job titles, including ANUM, CNS, Intensive Care Liaison NUM and Research Nurse. The respondents were grouped into two categories, specialist title and no specialist title to enable comparison of the results with other published studies (Labeau et al., 2008; H.-L. Lin et al., 2014). More than a third (*n* = 182, 64.1%) of the respondents across all three cohorts had a specialist title in ICU.

4.3.5 Governance of ICU

The majority (*n* = 231, 79.9%) of the overall respondents were employed in one ICU, mostly public ICU (*n* = 244, 84.4%), while less than 20% worked in both public and private ICUs. Nearly all (*n* = 288, 99.5%) of the respondents were working in Level 2 (5-15 beds) and Level 3 (>15 beds) ICUs. In Cohort C there were more respondents from ICUs with >15 beds (*n* = 99, 53.8%) compared to ICUs with 5-15 beds (*n* = 84, 45.7%).

4.4 Nurses knowledge of evidence-based guidelines

The second section of the questionnaire explored respondents' knowledge of VAE evidence-based guidelines. Figure 4.1 illustrates the percentages of respondents who responded correctly to the questions.

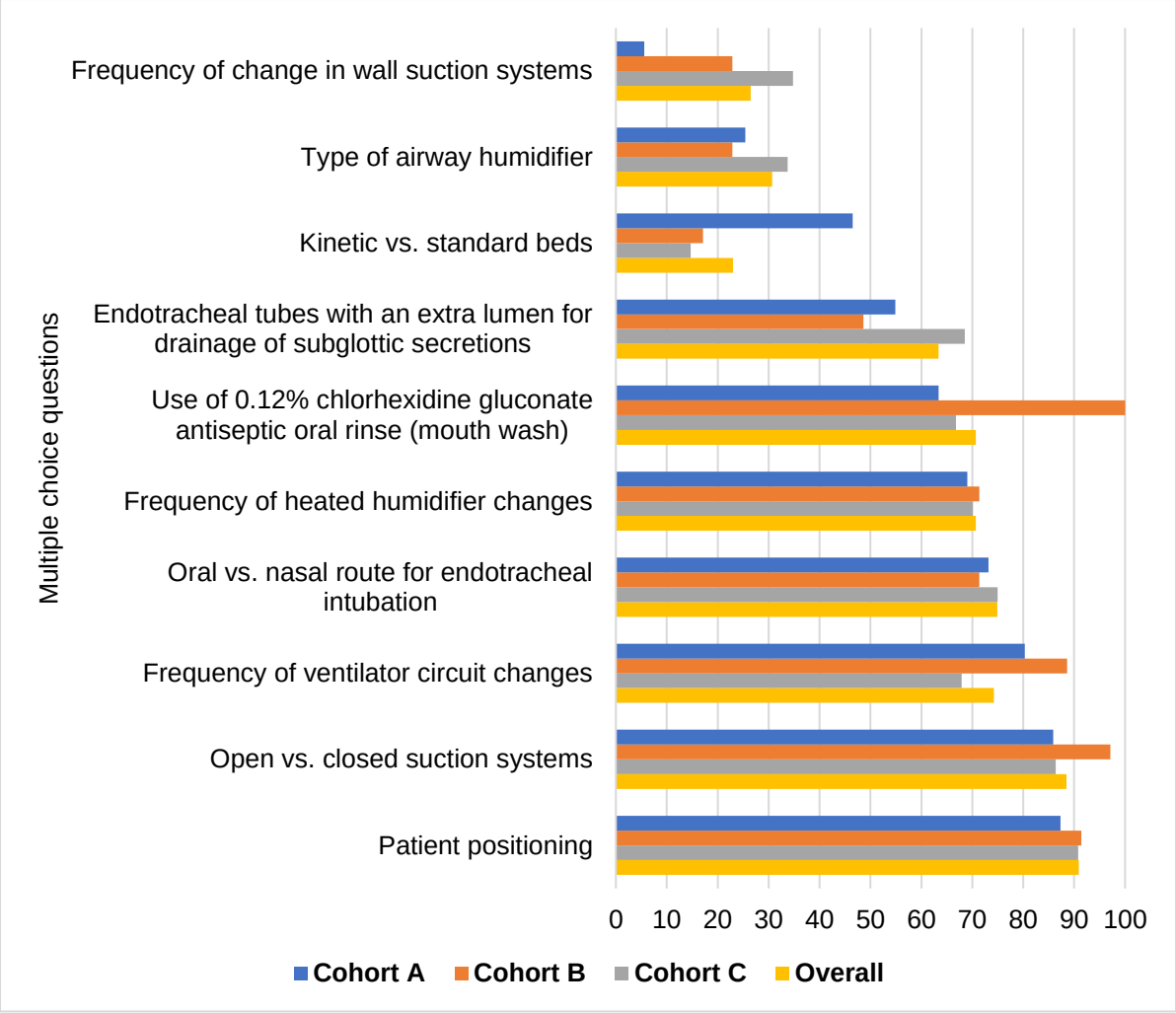

Figure 4.1 Percentages of correct responses to the knowledge questions

There were two questions which the majority of respondents answered correctly: Q9 'the positioning of mechanically ventilated patients in bed' (*n* = 261, 90.9%) and Q5 ‘open versus closed suction systems' (*n* = 254, 88.5%). However, there were three questions which more than two thirds of the respondents did not answer correctly: Q8 ‘the use of kinetic versus standard beds’ (*n* = 66, 23%), Q6 ‘frequency of change of wall suction system’ (*n* = 76, 26.5%) and Q3 ‘type of airway humidifier’ (*n* = 88, 30.7%).

The main difference in the three cohort responses was on Question 10. All respondents in Cohort B (*n* = 33, 100%) answered Question 10 correctly, 'the use of 0.12% chlorhexidine gluconate antiseptic oral rinse (mouth wash)'. In contrast, two thirds of respondents in both Cohort A: (*n* = 45, 63.4%) and Cohort C: (*n* = 123, 66.8%) responded to Question 10 correctly. The following subsections will present further analyses of the knowledge scores and the respondent's characteristics.

4.4.1 Nurses' total knowledge score of the evidence-based guidelines

The nurses' knowledge of evidence-based guidelines was assessed by multiple-choice questions; correct answers were assigned one mark each, with a total possible mark of ten. The figures, below, show the respondents' knowledge score out of ten per cohort (4.2) and per State/Territory (4.3).

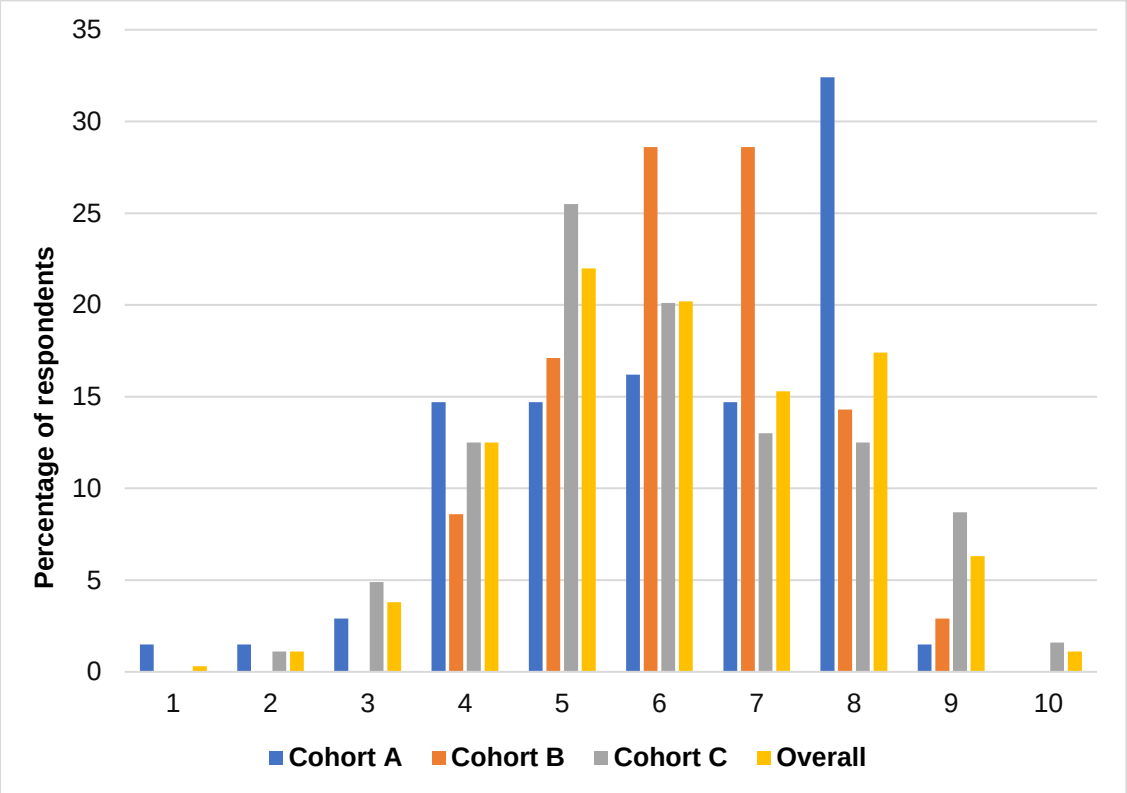

Figure 4.2 Respondents' knowledge score by cohort

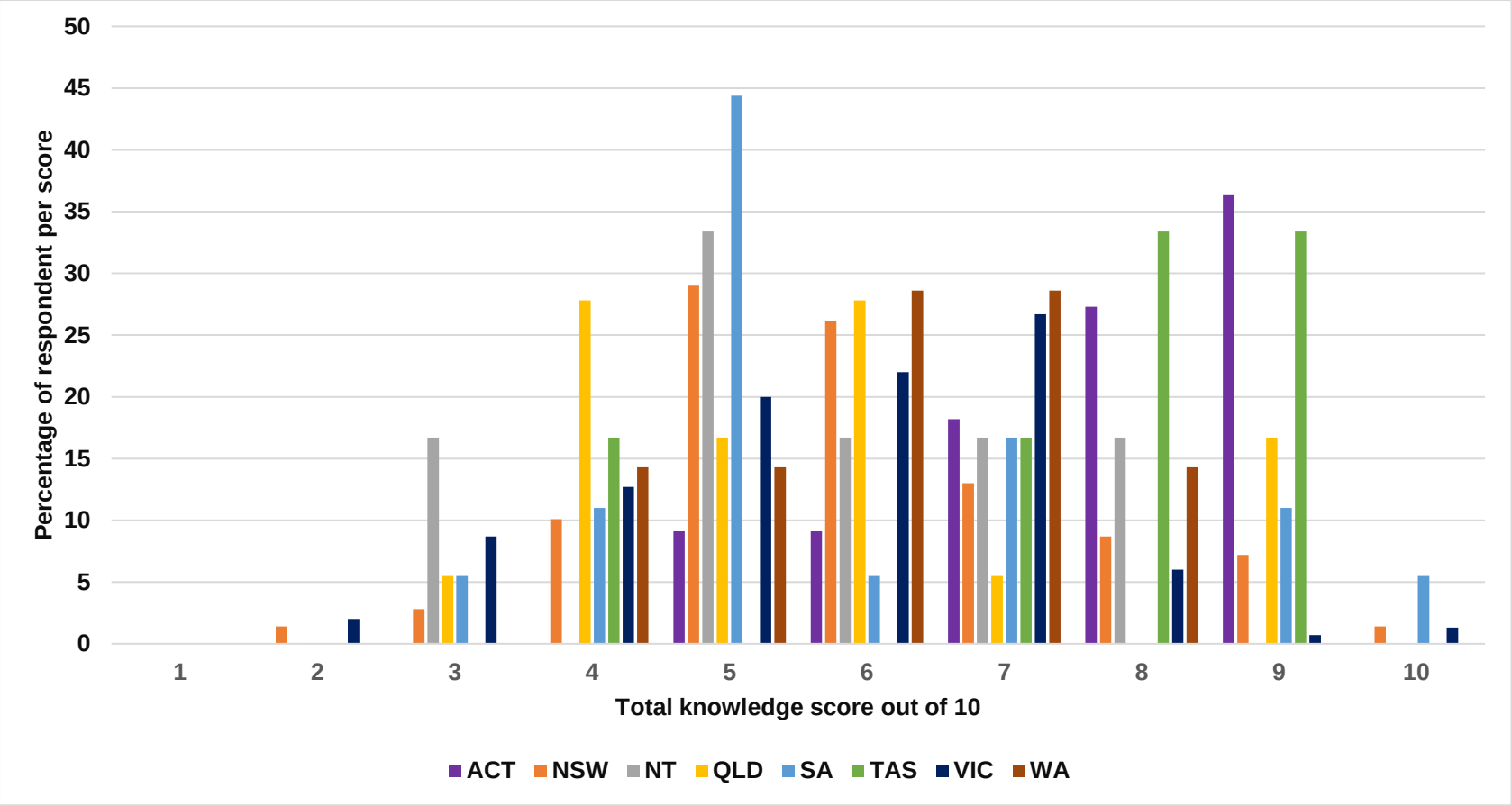

Figure 4.3 Respondent knowledge scores by State/Territory

Note: ACT = Australian Capital Territory; NSW = New South Wales; NT = Northern Territory; QLD = Queensland; SA = South Australia; TAS = Tasmania; VIC = Victoria; WA = Western Australia.

The distribution of the total knowledge scores were unevenly distributed across all the States/Territories, demonstrated by the Kolmogorov–Smirnov test *p* value <0.001, hence, non-parametric tests were used for analysis. Potential scores ranged from zero to 10. The overall cohort scores were positively skewed, clustered towards the left side of the graph with low scores. The overall median score for all the respondents was six, (IQR: 5-7). Table 4.3, below, illustrates the statistical analysis of the median scores and the respondents' characteristics, using Mann Whitney U and Kruskal Wallis tests. The results in Table 4.3 will be described in more detail in the following subsections.

Table 4.3 Comparison of median scores according to respondents' characteristics

	Cohort A (*N*=68)		Cohort B (*N*=34)		Cohort C (*N*=184)		Overall (*N*=286)	
Characteristics	**Median (IQR)**	***p* value**	**Median (IQR)**	***p* value**	**Median (IQR)**	***p* value**	**Median (IQR)**	***p* value**
Total respondents median score	**6 (5-7)**	**-**	**6 (5-7)**	**-**	**6 (5-7)**	**-**	**6 (5-7)**	**-**
Postgraduate qualification$		<0.001		0.036		0.001		0.006
Yes	7 (6-8)		7 (6-8)		6 (5-7)		7 (6-8)	
No	5 (4-6)		6 (5-7)		5 (4-6)		5 (4-6)	
Years of ICU experience*		0.297		0.183		0.184		0.431
1 – 5 years	5.5 (5-7)		6 (5-7)		5 (4-6)		6 (5-7)	
>5 -10years	6 (5-7)		7 (5-7)		6 (5-8)		6 (5-7)	
>10 years	7 (6-8)		7 (5-7)		6 (5-7)		6 (5-7)	
Specialist role in ICU$		0.421		0.745		0.049		0.386
Yes	7 (6-8)		6 (6-7)		6 (5-8)		6 (5-7)	
No	6 (5-7)		6 (5-7)		5 (4-6)		6 (5-7)	

Note: i) *p*-value significant at 0.05 level. ii) $ Mann Whitney U test iii) * Kruskal Wallis test

4.4.2 Postgraduate qualification in intensive care nursing

There was a significant difference in the knowledge score of participants with a postgraduate qualification (*Mdn* = 7; IQR: 6-8) compared to those without a postgraduate qualification (*Mdn* = 5; IQR:4-6; *U* = 9584, *z* = 2.764, *p* = 0.006, *r* = 0.16, *n* = 286). In Cohorts A and B, respondents with a postgraduate qualification in intensive care nursing had a higher median knowledge score (*Mdn* = 7; IQR: 6-8). Cohort C respondents with a postgraduate qualification had a lower median score than Cohorts A and B (*Mdn* = 6, IQR: 5-7) (see Table 4.3). Linear regression was also calculated to predict total knowledge score, based on postgraduate qualifications in intensive care nursing. Table 4.4 illustrates the statistical significance per cohort.

Table 4.4 Linear regression using median knowledge score

	B ± Standard error	95% confidence interval	*p* value	B ± Standard error	95% confidence interval	*p* value	B ± Standard error	95% confidence interval	*p* value
	COHORT A			**COHORT B**			**COHORT C**		
Postgraduate qualification	0.47 points ± 0.28[b]	0.63 - 1.75	<0.001	0.37 points ± 0.43[b]	0.11 - 1.87	0.028	0.25 points ± 0.29[b]	0.38 - 1.53	0.020
Years of experience in ICU	0.15 points ± 0.47[b]	-0.361 - 1.50	0.226	0.32 points ± 0.25[b]	-0.04 - 0.99	0.067	-0.01 points± 0.15[b]	-0.31 - 0.29	0.913
Specialist role in ICU	0.50 points ±0.45[b]	-0.40 – 1.40	0.271	0.28 points ± 0.45[b]	-0.64 – 1.20	0.535	0.57 points ± 0.27[b]	0.04 – 1.11	0.036

Note: [b] On a total of ten questions (one point each)

There was a statistically significant association between postgraduate qualification and knowledge score across all cohorts (95% CI: 0.11-0.99, p = 0.014), a weak, positive association across all cohorts (r = 0.145) and also a weak association in Cohort C (r = 0.235). Cohorts A and B illustrated a moderate positive association (r = 0.465 and r = 0.431, respectively). An independent relationship between nurses' total scores on the knowledge questionnaire and postgraduate qualification in intensive care nursing was illustrated by R^2 = 0.021 across all cohorts: Cohort A: R^2 = 0.216, Cohort B: R^2 = 0.138 and Cohort C: R^2 = 0.055. The postgraduate education explains variation in scores; total Cohorts: 2.1%, Cohort A: 21.6% of the variation in scores, Cohort B: 13.8% of the variation and 5.5% of the variation in Cohort C respondents. The small variation suggests that there are other factors that influence nurses' knowledge of evidence-based guidelines to prevent VAE in ICU. The analysis also showed that a postgraduate qualification in intensive care nursing was independently associated with an increase in total score on the ten multiple-choice questions on VAE prevention in the ICU; total Cohort: 0.553 points, Cohort A: 1.194 points, Cohort B: 0.989 points and Cohort C: 0.956 points.

4.4.3 Years of experience in intensive care nursing

The Kruskal-Wallis test was used to compare nurses' knowledge scores and their years of experience in the ICU (see Table 4.3). There was no statistically significant difference between the years of experience and the respondents' knowledge of VAE prevention in the ICU across all three Cohorts χ^2 (2, n = 284) = 1.685, p = 0.431 or in individual cohorts; Cohort A: χ^2 (2, n = 68) = 2.427, p = 0.297, Cohort B: χ^2 (2, n = 34) = 3.398, p = 0.183, Cohort C: χ^2 (2, n = 184) = 3.390, p = 0.184. There was no

significant difference in the median scores across all cohorts. The respondents' years of experience in the ICU was not associated with their total knowledge scores, no statistically significant difference across all cohorts; (95% CI: -0.18 - 0.28, $p = 0.674$).

4.4.4 Specialist role in ICU

The differences between the total knowledge scores of nurses with a specialist role and those without a specialist role were investigated using the Mann Whitney U test. The knowledge of respondents who had a specialist role in the ICU had no statistically significant difference to those without a specialist role across the three cohorts ($U = 9\ 687$, $z = 0.866$, $p = 0.386$). The same was illustrated in the cohorts; Cohort A: $U = 572$, $z = 0.805$, $p = 0.421$ and Cohort B: $U = 148$, $z = 0.357$, $p = 0.745$. In Cohort C, there was a statistically significant difference ($U = 4\ 322$, $z = 1.963$, $p = 0.049$) between nurses with specialist role in the ICU than those without. The respondents who had a specialist role had a better median score than those without in Cohort C (Table 4.3).

The linear regression analysis illustrated a weak, positive association between nurses with a specialist role in intensive care nursing and total knowledge score among the Cohort C respondents only ($r = 0.157$). The association was statistically significant ($p = 0.036$), $R^2 = 0.025$, which means a specialist role in the ICU explains 2.5% of the variation in score. A specialist role in the ICU was associated with an increase in the total score of 0.571 points (CI 0.37-1.11) in Cohort C respondents. However, there was no statistically significant association between nurses with a specialist role in intensive care nursing and total knowledge score in Cohort A and Cohort B

respondents, as illustrated in Table 4.4. The overall sample showed no association (95% CI: -0.20 – 0.62, p = 0.308).

4.5 Nurses' adherence to evidence-based guidelines

Section 3 of the questionnaire consisted of ten three-scaled questions, as shown in Table 4.5 below. The table presents the number and total percentages of respondents' self-reported adherence to evidence-based guidelines to prevent VAE. Most of the respondents reported a positive overall adherence across the ten three-scaled questions. The three-scale results (Table 4.5) are discussed in more detail in sections 4.5.1 to 4.5.5. Some of the results are discussed alongside the knowledge scores (refer to Figure 4.1).

Table 4.5 Percentages of respondents' adherence to evidence-based guidelines

	Guidelines	Done completely				Not done completely and accurately				Not done			
		A (%)	B (%)	C (%)	Overall (%)	A (%)	B (%)	C (%)	Overall (%)	A (%)	B (%)	C (%)	Overall (%)
1	I perform oral care for patients being mechanical ventilated.	85.1	85.3	94.0	90.9	14.9	14.7	6.0	9.1	0.0	0.0	0.0	0.0
2	I position mechanically ventilated patients in semi-fowlers position.	80.6	79.4	87.0	84.6	14.9	17.7	10.3	12.2	4.5	2.9	2.7	3.2
3	I monitor the cuff pressure of the endotracheal tube for my patient at least once every 8 hours.	80.6	67.6	82.9	81.4	14.9	32.4	16.6	17.2	4.5	0.0	0.5	1.4
4	I perform a daily assessment of patient readiness for extubation.	77.6	58.8	90.8	83.2	13.4	41.2	9.2	14.7	9.0	0.0	0.0	2.1
5	I wash my hands before and after contact with the patient.	76.1	64.7	89.7	83.5	23.9	35.3	10.3	16.5	0.0	0.0	0.0	0.0
6	I wash my hands after performing endotracheal suctioning.	76.1	50.0	88.1	80.7	20.9	50.0	11.4	18.2	3.0	0.0	0.5	1.1
7	I wash my hands before performing endotracheal suctioning.	71.6	38.3	73.9	69.1	26.9	58.8	23.9	28.8	1.5	2.9	2.2	2.1
8	I use normal saline irrigation for endotracheal suctioning.	43.4	17.7	48.4	43.5	28.3	17.6	19.5	21.4	28.3	64.7	32.1	35.1
9	I perform oral care with chlorhexidine solution on mechanically ventilated patients daily.	35.8	76.5	69.6	62.5	22.4	23.5	16.8	18.9	41.8	0.0	13.6	18.6
10	I use sterile gloves for open system endotracheal suctioning.	17.0	0.0	22.8	18.9	16.4	11.8	36.4	28.8	66.6	88.2	40.8	52.3

Note: **Cohort A: *N* = 67, Cohort B: *N* = 34. Cohort C: *N* = 184; Overall = *N* = 285**

Table 4.6 illustrates the association between nurse's qualification and adherence to evidence-based guidelines across all cohorts. The key findings from Table 4.6 will be explored below. A chi-square test for independence was used for this analysis.

Table 4.6 Nurses with postgraduate qualification adherence to evidence-based guidelines

	Guideline	χ^2	df	*p*-value	Effect size *(phi)*
1	**I perform oral care for patients being mechanical ventilated.**	1.016	1	0.439	0.060
2	**I position mechanically ventilated patients in semi-fowlers position.**	0.623	1	0.515	0.047
3	**I monitor the cuff pressure of the endotracheal tube for my patient at least once every 8 hours.**	7.015	1	0.014*	0.157
4	**I perform a daily assessment of patient readiness for extubation.**	0.350	1	0.682	0.035
5	**I wash my hands before and after contact with the patient.**	0.685	1	0.495	0.049
6	**I wash my hands after performing endotracheal suctioning.**	0.005	1	1.000	0.004
7	**I wash my hands before performing endotracheal suctioning.**	1.220	1	0.350	0.065
8	**I use normal saline irrigation for endotracheal suctioning.**	3.997	1	0.046*	-0.118
9	**I perform oral care with chlorhexidine solution on mechanically ventilated patients daily.**	3.052	1	0.081	0.103
10	**I use sterile gloves before open system endotracheal suctioning.**	1.622	1	0.277	0.075

Note: *significant *p*-value

4.5.1 Oral care

Oral care was the most adhered to element of the evidence-based guidelines. The majority of the respondents in all cohorts indicated that they performed: *'oral care on mechanically ventilated patients*' 'completely' (*n* = 259, 90.9%). However, there was one element that differentiated respondents' practice: *'the use of chlorhexidine solution for oral care for mechanically ventilated patients daily*'. In Cohort A, just over a third (*n* = 24, 35.8%) reported using chlorhexidine 'completely' for oral care compared to Cohort B (*n* = 26, 76.5%) and Cohort C (*n* = 128, 69.6%). Overall, over two thirds of respondents reported using chlorhexidine for oral care 'completely'.

In this study, Cohort B respondents' knowledge of the use of chlorhexidine was 100% (see Figure 4.1), which was in alignment with their self-reported practice, where the majority of the respondents reported using chlorhexidine 'completely', (*n* = 26, 76.5%). There was no association between postgraduate qualification and the use of chlorhexidine for oral care across the three cohorts, as illustrated in Table 4.6.

4.5.2 Hand hygiene

The majority of the respondents washed their hands 'completely' before and after endotracheal suctioning across all cohorts: (*n* = 230, 80.7%). More than three-quarters of the respondents in Cohort A and Cohort C washed hands 'completely' before and after contact with the patients; (*n* = 216, 86%), while in Cohort B nearly two-thirds (64.7%) washed their hands 'completely' before and after patient contact.

In this study, respondents who indicated that they washed their hands 'completely' after performing endotracheal suctioning were more than those who washed their hands before suctioning. Less was reported with Cohort B; half of the respondents, (50%) indicated that they washed their hands 'completely' after endotracheal suctioning. There was no statistical association between postgraduate qualifications and hand hygiene, as illustrated in Table 4.6.

4.5.3 Endotracheal tube care

There were differences in the reported monitoring of cuff pressure of the endotracheal tube on mechanically ventilated patients. More than three-quarters of the respondents indicated that they checked endotracheal cuff pressures 'completely' on mechanically ventilated patients (*n* = 232, 81.4%). Less was reported with Cohort B, two-thirds (67.6%), indicated that they checked endotracheal cuff pressures on mechanically ventilated patients 'completely'. However, there was a statistically significant association between nurses who had a postgraduate qualification and the checking of endotracheal cuff pressures on mechanically ventilated patients (χ^2= 7.015, df = 1, *p* = 0.014, phi = 0.157).

