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# **The role of New Zealand intensive care nurses in ventilation management**

A thesis submitted in partial fulfilment of the requirements for the degree of  
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## Abstract

**Introduction:** Previous research about the role of nurses in ventilation management suggests that it is a largely collaborative endeavour between doctors and nurses. These studies, however, are based on the views of nurse managers representing staff as a collective, rather than individual nurses answering from their perspective. Further, previous research only begins to account for the role of automation in ventilation management.

**Aim:** This study describes the role of the New Zealand intensive care nurse in ventilation management and the use of automated ventilator modes.

**Method:** A self-reported online survey using a non-probability sample of intensive care nurses who are members of the New Zealand College of Critical Care Nurses was used (n=204). Data were analysed using quantitative methods to describe and compare with international data.

**Results:** The sample (n=204) had a range of intensive care unit (ICU) experience (0-42years) and 136 (69.7%) had completed a post-graduate critical care specialty qualification. Participants worked in various sized units (2-26 beds). Nurse to patient ratios were 1:1 for intubated patients. Ventilation management protocols were available for 136 (66.7%) participants; however, the effect of protocol availability on clinical practice was insignificant. Nurses in this study had lower perceived autonomy ( $p=0.0006$ ) and more perceived influence ( $p=0.028$ ) in decision-making than their managers reported previously. Consistent with previous research, nurses collaborate with medical staff in fundamental decisions and largely act independently in titrating ventilator settings. New Zealand ICUs have high nurse to patient ratios compared to their European counterparts. While New Zealand ICU nurses have similar reported levels of independent decision-making in oxygen and PEEP titration, they have less independence in adjusting the six other ventilator settings. As in Europe, the most common automated ventilation modes used in New Zealand ICUs are ASV™ and SmartCare™.

**Discussion:** As automated modes independently titrate ventilator settings, the ventilator itself increasingly participates in a role largely identified as the nurses' domain. The study concludes that it is timely for nurses to re-evaluate their role in ventilation management. Rather than focus on the titration of

ventilator settings, nurses could strengthen their contribution in the collaboration of fundamental decisions.

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# The role of New Zealand intensive care nurses in ventilation management

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## **Chapter 1:**

### **Introduction to the study**

#### **Introduction**

Breathing is fundamental to human life. If one is to believe in the story of creation, then ‘in the beginning’ it was the breath of God that spoke life into creation and humanity (Qur'an 3.47, Ali Ünal Interpretation; Genesis 1:3, English Standard Version). In the late nineteenth century Florence Nightingale, the founder of modern nursing (Winkelstein, 2009) suggested the most fundamental clinical concerns of nursing start with ventilation and warming (Nightingale, 1860). Maslow (1943) places biological needs including breathing at a foundation of the ‘hierarchy of needs’ in his theory of motivation. However, the significance of breathing is perhaps most noticeable in its absence. When a person is in such a state of vulnerability that they cannot breathe, they require specialised care and ventilation support.

Mechanical ventilation is a relatively modern phenomenon. The ventilator became an established part of the clinical environment in the time of the polio epidemic, particularly with the introduction of the ‘Drinker Respirator’ in 1928, otherwise known as the ‘iron lung’ (Puri, Puri, & Dellinger, 2009). Since then, various improvements have led to the current ventilation technology that is discussed in this research.

A basic explanation of mechanical ventilation is that the patient’s airway is accessed (either by a tube or mask) and connected via tubing to a ventilator. The ventilator provides breath for the patient. The parameters of ventilation can be simplified by the equation:

Volume + pressure + oxygen + timing = ventilation. The desired outcome is to provide safe gas exchange, patient comfort and patient liberation (Mireles-Cabodevila, Hatipoglu, & Chatburn, 2013). These authors describe patient liberation as reducing ventilatory support as soon as the patient is able to

support themselves. The importance of reducing ventilator time has long been established to reduce both cost and risk of adverse events (Mancebo, 1996; Vincent et al., 1995).

Outside of operating theatres, mechanical ventilation most often takes place in intensive care units (ICUs). The College of Intensive Care Medicine of Australia and New Zealand (CICM) (2011, p. 1) describe an intensive care unit as “a specially staffed and equipped, separate and self-contained section of a hospital for the management of patients with life-threatening or potentially life-threatening conditions”. Ventilators head the CICM list of basic equipment in their ‘Minimum Standards for ICU’ document (2011), with four of the 14 items in the list related to airway and ventilation management: ventilators for invasive and/or non-invasive ventilation, hand ventilating assemblies, suction apparatus and airway access equipment, including a bronchoscope and equipment to assist with the management of the difficult airway (p. 4).

The first ICU in New Zealand (possibly the first in the southern hemisphere), was opened in Auckland in 1958, with several other units opening nationally over the following decade (Harper, 2011). There are now 261 beds within 29 adult ICUs in New Zealand (Turner, 2014). ICUs rank as level 1-3, depending on the resources and level of provision offered. Level one units provide immediate resuscitation and support, while level three or ‘tertiary’ units provide a comprehensive range of complex care, with a demonstrated commitment to academic education and research (College of Intensive Care Medicine of Australia and New Zealand, 2011). ICUs function within both public and private hospitals.

Ventilation management is influenced by unit structure and context. An international study investigated differences in ICUs and how these aspects affected practice (Rose, Blackwood, Burns, Frazier, & Egerod, 2011). A notable difference in ICU structures are open and closed units. In an open unit, patients are admitted into an ICU and the attending physician retains overall responsibility, regardless of their specialty. Closed ICUs admit patients and intensivists undertake responsibility for patient care, in consultation with other

specialties. Most ICUs in the United States (US) are open, while the closed structure operates in Europe and Australia/New Zealand.

Intensive care units (ICUs) in New Zealand (NZ) are not immune to changes experienced globally in the clinical workforce. In line with international trends (United Nations Department of Economic and Social Affairs: Population Division, 2002), New Zealand has an ageing population, an ageing workforce and increased reliance on technology in the clinical area (Nana, Stokes, Molano, & Dixon, 2013). Minister of Health, Tony Ryall publically acknowledged a workforce crisis in hospital specialists (Ryall, 2010). Intensivists and ICU nurses are both on the long term shortage list of priority occupations for immigration (Immigration New Zealand, 2014). Pressure to provide ICU beds alongside increased difficulty in recruiting and retaining specialists (Association of Salaried Medical Specialists, 2014) points to possible changes in how healthcare will be provided. How this will affect the ICU working environment is yet to be seen, but if there are fewer doctors, nurses may well have to step up and take on medical responsibilities.

## **Ventilation management and the nurses' role**

The primary function of the pulmonary system is to provide a gas exchange of oxygen (in) and carbon dioxide (out). Normally, a diaphragm contraction causes *negative* pressure in the lung fields, drawing air in as a breath. Exhalation occurs with relaxation of the diaphragm and airway. Breathing is reliant on the neurological system to initiate and regulate this process. Chemoreceptors provide feedback mechanisms to regulate breath depth and rate to keep a balance in the gas exchange. As the metabolic load changes (perhaps in the case of physical exercise, rest or fever), the pulmonary system adjusts to the change in the body's requirements (Wu et al., 2010).

Conversely, mechanical ventilation provides a *positive* pressure that forces a volume of air into the lung fields. The exhalation phase of a mechanical breath,

like natural breath, is passive<sup>1</sup>. Ventilation gives breath to a patient who cannot provide gas exchange for themselves, as well as providing support to breaths initiated by the patient (Mireles-Cabodevila et al., 2013). Blood gas analysis is one of the monitoring mechanisms used clinically to support the balance of gas exchange. Where the neurological system normally responds to chemoreceptors to regulate the breathing pattern, similarly, adjustments can be made on the ventilator. Adjustments include rate, pressure, volume, oxygen, timing and many nuances within these parameters (Singh, Borle, & Trikha, 2014). Inappropriate adjustment of these settings can cause harm to the lungs (Blackwood et al., 2011; MacIntyre, 2012).

Virginia Henderson (1960) described the role of nurses as professionals who provide support for patients until such time as the patient can support themselves. ICU nurses provide care for the most clinically vulnerable and ventilation is a key part of the support provided to patients in the ICU. Widely known as 'life support', mechanical ventilation provides respiratory support for patients who require sedation, anaesthesia or respiratory assistance (Kane & York, 2012). For the sake of clarity, management of ventilation can be seen as two-fold. Firstly, an overall plan of care that considers fundamental decisions, such as when to administer, when to reduce and when to stop providing ventilator support. Secondly, ongoing reactive titrations are made in ventilator settings in response to the patient's immediate condition. It is important that both fundamental decisions and titrations are made with expertise, as ventilation management that is inappropriate for individual patient need leads to increased risk of significant complications, such as ventilator-associated pneumonia, lung injury and the morbidities associated with prolonged sedation such as prolonged ventilation and delirium (Blackwood et al., 2011; Crocker, 2002; Harroche, St-Louis, & Gagnon, 2014; MacIntyre, 2012; Mietto, Pinciroli, Patel, & Berra, 2013).

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<sup>1</sup> The exception is high frequency oscillatory ventilation (HFOV), which is a mode that provides an active phase of exhalation. This mode requires ventilator hardware uniquely designed to provide HFOV.

Historically, Nightingale (1860) proposed that nurses need to “put the patient in the best condition for nature to act upon him” (p. 135). When the patient’s condition is unstable, frequent ventilator setting changes can be a part of providing the best conditions. How and the extent to which nurses contribute in decision-making about ventilation management can have an impact on whether (to contextualise Nightingale) conditions are provided for a healing process to take place.

Nurses play a role in the decision-making process in ventilation management, however, in general, overall responsibility rests with the medical staff (Rose, Blackwood, Burns, et al., 2011). The extent to which nurses are involved with and influence the decision-making process depends largely on delegation. Some NZICUs have clear role demarcation written in guidelines that include parameters to guide decision-making, while others rely on factors such as medical and nursing leadership models to guide practice (Rose, Nelson, Johnston, & Presneill, 2008). A collaborative model, where nurses and medical staff make decisions as a team has been linked with improved quality of care, patient safety and patient outcomes (Coombs, 2003; Rose, Blackwood, Burns, et al., 2011; Zwarenstein & Reeves, 2006).

## **Automatic ventilation modes**

Automated ventilation modes were pioneered in the late 1980s and introduced into the NZ market of medical devices in the late 1990s. While ventilation technology has steadily improved since the original ventilator models, automated ventilation is a significant change in design, as protocols use computerised algorithms to make changes to delivery (Jouvet et al., 2012). As these modes have developed, the vendors have marketed the technology’s ability to increase clinician efficiency and ease clinician decision-making (Chatburn & Mireles-Cabodevila, 2011).

Ventilator manufacturers provide a product at two levels for purchase: hardware and software. The hardware provides both a delivery system and an interface between the machinery and the clinician. In contrast, software is

patented technology and offers different modes unique to the manufacturer. Vendors use features of both the hardware and software to sell ventilators, with a few offering automated modes. Two such companies in the New Zealand market are Dräger Medical who offers SmartCare™ and Hamilton Medical who offer both ASV™ and IntelliVent-ASV™.

Despite potential gains in efficiency, uptake of automated ventilation technology has been slow. The clinical environment can be conservative and new practices or medical devices tend to be introduced and purchased with caution. Clinicians wish to see clear evidence of patient safety and efficacy before embracing new technology (Cheng-Min & Bor-Wen, 2012). Medical devices, such as ventilators, are used in the clinical environment where patient safety is paramount.

Although vendors are also concerned about patient safety, they wish to sell their products. A collision of priorities between sales and safe clinical practice can complicate the introduction of practices that are reliant on device procurement (Chatburn, 2010; Denton & Jaska, 2014). In addition to clinician caution, purchase of an automated mode usually requires purchase of a new ventilator, so is dependent on the timing and availability of a procurement process. Ventilators have a financial lifespan of ten years or more, so the opportunity to purchase must coincide with long-term replacement of the hardware (Inland Revenue Department, 2011).