Across all cohorts, there were two elements for which 35 to 50% of the respondents reported 'not done' in their nursing practice. The first element was the 'use of sterile gloves before open system endotracheal suctioning'; 52.3% (*n* = 149). The use of normal saline irrigation for endotracheal suctioning was the second element reported 'not done' by more than a third of the respondents across all cohorts; 35.1% (*n* = 100).

However, the respondents who had a postgraduate qualification reported that they ‘completely’ used normal saline irrigation for endotracheal suctioning across the cohorts (χ^2= 3.997, df = 1, *p* = 0.046, phi = -0.118).

4.5.4 Readiness to extubate

More than three-quarters (*n* = 237, 83.2%) of the respondents across all cohorts indicated that they perform a daily assessment for readiness to extubate on the mechanically ventilated patients. In Cohort A and C assessing patients for readiness to extubate practice was higher than in Cohort B respondents who reported just above half (*n* = 20, 58.8%). There was no association between nurses' postgraduate qualification and daily assessment of patient readiness for extubation in the overall sample.

4.5.5 Patient positioning

More than three-quarters of the respondents across the three cohorts indicated that they position mechanically ventilated patients in semi-fowlers position 'completely', (*n* = 241, 84.6%). This finding is in alignment with the correct response to the multiple-choice questions on patient positioning, which the majority of the respondents answered correctly; (*n* = 261, 90.9%). There was no association between patient positioning and postgraduate qualifications of respondents.

4.6 Chapter summary

The data relating to intensive care nurses' knowledge of evidence-based guidelines for VAE prevention and adherence practices have been reported in this chapter. The survey data were collected through three different sources: Cohort A, Cohort B and Cohort C. A total of eight Australian States and Territories were represented in this study sample. NSW and VIC had the most respondents, reflecting the ACCCN membership profile and hospital recruitment (VIC).

There was a diverse number of respondents aged between 21 and 50 plus years with a range of nursing experience, from one year to over 10 years, and respondents with and without postgraduate qualification in intensive care nursing. More than two-thirds of the respondents across the cohorts had a postgraduate certificate in intensive care nursing.

The nurses' median total knowledge score of evidence-based guidelines on prevention of VAE, on the ten multiple-choice questions, was 6/10 (IQR: 5-7) across the three cohorts. The respondents who had a postgraduate qualification had a higher median score than those without, across all three cohorts. The overall respondent years of experience in the ICU and their title in the ICU did not influence their knowledge score in this study.

Oral care was of one of the elements which the majority of the respondents across all three cohorts indicated they performed 'completely' for mechanically ventilated patients. However, there was one element which differentiated the three cohorts: 'the

use of the chlorhexidine solution for mouth care'. There were different levels of adherence reported by the respondents, and different knowledge levels about the use of chlorhexidine were also demonstrated. The respondents from Cohort A and Cohort C reported better adherence to the evidence-based guidelines than respondents from Cohort B. However, Cohort B respondents reported better adherence with the use of the chlorhexidine solution for oral care than Cohort A and Cohort C.

There were two elements of the evidence-based guidelines with the highest numbers of respondents reporting that they do not use: normal saline irrigation for endotracheal suctioning, sterile gloves for suctioning and chlorhexidine for oral care. Some survey questions were answered correctly at one setting but not at another, and the practice of respondents varied across the three cohorts. The differences in respondent practice were explored in the qualitative study and are presented in Chapter Six. The medical records review results will be presented in Chapter Five.

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Chapter Five – Phase 1, Study 2 Results

A manuscript reporting these findings has been accepted for publication:

Madhuvu, A., Endacott, R., Plummer, V., & Morphet, J. (2020). Ventilation bundle compliance in two Australian intensive care units: An observational study: *Australian Critical Care*, 31(5), 311–316. doi.org/10.1016/j.aucc.2020.09.002

5.1 Introduction

In this chapter, the use of the evidence-based guidelines for VAE prevention by healthcare professionals in two ICUs is presented. The specific evidence-based guidelines used were the IHI ventilation bundle with six elements (see Section 3.6.3). The two ICUs were in different healthcare services in Victoria, Australia (ICU A and ICU B; see Section 3.6.3). The evaluation was conducted through the prospective review of medical records of patients who were mechanically ventilated for more than 48 hours in ICU. The medical records were reviewed on three consecutive patient mechanical ventilation days (Days 3, 4 and 5 following the start of mechanical ventilation). The overall review was over three months in each ICU. The data were gathered from patients' medical records: observation charts, medication charts, progress notes, and all other patient care checklists located at the patient's bedside. Ward management documents, such as admission and discharge reports, daily bed capacity, and APACHE III score data, were also reviewed.

In this chapter, the patients' demographic characteristics will be presented, followed by a description of the IHI ventilation bundle adherence for both ICU A and ICU B.

The data are presented combined, but where there were important differences between the ICUs, the data are presented separately. Adherence will be described per element, initially, followed by combined element (bundle) adherence. Only one of the two Victorian ICUs used chlorhexidine for oral care, so this element was excluded in the combined data analysis. The independent variables such age, APACHE III scores met the assumption of normality, so parametric tests were used. Descriptive statistics were used to describe the data (frequencies, means and standard deviations). Inferential statistics were used to examine the relationship and differences between the study variables (chi-square test and independent samples t-test) (see Section 3.6.3). A total of 73 patients were mechanically ventilated for the full three days (Days 3, 4 and 5 following start of ventilation). In this chapter, demographic data (Section 5.2) are provided for the total cohort (*N* = 96), and adherence data are presented separately for the three days, to allow the appropriate denominator to be applied.

5.2 Demographic characteristics

A total of 989 patients were admitted to ICU A and ICU B during the study period. There were 513 admissions to ICU A during the three-month data collection period (22 October 2018 to 23 January 2019) and 376 to ICU B (01 December 2018 to 02 March 2019). ICU A had 22 beds and the mean bed occupancy per day over the three months was 19 (SD = 1.265), illustrating that the majority of the beds were occupied during the document review period. ICU B had 14 beds, the daily mean bed occupancy over the three months was 10 (SD = 0.548).

A total of 96 critically ill patients in ICU A and ICU B required mechanical ventilation for more than 48 hours, and their medical records were reviewed. The medical documents were reviewed for all eligible patients for three consecutive days. Among the 96, some were extubated on Day 4 or Day 5, resulting in 73 patient's medical records reviewed for the three consecutive patient mechanical ventilation days (see Table 5.1). Data for the 96 documents reviewed were included to facilitate analysis of trends in the use of the IHI evidence-based guidelines.

Table 5.1 Medical documents reviewed on days 3, 4 and 5 of mechanical ventilation

Day	ICU A *n*	ICU B *n*	Overall *n*
3	61	35	96
4	48	33	81
5	47	26	73

The age of the patients ranged from 24 to 95 years of age; the mean age was 64.50 years (SD = 14.89). Table 5.2 illustrates patient age ranges and APACHE III score ranges, which indicates the severity of illness and risk of death (see Section 3.6.3). The minimum APACHE III score (lowest risk of death) is 0, and the maximum (highest risk) is 299. The biggest group of patient medical records reviewed had an APACHE III score between 61 to 80. The Levene's test for equality of variances was greater than 0.05, which demonstrated equal distribution of data (Pallant, 2016), so parametric tests were used.

Table 5.2 Patient characteristics

Characteristic	ICU A *n (%)* of eligible patients *N* = 61	ICU B *n (%)* of eligible patients N = 35	Overall *n (%)* of eligible patients N = 96
Age			
≤40	8 (13.1)	4 (11.4)	12 (12.5)
41-50	8 (13.1)	4 (11.4)	12 12.5)
51-60	15 (24.6)	7 (20)	22 (22.9)
61-70	17 (27.8)	9 (25.7)	26 (27.1)
71-80	8 (13.1)	10 (28.6)	18 (18.8)
81-90	4 (6.6)	1 (2.9)	5 (5.2)
>90	1 (1.6)	0 (0)	1 (1.0)
APACHE III Score			
≤40	3 (4.9)	1 (2.9)	4 (4.2)
41-60	16 (26.2)	5 (14.3)	21 (21.9)
61-80	18 (29.5)	14 (40)	32 (33.3)
81-100	7 (11.5)	9 (25.7)	16 (16.7)
101-120	13 (21.3)	4 (11.4)	17 (17.7)
121-140	2 (3.3)	2 (2.9)	4 (4.2)
141-160	2 (3.3)	0 (0)	2 (2.1)

The APACHE III mean score was as follows; Overall: 79.27 (SD = 27.11), ICU A: 78.57 (SD = 28.40) and ICU B: 80.11 (SD = 24.13). An independent-samples t-test was conducted to compare the mean APACHE III scores between ICU A and ICU B; this showed no statistically significant difference (MD = 1.912, 95% CI: 13.020 – 9.196, *p* = 0.733). Across all the documents reviewed (*n* = 96), there were 24 different APACHE III diagnoses classifications; ICU A: (*n* = 21) and ICU B: (*n* = 14). Figure 5.1, below,

illustrates the percentage of patient admissions ventilated for more than 48 hours and their APACHE III diagnosis classifications.

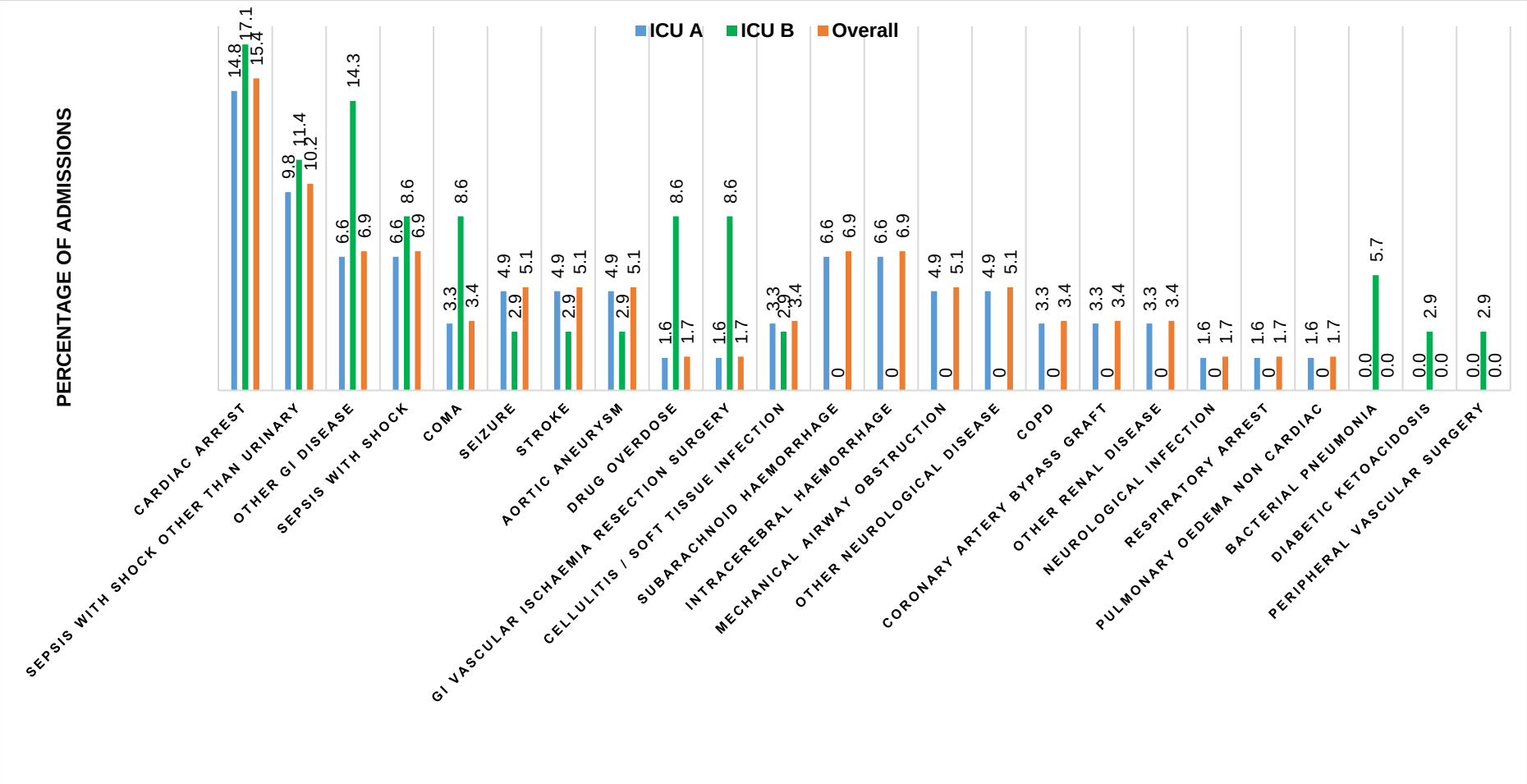

Figure 5.1 APACHE III Diagnosis classifications and percentage of admissions

Post cardiac arrest was the most common reason for admission among the patients in the sample (*n* = 15, 15.4%) followed by sepsis with shock other than urinary tract infection (*n* = 10, 10.2%) (Figure 5.1). Most of the neurological and cardiac surgical conditions were in ICU A, demonstrating differences in the ICU profiles (see Section 3.5).

5.3 Institute for Healthcare Improvement (IHI) ventilation bundle checklist

The amended IHI ventilation bundle consisted of six evidence-based elements: i) HoBE 30 - 45 degrees, ii) appropriate deep vein thrombosis prophylaxis, iii) peptic ulcer prophylaxis, iv) sedation infusion interruptions, v) daily assessment for readiness to extubate, and vi) daily oral care with chlorhexidine (IHI, 2017). The adherence to the IHI ventilation bundle was documented by medical staff on a daily medical plan checklist on the observation chart and in the patient's progress notes. In both ICUs, the medical plan checklist had an acronym FASTHUGS, which stands for Feeding, Analgesia, Sedation, Thromboembolic prophylaxis, Head of the bed elevation, Ulcer prophylaxis (stress), Glucose control and Spontaneous breathing trial (see Section 3.3). The medical plan checklist covered five of the bundle elements and did not include the use of chlorhexidine for oral care. The use of chlorhexidine was excluded in combined data, as one ICU did not use it. Table 5.3 below illustrates the adherence rates per IHI ventilation bundle element. 'Day 3 of mechanical ventilation', 'Day 4 of mechanical ventilation' and 'Day 5 of mechanical ventilation' will be referred to as 'Day 3', 'Day 4', and 'Day 5', throughout this section, to reduce repetition.

Table 5.3 Adherence rates per IHI ventilation bundle elements

IHI ventilation bundle elements	Day 3 *n* (%)			Day 4 *n* (%)			Day 5 *n* (%)		
	ICU A (*N* = 61)	ICU B (*N* = 35)	Overall (*N* = 96)	ICU A (*N* = 48)	ICU B (*N* = 33)	Overall (*N* = 81)	ICU A (*N* = 47)	ICU B (*N* = 26)	Overall (*N* = 73)
Thromboembolic prophylaxis	61 (100)	35 (100)	96 (100)	47 (97.9)	33 (100)	80 (98.8)	47 (100)	26 (100)	73 (100)
Peptic ulcer prophylaxis	61 (100)	35 (100)	96 (100)	47 (97.9)	33 (100)	80 (98.8)	46 (97.9)	22 (84.6)	68 (93.2)
Head of bed elevation	48 (78.7)	30 (85.7)	78 (81.3)	46 (95.8)	33 (100)	79 (97.5)	47 (100)	26 (100)	73 (100)
Sedation infusion interruptions	29 (47.5)	29 (82.9)	58 (60.4)	36 (75)	32 (97)	68 (84)	46 (97.9)	25 (96.2)	71 (97.3)
Readiness to extubate	28 (45.9)	25 (71.4)	53 (55.2)	33 (68.8)	29 (87.9)	62 (76.5)	44 (93.6)	24 (92.3)	68 (93.2)
Overall mean adherence			**381 (79.4)**			**369 (91.1)**			**353 (96.7)**

5.3.1 Thromboembolic and peptic ulcer prophylaxis

Medical records reviewed on Day 3 revealed that all patients (*n* = 96, 100%) were receiving the peptic ulcer and thromboembolic prophylaxis in both ICUs. The types of thromboembolic prophylaxis used were either mechanical or chemical or both, depending on the patient's diagnosis. On Day 4, nearly all patients (*n* = 47; 97.9%) in ICU A were on the peptic ulcer and thromboembolic prophylaxis while in ICU B, all patients (*n* = 33, 100%) were on the peptic ulcer and thromboembolic prophylaxis. On Day 5, all patients (*n* = 73, 100%) were on thromboembolic prophylaxis in both ICUs. In keeping with 100% thromboembolic prophylaxis, nearly all patients (*n* = 68, 93.2%) had peptic ulcer prophylaxis on Day 5 in both ICUs. The mean adherence rate over the 3 days of mechanical ventilation was: peptic ulcer prophylaxis 97.6% and thromboembolic prophylaxis 99.6%.

5.3.2 Head of the bed elevation

Overall, in the majority of the medical records reviewed (*n* = 78, 81.3%), patients had their HoBE on Day 3 (Table 5.3). The patients who did not have the HoBE were: i) on high doses of inotropes, ii) post-cardiac arrest or iii) contraindicated to HoBE, such as following spinal surgery. On Day 4, nearly all of the patients whose medical records were reviewed (*n* = 79, 97.5%) had the HoBE. All patients in both ICUs had their HoBE on Day 5. Adherence with the HoBE increased with the number of patient mechanical ventilation days.

The mean HoBE adherence for the 3 days of mechanical ventilation was 92%. Table 5.4, below, illustrates APACHE III score means per IHI ventilation bundle element on Days 3 and 4.

Table 5.4 Elements of the evidence-based guidelines and APACHE III score means

Characteristics		ICU A			ICU B			Overall		
		Number of patients	Mean APACHE III score	SD	Number of patients	Mean APACHE III score	SD	Number of patients	Mean APACHE III score	SD
Day 3 (*N* = 96)										
Head of bed elevation	Yes	48	74.13	25.28	30	75.73	22.17	78	74.74	24.00
	No	13	95.00	34.05	5	106.40	19.35	18	98.89	31.54
Sedation interruption	Yes	29	76.93	24.03	29	77.87	20.87	58	77.90	22.73
	No	32	80.06	32.17	6	84.42	29.97	38	81.37	32.91
Readiness to extubate	Yes	28	71.75	25.08	25	79.20	21.39	53	75.26	23.49
	No	33	84.36	30.11	10	82.40	31.18	43	84.21	30.55
Day 4 (*N* = 81) *										
Head of bed elevation	Yes	46	79.41	27.86	33	80.67	24.68	79	80.10	26.79
	No	2	133.50	26.16	-	-	-	2	133.50	26.16
Sedation interruption	Yes	29	76.93	24.03	32	80.94	25.03	67	80.04	26.54
	No	32	80.06	32.17	1	72.00	-	14	84.50	36.48
Readiness to extubate	Yes	33	75.39	25.53	29	81.86	23.71	60	78.63	25.22
	No	17	89.88	35.58	4	72.00	33.77	21	86.48	35.16

Note: i) *Sum difference as some patients were extubated on Day 4; ii) * Day 5 cannot compute the adherence rate approximately 100% or 100%

An independent-samples t-test was conducted to compare the APACHE III scores for patients who had the HoBE and those who did not. There was a statistically significant difference of APACHE III score means between patients who had HoBE and those without on Day 3; Overall: Mean difference (MD) = -24.15, 95%, CI: -37.40 to -10.89, p = <0.001). The higher the APACHE III score, the lower the chance of HoBE on Day 3. On Day 4, there was a statistically significant difference of APACHE III score means between patients who had the HoBE and those without; Overall: (MD = -53.40, 95% CI: -91.57 to -15.23; p = 0.007). On Day 4, all patients had the HoBE in ICU B (see Table 5.4). All patients had their HoBE in both ICUs on Day 5. The adherence with the HoBE increased with the number of mechanical ventilation days. The elements of the IHI ventilation bundle with adherence rates of less than 100% were analysed using t-test, and the results are presented in Table 5.5.

Table 5.5 Comparison of APACHE III Score means and elements of evidence-based guidelines

Characteristics	ICU A			ICU B			Overall		
	Mean difference in APACHE	95% confidence interval	*p* value	Mean difference in APACHE	95% confidence interval	*p* value	Mean difference in APACHE	95% confidence interval	*p* value
Day 3									
Head of bed elevation	-20.88	-37.95 to - 3.80	0.017	-30.67	-52.15 to - 11.24	0.007	-24.145	-37.40 to -10.89	<0.001
Sedation interruption	-3.13	-17.61 to 11.34	0.667	-6.55	-24.14 to -11.05	0.454	-3.47	-14.74 to 7.80	0.542
Readiness to extubate	-12.61	-26.97 to 1.74	0.084	-3.20	-21.81 to 15.41	0.729	-8.95	-19.90 to 2.01	0.108
Day 4									
Head of bed elevation	-54.09	-94.54 to -13.63	0.010	*	*	*	-53.40	-91.57 to -15.23	0.007
Sedation interruption	-6.573	-26.34 to 13.19	0.507	8.94	-42.90 to 60.78	0.727	-4.46	-21.04 to 12.13	0.594
Readiness to extubate	-14.49	-32.06 to 3.08	0.104	9.86	-17.18 to 36.90	0.463	-7.85	-21.91 to 6.22	0.270

Note: i) *p*-value significant at 0.05 level. ii) * adherence rate of 100%

5.3.3 Sedation infusion interruptions

The interruption of sedation was assessed as a planned decrease in sedation dose or temporary cessation of sedation for a certain period and based on a previous study: i) patients with sedation vacations or interruptions, ii) sedation completely off or iii) on minimal sedation following simple commands (Klompas et al., 2015). According to Klompas and colleagues, any form of interruption could allow the body to clear the drugs and promote patients being awake and spontaneously breathing (Klompas et al., 2015).

More than half (*n* = 58, 60.4%) of the patients had sedation interruption on Day 3 in both ICUs (Table 5.4). The patients who had no sedation interruption were diagnosed with intracerebral haemorrhage (*n* = 4, 4.2%), post cardiac arrest (*n* = 4, 4.2%), seizure (*n* = 4, 4.2%), sepsis (*n* = 3, 3.1%) and other gastrointestinal (GI) disease (*n* = 2, 2.1%). However, there was no statistically significant difference in APACHE III score means between patients who had sedation interruptions or not on Day 3 in both ICUs (MD = -3.47, 95%, CI: -14.74 to 7.80, *p* = 0.542).

On Day 4, the majority of the patients (*n* = 68, 84%) had sedation interruption in both ICUs (Table 5.4). There were episodes when patients were mechanically ventilated, but off sedation completely and they were included as sedation interruptions (*n* = 14, 17.3%).

On Day 5, nearly all of the patients had sedation interruptions in both ICUs (*n* = 71, 97.3%) (Table 5.4). There were also episodes when patients were on minimal

sedation, following simple commands, those were included as sedation interruptions (*n* = 4, 5.6%). The difference in the APACHE III score mean for Day 5 could not be statistically analysed, as it was minute. However, there was also a significant association between sedation interruptions and HoBE in both ICUs ($\chi^2 = 4.293$, *df* = 1, *p* = 0.038).

5.3.4 Readiness to extubate

Readiness to extubate was assessed as switching ventilation mode to complete spontaneous mode of ventilation for a given period or monitoring the patient in spontaneous ventilation mode throughout the day. The readiness to extubate was checked on the patient observation chart and in the progress notes. More than half (*n* = 53, 55.2%) of the patients were assessed for readiness to extubate on Day 3 in both ICUs (Table 5.3). There was no documentation whether the patient was assessed for spontaneous breathing or not on the remainder of the medical records reviewed (*n* = 43, 44.8%). Most of the patients who were not assessed for spontaneous breathing were diagnosed with post cardiac arrest (*n* = 7, 7.3%), sepsis (*n* = 5, 5.2%), intracerebral haemorrhage (*n* = 4, 4.2%) and stroke (*n* = 3, 3.1%).

There was no statistically significant difference in mean APACHE III score for patients who were assessed for readiness to extubate and those who were not assessed in both ICUs, on Day 3 (MD = -8.95, 95%, CI: -19.90 to 2.01, *p* = 0.108) (Table 5.5).
On Day 3, more than a third (*n* = 38, 39.5%) of the patients who did not have sedation interruption were also not assessed for readiness to extubate. There was a significant association between sedation interruption and readiness to extubate in both ICUs

(χ^2 = 17.541, *df* = 1, *p* = <0.001). On Day 4, over three-quarters (*n* = 62, 76.5%) of the patients were assessed for readiness to extubate in both ICUs (Table 5.4). There was no difference of mean APACHE III score for patients who were assessed for readiness to extubate and those who were not (MD = -7.85, 95%, CI: -21.91 to 6.219, *p* = 0.270) (Table 5.5). However, there was a higher adherence to readiness to extubate on Day 5 compared to Day 3 and 4. Almost all (*n* = 68, 93.2%) patients had assessments for readiness to extubate on Day 5 (Table 5.3). The mean readiness to extubate adherence for the 3 days of mechanical ventilation was 73.3%.

5.3.5 Overall IHI ventilation bundle adherence

The overall IHI ventilation bundle adherence over the three days of mechanical ventilation was 88.3%. Across all five evidence-based guidelines elements (excluding the use of chlorhexidine for oral care), the mean adherence per mechanical ventilation day was: Day 3 = 79.4%, Day 4 = 91.1% and Day 5 = 96.7%. The adherence rate increased with the number of mechanical ventilation days (Table 5.3).

5.3.6 Oral care

Assessment of oral care was achieved by checking the observation charts and progress notes of the patients who were mechanically ventilated for more than 48 hours. The chart legend illustrated that oral care was to be done every two hours in ICU A. However, the solution to be used was not stated. Oral care was documented on the observation charts, but the solution used was not indicated.

In ICU B, oral care frequency was not recorded on the chart, but there was a legend which illustrated what could be used for oral care. Oral care was performed using chlorhexidine or water or toothbrush in ICU B. Figure 5.2 illustrates the frequency of oral care in both ICUs, regardless of the solution used.

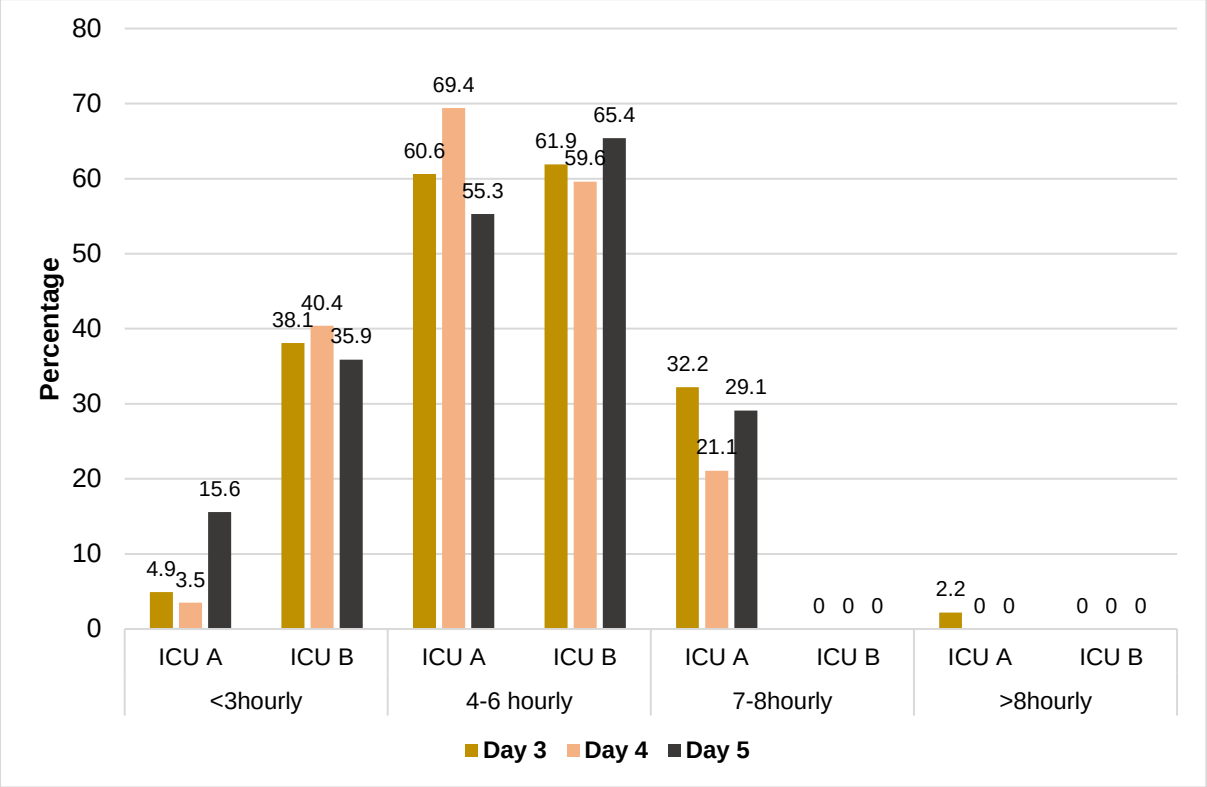

Figure 5.2 Percentages of oral care frequency per day in both ICUs

Oral care was done more often than every three hours in ICU A on Days 3, 4 and 5. In ICU A, oral care was done every 4 to 6 hours per day on more than half of the patients and every 7-8 hours in less than a third, on the three consecutive days as illustrated in Figure 5.2. The frequency of oral care decreased at night shift compared to day shift, according to the medical records reviewed in ICU A. Most of the 7 to 8 hours frequency (32.2%) was during the night, as patients would likely be sleeping.

In ICU B, oral care was done more often than every 3 hours or 4 to 6 hours, regardless of day or night. Most of the time, oral care was done every 4 to 6 hours in both ICUs, irrespective of the day of mechanical ventilation, as per documents reviewed.

On three episodes, on different patients, and different days, oral care was not documented for 11 to 13 hours in ICU A. The NIC was informed of the aggregated anomalies in weekly patient care, as there was an ethical reporting agreement before commencement of the study (see Section 3.6.3).

5.3.6.1 Oral care with chlorhexidine

The use of chlorhexidine adherence was analysed individually, as ICU A did not use it. Oral care with chlorhexidine was documented as a solution used most of the times (*n* = 89, 94.7%) in ICU B. The majority of the patients had oral care 4 to 6 hourly, and the frequency decreased with the number of mechanical ventilation days.

5.4 Chapter summary

The mechanically ventilated patient medical records were reviewed over three months in ICU A and B. Most of the medical records (*n* = 73) were reviewed for the three consecutive patient mechanical ventilation days in both ICUs. The patients' ages ranged from 24 to 95 years. There were 24 different APACHE III diagnoses classifications among the medical records reviewed in both ICUs. The largest number of patients were admitted post cardiac arrest in both ICUs. On Day 3, all the patients in both ICUs were on thromboembolic and peptic ulcer prophylaxis.

In ICU B, more than three-quarters of patients had their HoBE, thromboembolic prophylaxis and oral care with chlorhexidine on Days 4 and 5. ICU A did not use chlorhexidine for oral care, so this element was excluded in overall ventilation bundle adherence analysis. There was a statistically significant difference of mean APACHE III scores between patients who had the HoBE and those without on Day 3 in both ICUs. Patients who had a higher APACHE III score had no HoBE, sedation and spontaneous breathing trials on Days 3 and 4. The most adhered to element in both ICUs was thromboembolic and peptic ulcer prophylaxis. The least adhered to element in both ICUs was sedation interruption and spontaneous breathing trial. Adherence with IHI ventilation bundle elements increased with the number of mechanical ventilation days.

The reasons why one ICU implemented all elements of IHI ventilation bundle and not the other were not identified in the medical records reviewed. The reasons for poor knowledge, non-adherence and inconsistencies between the two ICUs will be explored in the qualitative phase (Phase 2) of the study. The interview semi-structured questions were developed according to these gaps and gaps identified in the online survey study results (see Appendix F template for interview questions).

Chapter Six – Phase 2, Interview Findings

6.1 Introduction

In this chapter, findings from the analysis of interviews with nurses and doctors will be presented. The aim of the semi-structured interviews was to explore the facilitators and barriers to evidence-based practice adherence, according to:

a) What are the nurses' and doctors' experiences of working in the ICU?

b) What are the nurses' and doctors' perceived barriers to the use of evidence-based guidelines?

c) Do facilitators and barriers to VAE prevention guidelines differ at the individual patient and ICU level?

d) What are the factors that interplay between structure, process, and outcome?

e) What recommendations do nurses and doctors offer for future implementations?

The data were thematically analysed (see Section 3.7.2). In analysing the interview data, four major themes and eleven subthemes were constructed and will be presented in this Chapter. The major themes were: i) The tailored approach to evidence-based practice for VAE prevention, ii) The use of evidence-based guidelines to underpin practice, iii) The impact of resources on care provision, and iv) Inadequate training and knowledge of evidence-based guidelines.

The interview findings are reported in six sections. In the first section, an overview of participant characteristics and their experience working in ICU will be presented. An

overview of themes and sub-themes will be presented next. The main themes of the study were presented in individual sections and the recommendations for future practice will be described. Finally, the interplay between structure, process and outcome will be presented.

6.2 Overview of study participants and their working experiences

The participants in this study were nurses and doctors working in the ICU. The interviews were undertaken over five weeks between July and August 2019. Twenty interviews were conducted. The interviews ranged in length from 15 to 41 minutes. The average interview time was 28.5 minutes. The shortest interview was with a medical consultant, who answered all the questions concisely, not requiring further prompting. The longest interview (41 minutes) was with nursing staff who had a wealth of experience and information to share. Purposive sampling was employed until data saturation was achieved (see Section 3.7.1). The participants' demographic characteristics are provided in Table 6.1. The majority of the nursing participants (*n* = 14, 87.5%) had a postgraduate qualification in intensive care nursing. The postgraduate qualifications were certificate (*n* = 8, 57%), diploma (*n* = 2, 14%) and masters (*n* = 4, 29%). Most of the participants (*n* = 15, 75%), including all the doctors, were recruited from ICU A.

Table 6.1 Participants demographics

Position in ICU	Years of experience	Postgraduate qualification	Qualification	ICU
ANUM	14	Yes	Cert	A
ANUM	4	Yes	Cert	A
CCRN	10	Yes	Cert	A
CCRN	2	Yes	Dip	B
CCRN	6	Yes	Cert	B
CCRN	3	Yes	Dip	B
CCRN	3	Yes	MN	A
CNE	25	Yes	MN	A
CNE	21	Yes	Dip	A
CNS	8	Yes	Cert	B
CNS	13	Yes	Cert	A
CNS	4	Yes	Cert	B
CNS	10	Yes	Cert	A
CNS	6	Yes	Dip	A
CON	11	NA	NA	A
CON	11	NA	NA	A
CON	10	NA	NA	A
PGRN	3	No	NA	A
REG	12	NA	NA	A
RN	2	No	NA	A

Note: ANUM = Associate Nurse Unit Manager, CCRN = Critical care Registered Nurse, CNE = Nurse Educator, CNS = Clinical Nurse Specialist, CON = Medical Consultant, REG = Registrar (Doctor), RN= Registered Nurse, PGRN = Postgraduate RN, Certificate = Cert, Diploma = Dip, Masters = MN, NA = Not applicable

The participants included a mixture of bedside nurses and unit leaders. The bedside nurses and doctors were CCRNs, CNSs, RNs, Registrars and PGRNs. The participants who were in the leadership roles were ANUMs, CNEs and Medical Consultants. The leadership team oversaw the unit and helped with high-acuity patients. The CNSs were involved in the leadership roles at times, when they were working as access nurses, also known as the team leader or admission and discharge nurse (see Section 1.2.1).

Most of the CNSs were reported to be responsible for a National Safety and Quality Health Service Standard (NSQHS). They promote awareness of the standard and encourage nurses and doctors to adhere to the activities that improve the quality of patient care. The nurses were allocated to a different patient daily, and only in rare circumstances would a nurse be allocated to the same patient on consecutive shifts. The majority of the participants were working on a rotating roster, other than the CNEs. The ICU Consultant roster varied from four to seven consecutive days.

All participants were assigned pseudonyms, and names of organisations were removed from transcripts to protect participants' identity. Pseudonyms were assigned based on the site, their position and number of the interview; for example, ICU A, RN, participant 12 is presented as A/RN 12. The researcher has added explanatory text to participants responses where necessary. This text is non-italics (regular font) and is in square brackets.

6.2.1 Participants' experiences in ICU

The participants had a median of seven years of experience in ICU (IQR: 3-11). More than two thirds of the participants (*n* = 13, 65%) had more than five years of experience in ICU. More than half of the participants were working in the same unit for the past five years (*n* = 11, 55%). Most participants reported working as a team, aiming to provide the best care possible (A/CNS 05, B/CNS 15). Most participants reported that staff and patient safety were important in ICU. At the beginning of every shift, nurses were required to complete a safety checklist of their environment. The reported

components of the safety checks included resuscitation equipment, such as air viva, oxygen and suction.

Most participants described their experience working in ICU as challenging, stressful and emotionally draining. A consultant reported that "*working with critically ill patients is challenging*" (A/CON 21). Other things reported to make working in ICU challenging were the unpredictable nature of the work, the severity of patient illness, the need for timely decision-making skills, and managing deteriorating patients and their family.

Some patients were reported to deteriorate rapidly, requiring prompt assessment and treatment decisions, which most participants found demanding. The participants found it demanding to support patients and their relatives in deterioration situations due to the multiple things happening at the same time and the complexity of patient conditions (A/CCRN 18). This is illustrated by the following quote:

> *"..it becomes quite demanding when the patient is unstable, or suddenly deteriorate not just respiratory-wise but in other areas, when they've got multiorgan dysfunction syndrome, so you have to be very efficient and you have to really prioritise because you're taking gases, you're modifying your ventilator regularly and you have the relatives (B/CNS 02).*

Some nursing participants in leadership roles reported that staff allocation on a shift was a problem when they were understaffed and had minimally experienced nurses with postgraduate qualifications. Some of them reported feeling guilty when they were required to allocate less experienced nurses to critically ill patients, due to poor skill

mix. They wished to be by the nurse's side, supporting them, but the demands of their leadership role did not enable that (A/ANUM 06).

> *"We've got a lot of junior staff, but the acuity is always the same, regardless of nurses qualifications. Most of the time we've got staff, but you don't know where to put them because of their qualifications and experience. When you've got junior staff who cannot look after the critically sick patients, that is really challenging, and you cannot be in different places at once, you have to do your job too. But you wish if you can be there every time" (A/ANUM 11).*

Some participants with less experience in the ICU reported that their challenges and stress were related to a lack of knowledge and experience in the ICU. They reported that it was confronting, and stressful working understaffed without access nurses (A/CNS 05, B/CCRN 16, B/CCRN 18). However, some participants who had less experience in ICU reported that they enjoyed the challenge and the unpredictable nature of their work. They appreciated the diversity in patient diagnosis and acuity and took it as an exciting learning opportunity (B/CCRN 14). This is illustrated below:

> *…it's challenging, but I enjoy being challenged every day and every day is new. Every patient comes in and has something completely different, so you just never really know what you're going to get, which is kind of exciting as well (A/RN 12).*

Some participants described the stress associated with nursing a critically ill patient with multi-organ failure as workload-related. They reported being worried about their patients, whether the care they were providing was adequate, whether they were able to recognise signs of deterioration in a timely manner (A/CCRN 18, A/RN 12). The

workload requires constant haemodynamic monitoring of a patient, frequent physical assessments, managing specialised medical equipment and providing general nursing care for a patient. Some participants found it difficult and stressful to try and balance the competing demands, interventions and patient assessment outcomes. This is illustrated below:

> *It becomes quite difficult when they've got multi-organ failure, …you're taking gases* [arterial blood gas]*, you're modifying your ventilator regularly, you're going up and down with different medications* (A/CNS 03).

Some participants at both sites found the work to be emotionally draining as most of the patients in the ICU were critically ill, some with life-threatening or life-limiting conditions. They described the ICU as an emotionally charged environment due to the severity of patient illness and loss of life at times. Some participants reported trying to disconnect themselves from patients, visualising their job like any other job and trying not to get attached to the patients, or to not think about their patients once they left the ICU. These strategies were used as a way of coping with the otherwise stressful situation. Most of the participants who reported the work as emotionally draining had less experience in the ICU (A/PGRN 13, A/REG 12, B/CCRN 14).

One participant stated:

> *When I go home, I kind of reflect on what's going on with my patient, the circumstances that patient's in.….I have to learn how to remove myself away from getting emotionally attached; otherwise, I would just crumble* (A/RN 12).

However, most of the participants in the leadership team reported that working in the ICU was satisfying because they provided all possible treatment options for patients.

They felt satisfied because of the appreciation which they received from patients and family members regardless of patient survival or death. Some participants reported that some patient relatives brought in gifts as a sign of appreciation; some even hugged the staff to thank them. A few participants reported that those actions sustained them in ICU, as illustrated below:

> *…even if the patient is dying, the family still thank you for that, which I've found very nice of them and kind of them and it feels like I'm doing a good thing for the family. I really feel happy; people appreciate what I'm doing; some families even give us gifts or a hug. That's why I still do ICU* (A/CON 22).

6.3 Overview of the themes and subthemes

Four major themes were inductively identified from the eleven subthemes (Table 6.2). The transcripts were analysed separately, and coded phrases were sorted and grouped with similar content from other transcripts. The coded phrases were then abstracted into subthemes, which were further abstracted into themes. The themes were refined to answer the research questions (see Section 3.7.2).

Table 6.2 Themes and subthemes

Theme	Subthemes
1. The tailored approach to evidence-based practice	• Patient diagnosis • Patient acuity • Prioritisation of workload • Providing best care
2. The use of evidence-based guidelines to underpin practice	• Lack of policies or procedures • Lack of audit or surveillance • Unit culture
3. The impact of resources on care provision	• Shortage of equipment • Inadequate staffing
4. Inadequate training and knowledge of the evidence-based guidelines	• Knowledge deficit • Providing educational opportunities

6.4 The tailored approach to evidence-based practice

In this theme, the participants described the type of patients they were providing care to as: critically ill, with life-threatening diagnoses such as sepsis, requiring specialised care to treat and prevent complications. The patients were continuously monitored, and they needed frequent assessments. The patients were often unstable, requiring frequent nursing and medical interventions. Most of the participants described how they frequently assessed patients using the algorithm DRSABCD (Danger, Response, Send for help, Airway, Breathing, Circulation and Drugs) "---*so, it's basically your normal ALS* [Advanced Life Support]*, DRSABCD that you go through" (B/CNS 02)*.

The participants acknowledged the importance of tailored care in the implementation of evidence-based guidelines to prevent VAE as illustrated by the following subthemes: patient diagnosis, patient acuity, workload prioritisation, and providing the best care. Some participants talked about patient diagnosis as a barrier to the

implementation of evidence-based guidelines to prevent VAE. The participants reported that they had to tailor care to suit the patient diagnosis, and they provided the best care possible according to patient acuity. A patient diagnosis, such as spinal injury, influenced the way patients were positioned in bed, as being on high doses of inotropic support determines how they are positioned in bed. However, patient acuity was fluid, and it changed during and between shifts. The nurse workload commonly increased with patient acuity, which forced most of the participants to prioritise immediate life-saving interventions over preventative measures, such as evidence-based guidelines for VAE prevention. Most of the data excerpts in this theme were from ICU A participants, which is a tertiary ICU with patients of higher acuity than ICU B.

6.4.1 Patient diagnosis

The subtheme, 'Patient diagnosis', relates to the patient's diagnosis as a barrier to the implementation of evidence-based guidelines to prevent VAE. Patients were admitted to ICU with varied diagnoses requiring specific individualised care, as appropriate to their situation. Some participants acknowledged the importance of VAE evidence-based guidelines, such as the HoBE to *"prevent micro-aspiration of secretions"* (A/ANUM 11, A/CCRN 07, B/CNS 02). However, there were situations reported when the HoBE was clinically inappropriate due to patient diagnosis, such as following spinal surgery. After spinal surgery, some patients were nursed in a neutral flat position. In such circumstances, most of the participants reported providing other appropriate VAE preventative interventions, such as regular oral care to prevent pooling of secretions

above the cuff (A/CNS 03). This view was shared by two participants, as represented in this excerpt:

> *….it's multifaceted, you cannot sit them* [patients with spinal injuries] *up to minimise the risk of aspiration, but having the cuff up at an appropriate level to minimise the risk of micro aspirates, even though it's not guaranteed and suctioning above the cuff helps as well (A/CCRN 18).*

At times, participants reported that they could not provide all required care, due to the patient diagnosis:

> *It just has to fall by the wayside because you can't be like, having a new mum that's PPH* [Postpartum haemorrhage] *and trying to pump in blood products and sit them up and all this other stuff when it's not necessarily appropriate given that clinical context (A/CNS 06).*

The patient diagnosis and clinical context informed the participants' decisions regarding the components of the VAE prevention evidence-based guidelines that were appropriate to implement. There were situations reported when the participants focused on immediate life-saving therapy rather than preventative care. These sentiments were reported at both sites.

6.4.2 Patient acuity

The participants reported that high patient acuity was a barrier to the implementation of VAE preventative evidence-based guidelines. Patient acuity is the severity of patient illness, resulting in increased requirements of complex care (Hyung-Jun et al., 2019). Patients were assessed at the beginning of each shift and, whenever necessary, throughout the shift. The participants reported that the assessment was an essential component of ICU patient care. The patient assessment findings informed the participants' decisions on which components of the guidelines should be implemented. Some participants reported situations when they assessed patients requiring high amounts of inotropes, and they tailored the prevention practice to suit the acuity, such as HoBE 30 degrees or less (A/CNS 05). Some participants reported relating patient acuity to increased length of intubation period. They reported using expected intubation period as a guide to the appropriate VAE prevention guidelines. Some participants reported that they adjusted the VAE prevention care on ventilated patients who were on minimal lifesaving support and expected to be ventilated for less than 48 hours. When caring for the higher acuity mechanically ventilated patients requiring life-saving support for more than 48 hours, participants reported implementing most of the evidence-based guidelines to prevent VAE. This is illustrated by the following quote:

> *So, sometimes a patient might be intubated for a short amount of time, in which case I probably wouldn't put in the same prevention strategies for VAE as I would for someone who I know is going to be ventilated for a lot longer. Those patients I'll instil a lot more prevention strategies for them, than for those that are probably going to be with us briefly (A/CNS 06).*

However, some participants reported situations in which nurses' decisions on assessment findings resulted in missing VAE preventative care when patient acuity increased. Participants described situations when patients were admitted with a drug overdose and then developed complications and required mechanical ventilation for an extended period, but only minimal elements of evidence-based guidelines to prevent VAE were implemented.

Some participants expressed concern in situations involving post-operative cardiac patients when nurses decided not to use inline suction catheters, anticipating same-day extubation. The patients missed some of the necessary VAE prevention when patient acuity changed, as patient demands and interventions increased. Most participants reported that they could not adapt VAE preventative strategies quickly when patient acuity changed (A/CNS 03, A/CNS 05, B/CNS 02).

One participant reported:

> *……if they deteriorated, we're not very good at getting them on wet circuits in a timely manner, getting them on an in-line suction catheter in a timely manner either (A/ANUM 04).*

Sedation breaks and spontaneous breathing are some of the evidence-based guidelines to prevent VAE. However, in both ICUs, they reported that they were aiming for low sedation levels rather than sedation breaks; they were targeting a Richmond Agitation Sedation Scale (RASS) of -1 to 0, which means their patients were able to open their eyes spontaneously and follow simple commands. The Richmond Agitation Sedation Scale is a scale used to measure agitation and sedations levels of mechanically ventilated patients. The patients on light sedation were reported not to

require sedation breaks, as they were awake already (A/CON 22). There were situations reported when patients had sedation breaks for a few days waiting for them to wake up. Most participants reported that high acuity patients were often deeply sedated and had occasional sedation breaks for assessment purposes. Deep sedation was necessary for some high acuity patients to *'reduce the cardiac workload'* (A/ANUM 11, B/CNS 02). There were also situations when prioritisation was given to reducing cardiac workload rather than preventing VAE. Sedation levels were tailored to patient acuity, as illustrated below:

> *…we like our patients to be within that range RASS -1 to 0,* [lightly sedated]*. For our sicker patients, they tolerate a higher RASS* [deeper level of sedation]*. So, like -4 to -3, maybe. It just depends on the patient acuity (A/ANUM 04).*

Most of the participants reported that patients were weaned off sedation when they were haemodynamically stable, in other words when blood pressure was supported with minimal inotropes and there were minimum oxygen requirements, illustrating low-level acuity. Lower acuity patients were likely to have VAE prevention care, such as weaning patient's sedation off facilitated spontaneous breathing and weaning off mechanical ventilation. One participant observed:

> *…. the blood pressure is okay and haemodynamic is fine, and his lungs are good, and his brain function is okay, then if that stage comes up, then we'll reduce the sedation and the pain killers a little bit, day by day and the patient will be breathing spontaneously (A/CNS 05).*

It is evident from the explanations that patient acuity assessment findings influenced the implementation of the evidence-based guidelines to prevent VAE.

6.4.3 Prioritisation of workload

Patients in ICU were admitted with life-threatening illnesses, requiring immediate life-saving therapy, constant monitoring of airway, breathing, circulation and medication evaluation. Most participants reported that priority of care was given to immediately life-saving interventions first and evidence-based strategies to prevent VAE were prioritised lower.

One participant highlighted that most people do not understand how there could be an increased workload when it was one nurse to one patient. However, most of the participants reported that there was a lot of work in caring for patients with multi-organ failure, who often required more than one nurse. The nurse workload was highlighted in the participants' ICU experience as challenging in both ICUs. The participants acknowledged the need for workload prioritisation. Some of the VAE prevention practices were missed due to the demands of immediate life-saving interventions. Most participants reported prioritising their nursing care to immediate life-saving care in unstable high acuity patients. They focused on immediate patient requirements, such as collecting blood, addressing required patient ventilation changes and administering medications over preventative care, such as oral care. This is illustrated by the following:

> *…sepsis patients, their condition changes rapidly and without notice; they often require multiple medication administration, needing to happen immediately, and all with the utmost importance, it can be challenging to choose which to attend to first. And as things change* [vital signs]*, and always having to change what is the most important thing to do, that can be very challenging (B/CCRN 16).*

Another participant provided a similar explanation:

> *If you were really busy, you'd definitely have to work out your priorities, and if they're really unwell, the mouth and eye care are not going to be a priority at the end of the day if you're trying to save their lives (A/RN 12).*

A similar explanation was provided by one of the leadership team members:

> *… you're running around, and your priority is to keep their blood pressure up and to keep them stable. The last thing that you're really thinking about is mouth care and brushing their teeth… (A/CNE 20).*

However, most participants were concerned and felt guilty that patients were missing out on necessary preventative care, which might result in VAE, poor outcome or death of mechanically ventilated patients. These sentiments were shared by the majority of the participants, from the bedside nurses to the leadership team. These were some of the incidences which nurses reported as challenging in the ICU (see Section 6.2.1). Most of the participants reported that they desired to provide all required care. However, in situations when the workload was out of control, life-saving interventions took precedence over preventative care, as illustrated below:

> *… it's not due to not wanting to or not knowing what needs to happen, but your priorities are taken out of your hands* [because of the high workload, life-saving care]*, and there are things that you just have to do. You don't get a choice to prioritise how you would prefer (B/CNS 02).*

These explanations illustrate the high workload of life-saving care in ICU as a barrier to implementation of evidence-based guidelines to prevent VAE. The increased workload was a barrier reported across the ICU hierarchy of ANUMs, CNEs, CNSs,

consultants and RNs. The increased organ life-saving support requirements meant an increased workload for bedside nurses, which resulted in the prioritisation of work to life-saving interventions first. The consultant acknowledged the nurses' 'heavy workload' and how some of the nursing care could be missed in high acuity patients, as follows:

> *Workload, so sometimes - but that shouldn't be a barrier, that shouldn't be an excuse because FASTHUGS* [evidence-based guideline to prevent VAE] *is really fundamental to good ICU care, the basic ICU care that shouldn't be overlooked. But unfortunately, the reality is that sometimes the workload is so heavy and there are so many unstable patients, and it gets busy, so small little things get overlooked (A/CON 19).*

Another common view amongst the participants was that workload had become an issue because there were a lot of junior nurses who required help and support with care of critically ill patients. Most of the senior nurses acknowledged that knowledge and experience helped them to deal with the required interventions in a timely manner with minimal help (A/ANUM 11, B/CNS 15). However, they found helping and supporting the junior nurses demanding, as that increased their workload. The junior nurses acknowledged that the workload was challenging, and they were reported to be slower and to take longer than expected with most of the interventions, as summarised by one participant below:

> *We have a lot of junior staff here. And they're just trying to keep their head afloat and trying to keep on top of everything. And they take two or three times as long to do everything because they're new (A/CNE 20).*

6.4.4 Providing best care

This subtheme focuses on how participants related to critically ill patients when providing care. There were two different and contradictory concepts shared. A few participants highlighted that relating themselves to the patient enabled them to avoid depersonalising the critically ill patient who could not make decisions for themselves. The same participants reported that they had to avoid the emotional connection with the patients as a way of coping with the challenges of intensive care nursing (section 6.2.1).