A growing body of literature has investigated automated ventilation modes and focuses on whether they are safe in the clinical environment, whether they are appropriate for use on certain patients or pathologies and how they compare with more traditional modalities (Arnal et al., 2012; Belliato et al., 2004; Cassina, Chiolerio, Mauri, & Revelly, 2003; Chen, 2011; Iotti et al., 2010; Sulemanji, Marchese, Garbarini, Wysocki, & Kacmarek, 2009). Data collected in NZICUs has not thus far included use of automated modes (Rose et al., 2008; Rose, Presneill, Johnston, Nelson, & Cade, 2009). Included in this study is data that describes which automated modes are used and how often. In addition, frequency of nurses' independent titration of %MV is investigated. Percentage minute volume (%MV) is a key setting in ASV mode and is described further in the key terms section below.

## **The research question**

The role of research is in developing, refining and expanding knowledge (Polit & Beck, 2011). The main research question in this thesis asks what is the role of New Zealand intensive care nurses in ventilation management? Secondary questions are how often automated modes of ventilation are used and how do study results compare with data previously gathered in NZ and internationally. The study uses an online survey of ICU nurses with the aim of developing and expanding what is already known about the role of nurses in NZ ventilation management.

## **Key terms**

Terms that are used in the thesis will be clarified here, starting with descriptions of some clinical roles.

‘NZICU nurses’ refers to registered nurses or nurse practitioners who work in intensive care units in New Zealand. In this study, ‘medical staff’ and ‘physician’ describe all levels of registered doctors of medicine employed in ICUs.

‘Intensivist’ refers to a doctor who has specialised in ICU medicine and is employed as a consultant to oversee medical management in the ICU. An ‘anaesthetist’ is a medical doctor who has specialised in anaesthesia and may work in an ICU in addition to their role in an operating theatre. An ‘ICU registrar’ is a medical doctor who has not yet specialised, working in the ICU as part of their specialty training, generally in one of Intensive Care, Emergency Medicine, Anaesthesia or Medicine. ‘Clinician’ refers to any staff working in the clinical environment of ICU, irrespective of discipline.

‘Ventilation management’ is a term used in this thesis in reference to the management and delivery of mechanical ventilation. Ventilation management is not standardised, either nationally or internationally.

‘Intubation’ is the clinical procedure of inserting an endotracheal tube into a patient’s airway or tracheostomy as an access pathway for mechanical ventilation. ‘Extubation’ is removal of the endotracheal tube from the patient’s airway. If the patient is not ready to breathe without support, the tube will need reinsertion. Reintubation comes with risks of airway injury, alveolar injuries and deoxygenation, as well as consuming staffing resources and emergency equipment.

‘Non-invasive ventilation’ (NIV) provides ventilatory support without the use of an endotracheal tube, usually by means of a sealed (or partially sealed) facial mask. Non-invasive ventilation can be used as part of the weaning process post-extubation or in its own right.

A ‘T-piece trial’ is a method used to assess readiness to extubate, whereby the ventilator is replaced with an apparatus that maintains positive end expiratory pressure (PEEP), but further ‘support breaths’ are not given. The T-piece trial is used less often as increasingly modern ventilators are equipped to provide PEEP without the need to disconnect and use distinct equipment (Brochard et al., 1994).

‘Mode’, in the context of mechanical ventilation, describes the predetermined pattern in which a ventilator interacts with the patient. Traditionally divisible into two categories of pressure or volume, there are now a plethora of modes available. Most ventilators offer a range of modes, which the clinician can select and modify, as well as manufacturer-specific modes. For this thesis, ‘automated modes’ will be used to refer to ‘intelligent’ technology that uses software and modelling to adapt to the patients’ need (Mireles-Cabodevila et al., 2013).

‘Closed-loop’, in mechanical ventilation terms, refers to the feedback loop of assessment and adjustments used in automated modes. Similar to autopilot technology used in the aviation industry, the ventilator assesses the patient and adjusts various settings continuously to optimise ventilation based on patient condition, lung dynamics and response. Depending on the mode, any of the settings may be automatically adjusted, including rate, pressures and FiO<sub>2</sub>. A

fully closed-loop minimises the need for input from the clinician in managing ventilation. Adaptive support ventilation is a mode released by Hamilton Medical. ASV and its update, IntelliVent-ASV are forms of closed-loop ventilation (Novotni & Arnal, 2013).

‘Positive end expiratory pressure’ (PEEP) is an underlying pressure that eases the work of breathing by providing airway support. PEEP does not provide the patient with ‘breaths’ of intermittent increased pressure and volume. Most ventilator modes use PEEP as a component of their delivery (Stocker et al., 1996).

Fraction of inspired oxygen ‘ $\text{FiO}_2$ ’ is equivalent to percentage  $\text{O}_2$  ( $\%\text{O}_2$ ) in that it describes the mix of oxygen and air in the gases supplied to the patient. Where  $\text{FiO}_2$  0.21 is equivalent to room air,  $\text{FiO}_2$  1.0 provides 100%  $\text{O}_2$  (Tehrani et al., 2002).

‘Pressure support’ or PS is the positive pressure provided by the ventilator with each breath to the patient. PS is usually associated with breaths that are initiated by the patient and provides synchronised support from the ventilator. As the name suggests, pressure provides support to the patient. Decreasing PS is often a key part of weaning, especially in NZICUs (Rose et al., 2009).

‘Rate’ is the rate of breaths offered by the ventilator per minute. A patient can initiate spontaneous breaths over and above this, so the ventilator rate does not always equate to the patient’s breath rate (Banner, Kirby, Kirton, DeHaven, & Blanch, 1995).

Percentage minute volume or ‘%MV’ is a ventilator setting unique to ASV. While minute volume is the volume of gas delivered via a ventilator in a minute, %MV adds the component of patient body size, working from their measured body height. 100%MV equates to a ‘normal’ minute volume required for the patient of their height, where a 200%MV setting provides twice that amount. The three main settings in ASV mode are %MV, PEEP and  $\text{FiO}_2$ . Manual adjustment of

%MV is made for significant changes in patient metabolic rate, increased to provide extra support and reduced to facilitate weaning (Arnal et al., 2008).

Centimetres water (cmH<sub>2</sub>O) is a unit that measures the pressure exerted by a column of water 1cm high. The cmH<sub>2</sub>O unit is used both as a measurement to describe airway pressures and as a setting to prescribe pressures (Iotti et al., 1995).

A 'blood-gas' is a lab test, which evaluates components of the blood, including oxygen, carbon dioxide and acidity. Analysis of this data guides ventilation management. Blood gas analysers are often provided at point of use within the ICU for convenience and immediacy of results (Foxall, 2008).

'COPD', or chronic obstructive pulmonary disease is a progressive condition characterised by chronically poor airflow. Successful ventilation management of patients with an underlying obstructive disease can require additional expertise, particularly with respect to carbon dioxide (CO<sub>2</sub>) management. Ventilatory support is kept to a minimum to allow CO<sub>2</sub> levels to stay high, based on blood gas results. Patients with COPD maintain high levels of CO<sub>2</sub>. To maintain a patient's respiratory drive, high CO<sub>2</sub> levels are permitted. Sometimes this is referred to as permissive hypercapnia (Mireles-Cabodevila, Diaz-Guzman, Arroliga, & Chatburn, 2012).

'ARDS', or acute respiratory distress syndrome is a condition with a high mortality rate that stems from inflammatory lung injury. ARDS can make effective ventilation management extremely difficult to achieve. Airway pressures and volumes are generally kept minimal in an effort to provide effective gas exchange without further damage or inflammation to the lungs (Hickling, Downward, Davis, & A'Court, 1986).

## **Overview of the thesis**

The thesis is organised into six chapters. The first, an introduction, provides background to the study, presents the research question, provides an overview of the thesis and defines some key terms.

The second chapter reviews and discusses current research related to ventilation management in ICU. The chapter outlines studies from New Zealand, compares these with Australian studies and those conducted further afield. Themes explored include weaning, timeframe, the nurses' role in ventilation management, knowledge level of nurses, how countries differ in practice and use of automated modes. The literature presented highlights the gaps in current research, and in particular the perspective of NZICU nurses themselves.

The details of the theoretical framework, methodology, method and analysis used in this study are explained in chapter three. This study uses positivist methodology to determine the role NZICU nurses play in ventilation management. The method used presented NZICU nurses with an online survey, comprised of multi-choice and Likert-style questions, to answer the research questions. Rose, Blackwood, Egerod et al. (2011) provides a basis for this study with most of the survey questions in this study taken from her survey tool.

Chapter four presents the analysis of the data collected in this study. In keeping with the quantitative methodology, t-tests and chi square analysis are used to test associations between variables in the data. Where possible, these data are then compared with other NZICU research and international studies.

Chapter five discusses the findings of the study. Key themes explored include the role of the nurse, with particular differentiation between fundamental decisions and titrations of ventilator settings. Variables that affect the findings are discussed, such as workplace culture, personal experience and education. Collaborative and independent decision-making are compared. The extent to which automated modes are used is presented, with comparison to usage in European ICUs.

The concluding chapter presents key findings from this study, limitations of this project, implications for clinical practice, how this study contributes to nursing knowledge and indications for future research.

## **Chapter 2**

### **Literature Review**

#### **Introduction**

Having outlined the context of ventilation management in NZ, this chapter explores the literature to discover the role of nurses in ventilation management. The search strategy is explained and the key themes presented, comprising of weaning, decision-making, international differences, interdisciplinary negotiation, autonomy, patient care management and automated modes. The gaps in the research are highlighted. The expected role of this study and how it aims to fulfil gaps in the literature are then outlined.

#### **Search strategy**

An initial review of the literature revealed three main themes of ‘automated modes’, ‘use of ventilation protocols’ and ‘weaning’. A search in PubMed using medical subject headings (MESH) (“MeSH) ‘Respiration, Artificial” [Mesh] AND “Nursing” [Mesh]), with limits of ‘clinical trials’ in the last five years came up with nine results. None of the studies were relevant to this topic. A further search for “Respiration, Artificial”[Mesh] AND “New Zealand”[Mesh]), with limits of ‘clinical trials’ in the last ten years came up with 48 results. Three of the studies were relevant; Louise Rose led each of these studies (Rose, Blackwood, Egerod, et al., 2011; Rose et al., 2008; Rose et al., 2009). She continues to be active in research in this area.

Further searches used key words ‘patient care management’, ‘intensive care’, ‘critical care’, ‘ICU’, ‘nurs\*’, ‘nursing role’, ‘weaning’, ‘automated modes’, ‘ASV’, ‘SmartCare’, ‘closed loop’ and ‘decision making’. Electronic databases used were PubMed, Scopus, The Cochrane Library and the Massey University federated search tool (Discover), which simultaneously searches EBSCOhost, CINAHL,

Health Source, Medline, Web of Science and Biomedicine & Health. In total, 131 research sources are referred to in this thesis.

The basis for inclusion was that literature was either published within the last ten years, or that the studies were considered relevant and warranted mention. Subject areas for inclusion were the role of practitioners, ventilator practice or ventilation management, automated modes and decision-making. Publications were gleaned from the reference lists of the research that bore particular relevance to the area of interest. A variety of books, e-books, theses, government and professional documents were also accessed. Quantitative and qualitative studies were included. This body of work was not extensive. Accordingly, opinion pieces and reviews were included. Grounds for exclusion were based on relevance to the research question.

Louise Rose and various colleagues have provided the main body of work on the topic of nurses' role in ventilation management. This body is referred to throughout the thesis and Table 1 provides a summary of this work.

## **Practice in New Zealand**

Mechanical ventilation practice in Australia and New Zealand (ANZ) ICUs does not mirror international practice (Rose et al., 2009). These authors used a one-day prospective point prevalence design, where the 284 ventilated patients were followed through to 48hrs after extubation, death or loss to follow up. ICU's in ANZ were found to be similar in patient characteristics, duration and modes of ventilation, leading to similar patient outcomes. In contrast to other large international studies (Esteban et al., 1994; Esteban et al., 2000; Esteban et al., 2002), Rose found a preference in ANZ units for using pressure support modes in weaning, minimal usage of T-piece trials and considerably fewer cases of COPD and ARDS in the patient population. These findings help to provide a picture of how ICU patient population and ventilation management in NZ compare to other parts of the world. There is no capture of automated mode usage in the study.