Some participants considered the golden rule, 'do unto others as you would like done unto you' in their day-to-day practice. The golden rule, as explained by the participants, implied applying the highest standard of care possible, as they would like for themselves. Some participants described it as providing care which is "above and beyond the expected care" (B/CCRN 14). They reported providing care for the patients as they would provide for themselves or their loved ones. One of the team leaders reported that they usually brushed their own teeth twice a day and, if they became unwell, they would still need their twice-daily oral care. They said, because of that, they felt compelled to do the same for the patients (A/ANUM 04, A/NUM 11). The essence of this subtheme is encapsulated as follows:

> *…I always put myself in their shoes and think if this was my mum or a family member, I wouldn't want them to have really bad nursing care. …so, I always kind of look at that in a way and, yeah, I guess I try and provide the best nursing care possible (A/RN 12).*

Another participant provided a similar explanation:

> *What would I want done for me? ….do unto others as I'd want done to me. So, that applies for the patient as well, and then there's the professional perspective of I professionally should fulfil my role of helping nurses to help the patient (A/CNE 08).*

Most of the participants reported that missing VAE preventative care may lead to complications, such as VAP, which leads to a prolonged hospital stay. The participants reported that they desired to implement the best care possible to prevent VAE. These explanations provide evidence that the nurses would not want to cause harm to patients but offer the best nursing care possible. However, due to workload and prioritisation of immediate life-saving interventions, it was not always possible to provide the best care, which includes evidence-based guidelines to prevent VAE. The participants reported that implementation of VAE prevention evidence-based guidelines was determined by the patient diagnosis, acuity, workload, prioritisation and the desire to provide best patient care possible.

6.5 Use of evidence-based guidelines to underpin practice

This theme contained three subthemes: the lack of policies or procedures, lack of audit or surveillance and unit culture. The FASTHUGS were the current evidence-based guidelines used in ICU A and ICU B to prevent VAE. The participants reported using FASTHUGS as a prompt, an acronym for VAE prevention, and highlighted that FASTHUGS was the basis of *"fundamental ICU care which should not be overlooked"* (A/CON 19).

However, some participants reported that FASTHUGS was not well-understood and there was a lack of policies and procedures to support their implementation.

6.5.1 Lack of policies or procedures for VAE prevention

In ICU A and ICU B, participants reported that there were no policies or procedures for VAE prevention. Policy is a set of principles or guidelines that reflect the organisation's values on a subject. All procedures are linked to a policy statement (ACSQHC, 2017). Procedures are "a set of instructions to make policies and protocols operational, which are specific to an organisation" (ACSQHC, 2017, p.74).

Most of the participants were concerned that there were no clear policies and or procedures to underpin the individual elements of FASTHUGS. There were no sources of reference for VAE prevention, to guide the way procedures were carried out in the unit. Some participants explained that procedures if followed would have helped them with consistency in patient care. One CNE explained how hard it was to teach someone how to do a procedure without a reference for them to check whenever necessary. This is illustrated below:

> *I think just the lack of consistent guideline or mandating of what's required. I think if there was a consistent thing* [procedure] *saying, "This is what you have to do, this is how often, this is how you have to do it." I don't know that there's a protocol. So, you can't say, "Oh, please do it this way because this is what's supposed to be done in this unit, and if you ever forget, please read this." It's just a generalised taught practice and expectation that could be interpreted inconsistently (A/CNE 08).*

According to another participant:

> *I haven't come across a standard policy* [for VAE prevention] *in our unit. I don't think I have seen a standard policy that we follow (A/CCRN 07).*

The reported lack of policies and procedures lead to inconsistencies in the prevention of VAE in both ICUs. Some participants were concerned with consultants' inconsistencies, reporting that each consultant used a different approach, which meant that patient care was dependent on the consultant on duty. The inconsistencies reported were mostly patient positioning and the use of sedation, especially in septic patients. One example given was that of a patient position changing from 30 to 45 degrees HoBE to a lateral position with less than 30 degrees HoBE, depending on the consultant on duty. The inconsistencies in practice might have been influenced by a different understanding of the current evidence (A/CNS 03, B/CCRN 14).

Another example was of patient sedation medication changing from one type to another and RASS score targets changing according to the preference of the consultant on duty. A couple of participants reported that there was one consultant who was interested in reduction of sedation in the morning for patient assessment and likelihood of extubation. The nurses on shift would reduce the sedation early in the morning, in preparation for patient assessment for readiness to extubate, if that particular consultant was on duty, as indicated below:

> *Our consultant in charge of ICU is very keen on early extubation. So probably every morning at about six, seven o'clock we know if he's on, right we turn sedation down or off (B/CCRN 14).*

Another participant reported similar inconsistencies in practice:

I think everyone is keen to utilise best practice, to undertake what needs to be put in place for the patients, but everyone's understanding is very different, and so it means what happens on one day, may not happen the next day, so it's lack of consistency sometimes (B/CCRN 17).

In addition, one intensivist reported there was a lack of adherence to evidence-based guidelines, such as FASTHUGS, in their unit. The lack of policy or procedure might have influenced the reported lack of adherence. The intensivist reported reminding the nurses to adhere to HoBE but the advice was not followed through into the next shift change.

There's a number of different things we should be doing …. with regard to head-up position I think we are pretty poor at that. When I'm on clinical, it's important that those patients who are unable to do it for themselves, it gets done. So, I make a point of reminding people [nurses looking after the patients]*. But shift change come back, and it's changed (A/CON 21).*

One participant reported a decrease in the use of FASTHUGS due to controversy around some FASTHUGS elements, such as the use of peptic ulcer prophylaxis. Some participants reported that not all patients were receiving peptic ulcer prophylaxis. Some consultants were reported to prescribe the gastric prophylaxis for a few days following admission and then stop it once patients were on nasogastric feeds. Some participants reported that peptic ulcer prophylaxis was dependent on the consultant on duty (A/CNS 06, B/CCRN 14). Two consultants reported situations when they stopped peptic ulcer prophylaxis when patients developed a fever of unknown origin. They reported that some recent studies reported that the use of peptic ulcer

prophylaxis was associated with increased risk of VAP, so some consultants used them conservatively. The consultant's explanation illustrates this:

> *……what I do in my round is not to give them too much antacids; the gastric prophylactics. If the patient doesn't need it, I will not give them routinely, because that* [peptic ulcer prophylaxis] *also might increase the incidence of VAP. However, the evidence of that is controversial (A/CON 22).*

6.5.2 Lack of audit or surveillance

ICU A and B provided care to patients who required mechanical ventilation for more than 48hours (see Section 1.2). Patients on mechanical ventilation for more than 48 hours are prone to VAE; there is no doubt that some patients in ICU A and B would have had a VAE. Some participants reported that there was lack of audit or surveillance of VAP or VAE in their units (A/CNE 20, A/REG 10, B/CNS 15). As stated above (see Section 6.5.1), there was no policy or procedures for VAE in both ICUs, so it was impossible to audit practice or prevalence of VAE as there was no standard policy followed.

Some participants stated that some patients had VAE and such diagnoses were written in patients' medical records. The intensivists were reported to diagnose mechanically ventilated patients with VAE according to their clinical symptoms. One of the registrars reported that daily they check patients' inflammatory markers, chest imaging and they conduct clinical patient assessment to check for any signs of VAE (A/REG 10). However, some participants reported that there was no audit of the

number of patients who were diagnosed with VAE in ICU A or B. This is illustrated in the following sentiments:

> *…It's not that patients don't get VAP, they do, but there is no surveillance, nobody takes notice of the adverse events, we see it [VAE] written in the patient's notes (A/ANUM 04).*

Some participants in the leadership team reported the need for audit or surveillance of VAE (A/CON 21, A/CNE 20, A/ANUM 04). They found it hard to prevent something when they did not know whether it existed in their unit. The prevalence and effects of VAE were unaccounted for, not recorded anywhere in both ICU A and B. One participant in the leadership team reported that there was a need for clinical evidence to negotiate implementation of VAE surveillance with management (A/CON 21). Auditing of the patients who were clinically diagnosed with VAE by the intensivist was important to demonstrate the need for VAE surveillance. Monitoring the progress of the patients clinical diagnosed with VAE was reported that it might help to demonstrate prolonged hospital stay and increased hospital costs (A/CNE 20, A/ANUM 04). This is illustrated below:

> *It's difficult because the hospital doesn't see the benefit from that* [VAE surveillance or prevention] *in clinical outcomes easily. You need a good safety issue ----to demonstrate that this is a clinical safety issue (A/CON 21).*

Some participants in the leadership team reported that the results of VAE audit or surveillance would help them to implement required changes to improve patient care. They reported that staff education could be focused on VAE if there were higher

numbers of VAE in their unit, but there was no audit or surveillance in their unit (A/CNE 08, A/ANUM 04). One participant stated:

> *If the infection control audit team came back and said look, you know, we've had six VAPs in the last week, which is a 600 percent increase in the past, then we'd refocus on how to prevent VAP and keep an eye on that, we will change our education program to fit that and increase supervision, but there is no audit here (A/CNE 20).*

6.5.3 Unit culture

The unit culture was considered a barrier to the implementation of VAE prevention guidelines in both ICU A and ICU B. Most of the participants in ICU B who identified unit culture as a barrier were junior staff, not the leadership team. In ICU A, from the junior staff to the leadership team, they all recognised unit culture as a barrier to the implementation of strategies to prevent VAE. The unit culture was associated with shared principles, assumptions and underlying beliefs, which influenced how specific procedures were carried out in the unit. Some participants in both ICUs reported that introducing changes in practice was not well accepted due to the unit culture. Some participants reported that each ICU has its own culture, and the culture influenced how some participants practised. The ICUs were self-contained, with closed doors all the time, and most of the resources were specifically for the ICU only, which might contribute to defining and shaping unit culture. They defended and protected what was happening in their environment (A/CNS 05). The unit culture was described in the following way:

Most intensive care units are sort of closed units, so implementing a new thing [change to practice] *within the practice of a unit might be a barrier because it has to be accepted. We tend to live by cultures. We're sort of tribes (A/REG 09).*

The main challenge was to change their current practice in the unit. Some CNSs tried to introduce new evidence into their NSQHS improvement portfolio, however, some participants did not recognise the need for change. Some participants were reported denying the new evidence, opting for the old approach, because they did not see the need for change. Some participants reported using the same approach for a long time and, since it has been working, they did not see the need to change for the sake of new evidence. The CNEs reported that it was challenging for them to educate the senior nurses, as they did not appreciate the education sessions. A couple of participants reported that the senior nurses thought that they knew most of the requirements and equipment and preferred to self-learn than be taught. An example of trying to teach senior nurses related to showing them how to use new inline suction catheters, which was not well received as they had already used them for a long period and could not appreciate receiving education on the new changes (A/NUM 04, A/CNS 05, B/CCRN 14). One participant stated:

So, educating your more senior nurses, especially if new equipment comes out – for example, they bought in the closed suction [inline suction]*, when to change it, how to utilise them, oh, "I* [senior nurse] *know how to do that. I don't need to be taught". Even though it does have its own little complications, and its own little things that you've got to do a little bit differently. Education and changes are not always well-received (A/CNE 20).*

Two participants mentioned that people might know new evidence or know the correct way of doing a procedure, but they tend to continue the practice of their old unit (A/ANUM 04). An example was given of nurses re-using single-use oral swabs, regardless of the swab labelled single-use (A/CNS 06). Some nurses reported that they did not want to be the one who was wasting the oral swabs by not re-using them. They felt safe doing what everyone else was doing. They were using the swab multiple times because they have always done it that way:

> *So, 'we've always done it this way'. So, someone will not question, even though they know that something can be done better, but they will continue on a specific practice (A/CCRN 18).*

Unit culture influenced how nurses and doctors implemented VAE preventative guidelines, regardless of their knowledge. Two participants in leadership roles alluded to the need for leadership involvement in change management, as the culture of the unit was determined by the management. Most of the participants who reported unit culture as a barrier were on the leadership team in ICU A. Most of the leadership team in ICU A also acknowledged that the implementation of new strategies might require resources which could be costly for the unit.

6.6 The impact of resources on care provision

Most of the participants reported inadequate staffing and equipment as barriers to implementation of evidence-based guidelines to prevent VAE. Several participants reported a staff shortage and inadequate staff skill mix as a barrier to providing adequate care to highly acute patients. Some participants reported a lack of

equipment, such as toothbrushes and Endotracheal Tubes (ETTs) with suction aid, which made it hard for nurses to provide the best care. Within the theme of the impact of resources on care provision, two subthemes were constructed: shortage of equipment and inadequate staffing.

6.6.1 Shortage of equipment

Shortage of equipment, such as ETTs with suction aid and mouth care products, was reported by most of the participants. Most nurses found it challenging not being able to provide the best possible care to their patients because of the shortage of products. Some participants reported that the scarcity led to ineffective oral care, as the nurses had to use whatever was there. The oral products were single-patient use, such as toothbrushes, so they could not share those between patients. The shortages of oral care products, such as toothbrushes, was associated with a lack of supply. Some senior nurses reported that oral care packs were re-used in the unit because of the expense associated with acquiring them. However, one participant in the leadership team questioned whether the benefit of cost-saving in re-using the oral care pack swabs was worth risk of contracting a VAE. Ultimately, there was no cost-saving if patients ended up with VAE, which leads to prolonged hospital stay and increased hospital costs (A/NUM 04). The reported shortages are illustrated below in comments by both members of the leadership team and bedside nurses in ICU A:

> *Sometimes we don't even have that toothbrush. It's just a sponge. The sponge is just to wipe the mouth, any debris or any mucous from the mouth and suctioning. …. if we won't brush – it won't remove anything from the teeth – mouth cavity (A/ANUM 11).*

A junior participant shared the same sentiments:

> *So, if we don't have the mouthcare products or toothbrushes, I mean, it's one patient use, so we don't go and share toothbrushes or lip balms or anything for the patients. So yeah, sometimes we are running low or we've run out which makes it hard to kind of deliver the care that you'd like to deliver (A/RN 12).*

However, the participants in ICU B reported no shortage of equipment, such as mouth care packs or toothbrushes**.** There were no reports of re-using oral care packs in ICU B. Oral care was said to be done every four hours or whenever necessary, using the 24-hour oral care bedside packs. The 24-hour oral care packs, which consisted of six single-use oral care kits, were stored at the bedside, acting as a reminder for nurses. The availability of oral care packs in ICU B is illustrated below:

> *-- - it's not like we don't have access to mouth care packs and things like that, we've got plenty of resources (B/CNS 15).*

The cost of equipment was described as a barrier to purchasing ETTs with suction aids. The participants acknowledged that the ETTs with suction aids were expensive. However, the ETTs with suction aids facilitated above-cuff suctioning, to help reduce micro-aspiration of secretions, which helps to prevent VAE. A few participants compared the cost of ETTs with suction aid to the cost of treating a patient with a VAE. Treating a patient with a VAE was reported to be more expensive than purchasing the ETTs with suction aids. The participants at both sites indicated that cost influenced the availability and use of the ETTs with suction aids in their units. Some participants reported that they used to have those ETTs but, because of their cost, the unit was not purchasing them anymore:

We used to use a lot of them [ETTs with above the cuff suction aid]*. They were great, but sadly, everything comes down to cost (B/CNS 02).*

A CNE described the variation of the expenses between ETTs with suction aid and management of a patient with VAP.

So, a normal ET tube is a dollar or so. But an ET tube with an inline suction above the cuff suction aid is like $27. But I think that would be a massive reduction in VAP by doing that, and to me yeah, it's $26 extra, but if you see someone getting VAP, you're saving like $20,000 in infection costs and that sort of thing. ……money seems to rule the roost when it comes to what we get (A/CNE 20).

The participants' explanations provided reasons for shortages, as summarised: i) the unavailability of ETT with suction aids was related to cost, which was reported in both units; ii) a lack of toothbrushes was reported in ICU A, which was related to lack of supply; and iii) the re-use of single-use mouthcare packs swabs in ICU A was associated with presumed expense. However, two discrete reasons emerged from the re-use of single use mouthcare packs in the setting of no reported insufficient supply. Two participants in the leadership team were concerned about the mouthcare packs expenses, so they re-used them. The junior staff said they followed what everybody else was doing, as they did not want to appear like they were wasting products. However, not following evidence-based guidelines in the setting of adequate supply or due to lack of supply was unlikely to be cost-saving, as a VAE increases patient hospital stay and increase costs associated with treatment (A/ANUM 04, A/CNE 20).

6.6.2 Inadequate staffing

Despite the 1:1 nurse to patient ratio in the ICU, participants reported inadequate staffing. Several participants in both ICUs reported staff shortages and lack of clinical support as barriers to the implementation of evidence-based practice to prevent VAE. Some participants reported that some leadership roles, such as team leader or access nurse, were often surrendered to replace clinical staff on sick leave which, while necessary for patient care, left nurses with little bedside clinical support. The team leaders were reported to help with patient workload in high-acuity patients. They reported that, on a fully staffed shift, they had one or two team leaders per ten ICU patients. Some junior participants found it challenging to work without the support of a team leader.

There were situations when nurses had to wait for long periods until someone was free to help them, which impacted patient care (B/CCRN 16). Some participants had to prioritise patient workload, focusing on immediate life-saving care over preventative guidelines, such as oral and eye care. One participant reported that:

> *So, if we lose our team leader, if we lose our admission and discharge nurse, they're extra people on the ward to assist high acuity patients and give some relief to someone with a heavy workload, some things will not be done (B/CNS 02).*

Poor nursing skill mix was also reported as an issue, which made it difficult to swap breaks or to get assistance with nursing care that required two people; for example, connecting a patient to dialysis. The junior nurses frequently needed clinical support

from qualified intensive care nurses. They expressed their need for help and support to the team leaders at the bedside. Some junior nurses said that there was no to minimal clinical support when they started working in the ICU. However, a nurse's patient allocation was done in such a way that senior nurses were allocated to work next to junior nurses so they could support them. Some senior nurses found it difficult to help and support the junior nurses because of their own patient workload. Some senior nurses reported that their workload was doubled by supporting the junior nurses. One participant stated:

> *So being a post-grad trained staff member, you often get the more critically ill patients. So those patients are the ones that you're active, I say re-assessing, not in terms of CPR, but preventing the deterioration or managing their deterioration and then when you're not, you've got junior staff beside you like a graduate nurse who has no idea about ICC* [intercoastal catheter] *also supporting them. So, it's kind of like you've got a double workload (A/CNS 06).*

The junior nurses acknowledge the required help, as illustrated below:

> *We've got a lot more junior nurses … while you're learning yourself there's no one there to kind of hold your hand and get you through those initial stages until you find your feet (A/PGRN 13).*

6.7 Inadequate training and knowledge of the evidence-based guidelines

The nurses in both ICUs reported a lack of knowledge and training on VAE prevention guidelines. Some participants did not understand the purpose of FASTHUGS in the ICU. Most of the participants who knew the evidence-based guidelines to prevent VAE

reported learning them during postgraduate courses. The two subthemes constructed were: knowledge deficit and the need for providing educational opportunities. Due to shortages of intensive care trained nurses, there were a few nurses without postgraduate qualifications who had poor knowledge of VAE and its prevention (see Section 4.4.2). Some participants recommended further education for those without postgraduate qualifications, including clinical support to improve the prevention of VAE in the ICU. Some participants suggested reinforcing postgraduate qualification requirements in intensive care nursing in the two ICUs: *"postgraduate qualification used to be a must and a certain number of qualified nurses were supposed to be on duty but now…"* (A/NUM 11). As described in Section 1.4.1, it is a requirement to have at least 50% of nursing staff with postgraduate qualification per shift.

6.7.1 Knowledge deficit

A few participants could not remember what FASTHUGS stood for, although the acronym represents the strategies used to prevent VAE in both ICUs. The participants remembered that the abbreviation was written on the patient charts but could not remember its purpose. Most of the participants suggested the use of visual aids around the unit as reminders. The lack of knowledge of evidence-based guidelines to prevent VAE was across the nursing hierarchy; participants with and without postgraduate qualifications. Some participants could not relate FASTHUGS to the prevention of VAE. They had no or minimal understanding of why they were using FASTHUGS. This is illustrated below:

> *I never really thought of it like that. I don't know. Yeah, I don't really know what that* [sedation breaks] *has to do with ventilator acquired pneumonia I'm not entirely sure (A/RN 12).*

The CNEs identified that some nurses could not relate FASTHUGS to VAE. An example was given of how they could not relate sedation breaks to the prevention of VAE. There was no realisation that providing the patient sedation break would facilitate periods of being awake and spontaneous breathing, which would lead to early extubation (A/CNE 08). The knowledge on how FASTHUGS would prevent VAE was lacking. A suggestion was made to rename FASTHUGS, to a name which directly relates to ventilation. One participant described her experience with VAE prevention in the United Kingdom (UK), as follows:

> *… We had all the same things* [FASTHUGS] *that we have here. But we call it ventilator care bundle. So, people could relate it to being about the ventilator, about preventing things happening with the patient who was sick. Whereas FASTHUGS is kind of a – it's not really related to the ventilator as such. Or it has no cohesion with it (A/CNE 20).*
>
> *Maybe a renaming of it, the FASTHUGS for ventilator care, would be a better title. So, people can put that into their mind that it's essential for our ventilated patients (A/CNE 20).*

The explanations from the participants seem to provide evidence of a knowledge deficit on prevention of VAE in the ICU. The clinical nurse educators' account suggests that they were aware that nurses could not relate FASTHUGS to VAE prevention.

6.7.2 Providing educational opportunities

All participants emphasised the importance of continuing education opportunities for VAE prevention. The participants reported the need for education on current evidence-based guidelines to prevent VAE. One participant reported that they had received no education on VAP or VAE for a few years (A/CCRN 18). However, there were regular weekly dedicated educational sessions on different topics for both doctors and nurses. The educational opportunities were, perhaps, covering other aspects of patient care rather than VAE prevention.

There were contradicting views regarding in-service education on VAE. Some nursing participants reported a lack of on-the-job training, while doctors described only a few available educational opportunities. Some nurses reported that they were relying on postgraduate education knowledge, as there was no current in-service education. They referred to what they had learnt during the postgraduate course, regardless of when they did their training (A/CCRN 18, A/NUM 04). The nurses reported a gap in current knowledge of evidence-based guidelines to prevent VAE.

The dedicated beside teaching sessions were reported to be helpful with management of different conditions and evaluation of the implementation of evidence-based guidelines to prevent VAE (A/REG 10). The ICU Registrar valued the passing on of information from the experts (Consultants) to juniors at the beside. A few nurses suggested that it could improve their understanding of disease processes and VAE prevention if consultants included them in bedside teaching sessions. One participant said:

> *I think bedside education as well, so involving consultants* [Intensivists] *who can come and teach, not only the junior doctors but the nurses themselves, because they obviously (have) a vast (amount) of knowledge. But then that includes having more time for education (B/CCRN 17).*

On the other hand, a few participants reported that they were unable to attend in-service sessions due to their employment arrangements. They were working part-time, often weekends, which means they missed out on in-service sessions usually conducted on weekdays in the unit (A/CNS 03, B/CNS 02). The senior nurses who worked 12-hour shifts during the week found it hard to leave the bedside for in-service education because of patient acuity and workload (A/CNE 20). They reported that it was a bit easier for the 8-hour shift staff to go to in-service sessions, as there was double staffing time between morning and afternoon shift. The junior staff had opportunities to attend in-service sessions. Most of the senior nurses had to seek ways of keeping up to date out of working hours. This is illustrated in the following quote:

> *If you are rostered on the weekend, work part-time, like me, I often just work weekends, really, I'm not here, I'm not on the floor when education is given. So, I'm usually not here for in-services, so it really is dependent on me to be independent about my own education (B/CCRN 16).*

A couple of participants suggested that prevention of VAE should be covered during the Transition to Specialty Practice Program (TSPP). Participants identified the knowledge gaps, which could benefit from in-house formal education. However, the CNEs explained how they had taught the concepts of VAE prevention in the TSPP.

The CNEs acknowledged that the nurses did not fully understand the VAE prevention guidelines in TSPP education sessions:

> *So, they're told about it* [VAE prevention guidelines], *and it is a medical and nursing combined effort to look into it. But I don't think it's really fully understood as much (A/CNE 08).*

The above explanations illustrate that there was knowledge gap in VAE prevention guidelines.

The participants identified that ICUs were busy with high acuity patients and suggested formal and informal ways of delivering education to the nurses and other healthcare professionals. In their creative suggestions, they considered time limitations when caring for a critically ill patient. A few participants suggested informal education in the form of reminders, such as the use of visual aids, including posters or prompts on computers (A/ANUM 04). The participants suggested putting posters with VAE guidelines around the unit and using warning signs on the bedside of a ventilated patient or as a computer pop-up (A/CNS 03, B/CCRN14). A suggestion was made to include small educational talks during huddles as a reminder of specific guidelines. The huddle timeslot was considered a prime time, as it was done at the beginning of the shift change, before nurse-patient allocation. A few participants suggested using morbidity and mortality meetings to intentionally educate staff about disease processes or complications and how to avoid VAE. If there were VAE acquired, such meetings would provide the opportunity to remind nurses and doctors on the importance of the preventative measures (A/NUM 11). This is illustrated below:

> *It might also be a good idea to include it when we're doing the huddles at the start of the shift. The in-charge nurse could also briefly mention that, if you're*

looking after ventilated patients, please make sure that you've met all the strategies for VAE prevention (A/CCRN 18).

We can talk about this during the M&M [Morbidity and Mortality] meetings. *If there's a complication that happened to a patient in terms of that's causing morbidity or mortality, then it would be a good teaching point (A/CON 19).*

Most of the senior nurses described how they influenced practice in their unit, as most of the junior nurses look to them for guidance. A few senior nurses reported that if they implemented all the VAE prevention guidelines in their practice, those around them would realise them and feel pressured to do the same (A/CNS 06). However, some senior participants acknowledged that there was a lack of equipment and also the re-use of single use products (oral care products), which lead to compromised patient care (Section 6.6.1). The CNEs reported that it was hard to get senior nurses to engage in educational sessions (Section 6.5.2). There were contrasting views of the senior nurses' behaviours.

Some participants discussed how nurses initiated a journal club as an attempt to get nurses together, to read journal articles and discuss current evidence (A/ANUM 04). However, participants reported poor participation in groups which challenge existing practice. Most of the participants found it challenging to attend the activities because there was no support or time allocated for them (A/CON 21, A/ANUM 04,).

I don't know that there's consistent maintenance beyond establishment. There's a thought, but there's no time allocated, there's no guarantee that people are on it. There's no ongoing support for someone to drive it (A/CNE 08).

Most participants acknowledged the importance of research in advancing the education and practice of VAE prevention. Both nurses and doctors in the ICU agreed on further education on VAE prevention in the ICU. They aimed to have more intensive care trained nurses who could guide and oversee the junior nurses. Incorporation of VAE prevention guidelines in the ICU in-services was also suggested. Some participants reported that being a participant in this study helped them to see the need to revise VAE prevention guidelines, as follows:

> *Research like this has really made me think oh, I need to look this up again or remind myself of this sort of stuff again (A/ANUM 04).*

6.8 The relationship between structure, process and outcome

In this study, participants reported that factors such as lack of equipment, staffing and unit culture influenced how nurses cared for mechanically ventilated patients. In situation when there was not enough equipment some patients missed the required care *(process)*, which led to poor adherence rates *(outcome)* to VAE prevention. Some participants reported feeling stressed when they were not able to provide the required care to prevent VAE. Some participants reported that knowing that patients were likely to acquire VAE due to missed care affected their emotional wellbeing. The unit culture that did not support implementation of VAE prevention measures led to suboptimal patient care. This shows the relationship between structure, process and outcome factors in prevention of VAE.

6.9 Chapter summary

The analysis of interviews conducted with nurses and doctors working in two ICUs were presented in this chapter. The participants had different role titles, educational qualifications and experience in ICU. They described their experience in the ICU as challenging, emotionally draining and stressful. However, some found fulfilment in the way families and patients appreciated their work.

Both ICUs used FASTHUGS as evidence-based guidelines to prevent VAE. However, not all participants knew what FASTHUGS represented. Most of the implementation barriers identified were common at both sites. The patient's diagnosis, acuity, prioritisation of workload, and provision of best care were some of the factors which influenced the implementation of VAE prevention practices. Some participants reported that some elements of the guidelines were clinically inappropriate in other patient diagnoses or acuity. The lack of policies and or procedures and unit culture might have influenced the inconsistencies in practice and the lack of adherence.

Inadequate staffing and equipment were a barrier identified at both sites; for example, a lack of ETTs with suction aids. However, the lack of oral care packs was reported in one ICU. Some participants in the leadership team reported how they influenced practice but also acknowledged the influence of a lack of equipment, such as oral care packs.

Most participants reported a lack of knowledge of evidence-based guidelines to prevent VAE, and they recommended incorporating VAE prevention education in the

unit. They also highlighted educational delivery modes, such as in-services and posters, which might be useful in busy environments. Supervision and clinical bedside support were recommended to improve practice in the ICU. Overall, this chapter presented the facilitators and the barriers in the implementation of evidence-based guidelines, identified the factors that influence the inter-relationship between structure, process and outcome in prevention of VAE and provided insight on similarities and difference between the two ICUs. An in-depth discussion is provided in Chapter Seven, together with the presentation of an integration of the Phase 1 and 2 results of the study.

Chapter Seven – Discussion

7.1 Introduction

In this chapter, synthesis of findings from quantitative and qualitative phases is presented to address the study aims: i) to examine intensive care nurses' knowledge and self-reported adherence to the evidence-based guidelines for VAE prevention, ii) to evaluate the use of evidence-based guidelines to prevent VAE in two ICUs, and iii) to explore facilitators and barriers to the implementation of evidence-based guidelines to prevent VAE in the ICU, Victoria, Australia. As explained in Chapter 3 (see Section 3.9), the integration of the results of both phases of the study offers complementary information, which enables conclusions to be more robust (Creswell & Plano Clark, 2018).

The key findings from this study, which have important implications for the prevention of VAE and the use of evidence-based guidelines in the ICU, are discussed in the context of existing literature. The discussion integrates the elements of Donabedian's model (structure, process and outcome) with the factors that affect the interplay between them. The key findings below, are discussed in this chapter:

1) Organisational factors that influenced the implementation of evidence-based practice were:

- nurses' knowledge and experience of evidence-based guidelines
- inadequate staffing and equipment
- individual unit culture

2) Procedural factors that influenced the implementation of evidenced-based practice were:

- nurses' prioritisation of critically ill patient care needs
- inconsistencies in the implementation of adherence
- missed patient care

3) Outcome of the use of evidence-based guidelines

- adherence rates
- healthcare professional's emotional stress

In Chapter One (see Section 1.8), Donabedian's model of structure, process and outcome was explained as it applies to this study. The findings from the literature review illustrated the inter-relationship between structure and process, highlighting how both structural and procedural factors affect outcome (see Section 2.6) (Blot, et al., 2008; Klompas, et al., 2016).

The findings of this study add to the initial Donabedian model that underpinned the design and conduct of the study (see Sections 1.8 and Section 3.4). Figure 7.1 (below) presents the adapted Donabedian (2003) model. It shows both factors that were identified in the literature and what this study adds. The factors that were added, according to the findings of this study illustrate the interplay between structure, process and outcome and shows how each component of the model influence one another.

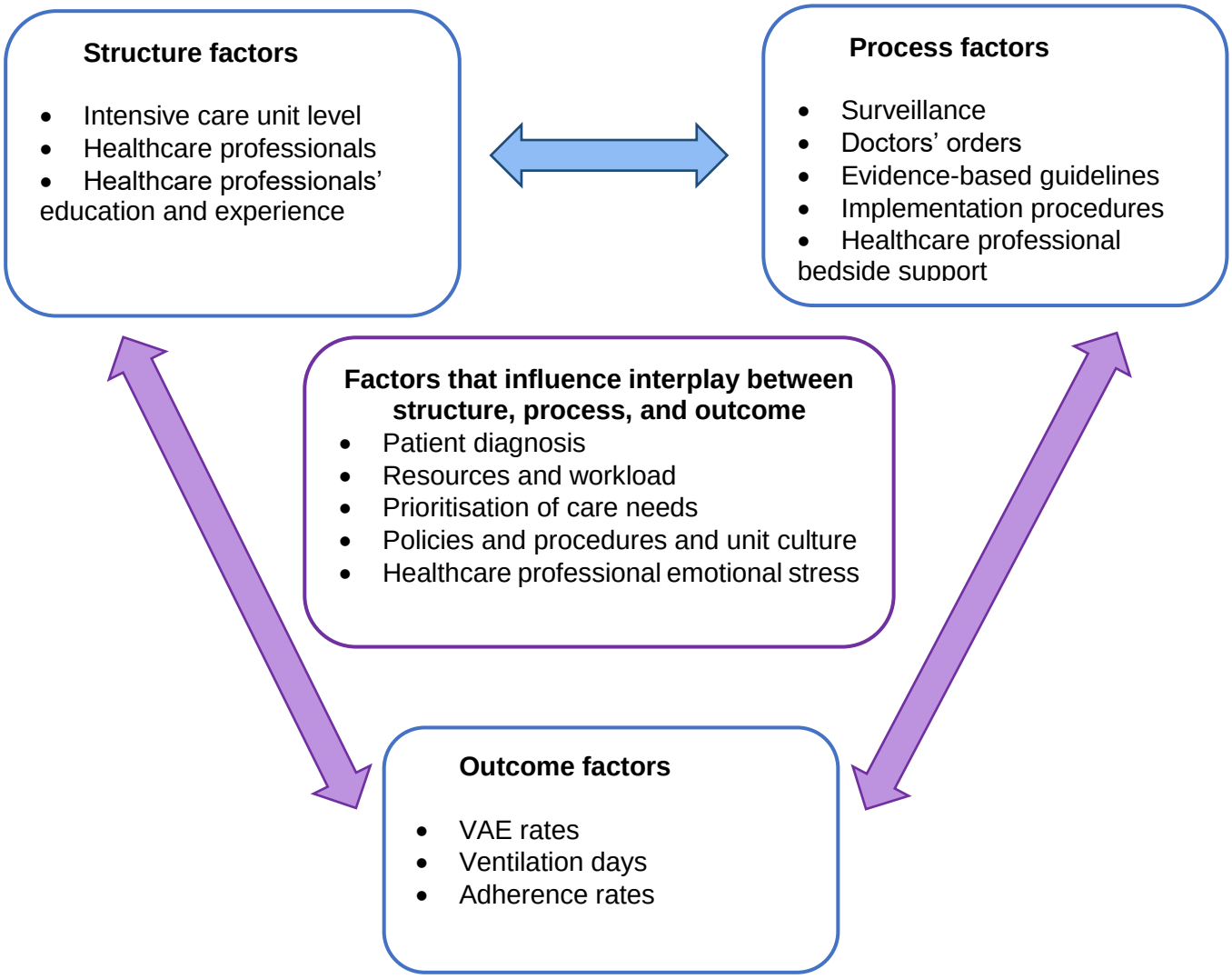

Figure 7.1 Adapted Donabedian (2003) model

The findings of this study confirmed some of the structural factors identified in the literature, such as healthcare professionals' education, knowledge and experience influencing the way they practice (see Section 2.8). The process factors supported by this study were evidence-based guidelines, implementation strategies, protocols and surveillance. The outcome factor confirmed by this study was the adherence rate. Apart from confirming previous factors, this study contributed to the adaptation of the Donabedian (2003) model (Figure 7.1) by identifying factors that influence the interplay

between structure, process and outcome. The survey and medical record review findings (Chapters 4 & 5) showed poor knowledge and poor adherence rates in VAE prevention; however, the reasons for poor knowledge and adherence were unclear. The interviews (Chapter 6) sought to address this.

When the findings of this study were synthesised, it was identified that there were organisational factors such as equipment, which influenced the interrelationship between the structure, process and outcome. These factors also influenced the whole model, as illustrated by double-headed arrows between the components (Figure 7.1). Structural factors such as the nurses' knowledge and experience in ICU influenced how nurses' practice. Participants reported emotional stress due to lack of knowledge and experience. They reported that some patients missed the required care due to their inability to complete all required care. Missed care was reported to cause emotional stress as they were aware of the likelihood to VAE in such situations. This is the first study to demonstrate the interconnectedness of the structure, process and outcome (Figure 7.1).

7.2 Organisational factors

The study findings show that, whilst the two Australian ICUs implemented VAE prevention strategies, there were organisational factors which influenced the implementation of those strategies. These factors were nurses' knowledge and experience, inadequate staffing, inadequate equipment and unit culture.

7.2.1 Nurses' knowledge and experience of the evidence-based guidelines

Most of the nurses in this study had more than five years of intensive care nursing experience and a postgraduate qualification in intensive care nursing. Participants who had a postgraduate qualification had a higher knowledge score. However, overall nurses' knowledge of evidence-based guidelines to prevent VAE was poor when measured using a pre-validated questionnaire; this was also evident in the interviews, for example some participants did not know what FASTHUGS stood for. This finding has been reported in previous studies with similar populations (Blot, et al., 2007; Jansson, et al., 2013; H.-L. Lin, et al., 2014). Some nurses were not able to articulate the link between evidence-based guidelines for VAE and the prevention of VAE. This finding is consistent with previous studies, which have reported that nurses could not relate oral care to systemic infections (Alja'Afreh, Mosleh, & Habashneh, 2018; Booker, Murff, Kitko, & Jablonski, 2013).

In the broader hospital context, previous studies have reported that registered nurses have inadequate knowledge of the use of evidence-based guidelines in clinical practice (Aiken et al., 2014; Koehn & Lehman, 2008). In an international study of healthcare professionals' knowledge of evidence-based guidelines to prevent Hospital-Acquired Infections (HAI), Labeau et al. (2016), reported that there was a lack of knowledge among healthcare professionals working in different departments of the hospital. The lack of knowledge was not limited to one infection, but across all HAI. The lack of knowledge might be related to a lack of awareness of the available evidence-based guidelines (Labeau et al., 2016).

In this study, there was no significant association between the nurses' knowledge scores and their experience in intensive care nursing, which is consistent with results of El-Khatib et al. (2010). In a cross-sectional survey of intensive care clinicians' (*n* = 59) knowledge of VAE prevention, there was no significant association between their experience and knowledge scores (El-Khatib et al., 2010). They also found no significant differences between knowledge scores across the different professions of physicians, nurses and respiratory therapists: 80.2% (SD = 11.4), 78.1% (SD = 10.6), and 80.5% (SD = 6.0), respectively (El-Khatib et al., 2010). This demonstrates that experience did not influence knowledge of VAE prevention across different professional groups in the ICU in this single-centre, small scale survey.

This finding is contrary to previous survey studies which have reported significant association between nurses' experience and knowledge score (Blot et al., 2007; Jansson et al., 2013; Labeau et al., 2008). Benner's seminal work defining five stages of nursing competence (novice to expert) illustrates that it takes time for nurses to develop skills and understanding of clinical practice (Benner, 1982). Once the nurses developed experience, there is increased knowledge dependence (Benner, 1982), therefore, experienced intensive care nurses were expected to have a better knowledge of VAE prevention. The interplay between experience and knowledge is illustrated in a specific example from the survey: All participants in ICU B answered the question on the use of chlorhexidine for mouth care correctly, according to the IHI guidelines, as they used it in their current practice. While in ICU A, where chlorhexidine was not used for mouth care, only two-thirds of participants answered that question correctly. Benner's theory supports this finding, emphasising the co-dependency of nurses' experience in practice and their knowledge (Benner, 1982).

The knowledge score of junior nurses who had no postgraduate qualification and less experience in intensive care nursing was lower than the score of other clinical staff. The junior nurses reported stress, which was associated with lack of knowledge and experience in dealing with critically ill patients and their care needs. These findings are consistent with the definition of work-related stress provided by the WHO (2020): “the response people may have when presented with work demands and pressures that are not matched to their knowledge and abilities and which challenge their ability to cope” (para.3). This shows that education, knowledge and experience are important to the implementation of evidence-based guidelines to prevent VAE in the ICU.

7.2.2 Resources and care provision

Intensive care nursing was reported by participants to be a demanding and highly skilled role. The study participants articulated the importance of an appropriately skilled and educated workforce. Most of the participants in both ICUs reported inadequate staffing and equipment as a barrier to the implementation of evidence-based guidelines to prevent VAE. The items most often in short supply were oral care products and ETTs with suction aids.

7.2.2.1 Perceptions of inadequate staffing

In this study, most participants reported that they were inadequately staffed at times, in particular, working without supernumerary team leaders; and, at times, they were working above the recommended staffing ratios (see Section 6.2). A team leader in ICU is an addition to bedside nurses and provides clinical and educational support to

untrained staff. The team leader helps with complex nursing care, which requires more than one nurse (ACCCN, 2016) (see Section 6.2). However, there were reported situations when the team leader was allocated patients to care for directly, leaving minimal or no bedside nurse support for the nurses without postgraduate qualifications. This study has confirmed findings reported previously; there were inadequate experienced nursing staff to mobilise mechanically ventilated patients in the ICU (Lin, Phelan, Chaboyer, & Mitchell, 2020). In a single-centre, Australian tertiary ICU cross-sectional survey of nurses, physicians and physiotherapists (*n* = 82), most of the participants (*n* = 59, 72%) reported that inadequate experienced nursing staffing was a barrier to the early mobilisation of mechanically ventilated patients (Lin et al., 2020).

The nurse-patient allocation in Australian ICUs is a 1:1 nurse-to-patient ratio for intensive care patients (ACCCN, 2016). The intensive care staffing model in Australia is different to some other countries, which have additional respiratory therapists or dialysis nurses (Chamberlain, Pollock, & Fulbrook, 2018; Sakr et al., 2015). Australian intensive care nurses have a smaller patient allocation (1:1 nurse: patient ratio) than in some of the reviewed international studies (Sakr et al., 2015).

In this study, nurses reported low adherence in the absence of a team leader, who was an extra person on top of the 1:1 nurse to patient allocation. These findings are consistent with West et al. (2014), who examined the relationship between the number of nursing staff and patient outcomes in a cross-sectional retrospective, risk-adjusted observational study of 65 ICUs (*n* = 38,168 patients) in the UK. The number of nursing staff was calculated by examining the staff roster and the number of occupied beds,

which did not account for sick leave on the days of data collection. The number of nursing staff was required to be at a 1:1 nurse to patient ratio. West and colleagues reported that increased nursing staff per bed (OR: 0.90, 95% CI: 0.83 - 0.97) was associated with high adherence rates and improved patient survival rate (West et al., 2014). These findings show that there was a relationship between the number of nurses and patient outcomes (West et al., 2014). This study did not examine patient outcomes but there are a few studies who have reported an association between low adherence and poor patient outcomes (Aragon Penoyer, 2010; Blot, Rello, & Vogelaers, 2011; Hugonnet, Uckay & Pittet, 2007; West et al., 2014).

In contrast to this study's findings, Sakr and colleagues reported that the Australian critical care nursing workforce and their nurse-patient ratio model significantly enhanced patient outcomes compared to Western Europe, North America and Asia (Sakr et al., 2015). In an international, multi-centre observational study conducted in ICUs in 75 countries investigating the prevalence of infection and hospital mortality; the nurse-to-patient ratio of 1:1.5 (two nurses to three patients) has been reported to provide stability in the patient's condition and was associated with a lower risk of hospital death (OR, 0.69; 95% CI: 0.47–1.01; p = 0.054) (Sakr et al., 2015). This suggests that in Australia, nurses could manage more patients; however, the nursing model was different, and the participants' demographic characteristics were not discussed. Sakr et al. (2015) findings are consistent with Aloush (2017), who reported that a 1:1 nurse-to-patient ratio was significantly associated ($p < 0.05$) with increased adherence to evidence-based practices. This shows that staffing can influence practice and adherence rates.

In this study, inadequate nurse staffing was reported to increase nursing workload, leading to missed care. 'Missed care' reflects the necessary nursing interventions that were missed due to inadequate resources or poor knowledge. In a large (*n* = 2917) cross-sectional survey of nurses in a non-ICU population in the UK, Ball and colleagues reported a significant association between nurse staffing and missed care (*p* = <0.001) (Ball, Murrells, Rafferty, Morrow, & Griffiths, 2014). They reported that care was 'left undone' during the day shift compared to the night shift (*p* = <0.001). The higher the patient care needs, the higher the number of missed nursing care activities (*r* = 0.23 and 0.18, *p* = <0.001) (Ball et al., 2014).

The participants in this study also reported inadequate staffing in the form of poor skill-mix as a barrier to the implementation of evidence-based guidelines. Some nurses in the leadership team reported that there were junior nurses with minimal experience and no postgraduate qualification having to care for critically ill patients with complex needs. In a four-year retrospective study of three adult hospitals in Australia, Twiggs and colleagues explored the impact of skill-mix on patient outcome (Twiggs, Duffield, Bremner, Rapley & Finn, 2012). They reviewed (*n* = 103,330) patient records and (*n* = 73,770) nurse staffing records. Increases in nursing skill-mix was associated with a decrease in the rates of patient adverse events, such as pressure ulcer, DVT and pneumonia (Twiggs et al., 2012). The findings of Twiggs et al. (2012) support the findings of another Australian study that was conducted in 80 hospitals over five years to determine the association between skill-mix and patient outcome (Duffield et al., 2007). They reported that a higher percentage of RNs was associated with a reduction in sepsis and pressure ulcers (Duffield et al., 2007). However, all of these studies were not conducted in the ICU.

There is a paucity of Australian studies on intensive care nursing staffing, skill-mix and patient outcome; this study did not examine the relationship between inadequate staffing and patient outcomes, but participants reported that inadequate staffing led to increased workload and missed care. Inadequate nurse staffing has been reported to affect the implementation of evidence-based guidelines to prevent VAE and adherence rate, thereby exposing patients to the risk of mechanical ventilation complications (Aragon Penoyer, 2010; Blot, Rello, & Vogelaers, 2011; Hugonnet, et al., 2007).

7.2.2.2 Inadequate equipment

In this study, participants acknowledged that inadequate equipment was a barrier to the implementation of evidence-based guidelines to prevent VAE. This explains the low adherence in oral care identified in the document review and the poor knowledge of some equipment used in the prevention of VAE in the ICU, such as the use of ETTs with suction aids. A lack of equipment in this study was reported to be associated with increased cost, which is related to a lack of budget for preventative care, regardless of HAI (see Section 6.6.1). Inadequate equipment led to missed care or compromised care. These findings confirm the findings of previous studies (Atashi, Yousefi, Mahjobipoor, & Yazdannik, 2018; Jansson et al., 2013; Rivaz, Momennasab, Yektatalab, & Ebadi, 2017; Yeung & Chui, 2010).

In an Iranian qualitative study of 23 critical care nurses' perceptions of barriers to VAP prevention, Atashi et al. (2018) reported that inadequate equipment (ETTs with suction aids) affected the provision of evidence-based practice to prevent VAE. As noted in

the literature review, inadequate resources were reported as a reason for non-adherence in the surveys of physicians (Rello et al., 2002) and nurses (Ricart et al., 2003). In the semi-structured interviews of this study, most of the participants reported that ETTs with suction aids were unavailable in their ICUs, which is consistent with the lack of availability reported by the participants in a European study (Baldwin, Gray, Chequers, & Dyos, (2016). The use of ETTs with suction aids has been reported to reduce the risk of VAE in a few studies (Damas et al., 2015; Lacherade et al., 2010; Muscedere et al., 2011), however, many participants reported its scarceness.

This study's findings are consistent with Wolfensberger and colleagues who reported that a lack of equipment was a primary barrier to the implementation of evidence-based guidelines to prevent VAE, utilising a mixed method study that explored nurses and doctors in six ICUs in Switzerland (Wolfensberger, Meier, Clack, Schreiber, & Sax, 2018). According to Wolfensberger et al. (2018), the lack of equipment, such as oral care products and closed suction catheters, were reported in the focus group interviews with 42 nurses and four physicians. Most of the previous qualitative studies reporting a lack of equipment were from developing countries, such as Iran, South Africa and China (Atashi et al., 2018; Malelelo-Ndou, Ramathuba, & Netshisaulu, 2019; Rivaz et al., 2017; Yeung & Chui, 2010). This shows that a lack of equipment is a barrier to the implementation of evidence-based guidelines to prevent VAE; and this is not limited to lower socio-economic countries only, but widely reported in different studies conducted in different countries.

7.2.3 Unit culture and evidence-based guidelines

In this study, some participants in the leadership team reported that some experienced nurses were reluctant to change their nursing practice and that a change of practice was not well-received by some experienced nurses. Some of the participants in the leadership team reported acting as role models for junior nurses and they also acknowledged that lack of equipment, the nurse's poor knowledge and practice and their failure to advocate for best practice decreased patient safety in the ICU. In this study, some participants in the leadership team reported feeling empathy with the patient, due to the sub-standard care provided. These findings are consistent with the qualitative findings of a study conducted in Iran with 15 critical care nurses (Davoodvand, Abbaszadeh, & Ahmadi, 2016).

The junior nurses in this study reported following the practice of experienced nurses. This study has confirmed findings reported previously, that some experienced intensive care nurses were using out-dated techniques for mouth care, regardless of the availability of current evidence-based practices (Berland, Natvig, & Gundersen, 2008; Soh, Wilson, Koziol-McLain, & Soh, 2007; Sole, 2005). According to Jansson et al. (2018), in the evaluation of critical care nurses' self-reported adherence to evidence-based guidelines, less experienced nurses reported higher adherence (29.0 [24.0-31.8]) than more experienced nurses (25.0 [21.0-29.0]) (p = 0.034). The experienced nurses found it hard to translate new evidence to practice because of their old-style ways of thinking and practice (Bakken et al., 2008; Jansson et al., 2018) and their decision-making that might be more intuitive rather than based on following procedures and guidelines (Benner, 1984).

In a cross-sectional study conducted in Croatia ICUs (*n* = 241 nurses), most of the junior nurses reported that they relied on the senior nurses as their primary source of information in ICUs without policies on VAE prevention (Jordan et al., 2014). This study's findings are consistent with a study by Jordan et al. (2014), in which participants reported that there were no policies on prevention of VAE but, rather, the practice was communicated from clinician to clinician. Benner (1984) states that less experienced nurses follow policies and guidelines in practice more than experienced nurses, who rely more on their intuition. In this study, most participants in ICU A and ICU B reported that, there were no clear policy or procedure to follow and that clinicians followed the unit culture to guide their practice. This might be related to the lack of knowledge of evidence-based guidelines, as highlighted in section 7.2.1. The participants associated unit culture with staff attitude towards practice, assumptions and underlying beliefs, which influenced how specific procedures were carried out in the unit.

In an exploratory qualitative study of factors affecting intensive care nurses provision of oral care in one hospital in China, Yeung and Chui (Yeung & Chui, 2010) reported that some nurses followed the experienced nurses' practice because they were fearful of departing from the unit culture. They feared that if they used other practices, and something went wrong, they would not be supported in the unit (Yeung & Chui, 2010). According to Ladbrook et al. (2019), unit culture influenced the priority setting and implementation of evidence-based guidelines for VAE prevention in the absence of policy and procedures. In cases where experienced intensive care nurses gave low priority to evidence-based practices to prevent VAE, junior nurses were likely to do the same (Soh et al., 2007; Yeung & Chui, 2010).

According to Gesme and Wiseman (2010), fear of change, complacency and apathy were hindrances to change, which requires full engagement by the leaders to happen effectively. In a quality improvement study to reduce urinary catheter infections in the ICU, Maxwell, Murphy and McGettigan (2018) acknowledged that, for successful implementation of evidence-based practice, it was essential to address unit culture. Likewise, Pronovost et al. (2008), in a state-wide cohort study of 108 ICUs in Michigan, introduced a Comprehensive Unit-based Safety Program (CUSP), which targeted the leaders and all other staff. The aim of the CUSP was to improve the safety culture, which significantly decreased Catheter-Related Blood Stream Infections (CR-BSI) by 57% after 18 months. The CUSP improved the unit safety culture and improved the evidence-based practice culture and, consequently, significant changes were seen in the reduction of CR-BSI (Pronovost et al., 2008). The link between HAI rates and unit culture in the ICU has been reported in a few studies (Miller et al., 2016; Sood et al., 2017; Vigorito, McNicoll, Adams, & Sexton, 2011). It is highly likely that the unit culture influenced how participants implemented VAE prevention guidelines in the two units.

7.3 Procedural factors

In this study, there were six elements in the evidence-based guidelines which were examined for adherence in two ICUs. The six elements of evidence-based guidelines will be referred to as the ventilation bundle, and the bundle elements were: HoBE 30 to 45 degrees, peptic ulcer prophylaxis, DVT prophylaxis, sedation interruption, readiness for extubating and use of chlorhexidine for mouth care.

Most of the participants reported that immediate, life-saving interventions took precedence over implementation of evidence-based practice to prevent VAE. This finding explains the results of the medical records review, where adherence rates increased with the number of mechanical ventilation days, with mean bundle adherence per mechanical ventilation day, as follows: Day 3 = 79.4%, Day 4 = 91.1% and Day 5 = 96.7%. The patients were critically ill on admission requiring complex care and the severity of sickness improved with the number of mechanical ventilation days. In this section, prioritisation of care needs, workload and inconsistencies in care will be discussed.