**Table 1: Sentinel studies the thesis draws on**

|          | <b>Authors</b>                                                                                                            | <b>Year</b> | <b>Country</b>                                                                             | <b>Participants</b>          | <b>Purpose</b>                                                                                                                                                                                                 | <b>Design &amp; method</b>    | <b>Results/ Conclusions</b>                                                                                                                              | <b>Points to note</b>                                                                                                                                                                                                                   |
|----------|---------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------------------------------------------------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1</b> | <b>Rose, L.,</b><br>Blackwood, B.,<br>Egerod, I.,<br>Haugdahl, H.,<br>Hofhuis, J.,<br>Isfort, M., . . .<br>Schultz, M. J. | 2011        | Denmark,<br>Germany,<br>Greece, Italy,<br>Norway,<br>Switzerland,<br>Netherlands<br>and UK | Nurse<br>managers<br>(n=586) | To describe the<br>professional group<br>with responsibility<br>for key ventilation<br>and weaning<br>decisions and to<br>examine<br>organisational<br>characteristics<br>associated with<br>nurse involvement | Survey of<br>unit<br>managers | Collaborative<br>decision making<br>for ventilation<br>and weaning in<br>most ICUs in all<br>countries                                                   | Potential clinical<br>implications of a lack<br>of collaboration<br>include delayed<br>adaptation of<br>ventilation to<br>changing<br>physiological<br>parameters, and<br>delayed recognition of<br>weaning and<br>extubation readiness |
| <b>2</b> | <b>Rose, L.,</b><br>Nelson, S.,<br>Johnston, L., &<br>Presneill, J.                                                       | 2008        | Australia/<br>New Zealand                                                                  | Nurse<br>managers<br>(n=54)  | To provide an<br>analysis of the<br>scope of nursing<br>practice and inter-<br>professional role<br>responsibility for<br>ventilation and<br>weaning practices                                                 | Survey of<br>unit<br>managers | Nurses described<br>high levels of<br>autonomy and<br>influence in<br>ventilator<br>decision-making                                                      | Collaborative practice<br>that encourages<br>nursing input into<br>decision-making may<br>improve patient<br>outcomes and reduce<br>complications.                                                                                      |
| <b>3</b> | <b>Rose, L., &amp;</b><br>Presneill, J.                                                                                   | 2011        | Australia/<br>New Zealand                                                                  | Intensivists<br>(n=164)      | To describe<br>frequency in which<br>various clinical<br>criteria were used<br>to predict weaning<br>and extubation,<br>and the weaning<br>methods employed                                                    | Survey of<br>intensivists     | Respiratory rate<br>and effective<br>cough were<br>reported to be of<br>greater clinical<br>utility than other<br>more recently<br>proposed<br>measures. | Nurses' contribution<br>mentioned by only<br>one participant                                                                                                                                                                            |

|   |                                                                          |      |                                                          |                                                           |                                                                                                                                                                                         |                                                 |                                                                                                                                                                          |                                                                                                                                                  |
|---|--------------------------------------------------------------------------|------|----------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 4 | Haugdahl, H., Storli, S., <b>Rose, L.</b> , Romild, U., & Egerod, I.     | 2014 | Norway                                                   | Nurse managers (n=38) and physician directors (n=38)      | To explore variability in perceptions of nurse managers and physician directors regarding roles, responsibilities and clinical-decision making related to mechanical ventilator weaning | Survey of unit managers and physician directors | Nurse managers perceived nurses to have greater autonomy, influence and collaborative interaction regarding decisions on mechanical ventilation than physician directors | Greater awareness and acknowledgment of nurses' role may promote interprofessional collaboration and improve patient care                        |
| 5 | <b>Rose, L.</b> , Blackwood, B., Burns, S. M., Frazier, S., & Egerod, I. | 2011 | Australia, New Zealand, Denmark, Norway, Sweden, UK, USA | Data review                                               | To assess differences in context and processes in intensive care units that could influence weaning                                                                                     | Review of existing national data                | Context and processes of care that could influence ventilator weaning outcomes varied considerably across countries                                                      | USA is particularly different in critical care provision, structure, skill mix, and staffing ratios                                              |
| 6 | <b>Rose, L.</b> , Nelson, S., Johnston, L., & Presneill, J.              | 2007 | Australia                                                | Nurses and doctors in one ICU, Melbourne (n=474 patients) | To characterise the role of Australian critical care nurses in the management of mechanical ventilation                                                                                 | 3-month, prospective cohort study               | A total of 3986 ventilation and weaning decisions. (64%) were made by nurses alone, 693 (17%) by medical staff, and 755 (19%) by nurses and staff in collaboration       | In this unit, critical care nurses have high levels of responsibility for, and autonomy in, the management of mechanical ventilation and weaning |

## **Role of the nurse**

Sentinel research for this review investigated the role of the nurse in ventilator-related decision-making in ANZ (Rose et al., 2008). The study aimed to develop a profile of role responsibility of nurses working in ICU's in ANZ. Surveys were sent to ICU nurse managers of eligible units in both countries requesting data about unit profile, staffing numbers, ratios, education and skill mix. Participants were asked to profile responsibilities in decision-making for key areas of ventilation and weaning. Paediatric and neonatal ICU's were excluded from the study, as well as units that do not routinely provide mechanical ventilation. The response rate was 54/180, with 71% of participants representing units from urban areas and 50% from tertiary-level centres. Fifty-four per cent of NZ ICU nurses had achieved a post-graduate qualification in the specialty. Nurse-to-ventilated patient ratios were all reported as 1:1; nurse to non-ventilated patient ratios in NZ were 1:2 in 79% of cases. Nurse managers reported that nurses in ANZ were actively involved in ventilation and weaning decisions. Nurses were reported as predominantly independent in titrating FiO<sub>2</sub>, pressure support and rate. Adjustment of PEEP was reported as the least likely parameter for nurses to adjust independently at 28-30% for increase and decrease respectively, followed by mode change at 37%. Mean perceived autonomy was rated as 'high' at 7/10. Although Rose et al. established how NZICU nurses are involved in ventilation management, participants were the nurse managers who provided data on behalf of nurses. Automated modes were not investigated and the level of nursing skill was not assessed.

## **Clinical knowledge of nurses**

If nurses are to contribute in ventilation management, then it is important they have a sound knowledge and can apply it in practice. Pirret (2007) looked at nurses' knowledge of respiratory physiology in two NZICU's. Using multiple methods, she collected data from 27 nurses who had completed an ICU education programme using a questionnaire, interviews and a blood-gas knowledge test.

Overall, Pirret (2007) described the NZICU nurses' knowledge level of respiratory physiology to be of low to medium level. This outcome was calculated using a table that ranked levels of respiratory physiology knowledge, put together by her and two other nursing experts. Pirret's results support findings in earlier research that describe the difficulty nurses have explaining their practice in biological terms (Baumann & Bourbonnais, 1982; Clancy, McVicar, & Bird, 2000). Using thematic analysis, Pirret identified and explored eight themes that were reported as perceived barriers to nurses progressing in this field: inadequate coverage of concepts in some ICU programmes; limited discussion of concepts in clinical practice; lack of clinical support; lack of individual professional responsibility; nurses' high reliance on intuitive knowledge; lack of collaborative practice; availability of medical expertise; and the limitations of guidelines and protocols. The working environment of the two units involved seemed significantly different. One unit is depicted as a place where nursing staff work with a high level of autonomy, good staff morale and a positive relationship with medical staff. In contrast, and portraying an environment less open to autonomy or initiatives, the language used to describe working in 'unit two' included phrases like "It's very frustrating", "your wings are quickly clipped" and "you pick your battles" (p. 152). Although Pirret's study was small, and the two units had quite different working cultures, nurses' knowledge was found to be comparable in both units. Pirret suggests that nurses need to have a working knowledge of respiratory physiology and the ability to articulate their knowledge to rationalise decisions. These factors enhance nurses' clinical credibility.

Ball and Cox (2004) identify clinical credibility as a necessary component of advanced practice. Using grounded theory, the authors interviewed forty nurses in Australia, Canada, New Zealand, UK and USA and claimed that nurses focus on patient welfare and outcome, rather than specific competencies and characteristics required for advanced nursing practice. Both Pirret (2007) and Ball and Cox (2004) approach advanced nursing practice as a definitive role. In contrast, Rose et al. (2008; 2009) describe ventilation management as an everyday part of the nurses' role in ICU. In her closing statement, Pirret (2007) challenges nurses to take responsibility in determining their future role and

practice (p. 154). As the literature base for advanced nursing practice grows, perhaps ICU nurses will need to be increasingly led by expectations of advanced practice to keep up with their everyday practice.

## **Weaning**

Approximately 75% of ICU patients resume spontaneous, unassisted breathing easily (Brochard et al., 1994; Esteban et al., 1995). The remainder present significant challenges to those involved in their care (Blackwood et al., 2011). Weaning, when used in the context of ventilation management, is variously described as “the process leading to discontinuation of ventilator support” (Blackwood et al., p. 5). For Knebel (1991) weaning means “the process of assisting the patient to breathe unaided” (p. 321) while Mancebo (1996) suggests weaning is the “transition from ventilator support to spontaneous breathing” (p. 1923). Crocker (2009) defines weaning as reduction of respiratory support “until the point has been reached when either the patient no longer requires assistance or has reached their maximal potential and further reduction of respiratory support is neither feasible nor realistic” (p. 185). Some authors use the term ‘ventilator discontinuation’ (Haas & Loik, 2012; Hess, 2012; MacIntyre, 2012) especially when referring to abrupt withdrawal of support; others refer to ‘ventilator liberation’ (Bittner & Schmidt, 2012; Bond, 2008; Mendez-Tellez & Needham, 2012) as the end-point of weaning. Regardless of the nomenclature, weaning is accepted as a significant challenge in ventilation management, occupying much research, particularly in regard to use of protocols or guidelines (Antonelli et al., 2011; Blackwood et al., 2011; Blackwood, Alderdice, et al., 2010; Rose, Blackwood, Burns, et al., 2011).

The time frame for weaning patients from mechanical ventilation has a potential effect on health outcomes. Prolonged mechanical ventilation is associated with adverse clinical outcomes (Lone & Walsh, 2011; Mietto et al., 2013). In contrast, premature reduction or removal of ventilator support increases the risk of fatigue, weaning failure and higher reintubation rates (Blackwood et al., 2011; MacIntyre, 2012). While timely and safe weaning is the objective, misjudgement in timing carries an increased risk in mortality, morbidity and cost.

Terms used in literature to describe the timeframes in relation to ventilation include short-term, long-term and prolonged ventilation. Crocker (2002) describes long-term ventilation as over seven days, Burns (2005) suggests three days, while others (Krishnan, Moore, Robeson, Rand, & Fessler, 2004), use 24hrs as a guide for 'prolonged' ventilation. How timeframe is discussed can indicate the clinician's approach to weaning management. Blackwood (2011) describes this debate, drawing from Marini (1995), who suggests that while some clinicians start weaning from the outset, some wait for relative recovery. Others fall between these two timeframes, for instance suggesting that weaning should commence when the patient is through the acute phase of their illness (Blackwood et al., 2011).

With advances in mechanical ventilation technology, automated modes also factor in the timing of weaning. Smartcare™ makes adjustments automatically, after the clinician screens the patient for the 'weaning phase' and sanctions automation (Lellouche & Brochard, 2009). ASV can be used from the outset and automatically initiates weaning as soon as the patient's spontaneous diaphragmatic effort is detected, unless the clinician adjusts the %MV so the ventilator does not wean. (Arnal et al., 2008; Arnal et al., 2012). While Smartcare™ is specifically focussed on the weaning phase of ventilation, ASV can be used from intubation to extubation and will initiate weaning independently (Morato, Sakuma, Ferreira, & Caruso, 2012).