7.3.1 Prioritisation of care needs

Critically ill patients admitted to the ICU had life-threatening conditions and nurses were frequently required to prioritise their care needs. While participants acknowledged that all elements of patient care were necessary for the patient's overall health and well-being, most participants reported that they had to prioritise interventions related to airway, breathing, circulation and drugs before all other patient care requirements.

Most of the participants (85%) in this study self-reported that they positioned their patients with the HoBE at 30 to 45 degrees and, on medical records reviewed, most of the patients (>80%) had their HoBE at 30 to 45 degrees. There was a statistically significant difference in mean APACHE III scores between patients who had HoBE and those without HoBE on day 3 of mechanical ventilation (p = <0.001). This was observed in nearly a fifth of the patients (18.7%) who were on high doses of inotropes

and diagnosed with post cardiac arrest who did not have HoBE on day 3. Most of the evidence-based practices to prevent VAE were implemented after the patients were haemodynamically stable.

The mean HoBE results in this study were higher than previously reported in the US (Bingham, Ashley, De Jong, & Swift, 2010; Hewson-Conroy et al., 2011). Hewson-Conroy et al. (2011) conducted a point prevalence survey to evaluate patient care in 50 ICUs in Australia and New Zealand and reported that 40% of patients had their HoBE at 30 to 45 degrees. In an evaluation of nurses (*n* = 100) in two ICUs in the US, focusing on adherence to HoBE following education intervention, Bingham and colleagues reported a 72% adherence rate, with no improvement post education (Bingham et al., 2010). In an observational cross-sectional study in a single ICU in Spain, Martí-Hereu and Arreciado Marañón (2017) assessed HoBE in mechanically ventilated patients and factors which influenced adherence. They reported lower adherence in patients with critical sickness, agitation and abdominal pathologies (Martí-Hereu & Arreciado Marañón, 2017).

The results of the current study are contrary to an observational study conducted by Liu et al. (2013) in 33 Chinese ICUs, who reported an adherence rate of 27.8% in 8,647 measurements of HoBE. The adherence rate reported was not associated with patient severity of sickness or the use of inotropes but, in a survey of the nurses, the critical contributing factor in non-adherence was *nurse workload* (Liu et al., 2013). The effects of nurse workload will be discussed later in this chapter.

Oral care frequency also increased with the number of mechanical ventilation days. These findings confirm the results of previous studies, which report that mouth care is considered less important than other nursing interventions (Furr, Binkley, McCurren, & Carrico, 2004; Ladbrook et al., 2019). In a national survey of 102 ICUs (*n* = 556 nurses) in the US, Furr and colleagues reported that oral care was given low priority and was perceived to be less critical and an unpleasant activity compared with other nursing interventions, so less time was allocated to it (Furr et al., 2004). These findings are consistent with the results of a qualitative study (*n* = 12), conducted in one ICU in Australia, in which nurses recognised the importance of evidence-based guidelines and viewed the use of evidence positively, however, preventive care was given a lower priority than the immediate therapeutic nursing interventions (Ladbrook et al., 2019). These study findings are also reflected in studies examining barriers to enteral feeding in ICU (Bloomer, Clarke, & Morphet, 2018; Cahill, Murch, Cook, & Heyland, 2012).

In a survey of Australian intensive care nurses' (*n* = 388) prioritisation of enteral feeding, Bloomer et al. (2018) reported that nurses recognised the importance of enteral nutrition, however, they prioritised it after other aspects of care. On a priority scale of 1 (highest) to 8 (lowest), the non-clinical nurses (academics, managers and researchers) ranked enteral nutrition statistically significantly higher, at 5, than the clinical nurses (specialist nurses and registered nurses), who ranked it at 6 (p = 0.0006). In this study, the bedside nurses reported how prioritisation of patient care was based on their clinical decisions (see Section 6.4), which support the results of Bloomer et al. (2018). However, in this study's survey of nurses, there was no statistical difference in self-reported practices between nurses' with or without postgraduate qualifications (p = 0.236) or specialist roles (p = 0.479), which is contrary

to the findings of Bloomer et al. (2018). When these findings were viewed together, there appears to be low prioritisation of oral care in ICUs in several countries (Australia, Croatia and US) over a substantial period (Furr et al., 2004; Jordan et al., 2014; Ladbrook et al., 2019). Most of the nurses in this study reported that the competing needs of a critically ill patient left them without options other than focusing on immediate life-saving interventions.

In contrast to our study findings and Bloomer et al. (2018), Cahill and colleagues (2012) reported that patient haemodynamics or severity of patient sickness did not make any difference to the way nurses prioritised care. In a Canadian multi-centre cross-sectional survey of critical care nurses (*n* = 138), barriers to enteral nutrition were related to a lack of equipment and staffing (Cahill et al., 2012). The Cahill study was conducted in North American ICUs and the levels of ICUs surveyed were not disclosed. The differences might be related to the type of ICUs and severity of sickness of the patients admitted to the units surveyed. The findings of this mixed methods study support a large survey of intensive care nurses in Australia (Bloomer et al., 2018) and the US (Furr et al., 2004), suggesting that these findings can be generalised to an international population.

7.3.2 Workload

Most participants reported that the workload involving critically ill, unstable patients with multi-organ failure was demanding and, at times, overwhelming. This finding helps to explain the low adherence rates to evidence-based practice with respect to patients who had multi-organ failure and high APACHE III scores in the medical

records reviewed. The findings from this study support previous studies (de Souza Nogueira & Poggetti, 2014; Kraljic et al., 2017; Padilha, de Sousa, Queijo, Mendes, & Miranda, 2008). In a one month prospective study of 200 patients in four ICUs in Brazil, factors related to nursing workload were explored using the Nursing Activities Score (NAS) per patient, and high scores (> 66.4%) were found to be associated with poor patient outcome ($p = 0.006$) (Padilha et al., 2008). The highest NAS scores were found to be associated with significantly increased patient length of stay and mortality rates (Padilha et al., 2008). However, there were other factors which increased the nursing workload in the ICU. In a cross-sectional study of 133 patients in Turkey, Öztürk and colleagues (2018) reported that patients with delirium in the ICU increased nursing workload, as measured using the Therapeutic Intervention Scoring System-28 (TISS) (26.33 +/- 5.57), compared to those patients without delirium (20.74 +/- 6.36) ($p = 0.03$) (Öztürk Birge & Bedük, 2018). Patients with delirium were reported requiring close observation and extra emotional support, which required a lot of time (Öztürk Birge & Bedük, 2018).

Neuraz et al. (2015) reported that increased patient-to-nurse ratio was associated with increased risk of mortality, from 7% (424/5,718) to 14.9% (851/5,718), in a multi-centre longitudinal study in eight ICUs in France involving 5,718 patients. The nursing workload measures were patient-based; they focused on the turnover of patients and the severity of patient illness but did not recognise nurse characteristics and their interaction with the environment (Carmona-Monge, Rollán Rodríguez, Quirós Herranz, García Gómez, & Marín-Morales, 2013). In a recent editorial, Da Palma (2018) stated that the experts were still debating the best and most accurate way to measure workload in the ICU. This study examined adherence and factors which influence the

implementation of evidence-based guidelines to prevent VAE but did not measure patient outcomes.

In a systematic review, intensive care nurses in Australia were reported to routinely operate highly technical equipment, continually assess and re-assess patients and adjust equipment settings, accordingly (Chamberlain et al., 2018). It is expected that the intensive care nurse problem-solves technical equipment issues and manages the multiple complex needs of a critically ill patient (Chamberlain et al., 2018). The intensive care nurse is expected to manage all other elements of patient care, including those which seem basic and non-technical. Some participants found it demanding and often challenging to continually assess patients, adjust ventilator settings frequently and collect bloods; this is also reflected in previous studies (de Souza Nogueira & Poggetti, 2014; Kraljic et al., 2017).

The less experienced nurses in this study reported that the workload was excessively demanding and they required help with patient care needs and supervision with complex procedures. Some of the activities reported as increasing nurses' workload were preparing and transporting patients for screening tests and performing pathological tests, such as arterial blood gases. The findings from this study support previous qualitative studies conducted in two countries (Canada and South Africa) (Ballem & Macintosh, 2014; Matlakala, Bezuidenhout, & Botha, 2014).

The experienced intensive care trained nurses in this study reported that working alongside junior nurses overwhelmed them and increased their workload, as they were expected to assist the junior nurses, which confirms the findings of Ballem and

Macintosh (2014) and Matlakala et al. (2014). In a narrative exploration of experienced nurses (*n* = 8) working with graduate nurses in two hospitals in Canada, the experienced nurses explained how having the newly graduated nurses significantly increased their workload (Ballem & Macintosh, (2014). These findings are consist with an exploratory descriptive qualitative study of nurses (*n* = 8) conducted in South Africa (Matlakala et al., (2014). Matlakala et al. (2014) reported that the experienced nurses felt responsible for the less experienced nurse, thereby causing an increase in workload (Matlakala et al., 2014). Both of these studies are qualitative, therefore, the findings are not meant to be generalisable. However, the similarity of the conclusions of each study is apparent. The competing demands of the nursing workload in the ICU has been identified as a demanding issue, which influenced the implementation of the evidence-based guidelines to prevent VAE for participants in this study.

Most of the participants in this study reported oral care was one of the evidence-based guidelines for VAE prevention that was often missed. In a scoping review of patient's perspectives on missed care, Gustafsson and colleagues reported that patients missed basic nursing care, including mouth care 32.1% to 50.3% of the time (Gustafsson, Leino-Kilpi, Prga, Suhonen, & Stolt, 2020). In this study, nurses reported lower rates of missed oral care (9.1%) than was reported by Gustafsson et al. (2020). However, the ICU findings were not reported separately in the study by Gustafsson et al. (2020).

In a cross-sectional study (*n* = 747 nurses) of two hospitals in two different countries (US and Lebanon), Kalisch and colleagues reported that, in the intermediate units and ICUs of medical and surgical units, most of the missed care was basic nursing care,

such as oral care and pressure area care (Kalisch, Doumit, Lee, & Zein, 2013). The particular reasons for missed care with, statistical significance, were equipment (p = 0.001) and communication (p = 0.004) (Kalisch et al., 2013). These findings were consistent with missed care reasons in non-ICU studies, which have also reported a lack of equipment and nursing resources (Ausserhofer et al., 2014; Ball et al., 2014).

Some non-ICU researchers have reported that HAIs and their impact on individuals and healthcare systems would likely decrease if there were an improvement in general nursing care (Ausserhofer et al., 2014; Ball et al., 2014). The effects of missed nursing care have been significantly associated with poorer patient outcomes and increased length of hospital stay (Ball et al., 2014; Kalisch, Landstrom, & Williams, 2009). This is consistent with the reported effects of mechanical ventilation complications, where low bundle adherence was associated with risk of VAE (Klompas, 2019; Klompas, et al., 2014). However, neither of these studies were undertaken in Australian ICUs. The patient workload determines the implementation of evidence-based practice to prevent VAE in the ICU.

7.3.3 Inconsistencies in the implementation and adherence to evidence-based guidelines

Most of the participants in the interviews reported inconsistencies in the implementation of evidence-based practice to prevent VAE. The reported inconsistencies in practice help to explain the answers some survey participants provided to questions. For example, participants who were from an ICU that used chlorhexidine for oral care answered the question related to chlorhexidine use

correctly (100%) compared to participants from another ICU, which did not use it (63.4%). Inconsistencies were identified in the following evidence-based practices: i) use of chlorhexidine for mouth care, ii) use of peptic ulcer prophylaxis, and iii) sedation interruption. The inconsistencies in practice influenced implementation of evidence-based practice and adherence rates.

7.3.3.1 Use of chlorhexidine for mouth care

More than 70% of the participants indicated that the use of chlorhexidine for mouth care was recommended for VAE reduction and nearly two-thirds reported adhering to the guideline. On the medical records review, we found that one ICU was not using chlorhexidine for mouth care. In the interviews, most of the participants in the ICU that was not using chlorhexidine could not explain why it was not used; they reported its unavailability. There is contradicting information in the literature on the use of chlorhexidine over other products or methods, such as 1.5% hydrogen peroxide, toothbrushing and sodium bicarbonate (de Lacerda Vidal et al., 2017). There are two independent meta-analyses which report on the use of chlorhexidine for mouth care in the ICU (Klompas, Speck, Howell, Greene, & Berenholtz, 2014; Price, Maclennan, & Glen, 2014). In a meta-analysis of 171 studies reviewing the use of chlorhexidine in mechanically ventilated patients, Klompas et al. (2014) reported a decrease in nosocomial infection rates in cardiac patients (RR 0.56, 95% CI: 0.41-0.77). However, there was no significant difference in patient outcome between the patients who had chlorhexidine (RR 0.88, 95% CI: 0.25-2.14) and those without (RR 1.13, 95% CI: 0.99-1.29) in cardiac surgery studies (Klompas, Speck, et al., 2014).

According to Price et al. (2014), in a systematic review of 29 prospective studies, there was an association between the use of chlorhexidine for mouth care and an increase in death rates in general ICUs (OR 1.25, 95% CI: 1.05-1.50). The findings of this systematic review were supported by a large retrospective study by Deschepper and colleagues (Deschepper, Waegeman, Eeckloo, Vogelaers, & Blot, 2018). The authors of the large, retrospective, observational, cohort analysis with more than 82, 000 patients reported that there was a strong association between the use of chlorhexidine for mouth care and increased risk of death (OR 2.61; 95% CI: 2.32–2.92), when chlorhexidine was used for mouth care in more than 11, 000 patients (Deschepper et al., 2018). According to these results of Deschepper et al. (2018) and the results of the meta-analysis by Price et al. (2014), Bouadma and Klompas (2018) advised global practitioners to stop using chlorhexidine for mouth care, as a precautionary measure until further research is undertaken. However, in an editorial published in the *Journal of Intensive Care Medicine* in the same year, Ricard and Lisboa (2018) criticised the studies, which reported the association between the use of chlorhexidine for mouth care and mortality. They claimed that more studies were required before ceasing its use in mechanically ventilated patients (Ricard & Lisboa, 2018).

7.3.3.2 Peptic ulcer prophylaxis

The mean adherence to peptic ulcer prophylaxis was 97.6% over the three days of mechanical ventilation. Despite higher adherence rates, there was a decrease in the use of peptic ulcer prophylaxis with an increase in the number of mechanical ventilation days. This is explained by the interview findings, when a consultant reported that if the patient was tolerating feeds or if the patient had a fever of unknown

origin, the use of peptic ulcer prophylaxis was stopped, as its use was controversial in such circumstances. However, the recommendation by the IHI is to use peptic ulcer prophylaxis in all mechanically ventilated patients (IHI, 2012).

The higher adherence rates demonstrated an improvement from previous quality improvement studies in the ICU, which reported adherence in similar populations, as follows: Hewson-Conroy et al. (2011) 86%, DuBose et al. (2008) 76.2% and Rafinazari et al. (2016) 53.5%. The difference in uptake might be related to the recommendations made by the Surviving Sepsis Campaign (SSC) guidelines, which recommends using peptic ulcer prophylaxis in mechanically ventilated patients (Society of Critical Care Medicine, 2016). Despite high adherence rates, there is no consensus on when peptic ulcer prophylaxis should be stopped, with recommendations suggesting i) when the patient tolerates enteral feeding, ii) at extubation, or iii) on discharge from the ICU (Goodwin & Hoffman, 2011; Ye, Liu, Cui, & Liu, 2016). The variability of outcomes from research studies on when to cease peptic ulcer prophylaxis might have influenced practice in both the ICUs.

There is contradicting evidence on the benefits of peptic ulcer prophylaxis in both ICU and non-ICU studies (Eom et al., 2011; Reynolds & MacLaren, 2019). In a systematic review of 31 (ICU and non-ICU) studies and a meta-analysis of eight observational studies, Eom and colleagues concluded that the use of proton pump inhibitors or histamine$_2$ receptor antagonists might be significantly associated with the increased risk of hospital-acquired pneumonia (Eom et al., 2011). The risk of pneumonia was reported to be higher with the use of proton pump inhibitors (adjusted OR 1.27, 95% CI: 1.11-1.46) and histamine$_2$ receptor antagonists (adjusted OR 1.22, 95% CI: 1.09-

1.36) in observational studies. While, in the randomised control trials, the use of histamine$_2$ receptor antagonists was significantly associated with increased risk of hospital-acquired pneumonia (adjusted OR 1.22, 95% CI: 1.01-1.48). The clinicians were urged to cautiously prescribe peptic ulcer prophylaxis for patients at risk of developing pneumonia (Eom et al., 2011). However, Reynolds and MacLaren (2019) undertook a systematic review with a meta-analysis of 34 randomised controlled ICU studies, and reported that the use of peptic ulcer prophylaxis significantly decreased gastric bleeding (RR 0.53, 95% CI: 0.37–0.76, p = <0.001). They reported no significant difference in hospital-acquired pneumonia or mortality rates (Reynolds & MacLaren, 2019). Reynolds and MacLaren (2019) claimed that peptic ulcer prophylaxis should be used until a large randomised clinical trial demonstrates the ineffectiveness of its use. These differences might reflect the differences between the use of peptic ulcer prophylaxis medications in the different studies, however, there is insufficient detail in the studies to draw this comparison.

7.3.3.3 Sedation interruption

In this study, a mean of 78.8% of patients had sedation interruption for the three consecutive days of mechanical ventilation. The participants reported that the inconsistencies in sedation interruption were related to i) the severity of patient sickness, ii) different approaches of consultants, and iii) a lack of policies and or procedures to follow. The mean adherence rate is higher than those previously reported in Australia and New Zealand (O'Connor, Bucknall, & Manias, 2010). In a cross-sectional survey of Australian and New Zealand intensive care nurses (n = 348), O'Connor, Bucknall and Manias (2010) reported an adherence rate of 62%.

The variability of evidence on the extent to which sedation interruption facilitates early extubation might have influenced the uptake of sedation interruption (Chen, Liu, Chen, & Wang, 2014; Mehta et al., 2012).

In a systematic review of eight randomised controlled trials (n = 757), Chen and colleagues reported that daily sedation interruption reduced the mechanical ventilation period ($Z = 5.36$, $p < 0.0001$) and length of stay ($Z = 2.93$, $p = 0.003 < 0.05$) (Chen et al., 2014). However, in a randomised controlled trial, Mehta et al. (2012) reported no difference in the number of mechanical ventilation days post-implementation of sedation interruptions (hazard ratio, 1.08; 95% CI: 0.86-1.35; $p = 0.52$). Mehta et al. (2012) reported that the ventilation period remained the same as those who were on light sedation. This shows the importance of the bundled approach, as the use of sedation interruption in combination with other elements was reported to decrease the number of mechanical ventilation days (Klompas, Branson, et al., 2014; Klompas et al., 2016).

One of the factors that might cause inconsistencies in practice is the availability of a range of new evidence to prevent VAE, as different ICUs may be adapting different elements of specific evidence-based practices (Labeau et al., 2008). It is highly likely that some of the Australian ICUs did not adapt all of the evidence-based practices for VAE prevention (see Section 2.3), so the experienced nurses could not relate to some of them. Poor articulation of the use of evidence-based guidelines was not limited to intensive care nurses.

Previous studies have reported that registered nurses working in different departments in hospitals have inadequate knowledge of the use of evidence-based guidelines in clinical practice (Aiken et al., 2014; Koehn & Lehman, 2008).

7.3.4 Lack of policy and or procedures

In this study, participants reported that there were no policies and or procedures on VAE for them to follow. There is a clear difference between policy and procedures (see Section 6.5.1) but the participants in this study did not clearly distinguish the difference; they used the terms interchangeably.

The consultants' preferences on prevention of VAE was reported to vary, with most of the prevention practices applied dependent on the consultant on duty. In a cross-sectional survey of intensive care nurses (*n* = 241) in 14 public hospitals in Croatia, Jordan et al. (2014) reported that the nurse's attitudes and adherence to evidence-based guidelines to prevent VAE was significantly associated with the presence of policies and the use of procedures in the unit. The establishment of clear policy and procedures was reported to increase adherence in previous VAE studies (Alja'Afreh et al., 2018; Jordan et al., 2014; Yeung & Chui, 2010).

According to Yeung and Chui (2010), a lack of oral care protocol led to inconsistencies in products used for oral care and the frequency of the application of oral care, as nurses' understanding and expectations varied. In the prospective medical records that were reviewed in this study, mouth care frequency ranged from one- to eight-hourly every 24 hours and the majority of the survey participants (90.9%) reported that

they regularly perform oral care on mechanically ventilated patients. These findings support the findings of a six-month, retrospective medical records review of 143 patients in the US (Goss, Coty, & Myers, 2011). This shows that there are inconsistencies in nursing practice, as the CDC has recommended mouth care every two to four hours and whenever necessary (CDCP, 2003). This shows the importance of using procedures and auditing practice to increase emphasis on the beneficial components of the ventilation bundle.

7.3.5 Lack of surveillance of VAE in the ICU

Some participants in this study reported that there was no surveillance of VAE in their ICU. In 2005, Friedman and colleagues reported that four out of fifteen ICUs were participating in VAP surveillance in Victoria (Friedman, Russo & Richards, 2005). Surveillance of VAP was considered to be labour-intensive and some nurses and doctors in Victoria did not see its benefit, so they did not participate (Friedman, et al., 2005). According to the VICNISS, surveillance of VAE remains important, although, a minimum number of ICUs in Victoria participate in it (VICNISS, 2018). This shows that there is no progression in VAE surveillance in Victorian ICUs. This might be due to the reported subjectivity in surveillance criteria, as discussed in Chapter One (see Section 1.3).

According to a systematic review and meta-analysis of 18 articles conducted in eight different ICUs, Fan and colleagues compared the older VAP surveillance with the new VAE surveillance guidelines. They reported that surveillance was important, although not all cases of VAP were identified using current surveillance guidelines (Fan et al.,

2016). VAE surveillance was recommended as a strategy that could improve care for mechanically ventilated patients, by creating awareness of the prevalence of the complications (Klompas, 2013). As stated in the narrative review (see Section 2.4), surveillance of VAE increased adherence and helped to decrease the number of mechanical ventilation days (Al-Dorzi et al., 2012; Al-Tawfiq & Abed, 2010).

7.4 Outcome of the use of evidence-based guidelines

Adherence rate per different elements of the study were discussed earlier. In this section, the mean ventilation bundle adherence rate and the emotional stress of healthcare professionals will be discussed.

7.4.1 Overall adherence rates using the ventilation bundle

The mean ventilation bundle elements adherence rate in this study was 88.3%, which confirms the findings of previous studies. In a pre and post audit and feedback study of nurses' compliance in two Australian ICUs, Lawrence and Fulbrook (2012) reported 90% mean overall compliance post audit and feedback. Baldwin et al. (2016) reported greater than 85% adherence with every element of the evidence-based guidelines in a self-reported national survey of UK nurses (*n* =121) and doctors (*n* = 68). Darawad et al. (2018), reported adherence of 81.3% in a self-reported survey of nurses (*n* = 208) in three Jordanian ICUs. In a randomised clinical trial of Jordanian critical care nurses (*n* = 120) focused on adherence to VAE evidence-based guidelines post education, Aloush (2017) reported that participants who had educational sessions on the guidelines had a better mean adherence score (14.1 ± 4.4) than the control group

(12.8 ± 3.7). However, the difference was not statistically significant (p = 0.15) (Aloush, 2017). The use of care bundles has been reported to increase adherence to evidence-based guidelines to prevent VAE (Rawat et al., 2017; Sachetti et al., 2014). In a longitudinal, quasi-experimental study to reduce VAE by using bundled care in 56 ICUs in the US, Rawat and colleagues reported increased adherence and decrease in VAE rates from 7.34 to 4.58 cases per 1,000 ventilator-days over 24months (p = 0.007) (Rawat et al., 2017). In a prospective, multi-centre, cohort study conducted over 16 months in five Spanish ICUs, Rello et al. (2012) reported a reduction of four days in the length of stay and the duration of mechanical ventilation with a high bundle adherence rate, with an incidence risk ratio of 0.78 (95% CI: 0.15–0.99), (p <0.05). This shows that the use of bundled care is effective in preventing HAI (Dawson & Endacott, 2011), as demonstrated by different care bundles evaluated by Pronovost et al. (2010). Pronovost and colleagues conducted an observational study to evaluate the implementation of five evidence-based guidelines to decrease CR-BSI in 90 ICUs in the US; the infection rates decreased from a baseline of 7.7 and 2.7 to 1.3 and 0 (0.24) at 16 to 18 months (Pronovost et al., 2010).

In this study, the participants' knowledge of the evidence-based guidelines to prevent VAE was not significantly associated with adherence; neither was their experience in intensive care nursing. The inconsistency between knowledge and practice might be related to factors which affect the interplay between structure and process such as availability of equipment. According to Labeau et al. (2008), specific organisational policies which do not support the practice, might cause inconsistency between knowledge and practice. This study finding was consistent with previous studies, which reported that healthcare providers' good theoretical knowledge of hand hygiene

evidence-based guidelines was not related to their adherence in practice (Atashi et al., 2018; De Wandel, 2017; De Wandel, Maes, Labeau, Vereecken, & Blot, 2010). The reported low adherence demonstrates that there are factors, other than knowledge, which influence adherence to the implementation of evidence-based guidelines. This shows that there were other factors, which influenced the implementation of evidence-based guidelines (Figure 7.1) to prevent VAE in ICUs. In this study, healthcare professionals *(structure)* and the availability of resources influenced the implementation of evidence-based guidelines *(process)* to prevent VAE. In cases of inadequate resources, participants reported that care was not given, leading to poor adherence rates *(outcome)*. Inconsistencies in bundle adherence or poor adherence rates have been reported to prolong the mechanical ventilation period and increase hospital stay (Klompas et al., 2016; Rello et al., 2012), thereby directly impacting on resource requirements *(structure)* of the ICU.

7.4.2 Healthcare professionals' emotional stress

Most of the participants, the junior nurses and the leadership team, reported their desire to provide the best care possible and to 'do unto others as you would like done unto you'. They reported feeling stressed and challenged by the inability to complete the required care. The reported distress by the junior nurses was associated with a lack of knowledge and experience to manage critically ill patients. Some were worried that they would not be able to detect patient deterioration in a timely manner, which might lead to poor patient outcome. Most of the participants felt guilty that the patients were missing care which could help prevent VAE. Some ANUMs reported that the worst part of their job was patient-nurse allocation, as the skills of some junior nurses

did not suit the acuity of the patients. They felt guilty, however, they went ahead and allocated the patients anyway. Most of the participants in the leadership team acknowledged that there was a poor skill-mix, a lack of VAE preventative knowledge, a high workload, and inconsistencies in the implementation of preventative care. While most of the junior nurses were more distressed about the situation, most of the team leaders seemed to have passively accepted the situation.

According to Mealer and Moss (2016), the ICU is a complex, difficult, tension-filled, stressful environment with critically ill patients. Some of the stressful factors reported confirms our study findings, such as inadequate staffing and a lack of unit policy (Mealer & Moss, 2016). In a national survey of 21,767 ICU nurses in Iran, a lack of resources and poor staffing ratios were reported as stressful factors (Vahedian-Azimi et al., 2017), which is consistent with the findings of this study.

In this study workload was reported to be demanding, challenging and stressful at times. This finding is consistent with previous studies conducted in Australia, China and Saudi Arabia (Alenezi, Aboshaiqah, & Baker, 2018; Happell et al., 2013; Li & Lambert, 2008). In a cross-sectional study of nurses (n = 347) in five hospitals in Saudi Arabia, workload was significantly associated *(p= <0.001)* with work-related stress (Alenezi, et al., 2018). The link between workload and work-related stress has been reported in ICU and acute hospitals (Happell et al., 2013; Li & Lambert, 2008). In a qualitative study of nurses (n = 38) workplace stressors of registered nurses working in an Australian acute hospital; Happell and collegues reported that the nurses main stressor was high workload as a result of poor skill mix (Happell et al., 2013).

According to Vahedian-Azimi et al. (2019), critical care nurses usually form a bond with the patient and they develop a sense of responsibility for the patient's outcome. It has been reported that missed care can cause emotional and moral distress (Ausserhofer et al., 2014). In a study of critical care nurses' perspectives on delivering the best care and personal well-being, Siffleet and colleagues reported that, when nurses were able to provide the best care, they reported feeling satisfied and happy (Siffleet, Williams, Rapley, & Slatyer, 2015). The feelings of satisfaction and happiness were reported to have a direct positive impact on their emotional health (Siffleet et al., 2015). This study did not explore the effects of feeling stressed and challenged on participant well-being, however, there are a few studies who have reported an association between healthcare professional's well-being and patient care (Harris, 2001; Berland et al., 2008).

In a qualitative study of critical care nurses (*n* = 23) on patient safety and work-related stress in two Norway acute hospitals, Berland and colleagues reported that nurses' workload related stress could have effects on patient care and safety (Berland et al., 2008). According to Harris (2001), work-related stress can lead to increased sick leave, high staff turnover and unsafe practice. In a systematic review examining the sources and consequences of work-related stress; Eleni and colleague concluded that work-related stress negatively affected patient care (Eleni & Theodoros, 2010). This shows that work-related stress can affect healthcare professionals' *(structure)* well-being, and directly or indirectly could affect their practice *(process)* as a result of inadequate staffing, which in turn increase the workload of the available staff, and therefore affecting patient care and adherence rates *(outcome)*. This shows the factors that interplay between structure, process and outcome.

7.5 Chapter summary

The findings of this study demonstrated that evidence-based guidelines to prevent VAE were used in Australian ICUs. The use of mixed methods has contributed to a level of insight into factors influencing the use of the evidence-based guidelines to prevent VAE in the ICU. The findings from this study added the factors, which influence the interrelationship between the *structure*, *process* and *outcome*; and the findings suggested that the Donabedian (2003) model has a double headed arrow between the components. The findings were discussed in the context of the Donabedian model and factors that affect the interplay (Figure 7.1).

The participants' education and experience, inadequate staffing, inadequate equipment and unit culture were significantly associated with the implementation of evidence-based practice in Australian ICUs. These were the factors which influenced the implementation of evidence-based guidelines. The nurses' educational qualifications were significantly associated with the way they answered the questions; the nurses who had postgraduate qualifications had better knowledge scores. The unit culture also influenced the implementation of evidence-based guidelines to prevent VAE.

The competing care needs of critically ill patients led intensive care nurses to prioritise immediate life-saving interventions over other nursing interventions. The prioritisation of patient workload to immediate life-saving interventions led to placing evidence-based practice for VAE prevention lower than other interventions, leading to missed patient care. Oral care was one of the ventilation bundle elements reported often

missed, due to competing demands, lack of equipment and inadequate staffing. The missed care led to poor adherence with the bundled care, which affected the structural factors of the ICUs, leading to work-related stress. Inconsistencies in the implementation of evidence-based guidelines to prevent VAE were in the use of chlorhexidine for mouth care, peptic ulcer prophylaxis and sedation interruption. There were inconsistencies in the available literature, which might have influenced the way evidence-based guidelines were implemented in the Australian ICUs. The lack of policies, procedures and surveillance of VAE was reported in the two ICUs, which might have led to the inconsistencies in practice.

There are various factors which influenced adherence with the implementation of evidence-based guidelines for VAE prevention in the ICU; factors such as lack of equipment and inadequate staffing affected the implementation of care, thereby affecting the adherence rates and stress of healthcare professionals. In Chapter 8, the conclusion of the thesis is provided, including the recommendations for practice, education and research. The limitations of the study will also be discussed.

Chapter Eight - Conclusion

8.1 Review of study aims and questions

The overall aim of this research was to explore Australian ICU nurses' knowledge of VAE prevention and evaluate the implementation of evidence-based guidelines in ICUs in Victoria, Australia. Findings highlighted the gaps in practice and factors which influenced the implementation of evidence-based guidelines in Australian ICUs. In this chapter, each of the main research questions will be addressed, followed by recommendations for education, practice and future research. The study strength and weaknesses will be discussed and, finally, the summary of the study presented.

What are Australian intensive care nurses' knowledge and self-reported adherence to evidence-based guidelines to prevent VAE?

The participants' overall median score in the knowledge of evidence-based guidelines was 6/10 (IQR: 5-7). Some participants could not relate evidence-based practices to VAE prevention. They could not explain the purpose of FASTHUGS in their unit. There was a significant difference (p = 0.006) in the knowledge score between the participants who had postgraduate qualifications in intensive care nursing (*Mdn* = 7; IQR: 6-8) and those without (*Mdn* = 5; IQR: 5-7). The participants' age, years of experience in the ICU or specialty role in the ICU had no significant association with their knowledge score. The question which the majority of the participants answered correctly was related to patient positioning (n = 261, 90.9%). The questions related to equipment were answered correctly by a minority of the participants, such as the use

of kinetic beds (*n* = 66, 23%). There were no differences in knowledge scores across the different types of ICU. However, all participants from ICU B (100%) answered the question on the use of chlorhexidine for mouth care correctly, while nearly two thirds (63.4%) answered it correctly in ICU A.

The overall median self-reported adherence to evidence-based practices was 8/10 (IQR: 6-8). Mouth care was the most self-reported adhered to procedure (*n* = 259, 90.9%), followed by patient positioning in the semi-recumbent position (*n* = 241, 84.6%). There were some poorly adhered to procedures, such as the use of normal saline for endotracheal suctioning (*n* = 124, 43.5%). There was no significant difference in adherence between participants who had postgraduate qualifications and those who did not; neither did the participants' years of experience influence their self-reported adherence. The participants' knowledge score had no significant association with their self-reported adherence to practice.

How are evidence-based guidelines to prevent VAE implemented in two ICUs in Victoria?

In both ICUs, some participants reported that FASTHUGS were used in VAE prevention. Most of the medical records reviewed contained a FASTHUGS checklist. Some of the elements checked for adherence were similar to the IHI ventilation bundle elements except the use of chlorhexidine for mouth care. The overall mean adherence rate on the three consecutive mechanical ventilation days was 88.3%. The mean adherence rate was poor on Day 3 (79.4%) compared to Day 4 (91.1%) and Day 5 (96.7%). Overall, adherence rates increased with the number of mechanical ventilation days. The most adhered to elements across the two ICUs were the use of peptic ulcer

prophylaxis and DVT prophylaxis. However, the implementation of peptic ulcer prophylaxis decreased with the number of mechanical ventilation days. The least adhered to elements were sedation interruption and assessment for readiness to extubate.

There was a significant difference in mean APACHE III scores between patients who had HoBE and those without HoBE on Day 3 (p = <0.001) and Day 4 (p = 0.007) of mechanical ventilation. HoBE was associated with sedation interruption on all three consecutive days of mechanical ventilation. Despite the fact that in ICU A they were not using chlorhexidine for mouth care, the adherence rate for mouth care was high in ICU B.

What are the facilitators and barriers to evidence-based guidelines adherence?

All participants stated that there were facilitators and barriers to the implementation of evidence-based practice to prevent VAE. The facilitators were postgraduate education, availability of equipment and adequate staffing. The barriers to implementation of evidence-based practice at the unit level were: i) lack of policies and or procedures to follow, ii) unit culture, iii) shortage of equipment, iv) inadequate staffing and v) nurses' knowledge deficit. However, when facilitators and barriers were viewed together, some were factors which influenced implementation at the individual level, such as patient diagnosis, severity of patient sickness and nurse workload.

Missed care was not directly related to any of the research questions but it was reported as a result of barriers to implementation of evidence-based practice. There were incidences when patients would miss required care due to the above-mentioned

barriers. Some participants also reported feeling emotionally stressed due to the inability to deliver the best care possible. Most participants recommended continuing education opportunities on VAE, including prevention and auditing of care, to increase adherence.

8.2 The key findings

The aims of this study, to examine nurses' knowledge of VAE prevention across Australia and to explore the implementation of evidence-based guidelines in intensive care units in Victoria, Australia, have been met. The findings of this study contribute to an understanding of the structure, process, and outcome factors, which influence the implementation of evidence-based guidelines to prevent VAE in the ICU. The key findings that interplay between structure, process and outcome, and have implications for the implementation of evidence-based guidelines for VAE prevention from this study are:

i) organisational factors that influenced the implementation of evidence-based practice were the nurses' knowledge and experience, inadequate staffing and equipment and the unit culture

ii) process factors that influenced implementation of evidence-based practice were the nurses' prioritisation of critically ill patient care needs, nurses' workload, inconsistencies in the implementation of care and missed care and

iii) outcome factors such as the healthcare professional's emotional stress

8.3 Strength and limitations of the study

As described in Chapter Three, mixed methods were used to explore nurses' knowledge and adherence to evidence-based guidelines to prevent VAE in the ICU. An explanatory sequential design was used for this study. The qualitative study findings provided insight to the quantitative data first collected. The design was appropriate for this study, as all questions were answered.

The questionnaire used to collect the data was developed in Europe, so some of the questions might have targeted European practice, which is not common practice in Australian ICUs. The words used in European practice might be slightly different from Australian wording, which might have affected the way the participants answered the questions. However, the questionnaire was tested for content and face validity with five experts in adult ICUs in Australia. The average scale-level content validity index (S-CVI) was 0.97 based on the experts' rating, which is high (Polit et al., 2007).

The checklist used to review the medical records was developed in North America, so there was a possibility that some elements of practice were not common in Australia. However, the checklist has been used in several studies worldwide and it was tested for face validity using experts from non-participating ICUs in Australia, and the changes were implemented as recommended. Despite the face validity, during data collection, we found one ICU was not using chlorhexidine for mouth care. The use of chlorhexidine for mouth care was excluded in the combined data analysis. The data on chlorhexidine use was analysed independently.

This study has limitations that should be considered when interpreting the findings. In the survey study, it was difficult to find the exact number of nurses invited to participate, owing to the lack of data on the nurses who met the selection criteria. Recruitment from the professional association might have limited the type of participants recruited, as nurses with post graduate qualifications or with specialist roles were likely to be members of the ACCCN. All participants were currently working in the ICU and had more than six months experience in intensive care nursing. The use of an online survey may help to explain the low response rate (Braithwaite, Emery, De Lusignan, & Sutton, 2003).

The low response rate may reflect the heavy workload in the ICU or survey fatigue or might be due to under-development of research culture in nursing (Sinickas, 2007). The self-reporting might threaten the reliability of the findings, as the participants relied on their memory to answer the knowledge questions. The survey sample was from three different cohorts, and the data collection was staggered, so some participants might have participated more than once. Data collection at the same time might help to prevent participants from participating more than once. The sample size was small, so Type II errors cannot be excluded. Although the survey sample was small, the participants in this study represented different age groups, levels of education, levels of experience and different titles in the ICU, which shows a wide interest in VAE prevention at different levels. According to Cooper and Brown (2017), it is vital to obtain a sample which represents the study population in terms of age, qualifications and specialty, rather than a largest sample possible. The online survey results of this study can be regarded as representative of Australian intensive care nurses, as it represents different age groups, levels of experience and nursing roles. This study

was a national survey, so the results can improve our understanding of Australian intensive care nurses' knowledge and adherence to evidence-based guidelines to prevent VAE in adult ICUs.

The sample size of the medical records reviewed was small. The current evidence-based guidelines used to prevent VAE in the two ICUs were not reviewed for comparison against recorded practice. The medical records were reviewed prospectively, which reflected current practice in each of the ICUs. The study was conducted at two different sized ICUs, with different case-mixes, which facilitated diversity in patients for whom medical records were reviewed. Therefore, the results can inform our understanding of the use of evidence-based guidelines in two Australian ICUs.

The length of some interviews was short because the participants were 'direct' with their answers and did not require further exploration. Most of the participants were from ICU A, which might have impacted the findings. The findings from the interviews could not be generalised in the same way as the quantitative results. The qualitative findings represent the reality from the participants' points of view.

This study did not examine the relationship between adherence to evidence-based guidelines and patient outcomes. However, there is replete literature on adherence to evidence-based guidelines and positive patient outcomes (Blot et al., 2008; Klompas et al., 2016; Parisi et al., 2016). The use of an explanatory sequential design facilitated the analysis of results from Phase One, and allowed further exploration of the findings, which added rigour to this study.

8.5 Recommendations

There are various recommendations for education, policy and practice and research identified from this study. The recommendations were derived from the knowledge generated from the findings of this study. The recommendations address the factors that interplay between the components of the Donabedian (2003) model of structure, process and outcome, as each component has an influence on the implementation of evidence-based guidelines to prevent VAE.

8.5.1 Education

The participants in this study highlighted the importance of ongoing education to raise awareness of evidence-based guidelines to prevent VAE. There is a need for the development of an education package, which focuses on VAE preventative guidelines in the ICU. Educational training should provide the nurses with the necessary practical instructions. A strong emphasis should be on the importance of oral care and HoBE in the prevention of VAE, which would promote a cultural shift in practice. The education should target both junior and senior nurses. A variety of teaching styles to accommodate different learning styles and to suit the busy ICU environment are also recommended. The formal and informal teaching sessions proposed by the participants were ward rounds, huddles, one-on-one tuition at the bedside, in-services, and posters around the unit. Most of these suggested teaching strategies have also been recommended in previous studies (Alja'Afreh et al., 2018; Jordan et al., 2014).

In a literature review, Sinuff et al. (2008), reported that passive strategies of education might lead to increased compliance, but may not lead to sustained behaviour change. They suggested a multifaceted approach that include both active and inactive strategies to foster long term compliance; active educational strategies such as audit, feedback and provide required education and inactive strategies such as written material and visual reminders around the unit (Sinuff et al., 2008). The use of visual reminders was used as a tool for educating both staff and family members (DuBose et al., 2008). The provision of audit and feedback and continuing staff education might help to bridge the gap between junior and senior nurses, thereby increasing adherence to VAE prevention.

8.5.2 Policy and practice

It is recommended that intensive care managers and administrators promote care environments which continuously influence the implementation of evidence-based guidelines to prevent VAE. The findings indicate that while, overall, VAE is mostly understood, there were no developed policies and procedures for VAE prevention and there were inconsistencies in practice in the two units. There is a crucial need for the development of sedation interruption and oral care policies and procedures to improve implementation and consistency in care of mechanically ventilated patients in both ICU A and B. Once the policies and procedures are developed there will be need for regular reviews to keep them update with current evidence-based practice. Daily practice audit and feedback has been reported previously to increase adherence and prompt staff to address every element of the bundle (Westwell, 2008). However, the effects of feedback on evidence-based practice need to be examined in ICU.

Surveillance and auditing of VAE is recommended. The findings indicated that the nurses and doctors in the two ICUs were not aware of the rates of VAE in their units. They reported that it was difficulty for them to invest more time in VAE prevention when they do not know its prevalence. Surveillance of VAE will increase awareness of its prevalence, which prompts a review of care processes. The participants recommended regular feedback between bedside nurses and managers to increase adherence. Regular feedback between bedside nurses and managers provides useful information that could be used to develop evidence-based guidelines to minimise the negative impact of missed care on patient safety and quality of care. Auditing of the implementation of evidence-based practice would create awareness of missed care, which could threaten patient outcome in the ICU. A review of the nurses' workload in the ICU would benefit the nurses and patients.

8.5.3 Further research

Currently, there are inconsistencies on recommended evidence-based practices. The development, implementation and evaluation of current evidence-based guidelines for VAE prevention in Australian ICUs is recommended. There is a need for a Delphi-type study to develop a consensus on current evidence-based guidelines use in Australian ICU, as an attempt to increase consistency in VAE prevention. Key stakeholders, such as specialist nurses, medical specialists, allied health professionals, nursing managers and patient representatives, should be engaged to reach consensus on best evidence-based practice.

Exploring healthcare professionals' attitudes towards VAE and their prevention is important as participants' knowledge or experience in this study did not appear to influence their practice. Investigating ventilation bundle adherence and patient outcomes in Australian ICUs would be important. In this study, bundle adherence was evaluated but patient outcomes were not assessed. Evaluating patient outcomes will help to increase awareness of VAE on patient outcomes in ICUs. A systematic review and meta-analysis of the effectiveness of interventions to prevent VAE is also recommended.

8.6 Summary

This thesis provided a detailed analysis and description of Australian nurses' knowledge of evidence-based guidelines to prevent VAE in the ICU and the use of evidence-based guidelines in two Australian ICUs. The importance of VAE prevention in the ICU cannot be overstated; it is complex and requires a multidisciplinary approach, bundled evidence-based practices and evaluation of implementation strategies to enhance adherence. Donabedian's framework of structure, process and outcome was used to examine and give context to the structure, processes and outcomes of VAE prevention (Donabedian, 2003).

Examination of the structural factors which influenced the implementation of evidence-based guidelines in the ICU facilitated the drawing of clear links between healthcare professionals' qualifications and experience, their knowledge and the implementation of evidence-based practice and adherence rates; it led to the adaption of Donabedian's (2003) framework. These study findings demonstrated an interaction

between structure and process in both directions and structure and outcome in both directions. Structural and processes factors can influence the outcome and outcome factors, alone, can influence structure, according to our findings.

The participants' knowledge of the evidence-based guidelines was poor, overall. The overall adherence rate was greater than 80%. There were no educational programs which focused on VAE prevention. A lack of education influenced process and adherence. The participants reported inadequate staffing and equipment *(structure)* as some of the barriers to the implementation of guidelines, which directly influenced adherence rates.

Overall, the findings of this study challenge administrators, NUMs, specialist nurses, intensive care doctors and researchers to find ways to: i) strengthen and advance knowledge of VAE prevention, ii) increase educational opportunities and iii) support and increase adherence in the implementation of evidence-based guidelines to prevent VAE in the ICU. In turn, this will improve awareness of VAE, improve healthcare professional practice and work experience in the ICU, thereby improving patient care.

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Appendices

Appendix A: Questionnaire

Ventilator-Associated Events Preventative Measures: Knowledge and Adherence Survey

Ventilator-associated events include ventilator-associated pneumonia, ventilator-associated conditions and infections related to ventilation.

Thank you for agreeing to participate in this survey. Please tick or write the answer which best matches your response

Section 1 Demographic and nursing experience

1. Please indicate your current age.
   - ◻ 21-25
   - ◻ 26-30
   - ◻ 31-35
   - ◻ 36-40
   - ◻ 41-45
   - ◻ 46-50
   - ◻ 50+

2. How many years of ICU experience do you have?
   - ◻ Less than 6 months
   - ◻ More than 6 months

   If less than 6 months, thank you for your interest in this study but you do not meet the inclusion criteria.

3. If more than 6 months, please enter exact years.

   [ ]

4. Are you working in an adult ICU?
   - ◻ Yes
   - ◻ No

   If No, thank you for your interest in this study but you do not meet the criteria

5. Do you look after ventilated patients?
   - ◻ Yes
   - ◻ No

   If No, thank you for your interest in this study but you do not meet the inclusion criteria.

6. Do you have a post-graduate intensive care nursing qualification?
   - ◻Yes
   - ◻ No

7. If Yes, please indicate which qualification
   - ◻ Certificate in intensive care / critical care
   - ◻ Diploma in intensive care / critical care
   - ◻ Masters
   - ◻ Other, please specify:

8. What is your current role in ICU?
   - ◻ Registered Nurse
   - ◻ Post graduate student
   - ◻ Clinical Nurse Specialist
   - ◻ ICU Liaison Nurse
   - ◻ Research nurse
   - ◻ Associate Nurse Manager
   - ◻ Nurse Unit Manager

9. In which Territory or State are you currently employed?

   ◻ ACT ◻ NT ◻ NSW ◻ QLD ◻ SA ◻ TAS ◻ VIC ◻ WA

10. What type of hospital are you working in?
    - ◻ Public hospital
    - ◻ Private hospital
    - ◻ Both

11. Are you working in more than one ICU?

    - ◻ Yes
    - ◻ No

12. In the ICU in which you are primarily employed, how many beds are there?
    - ◻ < 5 beds
    - ◻ 5 – 15 beds
    - ◻ >15 beds

    If <5, thank you for your interest in this study but you do not meet the inclusion criteria.

Section 2 Knowledge of Evidence-Based Guidelines for Prevention of VAE (Labeau et al., 2007)

Please tick the most appropriate answer.

13. Oral vs. nasal route for endotracheal intubation
    A. *Oral intubation is recommended*
    B. Nasal intubation is recommended
    C. Both routes of intubation can be recommended
    D. I do not know

14. Frequency of ventilator circuit changes
    A. It is recommended to change circuits every 48 hours (or when clinically indicated)
    B. It is recommended to change circuits every week (or when clinically indicated)
    C. *It is recommended to change circuits for every new patient (or when clinically indicated)*
    D. I do not know

15. Type of airway humidifier
    A. Heated humidifiers are recommended
    B. *Heat and moisture exchangers are recommended*
    C. Both types of humidifiers can be recommended
    D. I do not know

16. Frequency of heated humidifier changes
    A. It is recommended to change heated humidifiers every 48 hours (or when clinically indicated)
    B. It is recommended to change heated humidifiers every 72 hours (or when clinically indicated)
    C. *It is recommended to change heated humidifiers every week (or when clinically indicated)*
    D. I do not know

17. Open vs. closed suction systems
    A. Open suction systems are recommended
    B. *Closed suction systems are recommended*
    C. Both systems can be recommended
    D. I do not know

18. Frequency of change in suction systems
    A. Daily changes are recommended (or when clinically indicated)

B. Weekly changes are recommended (or when clinically indicated)
C. *It is recommended to change systems for every new patient (or when clinically indicated)*
D. I do not know

19. Endotracheal tubes with an extra lumen for drainage of subglottic secretions
A. *These endotracheal tubes reduce the risk of VAP*
B. These endotracheal tubes increase the risk of VAP
C. These endotracheal tubes do not influence the risk of VAP
D. I do not know

20. Kinetic vs. standard beds
A. Kinetic beds increase the risk of VAP
B. *Kinetic beds reduce the risk of VAP*
C. The use of kinetic beds does not influence the risk of VAP
D. I do not know

21. Patient positioning
A. Supine positioning is recommended
B. *Semi-recumbent positioning is recommended*
C. The position of the patient does not influence the risk of VAP
D. I do not know

22. Use of 0.12% chlorhexidine gluconate antiseptic oral rinse (mouth wash)
A. *0.12% chlorhexidine gluconate antiseptic oral rinse reduce the risk of VAP*
B. 0.12% chlorhexidine gluconate antiseptic oral rinse increases the risk of VAP
C. 0.12% chlorhexidine gluconate antiseptic oral rinse does not influence the risk of VAP
D. I do not know

Section 3 Nurses' Adherence to Evidence-Based Guidelines for Prevention of VAE

23. For the following strategies, choose the most appropriate answer relevant to your practice in your primary place of employment.

Strategies	Done completely	Not done completely and accurately	Not done
I perform oral care for patients being mechanical ventilated.			
I perform oral care with chlorhexidine solution. on mechanically ventilated patients daily.			
I perform a daily assessment of patient readiness for extubation.			
I wash my hands before and after contact with the patient.			
I wash my hands before performing endotracheal suctioning.			
I use sterile gloves before open system endotracheal suctioning.			
I wash my hands after performing endotracheal suctioning.			
I use normal saline irrigation for endotracheal suctioning.			
I monitor the cuff pressure of the endotracheal tube for my patient at least once every 8 hours.			
I position mechanically ventilated patients in semi-fowlers position.			

Adopted with permission from Labeau et al, 2007 and Aloush, 2017

The End

Thank You for Your Participation

Appendix B: Sample survey email invitation

Dear Sir or Madam

You are invited to participate in this project, which aims to explore intensive care nurses' knowledge and adherence to evidence-based guidelines for prevention of ventilator-associated events such as ventilator associated pneumonia.

The project intends to identify participants' knowledge of, and adherence to, evidence-based guidelines for prevention of ventilator associated pneumonia. The results of this project will contribute to further qualitative research in the future. It may also act as a quality improvement initiative in ICU.

This project is part of Doctor of Philosophy degree by Auxillia Madhuvu and her supervisors are Dr Julia Morphet, Associate Professor Virginia Plummer and Professor Ruth Endacott at the School of Nursing and Midwifery, [redacted].

If you would like to participate, please see survey link below. It takes less than 10 minutes to complete the survey. For further information please contact me via email at [redacted] or Julia Morphet [redacted]

Survey link here

https://monash.az1.qualtrics.com/jfe/form/SV_bwuQuZEeGPqJfp3

OR just scan the QR code below

By submitting the survey, you will be consenting to the research team collecting and using the information you provide for the research project.

Thank you for your participation.
Auxillia Madhuvu

Appendix C: Sample survey explanatory statement (Health Service Log Covered)

[redacted]

Participant Information Sheet

Health/Social Science Research - *Adult providing own consent*

Title	A survey of intensive care nurses' knowledge of, and adherence to evidence-based guidelines for prevention of ventilator associated events in ICU.
Short Title	Knowledge and adherence survey of ICU nurses
Protocol Number	
Project Sponsor	Not applicable
Coordinating Principal Investigator/ Principal Investigator	Dr Julia Morphet
Associate Investigator(s)	A/Prof Virginia Plummer, Prof Ruth Endacott and Auxillia Madhuvu
Location	[redacted]

Part 1 What does my participation involve?