## **Work of breathing**

Work of breathing is fundamental to artificial ventilation; it is after all, the role of the ventilator to provide support in this work (Cabello & Mancebo, 2006). The mechanisms involved in pulmonary mechanics were examined in the middle of last century (Otis, 1954; Otis, Fenn, & Rahn, 1950; Otis et al., 1956; Otis, Proctor, & Rahn, 1947) and has provided the fundamental understanding of pulmonary gas exchange. The 'Otis equation' provides the mathematical basis for obtaining an optimal breathing pattern in ASV mode (Arnal et al., 2008).

The work of breathing can be both measured and observed. Numerical measurement includes ‘implied work of breathing’ (Joules/Litre) and  $PO.1^2$  (cmH<sub>2</sub>O). Observational measurement includes observing accessory muscle use and ventilator graphic displays. Of these methods, assessment of accessory muscle use is the most common technique amongst ANZ intensivists when accessing patients for readiness to wean or extubate (Rose & Presneill, 2011). A group of US nurses (S. Burns et al., 2012) advocate for a tool for determining readiness for weaning. Named the Burns Weaning Assessment Programme (BWAP) the bedside checklist contains 26 factors to be assessed. Of these factors, 7 were closely associated with work of breathing: laboured breathing/increased respiratory rate, presence of adventitious breath sounds, secretion viscosity, neuromuscular disease/deformity, abdominal distention/obesity/ascites and small endotracheal tube (<8.0) or tracheostomy tube (<7.0). Although assessment of work of breathing is within the scope of NZICU nurses and part of their decision-making process (Pirret, 2007), how nurses make these decisions has only been investigated and compared to medical staff at a nurse-practitioner level in New Zealand (Pirret, 2013).

## Knowing the patient

Rather than focusing on nurses’ physiological knowledge, Crocker and Scholes (2009) explored the theme of ‘knowing the patient’ as a characteristic of expert nurses who wean patients from mechanical ventilation. They observed and interviewed nurses over a six-month period, in a large UK ICU. The authors support nurses’ involvement in weaning, suggesting that their patient knowledge improves patient outcomes. Two key prerequisites were found for

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<sup>2</sup>  $PO.1$  is the change in airway pressure generated within 0.1 seconds (s) of taking a breath. It is a measurement, not a setting. If a patient’s breathing pattern is relaxed then the  $PO.1$  will be around -2 cmH<sub>2</sub>O as the patient generates a small reduction in airway pressure in 0.1s. If a patient gasps, they may achieve a significant reduction in airway pressure in 0.1s, such as  $PO.1$  - 22cmH<sub>2</sub>O. Readings such as the later may be an indication of gas-hunger, anxiety or both.  $PO.1$  readings can indicate readiness to wean or extubate (Kera, Aihara, & Inomata, 2013).

knowing the patient: nursing expertise and continuity of care. Ironically, more experienced nurses are generally not attracted to the work of weaning. The authors found that patients to be weaned were typically allocated to ‘junior’ nursing staff (with less experience) and different staff, hence disrupting continuity of care. Reasons given were that the more critical patients who did not require weaning were “more interesting” (p. 292) and therefore more attractive for expert nurses to work with.

Other features of weaning practice are described by Crocker (2009) who identifies prerequisites for assessing readiness for weaning, predictors for successful weaning, methods of weaning, transfer of the role from medicine to nursing and factors around allocation of patients. As per the subtitle ‘*current state of the science and art*’, Crocker endeavours to interweave the scientific knowledge with the more intuitive art of nursing, proposing that nurses address barriers in providing patient-centred care in weaning. The study highlights skills that nurses can offer, as part of the ICU team, in improving ventilation management. Crocker’s contributions build a case for the value of nurses’ contribution to ventilation management, particularly for longer-term patients that are difficult to wean. She advocates for individualised weaning plans, led by experienced nurses, who provide continuity of care.

## **Ventilation protocol usage**

Protocols provide structured guidance to the process of weaning. From here on, protocol/guideline/policy for ventilation management will be referred to as ‘protocol’. Historically at least, doctors tend to underestimate the success of stopping mechanical ventilation (Strickland & Hasson, 1993; Stroetz & Hubmayr, 1995). Protocols aim to address inefficiency of weaning through consistent practice, in the hope that weaning times will be safely reduced (Blackwood et al., 2011). According to Blackwood et al., protocols generally have three main components: determining readiness to wean, method of weaning and determining readiness to extubate. Use and value of weaning protocols consume much of the debate of nurses’ role in ventilation management. While some authors traditionally view protocols as increasing nurses’ autonomy

(Briggs, 1991; Crocker, 2002), others describe them as restrictive (Blackwood & Wilson-Barnett, 2007; Haugdahl, Storli, Rose, Romild, & Egerod, 2014).

Another study by Louise Rose (Rose, Nelson, Johnston, & Presneill, 2007), provided a profile of critical care nurses in ventilation and weaning decision-making working in an Australian ICU. The authors stated that the majority of studies look at implementation of protocols rather than the role of nurses in initiating changes. Having claimed in earlier work (Rose & Nelson, 2006) that Australian nurses work with a high level of autonomy in ventilation management, to a degree that supersedes the need for weaning protocols, the authors set about to provide data to qualify this view.

The authors (Rose et al., 2007) conducted a prospective cohort study over three months, capturing the decisions resulting in setting changes made on all patients receiving mechanical ventilation. A total of 3,986 decisions were documented from the 319 patients in the 24-bed unit in the Royal Melbourne Hospital. With 50% of these patients requiring ventilation for cardiovascular indications, the majority of the remainder indications were postoperative, coma and trauma. Overall, basis for ventilation management decisions were predominantly made on weaning (61%), arterial blood gas analysis (14%) and requirements for transport (14%). The decisions were predominantly changes in FiO<sub>2</sub> (43%) and mode (31%). Nurses made 64% of these decisions; doctors made 17% and 19% of decisions were made collaboratively. Nurses were less inclined to make autonomous decisions in cases involving respiratory disease and multi-organ failure. This study describes an autonomous cohort of nurses, responsible for making the majority of ventilation changes.

The authors (Rose et al., 2008) challenge the applicability of weaning protocols in the Australian environment, describing them as an imposition. They cite an earlier study (Keogh, Courtney, & Coyer, 2003) in which the authors trialed a weaning guideline in a paediatric ICU (PICU) in Brisbane. With only one pilot study evaluating weaning protocols in children available in the literature at the time, a team of physicians and nurses constructed a weaning algorithm, based on practice and evidence in the literature. The study employed a quasi-

experimental time series design to evaluate the protocol over a 12-month period, measuring its effectiveness on 107 patients. Whilst Rose et al. (2007) cite this study as an example of how weaning guidelines in the Australian environment may prolong the time to wean a patient from ventilation, Keogh et al. (2003) defend the extra time taken where guidelines were employed with a slight reduction in weaning failure and reintubation rates. While a protocol may make a slight difference, both research teams agree that the nursing workforce in the Australian ICU environment works with a large level of autonomy and is intimately involved with ventilation changes.

Rose et al. (2007) suggest that weaning protocols based on US studies are not transferrable into the Australian ICU environment, due to workplace differences. In a US study, Krishnan et al. (2004) reasoned a protocol unnecessary due to a generous ratio of available physicians and a closed ICU environment, where skilled staff are available to initiate changes. Apart from this study, which Rose likens to the Australian environment, Rose and Nelson (Rose et al., 2007) describe results from US studies as having limited application to the Australian setting. While Rose and Nelson found a median time of ventilation to be 1.9 days in the Melbourne unit, they cite four large international studies that advocate for weaning protocols, who reported improved medians ranging from 2.8 to 4.5 days. So although protocols may decrease weaning times in the US, the work environment of Australian ICUs result in weaning times that are already considerably shorter than times achieved in the US study.

A review (Rose, Blackwood, Burns, et al., 2011) of existing international data looked at ICU context and processes of care in seven countries. Investigating Australia, Denmark, New Zealand, Norway, Sweden, United Kingdom and the United States, the authors highlighted similarities in all of these countries apart from the US. The study found the main two differences about the US model was their predominantly open structure of the ICU and the presence of respiratory therapists. Open ICU's were defined as departments where the attending physician retains overall responsibility, rather than the closed model where the patient's care is transferred to an intensivist, who consults other specialties as

required. The authors suggest that studies which advocate for ventilator practices and weaning protocols and are tested on the US ICU clinical model should be scrutinised carefully before being introduced elsewhere, as the US context and working processes are unique. The review suggests that further quantification of contextual influences should be taken into account, before either adopting practice or designing trials.

Rose led another study that is pivotal for this review of literature (Rose, Blackwood, Egerod, et al., 2011). The European ICU study used a similar methodology to the earlier work in ANZ by Rose et al. (2008) and examined the role of the ICU nurse in ventilation management. To date, this is the largest study to describe inter-professional role responsibility across Europe. Six key decision-making areas were looked at: initial settings, titration, weaning readiness, weaning method, weaning failure and extubation readiness. With widespread commercial availability of automated closed-loop modes, questions were added about availability and usage of these computer-assisted modes, making it the first study to describe usage of automated modes in practice. Other aspects investigated were staffing ratios, nurses' perceived autonomy, nurses' level of contributing to decisions, existence of protocols and ventilator-related education. The authors distributed a self-administered survey that was translated into the local language and sent to nurse managers in Denmark, Germany, Greece, Italy, Norway, Switzerland, Netherlands and the United Kingdom.

A total of 586 surveys were returned in the European study (Rose, Blackwood, Egerod, et al., 2011) with response rates ranging from 39% in the UK to 92% from Switzerland. Results ranged, particularly depending on the country, with UK nurses comparing well to the ANZ population in earlier work (Rose et al., 2008) in high staff ratios, perceived autonomy and level of decisional responsibility. Overall, inter-professional collaboration was the predominant model of decision-making described. Factors that influenced level of nurses' involvement included nurse-to-patient ratios and availability of protocols. Automated modes were available in 55% of ICUs, however frequent usage was much lower: ASV 16% and SmartCare 12%.

Regarding inter-professional decisional responsibility, Rose et al. (2011) suggest that nurses may be best positioned for titrating ventilation settings, as they maintain a near-continuous presence in the bedspace. The authors go further to suggest that failure to include nurses in decision-making may lead to unnecessary prolongation of weaning and extubation.

Crocker and Scholes (2009) propose that weaning protocols “belie the complexity of the weaning trajectory” (p. 295) and that expertise, not protocols are needed for weaning. A Cochrane review and meta-analysis (Blackwood et al., 2011) determined the use of weaning protocols for reducing duration of mechanical ventilation, reporting findings as significantly heterogeneous. Blackwood et al. found that protocols were favoured, with caution, in some clinical areas. Rose et al. (2007) suggest that protocols are largely redundant in the ANZICU environment. The authors maintain that because Australian and NZICU nurses are independent, autonomous and have excellent staff ratios (1:1), the guidance that ventilation protocols provide is unnecessary, although some NZICU nurses do not agree. Pirret (2007) found 66.7% (n=27) of NZICU nurses rated protocols as supportive in their decision-making. Nine participants in Pirret’s study requested further discussion, describing protocols as limited in their lack of individualised approach, inaccessibility, preventing knowledge development and stifling creative practice. Availability of protocols had no measurable effect on practice in this study.

## **Interdisciplinary perspectives in Norway**

As a part of the European study detailed above (Rose, Blackwood, Egerod, et al., 2011), the authors also sent the questionnaire to physician directors of Norwegian ICUs and compared results with data collected from nurse managers (Haugdahl et al., 2014). Nurse managers perceived nurses’ autonomy, influence and collaborative interaction in ventilation management as greater than what was perceived by physician directors. This study substantiates nurse managers over-representation of nurses’ role, as raised as limitations in the previous studies linked to this work (Rose, Blackwood, Egerod, et al., 2011; Rose et al.,

2008), however, it is not known which profession more accurately estimates practice. While nurse managers' perceptions are compared to physicians, the clinical nurses' perceptions were not measured. The authors suggest that collegial awareness and acknowledgement of the nurses' role in ventilation management may promote collaboration with medical staff and lead to improved patient care.

Lavelle and Dowling (2011) investigated nursing practice around ventilator weaning in an ICU in Galway, Ireland. This qualitative study in one ICU used thematic content analysis to confirm what other studies had previously brought to light around factors influencing nursing practice in ventilation management. The authors highlighted the complexity of the area, in that even finding a definition of 'weaning' seemed problematic. They reported the nurses' role as 'significant', describing the boundaries of the role as 'blurred'. Although the study does not add new content, it confirms common themes that face other geographical areas regarding blurred roles in ventilation management.

To capture the perspective of medical staff in weaning, ANZ intensivists were surveyed (Rose & Presneill, 2011). Out of a possible 230 contributors, 164 from 55 ICU's participated, providing predictors for weaning readiness and extubation readiness. The three main predictors, as measured out of ten using a visual analogue scale for weaning readiness were respiratory rate ( $m=8$ ), effective cough ( $m=7.3$ ) and pressure support setting ( $m=7.2$ ). The three main predictors for extubation readiness were effective cough ( $m=8$ ), respiratory rate ( $m=8$ ) and Glasgow coma score ( $m=7.9$ ). Notably, only one participant identified clinical judgment of the bedside ICU nurse as contributing to this decision making process. In the face of Rose's other data that puts nurses as significant collaborators in the team of decision-makers, this provides a contrast with medical staff failing to acknowledge nurses as on the same team.

## **Automated modes**

Automated modes take a significant role in weaning and bring some significant changes to ventilation management. Adaptive support ventilation (ASV) uses

software to automatically wean the patient as soon as diaphragmatic effort is detected, without waiting for a directive from the clinician to commence weaning (Brunner & Iotti, 2002; K. Burns, Lellouche, & Lessard, 2008; de Abreu, Guldner, & Pelosi, 2012; Kirakli et al., 2011; Rose et al., 2014). An extension of this software, only released commercially in 2012, IntelliVent-ASV™ is the first fully closed-loop mode available. The software can automatically adjust any of the settings to provide ventilator support/weaning, as it measures lung mechanics, underlying pathology, capnography and oxygen saturations to guide progress (Arnal et al., 2012; Chatburn & Mireles-Cabodevila, 2011; Jouviet et al., 2011). Implications for the role of the nurse in ventilation management when using these modes has not yet been covered in the literature, however, increased usage of automated modes is likely to bring about significant changes in the way nurses approach ventilation management.

It is clear from research in Europe (Rose, Blackwood, Egerod, et al., 2011) that automated ventilation modes have become increasingly embedded into clinical practice. Despite a range of trials measuring the effectiveness of automated ventilation modes against traditional modes (Arnal et al., 2012; Chen, 2011; Iotti et al., 2010), there is only one study investigating how to maximise use of automated modes in ICUs (Wu et al., 2010). Clinicians are predominantly led by transference of traditional ventilation knowledge and ventilator manufacturers' advice, rather than relevant evidence and discussion of findings.

## **Summary**

The literature reviewed suggests that ventilation is managed differently, both at a local and international level. Nurse roles in NZICUs are comparable with those in Australia. By international standards, NZICU nurses work with a high degree of autonomy in contributing to ventilation management.

Data that describes the NZICU nurse role has been collected from nurse managers, representing staff as a collective, rather than individual nurses answering from their perspective. With individual nurse data not available,

variables such as education, experience and work environment have not been compared with individual practice.

Although the literature gives some insight into recent historical ventilation management in NZ and how this differs from international data, it provides no insight into the use of automated modes. It is timely that usage of this technology is collected. The following chapter outlines the methodology used to answer the research question.

## **Chapter 3**

### **Research Design**

#### **Introduction**

This chapter presents the methodology, method of data collection and data analysis used to answer the research question ‘What is New Zealand Intensive Care nurses’ role in ventilation management?’ Good research is characterised by addressing a single, clear and explicit research question (Kelley, Clark, Brown, & Sitzia, 2003). The aim of this study was to answer questions regarding the role of NZICU nurses in ventilation management, with an online survey as the chosen method to do this. Quantitative surveys require a structured approach to data collection and analysis (De Vaus, 2007). Polit and Beck (2011) describe research as “systematic inquiry that uses disciplined methods to answer questions or solve problems” (p. 3). This chapter describes the strategies used to ensure a sound research process in answering the research question.

#### **Methodology**

According to Tashakkori and Teddlie (2010), nursing research in the 20th century began with a strong traditional or scientific perspective, drawing to a close in what the authors describe as a series of ‘paradigm wars’. Nursing researchers traditionally favour approaching their work from a qualitative paradigm, with medicine preferring the domain of quantitative research (Schneider, Whitehead, & Elliott, 2007). While the hierarchy of evidence model ranks quantitative studies higher than qualitative (Blackwood, O'Halloran, & Porter, 2010), Polit and Beck (2011) suggest a more moderate approach; that paradigms be viewed as lenses that sharpen our focus, rather than blind our view (2011). Evans (2003) suggests that different methods are needed to answer different questions and a more appropriate framework than the hierarchy is to ask whether the method is effective, appropriate and feasible. Although research paradigms are historically debated, with nursing traditionally siding with

qualitative thinking, efficacy and feasibility must be considered in the approach of answering a research question.

Methodology refers to the philosophical stance taken by the researcher in relation to the subject and process of research. Method on the other hand, refers to the technique used to gather data (Tarling & Crofts, 2002). A study's paradigm is a combination of epistemology, ontology and methodology (Maltby, 2010).

Methodology provides a framework and process for conducting the study. In using the research strategy of a survey, there is no attempt to control conditions or manipulate variables. A survey provides a quantifiable description of attitudes or opinions of a sample from which the researcher generalises about the population (Creswell, 2009). This quantitative approach is therefore informed by the traditional scientific principles of positivism. Positivism is the original historical observational methodology of the natural sciences (Maltby, 2010). The survey used in this study asks closed questions, requiring specific information from the participants. Positivists value objectivity, retaining tight control in the study design, to minimise subjectivity. Although there is an acknowledged limitation in seeking total objectivity, positivists aim to provide data with a high degree of likelihood of describing the phenomena accurately (Polit & Beck, 2011). This study brings clarity to a part of the NZICU nurses' role, with quantifiable findings.

Epistemology is the theory of knowledge and provides a focus for the study (Gomm, 2009; Maltby, 2010). Epistemology asks questions about how we know what we know and how we can (or cannot) verify this (Gomm, 2009). It influences the questions in the survey and the research question asked. This study utilises an objective approach of asking the population of interest to quantify their experience. Interaction between the researcher and participants is limited to the survey, with the researcher's influence only from within the composition and selection of the questions asked. The researcher isolates themselves from participants, asking closed questions to collect objective data, in the approach to answering the research question.

Ontology provides the world-view or nature of reality that guides the study (Polit & Beck, 2011). Ontology refers to questions around existence and theory of being, asking what exists and what is the nature of existential entities (Gomm, 2009). As a positivist study, there is an assumption that the truth is 'out there' and by asking the population of interest to respond to particular questions, the research question can be answered and the truth discovered. The paradigm of positivism requires the researcher to construct the area of inquiry.

Ontologically, intensive care nurses have both strong positivist tendencies and well-honed wisdom from practice. Numeric data is constantly being collected and analysed at the bedside, yet engaging intuition based on clinical experience is, according to Benner (1984), the key ingredient in 'expert' nursing and all the more essential in the unforgiving environments of high-acuity nursing. This study asks nurses to describe specific aspects of their role in ventilation management in a way that can be measured. NZICU nurses have a strong reliance on empirical knowledge in their decision making (Pirret, 2007), their continual collecting and analysis of numerical data (perhaps more than in any other field of nursing) helps maintain a strong value for the use of numerical data in assessment.

A hallmark of quantitative research is the collection and analysis of numerical data (Maltby, 2010). Closed questions are used to provide clarity of professional roles in ventilation management. This question style compartmentalises data collected, so that it can be converted into numeric form. All questions in this survey that require nominal data have the option of 'other', with a blank space for insertion of individual answers. This allows for answers other than those offered and to some extent addresses one of the fundamental limitations of the researcher-led positivist methodology. A survey using closed questions collects data to represent people's experience in a quantifiable form.

## Design

The study is descriptive, capturing self-reported empirical data. A cross-sectional online survey was used for the collection of data. Cross-sectional studies use a single timeframe to collect data and are appropriate for measuring variables of interest in a broad sample. As causal relationships are not part of the research question, the cross-sectional approach is a more appropriate design than the longitudinal approach for providing a description of current role demarcation (De Vaus, 2007; Polit & Beck, 2011).

Survey Monkey was used to administer the survey online. For the purposes of this research, both time and finance are limited. The online survey minimises requirement of travel, postage and face-to-face contact. Many of the participants work unsociable hours and this format allows for flexibility within the timeframe.

Online surveys, like all methods, have advantages and disadvantages. When the researcher wishes to collect a large sample where time is limited, resources are limited, privacy is protected and only superficial data is required, online surveys are ideal. De Vaus (2007) describes social desirability as “the tendency of people to answer a set of questions in a socially approved manner, rather than in a way that truly reflects their own views” (p. 364). The researcher wishes to avoid confounding variables and collect data that is as close as possible to reflecting the truth. De Vaus suggests that the anonymity of an online survey is valuable in reducing social desirability.

Disadvantages of online surveys may include coverage bias, reliance on software, access to the online environment and anonymity (Sue & Ritter, 2007). Coverage bias or coverage error occurs when part of the population is not represented, sometimes due to omissions in the sample frame. The total New Zealand College of Critical Care Nurses (NZCCCN) membership was given opportunity to participate, minimising coverage bias. Not all NZICU nurses belong to the NZCCCN, however, the assumption here is that most of them do. Regarding reliability of software, the Survey Monkey website proved reliable

throughout the time of setup and data collection. There were no impediments in creating an online survey and costs for setting this up were minimal. It is not possible to control internet access issues for nurses directly, however, if participants wished to utilise computers in work time to complete the survey, Survey Monkey is a reputable, stable format that is perceived as a 'safe' internet site to access (IT helpdesk of the local hospital, personal communication, January 8<sup>th</sup> 2013).

Although this study did not solicit personal identifiers, such as name, place of work or geographical region, the boundaries of professional role can become a sensitive issue for some (Niezen & Mathijssen, 2014). Participants remained anonymous in their participation unless they chose to offer their email contact at the end of the survey. No IP addresses or geographical information was gathered. Anonymity served to protect participants in the hope that this would increase their honesty and reduce social desirability.

Research design can influence abandonment, or indeed participation in the first place. When utilising an online survey, usage of a navigation guide such as a progress bar prevents the respondent feeling lost and giving up (Sue & Ritter, 2007). Moreover, Sue and Ritter suggest that the placement of questions within the survey can be designated in such a way as to maximise progress of the navigation tool, by making progress in the initial part of the survey expedient. Both of these techniques were utilised in this survey with an aim to discourage abandonment. Rather than starting with gathering of personal information, the survey began by asking participants some fundamental questions related to the research question, covering their role in ventilation management. This was intended to engage the participants from the start, so they might feel less like they are filling in a form and more like they are contributing to a research project and hence less likely to abandon the survey. The time to complete the survey was estimated by the researcher as around ten minutes. This was stated in the email invitation and repeated in the information about the survey.

It has been proposed that ICUs practice in a culture of their own (Levin & Sprung, 2003). For this reason, discussion was maintained with a group of

senior nurses who work in ICUs throughout the time of study design. Specifically, the NZCCCN reviewed the survey for appropriateness of the language used in the questions, and they were offered the opportunity to include questions of their own should they wish. This did not result in any changes.