1 Introduction

You are invited to take part in this research project, titled "A survey of intensive care nurses' knowledge of, and adherence to evidence-based guidelines for prevention of ventilator associated events in ICU". You have been invited because you are working in an adult intensive care unit. Your Monash Health contact details were used by the ICU secretary to contact you.

This Participant Information Sheet tells you about the research project. It explains the processes involved with taking part. Knowing what is involved will help you decide if you want to take part in the research.

Please read this information carefully. Ask questions about anything that you don't understand or want to know more about.

Participation in this research is voluntary. If you don't wish to take part, you don't have to complete the survey.

If you decide you want to take part in the research project, by completing the survey, you are providing consent for the data to be used and presented. Also by completing the survey you are telling us that you:

- Understand what you have read
- Consent to take part in the research project
- Consent to be involved in the research described
- Consent to the use of your personal and health information as described.

You will be given a copy of this Participant Information Form to keep.

[redacted]

2 What is the purpose of this research?

The aim of the project is to explore intensive care nurses' knowledge and practices related to prevention of ventilator-associated events. There is no previous formal exploration of nurses' knowledge and practices for prevention of ventilator associated events in intensive care units in Australia.
The project is intended to start to address this gap in knowledge by asking specific questions about your knowledge and practices related to ventilator associated events.
Presenting the results of this project will contribute to further qualitative research in the future. It can also act as a quality improvement initiative in ICU. VAE affects five to ten percent of mechanically ventilated patients; it is estimated that mortality rate of patients with VAE is 31 to 35 percent (Magill et al., 2016; Wunsch et al., 2010).

The results of this research will be used by the researcher Auxillia Madhuvu to obtain a Doctor of Philosophy from [redacted]

This research has been initiated by the researcher, Auxillia Madhuvu and has not received any grant funding.

3 What does participation in this research involve?

Participation in this study involves completing an online survey. A survey will be sent by a delegate of the Nurse Unit Manager via email to all nurses working in ICU. Completing the survey will be taken as consenting to the research. Completing the survey will take approximately10 minutes; no identifying information about you will be collected.

This research project has been designed to make sure the researchers interpret the results in a fair and appropriate way.

4 Other relevant information about the research project

Approximately 100 nurses currently working in [redacted] will be invited to take part in this study. The participants will have worked in ICU for more than six months and will have provided care to mechanically ventilated patients.

5 Do I have to take part in this research project?

Participation in this research project is voluntary. If you do not wish to take part, you do not have to. If you decide to take part and later change your mind, you will not be able to withdraw from the project once you have submitted the survey, as the submitted surveys will be anonymous. However, you can leave the survey at any point before submitting your data.

Your decision whether to take part or not to take part, will not affect your relationship with the researchers, or your employment wit[redacted] employer will not know whether you have participated.

6 What are the possible benefits of taking part?

We cannot guarantee or promise that you will receive any benefits from this research; however, possible benefits may include improvements in education related to ventilator associated events and increase in awareness of ventilator associated events prevention evidenced-based guidelines.

7 What are the possible risks and disadvantages of taking part?

The survey does not have any questions which might cause any psychological disturbances or harm. However, you are free to stop or withdraw from completing the survey if you find it disturbing.

8 What happens when the research project ends?

After collection of data, it will be analysed. The findings of this study will be used in a follow up qualitative study. Aggregate findings will be used to finalise the thesis research and might be presented at conferences which will be open to everyone.

Part 2 How is the research project being conducted?

By submitting the survey, you will be consenting to the research team collecting and using the information you provide for the research project. Any information obtained in connection with this research project will remain confidential. The data will be coded. Your information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

Your information obtained during the research project is subject to inspection (for the purpose of verifying the procedures and the data) by my supervisors, the institution relevant to this Participant Information Sheet, [redacted] as required by law. By completing the survey, you authorise release of, or access to, this confidential information to the relevant research personnel and regulatory authorities as noted above.

It is anticipated that the results of this research project will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified. The survey will be anonymous and the data will be coded.

9 Who is organising and funding the research?

This research project is being conducted by Dr Julia Morphet, Associate Professor Virginia Plummer, Professor Ruth Endacott and Auxillia Madhuvu. The research forms part of the PhD undertaken by Auxillia Madhuvu and has not received any funding.

10 Further information and who to contact

The person you may need to contact will depend on the nature of your query. If you want any further information concerning this project or if you have any problems which may be related to your involvement in the project, you can contact the researcher on [redacted] following people: Julia Morphet [redacted]

Research contact person

Name	Dr Julia Morphet
Position	Senior Lecturer / Senior Research Fellow
Telephone	[redacted]
Email	[redacted]

For matters relating to research at the site at which you are participating, the details of the local site complaints person are:

Complaints contact person

Name	[redacted]
Position	HREC Manager
Telephone	[redacted]
Email	[redacted]

Appendix D: Survey invitation to ACCCN members

Letter to ACCCN members

Dear Sir or Madam

You are invited to participate in this project, which aims to explore intensive care nurses' knowledge and adherence to evidence-based guidelines for prevention of ventilator-associated events such as ventilator associated pneumonia.
The project intends to identify participants' knowledge of, and adherence to, evidence-based guidelines for prevention of ventilator associated pneumonia. The results of this project will contribute to further qualitative research in the future. It may also act as a quality improvement initiative in ICU.

This project is part of Doctor of Philosophy degree by Auxillia Madhuvu and her supervisors are Dr Julia Morphet, Associate Professor Virginia Plummer and Professor Ruth Endacott at the School of Nursing and Midwifery [redacted]

If you would like to participate, please see survey link below. It takes less than 10 minutes to complete the survey. **Please do not complete the survey if you have already done so.** For further information please contact me via email at [redacted] or Julia Morphet at [redacted]

Survey link here.
https://monash.az1.qualtrics.com/jfe/form/SV_00cu4b3nUPcgv3v
OR just scan the QR code below

By submitting the survey, you will be consenting to the research team collecting and using the information you provide for the research project.

Thank you for your participation.

Auxillia Madhuvu

Appendix E: Ventilation bundle checklist

VENTILATOR BUNDLE CHECKLIST
(Individual Patient)

Patient Hospital Number: _____

Admission Date:

Patient diagnosis: _____

Daily ICU Acuity:

ICU Day	3	4	5
1. Head of the Bed 30 - 40^0	☐	☐	☐
2. Daily sedative interruption	☐	☐	☐
3. Daily assessment of readiness to extubate	☐	☐	☐
4. Peptic ulcer disease prophylaxis	☐	☐	☐
5. Deep vein thrombosis prophylaxis	☐	☐	☐
6. Daily Oral Care with Chlorhexidine	☐	☐	☐
Nurse in Charge informed			
Yes	☐	☐	☐
No	☐	☐	☐

Other comments:

(IHI, 2012)

ICU VAE Bundle Checklist_V1 11/05/18

Appendix F: Sample interview schedule template

Nurses' Interview Template

Demographic characteristics

1. How long have you been working in ICU?

2. How long have you been working in the current Unit?

3. Do you have post-graduate qualifications in intensive care nursing or critical care nursing?

   □ Yes

   □ No

   Please, specify what type of qualification?

   □ Graduate Certificate

   □ Graduate Diploma

   □ Masters

   □ PhD

4. What is your current position in ICU?

   □ Registered Nurse (RN)

   □ Critical Care Registered Nurse / RN with postgraduate intensive care qualification

   □ Clinical Nurse Specialist

   □ Associate Nurse Unit Manager

   □ Other, please specify

5. How long you have been working in this role?

6. What are terms of your employment?

□ Full-time

□ Part-time

□ Casual

Semi-structured interview questions

1. Can you describe your experience caring for mechanically ventilated patients?
2. Ventilator associated events include conditions such as ventilator associated pneumonia, acute lung injury, acute respiratory distress syndrome.

   What are the strategies used to prevent ventilator associated events in your unit? *(prompt: head of bed elevation, use of chlorohexidine mouth wash, sedation interruptions, spontaneous ventilation mode)*
3. What influences the care you provide to prevent VAE in mechanically ventilated patients in ICU? *(prompt: education, policy, current evidence)*
4. What helps you to implement evidence-based practices to prevent VAE (VAP, ARDS) in your unit? (*prompt: organisational factors, workload factors)*
5. What factors stop you from implementing evidence-based practices to prevent VAE (VAP, ARDS) in your unit? *(prompt: organisational factors, workload factors)*
6. Is there anything that concerns you regarding evidence-based guidelines for preventing VAE? (*prompt: in your Unit, related to the evidence*)
7. What could you recommend improving knowledge and practice related to VAE prevention in ICU?
8. Is there anything else you think would help us to understand how evidence-based practice to prevent VAE is implemented in your Unit?

Thank you for your time.

Appendix G: Interview advertising poster

[redacted]
School of Nursing and Midwifery

Project title: An exploration of ventilator-associated events prevention measures in intensive care unit.

Aim: To explore factors affecting the implementation of evidence-based guidelines for prevention of ventilator-associated events in intensive care unit.

IF YOU ARE

- **an ICU DOCTOR OR NURSE**
- **currently working in ICU and look after mechanically ventilated patients**

I would like to learn about your experiences and perspectives of evidence-based guidelines for prevention of ventilator-associated events in ICU.
Participation in this research is voluntary and confidential. It involves a 30–40-minute face to face interview at a mutual place and at a time convenient to you.
Participants will be offered a $10 coffee voucher as a token of appreciation.

If you would like to participate or require further information, please contact

Auxillia Madhuvu
PhD Candidate
[redacted]
Email [redacted]
Phone: [redacted]
This study has been approved by the [redacted] HREC/[redacted]

Advertising poster_V1 10/06/2019

Appendix H: Interview invitation letter

Dear ICU medical and nursing staff,

You are invited to participate in this project, which aims to explore factors affecting the implementation of evidence-based guidelines for the prevention of ventilator-associated events such as ventilator-associated pneumonia.

The project intends to explore factors which influence participants' practice, in the implementation of evidence-based guidelines for the prevention of ventilator-associated events. The results of this project will contribute to quality improvement initiatives in the future. It may also inform a quality improvement initiative in your unit.

This project is part of Doctor of Philosophy (PhD) degree by Auxillia Madhuvu, and her supervisors are Associate Professor Julia Morphet, Associate Professor Virginia Plummer and Professor Ruth Endacott from Nursing and Midwifery [redacted]

The interview will take 30 - 40minutes. If you would like to participate, please contact Auxillia Madhuvu via email: [redacted] or Phone: [redacted]

We look forward to your responses.

Kind regards,

[redacted]

Auxillia Madhuvu

Appendix I: Interview explanatory statement and consent forms

Participant Information Sheet

Health/Social Science Research - *Adult providing own consent*

Title	A qualitative study of intensive care doctors and nurses' adherence to evidence-based guidelines for prevention of ventilator associated events
Short Title	Interviews on prevention of VAE practices
Protocol Number	
Coordinating Principal Investigator/ Principal Investigator	Associate Professor Julia Morphet
Associate Investigator(s)	A/Prof Virginia Plummer, Prof Ruth Endacott and Auxillia Madhuvu
Location	[redacted]

[redacted]

Part 1 What does my participation involve?

1 Introduction

You are invited to take part in this research project, titled "An exploration of intensive care doctors and nurses' practices in prevention of ventilator associated events in ICU". You have been invited because you are working in an adult intensive care unit. Your [redacted] contact details were used by the ICU delegate to contact you.

This Participant Information Sheet tells you about the research project. It explains the processes involved with taking part. Knowing what is involved will help you decide if you want to take part in the research.

Please read this information carefully. Ask questions about anything that you don't understand or want to know more about.

Participation in this research is voluntary. If you don't wish to take part, you don't have to contact the researcher.
If you decide you want to take part in the research project, you will be asked to sign the consent section. By signing it you are telling us that you:

- Understand what you have read
- Consent to take part in the research project
- Consent to be involved in the research described
- Consent to the use of your personal and health information as described.

You will be given a copy of this Participant Information Form to keep.

2 What is the purpose of this research?

The aim of the project is to explore intensive care doctors and nurses' practices related to prevention of ventilator-associated events (VAE) such as ventilator associated pneumonia (VAP). There is no previous formal exploration of doctor's and nurses' practices for prevention of ventilator associated events in intensive care units in Australia.
The project is intended to start to address this gap in practice by a short interview about your practices related to ventilator associated events such as VAP.
Presenting the results of this project will contribute to further research and policy developments in the future. It will more likely inform quality improvement initiative in ICU. VAE affects five to ten percent of mechanically ventilated patients; it is estimated that mortality rate of patients with VAE is 31 to 35 percent (Magill et al., 2016; Wunsch et al., 2010).

The results of this research will be used by the researcher Auxillia Madhuvu and contribute to a Doctor of Philosophy (PhD) from Monash University.

This research has been initiated by the researcher, Auxillia Madhuvu and has not received any grant funding.

3 What does participation in this research involve?

Participation in this study involves a 30-40minutes interview, in the interview you will be asked about your practice in preventing VAE in critically ill patients in ICU. The interviews will be audio recorded with consent and transcribed verbatim for analysis. You will not be paid for your participation in this research but a complimentary coffee voucher will be given to you.
This research project has been designed to make sure the researchers interpret the results in a fair and appropriate way.

4 Other relevant information about the research project

Approximately 14 doctors and nurses working in [redacted] ICU will be invited to take part in this study. The participants will have worked in ICU and provided care to mechanically ventilated patients.

5 Do I have to take part in this research project?

Participation in this research project is voluntary. If you do not wish to take part, you do not have to. If you decide to take part and later change your mind, you may only withdraw prior to transcription being de-identified, approximately one week after interview. This is because data will be de-identified after transcription, so cannot be linked to you or be identified for removal.

Your decision whether to take part or not to take part, will not affect your relationship with the researchers, or your employment with [redacted] Your employer will not know whether you have participated.

6 What are the possible benefits of taking part?

We cannot guarantee or promise that you will receive any benefits from this research; however, possible benefits may include improvements in education related to ventilator associated events and increase in awareness of ventilator associated events prevention evidenced-based guidelines.

7 What are the possible risks and disadvantages of taking part?

It is not anticipated that participation in this study will cause you discomfort. The interview will be conducted at a time which is convenient to you. If you become upset or distressed as a result of your participation in the research, the researcher is able to arrange for counselling or other appropriate support. Any counselling or support will be provided by staff who are not members of the research team.

8 What happens when the research project ends?

After collection of data, it will be analysed. Aggregate findings will be used to finalise the thesis research and might be presented at conferences which will be open to everyone.

Part 2 How is the research project being conducted?

After you have signed the consent form, an interview will be arranged at a time convenient to you. You will be consenting to the research team collecting and using the information you provide for the research project. Any information obtained in connection with this research project will remain confidential. The data will be transcribed and aggregated. Your information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

Your information obtained during the research project is subject to inspection (for the purpose of verifying the procedures and the data) by my supervisors, the institution relevant to this Participant Information Sheet, Monash University, or as required by law. By signing the consent, you authorise release of, or access to, this confidential information to the relevant research personnel and regulatory authorities as noted above.

It is anticipated that the results of this research project will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified.

9 Who is organising and funding the research?

This research project is being conducted by Associate Professor Julia Morphet, Associate Professor Virginia Plummer, Professor Ruth Endacott and Auxillia Madhuvu. The research forms part of the PhD undertaken by Auxillia Madhuvu and has not received any funding.

10 Further information and who to contact

The person you may need to contact will depend on the nature of your query. If you want any further information concerning this project or if you have any problems which may be related to your involvement in the project, you can contact the researcher on

Research contact person

Name	Associate Professor Julia Morphet
Position	Associate Professor / Senior Research Fellow
Telephone	
Email	

For matters relating to research at the site at which you are participating, the details of the local site complaints person are:

Complaints contact person

Name	
Position	HREC Manager
Telephone	
Email	

[redacted]

Consent Form

I have read the Participant Information Sheet.

I understand the purposes, procedures and risks of the research described in the project.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described.

I understand that I will be given a signed copy of this document to keep.

[redacted]

Name of Participant (please print) _____

Signature _____ Date _____

Declaration by Researcher

I have given a verbal explanation of the research project, its procedures and risks and I believe that the person responsible has understood that explanation.

Researcher's name (please print) _____

Signature _____ Date _____

Note: All parties signing the consent section must date their own signature.

Appendix J: Health Service Human Research Ethics Committee approval letter

[redacted]

26 June 2018

[redacted]

Dear Researcher,

Study title: An exploration of ventilator associated events prevention measures in intensive care units

NMA HREC Reference Number: HREC/18/[redacted]

[redacted]Ref: RES-18-0000-310L

[redacted]Human Research Ethics Committee Low Risk Panel has reviewed the above application. In addition, the Low Risk Panel is satisfied that the responses to our correspondence of 13 June 2018 have been sufficiently addressed.

The Low Risk Panel approved the above application on the basis of the information provided in the application form, protocol and supporting documentation.

This reviewing Low Risk Panel is a Sub-committee of the Human Research Ethics Committee which is accredited by the Consultative Council for Clinical Trial Research under the single ethical review system.

Approval

The Low Risk Human Research Ethics approval is from 26 June 2018.

Approval is given in accordance with the research conforming to the *National Health and Medical Research Council Act 1992* and the *National Statement on Ethical Conduct in Human Research (2007)*. The HREC has ethically approved this research according to the Memorandum of Understanding between the Consultative Council and the participating organisations conducting the research.

Approval is given for this research project to be conducted at the following sites and campuses:

- [redacted]
- [redacted]

You must comply with the following conditions:

The Chief Principal Investigator is required to notify the Manager, Human Research Ethics Committees, [redacted]

1. Any change in protocol and the reason for that change together with an indication of ethical implications (if any)
2. Suspected Unexpected Serious Adverse Reactions (SUSARs) involving a Monash Health participant or a participant at site that Monash Health has provided HREC Review.
3. Serious Adverse Events (SAEs) that occur with a Monash Health participant or with a participant from a site that Monash Health has provided HREC review that are

considered by the Investigator as being definitely related, probably related, possibly related and unknown.

4. Any unforeseen events that might affect continued ethical acceptability of the project.
5. Any expiry of the insurance coverage provided in respect of sponsored trials.
6. Discontinuation of the project before the expected date of completion, giving reasons.
7. Any change in personnel involved in the research project including any study member resigning from Monash Health &/or the study team.

At the conclusion of the project or every twelve months if the project continues, the Principal Investigator is required to complete and forward an annual progress report to the Committee.

Reminders to submit annual progress report forms will be forwarded to the researcher.

The Coordinating Principal Investigator is responsible for notifying Principal Investigators. The Coordinating Principal Investigator and Principal Investigators should forward a copy of this letter to their site's Research Governance Officer.

Approved documents

Documents reviewed and approved are as follows:

Document	*Version*	*Date*
Human Research Ethics Application Form	AU/1/0A86320	23/5/2018
Protocol	1	11/5/2018
Victorian Specific Module		26/6/2018
Master Participant Information Form	2	14/5/2018
Invitation email	2	25/6/2018
Reminder Email	2	25/6/2018
ACCCN Email invitation	2	25/6/2018
ACCCN Reminder Email	2	21/6/2018
Observation Checklist	1	11/5/2018
ICU VAE Survey	1	11/5/2018

Site-Specific Assessment (SSA)

SSA authorisation is required at all sites participating in the study. SSA must be authorised at a site before the research project can commence.

The completed Site-Specific Assessment Form and a copy of this ethics approval letter must be submitted to the Research Governance Officer for authorisation by the Chief Executive or delegate. This applies to each site participating in the research.

If you should have any queries about your project please contact [redacted] by email [redacted]

The Low Risk Panel wishes you and your colleagues every success in your research.

Yours sincerely

[redacted]

Manager, Human Research Ethics Committee

[redacted]

Cc: Ms Auxillia Madhuvu, [redacted]

Checklist: Post-ethics approval requirements that must be met before a research project can commence at a study site.

Please ensure that as a PI (including the CPI) the following are completed at each study site.

Requirements	**Yes/No/NA**
Ethics approval notification The PI must send a copy to the RGO at that study site.	Yes
HREC Review Only Indemnity The PI must forward a copy of the signed HREC Review Only Indemnity to the RGO at that study site.	N/A
SSA authorisation notification The PI must forward the SSA form and attached documents (e.g. CTRA) to the RGO so the authority approving the conduct of the trial, at that site, can complete and sign.	Yes
Other Commonwealth statutory requirements Ensure compliance with the following e.g. Office of the Gene Technology Regulator, NHMRC Licensing Committee, NHMRC Cellular Therapies Advisory Committee.	N/A

Appendix K: University HREC Ethical Approval

[redacted]

[redacted] Human Research Ethics Committee

Confirmation of Registration

Project Number: 14750
Project Title: An exploration of ventilator associated events prevention measures in intensive care units
Chief Investigator: Dr Julia Morphet
Registration Date: 16/07/2018
Expiry Date: 16/07/2023

Terms:

1. Registration is valid whilst you hold a position a[redacted] and approval at the primary HREC is current.
2. This notification does not constitute HREC approval. It is the responsibility of the Chief Investigator to ensure that approval from the primary HREC continues for the duration of the research.
3. End of project: You should notify [redacted] e conclusion of the project or if the project is discontinued before the expected date of completion.
4. Retention and storage of data: The Chief Investigator is responsible for the storage and retention of the original data pertaining to this project in accordance with the *Australian Code for the Responsible Conduct of Research*.

Kind Regards

[redacted]

CC: Assoc Professor Virginia Plummer, Professor Ruth Endacott, Mrs Auxillia Madhuvu

Appendix L: ACCCN approval letter

Rand Butcher
Chief Executive Officer
Australian College of Critical Care Nurses
(ACCCN)
Locked bag 8, Surrey Hills, Victoria, 3127
7/08/2018

Auxillia Madhuvu
[redacted]

Re: "An exploration of ventilator associated events prevention measures in intensive care unit" HREC/1[redacted]
RES-18-0000-310L

Dear Auxillia,

The ACCCN has reviewed your request to email our current members requesting participation to participate in the survey relating to your research. We note that you have HREC approval and are a current financial member with the ACCCN. This letter is to confirm that the ACCCN will send out 1 email to our members to request participation in your research. Unfortunately we are not able to send out a reminder email as requested.

Please advise when you would like this email sent out. We will send you a draft for you to confirm the content prior to sending the email out to our members.

Good luck with your research,

Please feel free to contact me with any questions.

Best Regards,

[redacted]

[redacted]

Appendix M: Example of qualitative data analysis; coding of a transcript

190730_0006

Interviewer: Thank you for agreeing to be one of the participants in this study.

Participant: No problems.

Interviewer: The study is looking at your experiences and your perspectives of the guidelines on prevention of ventilated associated events. Can you describe, or can you tell me your experience caring for a mechanically ventilated patient?

Participant: So primarily when I take care of a patient that is on a ventilator, I usually perform a full patient assessment and safety checks as well to ensure that should anything happen on my shift that they're safe. One of them being that if they've got an artificial airway, that it's secure, that's it's the correct insertion depth, that the mode in which I'm ventilating them and also assessing their chest as well and comparing their most current chest x-ray with their previous ones as well to make sure is there's any new consolidation, any improvements, any line migration, anything like that.

Interviewer: Sure. What will be your personal experience looking after them?

Participant: I think initially especially when you're a junior staff member it's quite intimidating because there's lots to remember. But now I kind of have a pattern I follow and that kind of ensures that I'm not skipping anything, and I do kind of adjust it depending on the type of patient that I have but it's overall like a similar format, so airways, breathing, circulation. That just means that if during handover they're deteriorating, I can do a rapid assessment and even if shortly after I've assessed them that they're deteriorating that I can be kind of quick enough that I get enough information in such a short amount of time.

Interviewer: So, you said initially it will be a bit intimidating, can you elaborate a little bit more on that?

Participant: I think because you're still learning about the ventilator and the modes and you're also still looking after a critically unwell patient, it's kind of like putting those two together. So, you've spent a lot of

AM **Auxillia Madhuvu**
Patient assessment

AM **Auxillia Madhuvu**
Safety checks

AM **Auxillia Madhuvu**
Secured airway
Safety check

AM **Auxillia Madhuvu**
Comparison of investigations to check for improvement or complications
-Pt assessment

AM **Auxillia Madhuvu**
Intimidating environment as a junior nurse

AM **Auxillia Madhuvu**
High requirement

AM **Auxillia Madhuvu**
-Assessment pattern
-assessment style

AM **Auxillia Madhuvu**
Patient condition

AM **Auxillia Madhuvu**
Patient assessment

AM **Auxillia Madhuvu**
Sense of urgency in assessments

AM **Auxillia Madhuvu**
Integrating theory to practice

time learning theory and then looking after the person a lot of your energy's spent integrating those two. So, tapping back into your theory into how you're going to care for that mechanically ventilated patient. As I said, just making sure that you've selected the appropriate ventilation mode depending on what you're wanting to achieve.

Even little things like communicating issues I found really difficult at the start because I didn't necessarily have the words to describe what I was seeing or hearing. Like chest auscultation and you're like, oh I just know it doesn't sound right. I don't know what it is but.

Interviewer: That's interesting. So, if I've got it right, you said I tried titrating the ventilation. So, does the nurse have control of the ventilation modes and things like that? Can you elaborate on that?

Participant: It can depend on the consultant and also sometimes depending on the severity of the patient's condition as well. So obviously if you've got quite a sever patient coming in with ARDS I think especially because we're using modes of ventilation we probably don't use as much, like APRV, people are less reluctant to touch and adjust those ventilation settings for the patient, but then as soon as you are using more modes that you're more comfortable with, so SIB and CPAP and things like that I feel more comfortable adjusting any of those settings.

But obviously, usually it depends on the consultant and how well you've worked with those consultants before because especially in our unit we've got such a varied skill mix that you can't just kind of expect everyone to be able to do that and to do it safely. So, it's more about how well you know your staff.

Interviewer: Sure. So ventilated associated events include conditions such as VAP, such as ARDS, acute lung injury, sepsis. So, what are the strategies which are being used in your unit to prevent these events?

Participant: I'm just thinking. I can't think of any specific strategies, but I know especially when I was taught, we had a lot of the prevention strategies drummed into us, like that making sure that you've got a good cuff seal and haven't got a leak, so you don't have migration of secretions into the lung. And then obviously making sure there's no tube migration as well preventing any collapse.

Auxillia Madh... Time consuming

Auxillia Madh... Ability to choose the right mode

Auxillia Madh... Lack of knowledge

Auxillia Madh... Consultant dependent

Auxillia Madh... Patient condition

Auxillia Madh... -Lack of experience with other

Auxillia Madh... Pt condition

Auxillia Madh... Consultant dependent

Auxillia Madh... -Different levels of experience

Auxillia Madh... Relying on previous education

Auxillia Madh... Maintaining good cuff seal

Auxillia Madh... Patient assessment