## **Survey tool**

Questions in the survey cover ventilation management decision-making, availability of protocols/guidelines for ventilation management, usage of automated modes, nurse education, nurse experience and ICU demographics. The full survey can be found in Appendix D.

This study provides up-to-date information about NZ nurses' involvement in ventilation management with additional information on usage of automated ventilation modes, allowing a comparison to the European data of using these modes. Until recently, inquiry about dispersion of roles within ventilation management has only been between different professions, predominantly medical and nursing staff. With the relatively recent addition of automated modes into the market we now have some of these decisions being made by the ventilator itself. Although the implications of this phenomenon have not been looked at in the literature, usage of these modes has recently started to be measured (Haugdahl et al., 2014; Rose, Blackwood, Egerod, et al., 2011).

Survey questions were adapted from the most recent (at the time) of studies (Rose, Blackwood, Egerod, et al., 2011) which increases comparability of data. Questions used in this survey were modified from the original studies for the two reasons of matching with local terminology and with the modified sample frame. Where the medical role 'Resident' was used in the original, this was changed to 'House Officer', as this is the more common nomenclature used in NZ for a junior doctor and is comparable with usage of the role 'resident' in Europe. As the survey is personalised to individual nurses rather than nurse managers, adjustments were made to take this into account, as follows.

Questions were added to clarify education completed and underway by the participant, as well as their principal role in the ICU. This provided a chance to compare individual education with individual practice. The original study asked the manager for the number of nurses holding a post-graduate critical care specialty qualification which presumably would have required an element of approximation on the manager's part. This was presented as a percentage of nurses holding such a qualification. Asking detail of study completed and underway, as well as principal role in the ICU has provided more specific variables to be compared, with specific interest in how this education has affected the participant's practice.

Questions adjusted included question 23, a series of Likert-scale scales enquiring about individual implementation of ventilator settings. Two rows were added to this for increase and decrease of '%Minute Volume' (%MV) parameter. %MV is a unique and fundamental setting used in ASV. One of the significant findings from Rose et al. (2011) was that most European ICU's involved in this study have this mode available, however data on who was changing the settings was not collected. This study is the first time data has been collected about role in adjusting ASV settings.

Due to the relatively small number of ICU's in NZ compared to Europe, the question asking if the ICU had a medical specialty was removed. This question might have reduced anonymity. For instance, if the participant answered that they were a nurse educator in a paediatric ICU, this would narrow the participant down to a few people nationally. As mentioned earlier in this chapter, all questions in this survey that require nominal data have the option of 'other', with a blank space for insertion of individual answers.

Four experienced ICU nurses were individually asked to pilot the survey. Their suggestions resulted in the addition of a question about stopping sedation. It was rightly pointed out that actioning changes in sedation had a significant effect on ventilation management and often signaled the start of spontaneous breathing. Questions 7-9 were added, asking who determines that sedation is stopped and the seniority of medical/nursing staff involved. Intensive care

nurses were then invited through advertising in the national NZNO publication, Kai Tiaki and by direct email from the NZCCCN to participate.

An opportunity was provided at the end of the survey to offer a contact email for follow-up. This opportunity allowed for further data collection, amongst those who were interested in participating further. Follow-up was used to clarify answers, as necessary. However, no further data was collected.

## **Method**

### **Sample population**

The population of interest for this study are ICU nurses working in NZ. The sample comprised of members of the NZCCCN, a part of the New Zealand Nurses Organisation (NZNO). Nurses who work in ICU and are NZNO members tend also to have membership with the NZCCCN, as there is no financial cost to belong. Using the NZNO to contact members directly allowed for a large sample capture of widely spread geographically and who work in a range of ICUs.

There were 776 members in the critical care nurses section of the NZNO at the time of the study and each of them (who have an up-to-date email address) was sent an email inviting them to participate. Those invited to participate made up the majority of the population of NZICU nurses. The total number of ICU nurses working in New Zealand is difficult to gauge. Data gathered on renewal of annual practicing certificates by the Nursing Council of NZ (2013) combines ICU nurses with those working in cardiac care areas. So although this figure totals 1662, it is difficult to know how many of these nurses work specifically in the ICU environment.

A random sample was not generated, as the intention was to maximise participation. The survey was available online from May 7th 2013. Four experts tested the survey that week and fed back responses via email. Participants were invited to complete the survey in the NZNO Kai Tiaki publication released on May 20<sup>th</sup> 2013. NZCCCN members were invited by email to participate on May

22<sup>nd</sup> 2013, with a follow-up reminder email sent on June 17<sup>th</sup>. The survey was closed on June 21<sup>st</sup> 2013. Of 223 participants, 204 completed more than 50% of the survey and were included in analysis.

## **Ethics**

Ethical consideration is an important aspect for anyone wishing to conduct research. Approval was sought and approved through the Massey University Human Ethics Committee (MUHEC). The NZNO policy on ‘external researchers requesting support from NZNO’ (2012) outlines the process required to access the organisation’s membership. This process was duly followed and included collaboration with the NZNO and NZCCCN committee throughout the process of designing and carrying out the study. Access to the sample was gained by requesting permission from the NZNO office to contact the Section directly for the purposes of arranging a survey of its members. Verbal permission was gained by the NZCCCN secretary, followed by written permission from the Section committee, outlining the process of accessing the members of the section. An email was sent out to NZCCCN membership inviting them to participate, with a follow-up reminder emailed three weeks later.

Permission was sought to use the survey tool from previous work of Rose et al. (Rose, Blackwood, Egerod, et al., 2011). Louise Rose was contacted by email and a copy of this correspondence and approval can be found in Appendix B.

It is important for potential respondents to feel fully informed about research before they decide to participate. The researcher drew up an information sheet containing necessary detail in a succinct, easy to read format. The information sheet can be found in Appendix C. The information sheet was emailed by NZCCCN to all membership with the invitation to participate and featured on the front page of the survey. The NZCCCN chairperson offered to publish a supportive reminder in the Section’s biannual newsletter, if timing of the publication and the survey coincide, however timing did not allow for this.

The potential for risk in the survey relates mostly to an inadvertent breach of a participant's anonymity. If a particular nurse who participated wished to remain anonymous, then the possibility of the researcher identifying them from the data was deemed highly unlikely, although short answer responses could have led to this possibility. Participants most likely remained anonymous to the researcher in their participation unless they chose to offer their email contact at the end of the survey. Participants were reminded in the information sheet of their potential to be identified by their written responses. To ensure anonymity of participants, information about the study has been kept confidential, results have been published and/or presented in aggregate form only and identifying information from written survey responses has been removed.

Ethical issues were discussed with the NZCCCN chairperson regarding how best to contact members. The researcher does not have access to the NZCCCN database; the administrator of the committee communicated to members on the researcher's behalf. Email correspondence to members was sent from the organisation's administrator and not the researcher. The researcher did not know whether nurses participated or not due to the method of an online survey data collection.

Data of ethnicity, gender and age were not collected in the survey. These were not variables that were deemed helpful in answering the research question and would only serve to jeopardise anonymity. Similarly, participants were not asked which region they work in.

It is important to consider the consent process when designing a study. In this study, consent was implied by participation in the survey.

## **Data analysis**

Before undertaking analysis of data, it is important that errors in the data are screened out and corrected. Pallant (2010) describes this two-step process as an essential part of "avoiding heartache" (p. 43) in the analysis period. As the two-step process is easily completed using Statistical Package for the social sciences

(SPSS) software (SPSS, Chicago, IL, USA), the data was first exported from Survey Monkey to Microsoft Excel. Data with more than 50% of answers completed was then transferred to version 20 of SPSS. The process of screening and cleaning the data is outlined as follows.

First of all, categorical variables were screened for errors. Utilising the 'frequencies' function in SPSS, categorical variables were processed, giving the dispersion of minimum and maximum values listed in a table. These values were then checked for dispersion within valid responses for each question and were found to be so. Missing cases were also screened against the context of the questions. The majority of missing data was found in two types of questions. A few of the questions were only required conditional to a positive response in the previous question, so missing data was expected there. Data was also missing in questions asking about usage of automated ventilation modes. It was surmised that rather than answering with usage of 'never', the participant instead skipped the answer. Categorical data was therefore considered to be entered correctly and not unduly missing.

Continuous data were dealt with similarly, with minimum, maximum, mean and standard deviation being calculated and examined. Minimum and maximum limits were checked against valid responses, with all data found to be within the range of valid answers. One outlier had entered sixty hours as a weekly average of how much she worked in ICU. As this nurse had also entered her email in the survey, she was contacted for verification of her answer. She confirmed that although her paid work consisted of 40 hours per week, she regularly offered more time than this. Her answer was adjusted to 40, accordingly. Mean and standard deviation scores were checked for distribution. These results looked in keeping with each of the associated questions. With categorical and continuous data now checked for errors, missing data and distribution, this concluded the preparation of data required prior to analysis.

## **Descriptive statistics**

According to McKenzie and McKenzie (2013, p. 34), “things tend to even out over time”. In measuring this central tendency within sets of data, there are measurements that are useful for describing groups of data. The type of measure used depends on the type of data collected and categories are used to describe these. De Vaus (2007) suggests that the way in which variables relate to one another is the key to their classification. The three characteristics he proposes are whether there are different categories; whether these categories can be ranked in order; whether the intervals between the rankings can be meaningfully specified numerically. Data that only features different categories is categorical data. Data with categories that can be ranked in order is ordinal data. Interval data boasts all three characteristics, with categories that can be ranked in order and the intervals between them are numerically significant. These categories can also be ranked accordingly, with increasing amounts of information contained within. Which statistical test can be conducted depends on the category of data that is analysed.

## **Mean, median and mode**

Three calculations that can be used to describe central tendency of interval data are the mean, median and mode. The mean is most commonly used as an average score and is calculated by adding the scores and dividing by the number of scores. From this, variance and standard deviations are calculated to describe the dispersion of data around the mean. The median is used to minimise the effect of outliers. It is calculated by lining up the scores in order of value and selecting the middle number. The mode is simply the most commonly occurring result. It can also be used for nominal and categorical data. The mode does not measure distribution or averages within the data, simply the most common result.

Displaying the distribution of a single continuous variable can be effectively done using a histogram (Pallant, 2010). Histograms have been used to graph years of experience, number of ICU beds, perceived autonomy and perceived influence.

## **Inferential statistics**

Where descriptive statistics provide information about the sample, inferential statistical tests use the sample to make inferences and test hypotheses about the population. This process can help in the prediction of outcomes of a population or determining whether a null-hypothesis should be accepted or rejected.

Accepting a null-hypothesis means arriving at the conclusion that two groups are not statistically different. Rejecting the null-hypothesis means concluding that the two groups are indeed different. The strength in accepting or rejecting the null hypothesis is measured using a 'p value', and helps to determine whether a difference indicates a sampling error or a real difference. Sampling error depicts the inadequacies of testing a sample rather than the whole population. The error takes place when the participating sample is not representative of the population. If the statistical significance of a real difference is calculated as  $p < 0.05$ , then rejection of the null hypothesis will be estimated for all but  $\leq 5\%$  of the population (De Vaus, 2007). The alpha value set for this study is 0.05. While the p-value measures the finding within the sample, confidence intervals are used to indicate a range either side of the mean that are expected to be found in the population.

An example for use of a null-hypothesis in this study is in calculating whether nurses with higher perceived autonomy in decision-making make more or less frequent changes to ventilator settings than those with lower perceived autonomy. Confirming the null-hypothesis would mean that there is no statistically significant difference in the number of independent titrations made by either group of nurses (with more or less perceived autonomy). Rejection of the null-hypothesis would mean that the two groups make more or less independent titrations and the difference is found to be statistically significant.

For an inference to be made using statistics, certain assumptions must be met (or at least considered) before choosing the appropriate test. Parametric and non-parametric tests are different models that have been applied in the analysis

of this data. Parametric tests utilise more assumptions than non-parametric tests, allowing them to offer more power, however, they need to be used appropriately. The assumptions that should be fulfilled in using parametric tests are as follows. Either interval or ratio scales are used. Random sampling should be used from the defined population. The sample size should not be too small, with authors describing minimum participation as 20-30. Groups to be compared require a similar variance and the distribution of data is required to conform similarly to the curve of normal distribution (McKenzie & McKenzie, 2013). Normal distribution occurs when the distribution of data can be depicted as a bell-shaped curve and variance describes the spread of this data.

### **T-test**

A parametric tests used in this study is the t-test. Participants in this research were not randomly sampled, as the intention was to maximise participation. As parametric tests require the sample to be randomised, this assumption of the t-test was violated. As a consequence, t-test results should be treated with some caution.

The t-test is used to measure the reliable difference in mean scores of two variables, resulting in a calculation of whether any difference holds statistical significance (McKenzie & McKenzie, 2013). The t-test gives the probability of whether a sampling error has occurred by providing a p-value. As this is a cross-sectional study (without subsequent follow-up or measurement), the two types of t-tests used are the one-sample t-test (used for measuring one group of people) and independent-samples t-test (used for measuring two groups of people). Levene's test is used in each t-test to determine equality of variance in the two groups being compared. Where variance is measured as unequal, Welch's t-test are reported, giving a compensatory adjustment for unequal variance (Pallant, 2010). To allow for t-tests to be performed, autonomy, influence and beds are dichotomised at the median (6, 7 & 12).

### **Chi-square test**

The chi-square ( $\chi^2$ ) test for independence is a non-parametric test that is used to compare differences in proportions using two sets of categorical or ordinal data. The test then calculates whether this difference is statistically significant. As the data used is categorical or ordinal, frequencies and proportions are used rather than means and standard deviations. Chi-square tests used were 2x2 crosstabs, comparing two categories with two variables. Yates correction for continuity was used, as the low number of variables in a 2 by 2 table can overestimate the  $\chi^2$  value without this correction (Pallant, 2010).

The chi-square ( $\chi^2$ ) test for goodness-of-fit, or one-sample chi square is a non-parametric test used to compare differences in proportions from a sample with either hypothesised values or those obtained previously. The test then calculates whether this difference is statistically significant (Pallant, 2010). In this study, data was compared with that obtained by Rose et al. (2008).

### **Correlations**

Spearman's rank order (rho) correlations were used to compare the non-parametric variables of perceived autonomy and influence with the twelve titrations made autonomously. Autonomy and influence was collected using a Likert scale ranked 0-10, making them fall under the non-parametric category. Spearman's rho is useful when examining non-parametric data where the Pearson correlation is used with parametric data, giving a correlation between -1 and 1, with a  $p$  value. The negative or positive denotes whether the correlation is positive or negative. The closer the value is to 1 (or -1), the closer the correlation.

### **Wilcoxon signed ranks**

The one-sample Wilcoxon signed rank test was used to compare medians of perceived autonomy or influence between different studies. The test uses non-parametric ordinal data and compares the ranking of data between two samples without assuming that these datasets have statistically normal distribution (Gomm, 2009).

## **Statistical methods**

Data from this study were compared to that of Rose et al. (Rose, Blackwood, Egerod, et al., 2011; Rose et al., 2008). The results are benchmarked with this work to provide more recent information about nurses' involvement in ventilation management. Categorical variables were analysed using proportions with 95% confidence intervals (CI). A p-value of 0.05 is considered as statistically significant. Incomplete surveys have been included, resulting in varied denominators within the results; however surveys with <50% completion were not included. These methods are in accordance with the methods of research this study draws on (Rose, Blackwood, Egerod, et al., 2011; Rose et al., 2008).

## **Data quality**

Generalisability, reliability and validity are criteria used in assessing the quality of quantitative designs. Generalisability describes the degree to which research findings can be generalised to those outside the sample. Reliability is described as the ability to obtain the same accurate result on repeating the research. Validity is the degree to which an instrument measures what is meant to be measuring (Polit & Beck, 2011).

As this study is based on the work of Rose et al. (2011), the researcher contacted Rose by email (personal communication, April 27<sup>th</sup>, 2013), to enquire whether the instrument used in the original study underwent any formal validity or reliability tests. She confirmed that the authors had not run any such formal testing, as they saw the study as primarily descriptive. The study was international, so face/content validity was tested in the different survey translations to ensure validity in all languages used. Sensibility assessment was undertaken with a six-question survey sent to experts to evaluate the instrument.

Rose assessed the tool in this study and suggested two changes. First, the order of questions on use of protocols was changed to start with weaning protocols,

rather than more general ventilation protocols. This adjustment was made to the survey. Secondly, Rose suggested that if the place of employment was specified, data could be clustered. As the ethics proposal specified that location of employment would not be requested, it was considered the second suggestion would not be accepted.

From the outset, the research design in this study sought to improve on previous data collection methods and increase the validity of this study. By inviting nurses to contribute as individuals rather than asking nurse managers to collectively represent a group of ICU nurses, the sample size was enlarged, while the population of NZICU nurses stayed relatively the same. Though these data groups were collected by different methods, it was decided that results from the different groups could be statistically compared.

## **Summary**

This chapter has outlined the approach, design and method used in this study. Traditions of positivism informed the basis of this study, where the researcher retains control and asks closed questions, so that answers can be quantified. The study received ethical approval from MUHEC with details provided in Appendix A. Access to participants was granted via NZNO and NZCCCN. A cross-sectional online survey was used to collect data. Data was screened, cleaned and analysed with SPSS 20.0 (SPSS, Chicago, IL, USA). T-tests and chi-square analysis were the most commonly used statistical tests, the results of which are presented in the next chapter.

## **Chapter 4**

### **Analysis of findings**

#### **Introduction**

In this chapter the results of the data analysis are presented. The data were collected and then processed according to the processes outlined in the methodology chapter. Descriptive data are examined first, including personal demographics and workplace descriptions. Decisional responsibilities are outlined, use of automated modes and perceived autonomy and influence. Variables are compared, with mainly either t-tests or chi-square analysis. Data from this study are compared with international data and historical NZ data.

#### **Description of sample**

##### **Response rate**

A response rate of 28% provided 223 participants, based on 776 ICU nurses who received the invitation to participate. Of these, 204 completed more than 50% of the survey and were therefore included in the analysis. The sample size varies throughout the analyses, due to some respondents skipping some questions.

##### **Role in ICU**

Participants are predominantly in staff nurse roles (n=139, 69.5%). Thirty-one (15.5%) are in a coordinator/charge nurse manager or associate charge nurse manager role (see Table 2).

**Table 2: Role in ICU**

| <b>Role</b>                   | <b>Count</b> | <b>Percentage</b> |
|-------------------------------|--------------|-------------------|
| Staff nurse                   | 139          | 69.5              |
| Nurse coordinator/charge/ACNM | 31           | 15.5              |
| Nurse educator                | 8            | 4.0               |
| Nurse manager                 | 7            | 3.5               |
| Nurse specialist              | 6            | 3.0               |
| Research nurse                | 3            | 1.5               |
| Other                         | 3            | 1.5               |
| Nurse practitioner            | 2            | 1.0               |
| Outreach/PAR nurse            | 1            | 0.5               |
| <b>Total</b>                  | <b>n=200</b> | <b>100.0</b>      |

ACNM, associate charge nurse manager; PAR, patient at risk outreach team

### **Nursing qualifications**

Table 3 shows the highest level of education completed. Of those, 70% (n=201) have completed a postgraduate qualification. The six participants who chose 'other' had completed either Honours degrees or poorly specified qualifications.

**Table 3: Qualification**

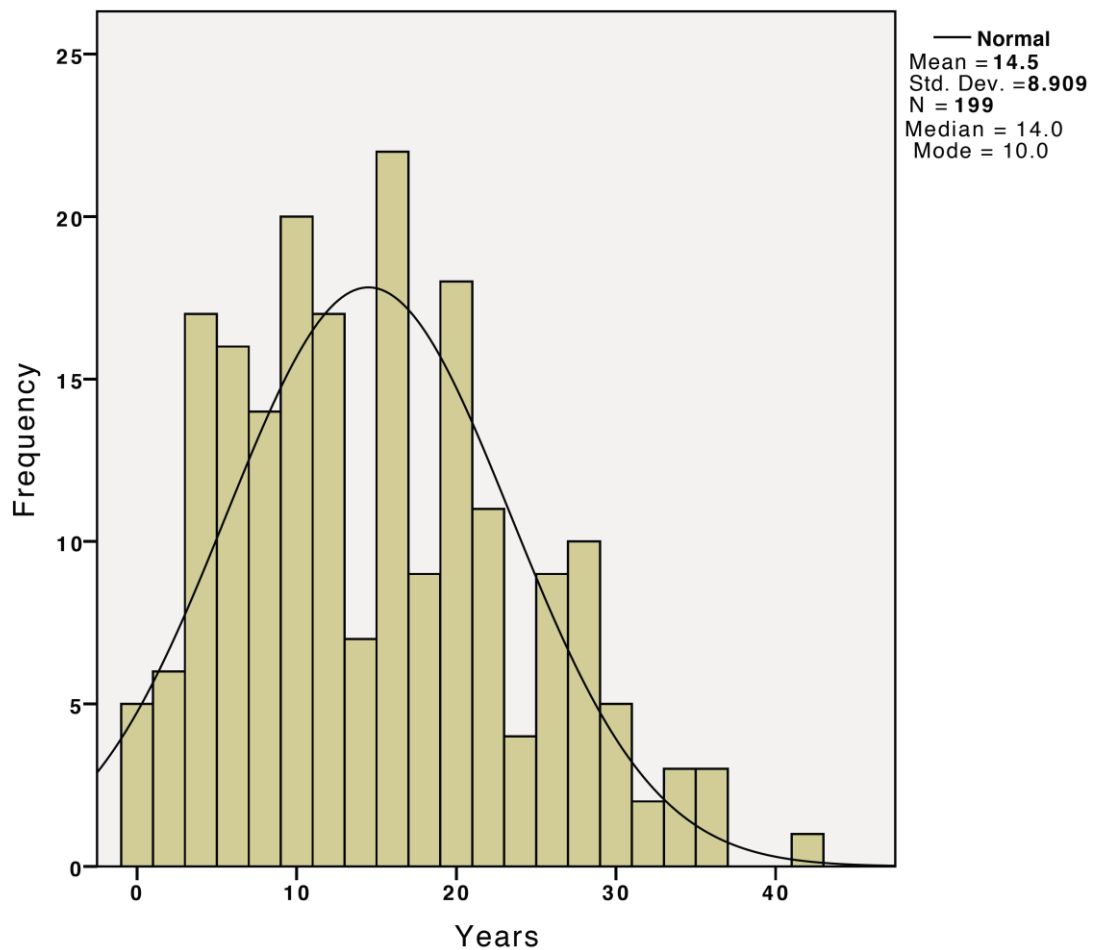
| <b>Highest qualification</b> | <b>Count</b> | <b>Percentage</b> |
|------------------------------|--------------|-------------------|
| Hospital Cert                | 9            | 4.5               |
| Dip. Nursing (Polytechnic)   | 4            | 2.0               |
| Dip. Nursing (University)    | 5            | 2.5               |
| BN                           | 43           | 21.4              |
| PG certificate               | 53           | 26.4              |
| PG diploma                   | 47           | 23.4              |
| Masters                      | 32           | 15.9              |
| PhD                          | 2            | 1.0               |
| Other                        | 6            | 3.0               |
| <b>Total</b>                 | <b>n=201</b> | <b>100.0</b>      |

Dip, diploma; BN, Bachelor of nursing; PG, post-graduate; PhD, doctor of philosophy.

Participants were asked separately if they hold a critical care specialty post-graduate qualification. Of 195, 136 (69.7%) of the sample had this qualification and a further 8 (4.1%) were currently enrolled in a programme. Overall, 104 out of 150 (69.3%) of the nurses with post-graduate ICU qualifications had gained them through a university-associated programme. In total, 104 out of 201 (53%) of the participants in the sample have a post-graduate ICU specialty qualification associated with a university.

### Length of time as an ICU nurse

Participants were asked to identify the number of years they have worked in an ICU environment, including experience in previous ICUs and in other countries. The distribution of the participant's experience is shown in Figure 1 (n=199). Experience is counted as zero for those who have worked in ICU for less than a year. A curve of normal distribution is overlaid to allow for comparison. The mean years ICU experience is 14.5 years (SD=8.9) and the range is 0 to 42 years.

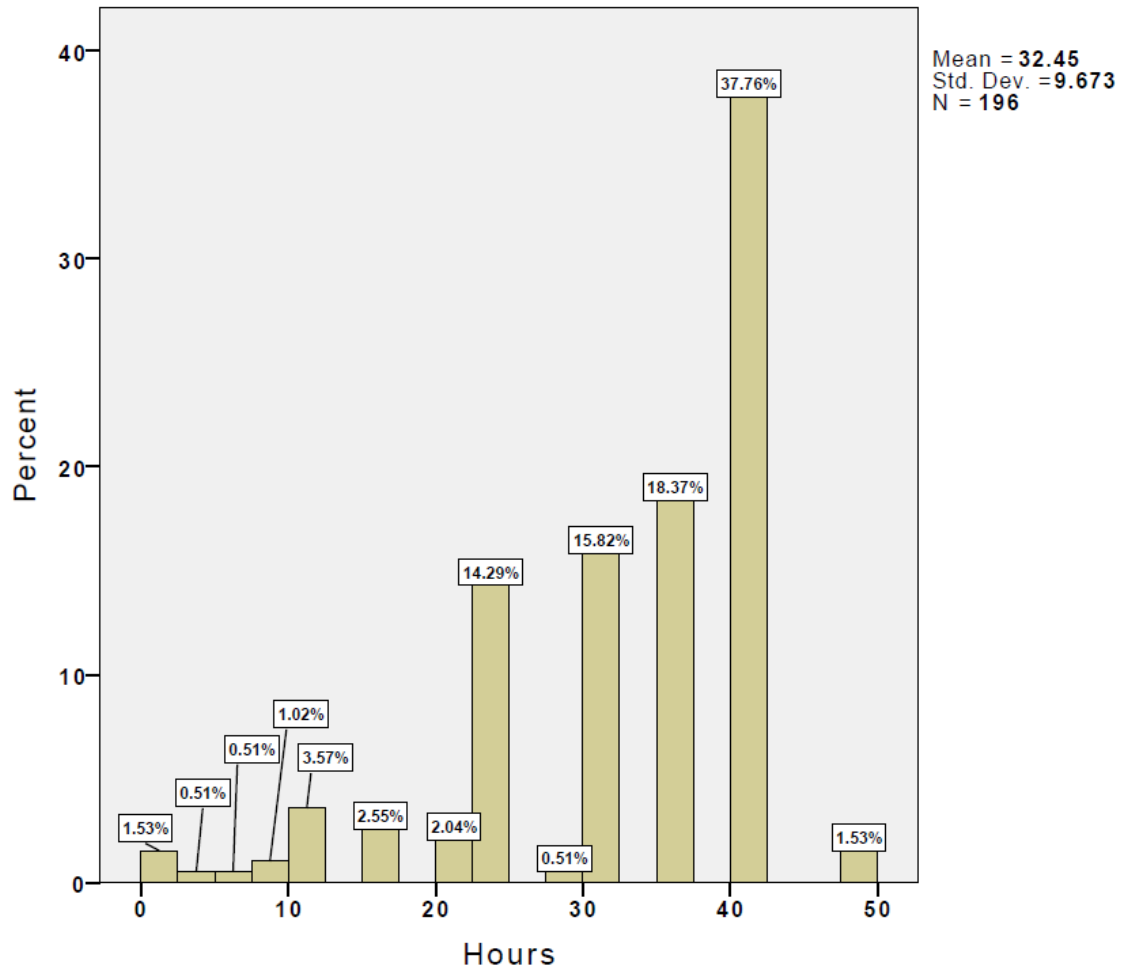


**Figure 1: Years worked in ICU**

### Hours worked

The distribution of hours per week worked in ICU by the participants is shown in Figure 2. As nurses generally work either eight or twelve hour shifts, peaks occur in the data at numbers divisible by eight and twelve. The data has a large negative skew with the majority of the participants working toward one full-time equivalent (FTE), where full-time is 40 hours per week. Most (88.3%,

n=196) participants work in ICU  $\geq 0.5$ FTE and 73%  $\geq 0.8$ FTE. Participants collectively draw from over 6,000 hours of weekly experience working in the ICU.



**Figure 2: Hours worked each week in ICU**

### Size of ICU

The size of the ICU where each of the participants works is measured by the number of ICU beds in the unit. Large units are in tertiary level hospitals and provide specialty medical services and long-term ICU care. Provincial units are smaller in numbers and offer short-term care, before transfer is made to tertiary centres, if necessary. There are currently 29 adult ICUs in NZ, six of these are tertiary level ICUs (Turner, 2014). Although participants were not asked which unit they work in (in the interests of anonymity), most of the data provided

came from the tertiary level ICUs, based on a comparison of bed numbers in the data collected and bed numbers published by Turner. Table 4 shows the spread of bed numbers, with minimal uniformity, as per the mix of unit sizes nationally (ANZICs). The mean number of ICU beds was 11.49 (SD=5.91). The most commonly reported number of beds was 6 and 18.

**Table 4: Size of unit**

| <b>Number of ICU beds in unit</b> | <b>Count</b> | <b>Percentage</b> |
|-----------------------------------|--------------|-------------------|
| 2                                 | 6            | 3.0               |
| 3                                 | 12           | 6.0               |
| 4                                 | 11           | 5.5               |
| 5                                 | 2            | 1.0               |
| 6                                 | 41           | 20.6              |
| 7                                 | 3            | 1.5               |
| 8                                 | 6            | 3.0               |
| 10                                | 6            | 3.0               |
| 11                                | 5            | 2.5               |
| 12                                | 18           | 9.0               |
| 13                                | 1            | 0.5               |
| 14                                | 6            | 3.0               |
| 15                                | 5            | 2.5               |
| 16                                | 26           | 13.1              |
| 17                                | 2            | 1.0               |
| 18                                | 41           | 20.6              |
| 19                                | 1            | 0.5               |
| 20                                | 2            | 1.0               |
| 22                                | 1            | 0.5               |
| 24                                | 3            | 1.5               |
| 26                                | 1            | 0.5               |
| <b>Total</b>                      | <b>n=204</b> | <b>100.0</b>      |

### **Staffing ratios**

A nurse-to-patient ratio of 1:1 is used exclusively (100%) for invasively ventilated patients (n=204). Nurse-to-patient ratios for patients receiving non-invasive ventilation (NIV) resulted in a near-even split between 1:1 (51.5%) and 1:2 (45%). Twenty participants (9.8%) mention that this ratio was dependent on either patient acuity or staff availability. Only two participants (1%) reported the usual ratio as 1:3.

### **Guidelines, policies and protocols**

Two thirds (66.5%, n=204) of the nurses work in ICUs in which there are guidelines, policies or protocols to guide staff in ventilation management. The

same number (n=133) have a document for non-invasive ventilation (NIV) management. Of these, 89 (43.8%) have information on weaning and 65 (47.8%) have management of weaning failure.

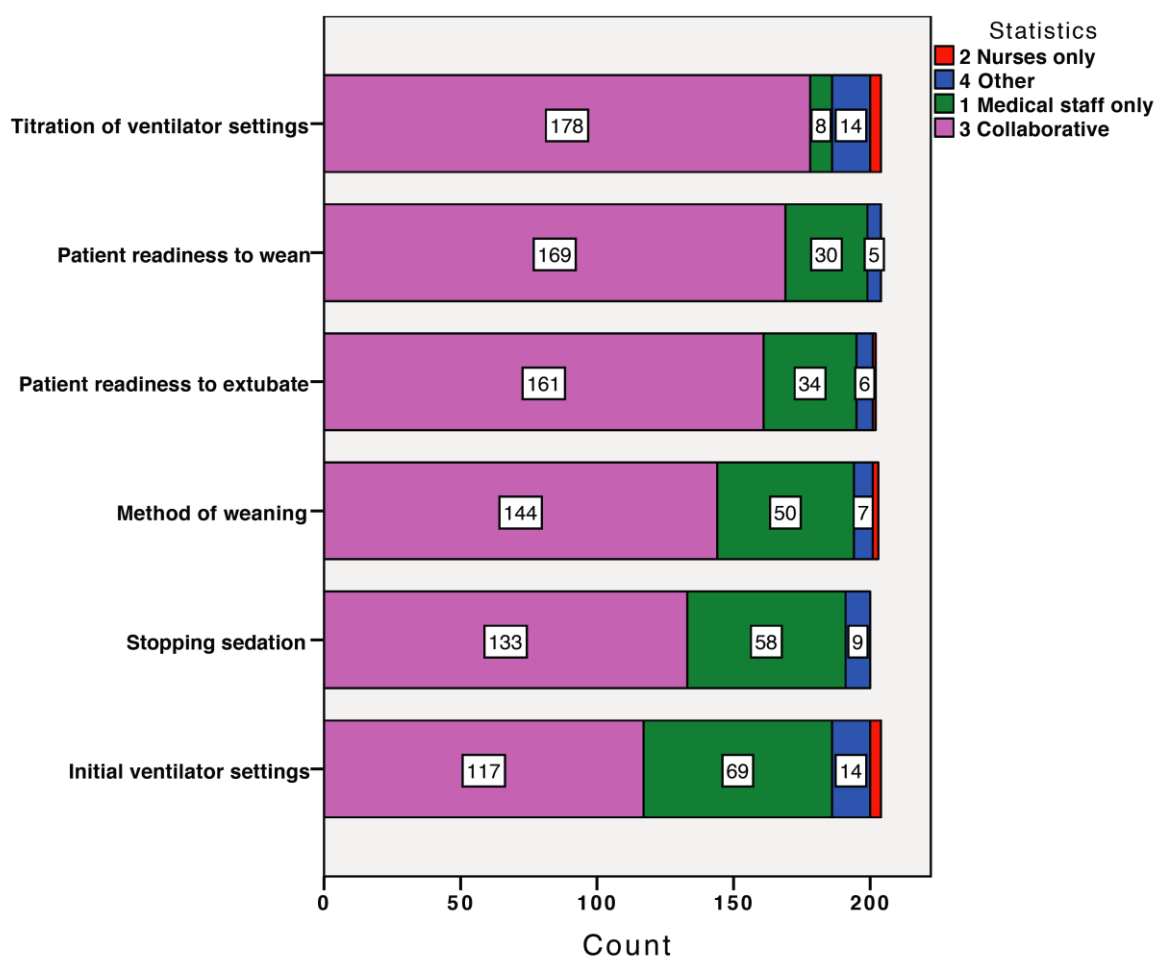
### **Ventilation education available to nurses**

Education on ventilation management is provided during orientation to 187 (93%, n=201) respondents, and 159 (79%, n=202) are offered ongoing professional development related to ventilation.

The following section presents the findings on two aspects of decisional responsibility: fundamental ventilation-related decisions and minor titration or adjustments of ventilator settings.

### **Fundamental decisions**

Participants were asked to identify which professional is primarily responsible for six *fundamental* ventilator related decisions. In this study, fundamental decisions refer to the turning points of ventilator decision making such as whether sedation is stopped, when the patient is ready to be weaned or extubated. These questions are covered in the first eighteen questions of the survey. Figure 3 shows that collaboration is the predominant model of decision-making in all six decisions. In some cases medical staff are the exclusive decision-makers. Nurses rarely act alone making these fundamental decisions.



**Figure 3: Responsibility for fundamental decisions\***

\*Not all nurses answered these questions, so the denominator varies between 200 and 204.

Participants who chose ‘other’ for these questions offered three main alternative answers of patient acuity, medical staff availability and use of protocols. Nurses are the decision-makers for clinical scenarios that are seen as ‘routine’ and medical staff get involved with scenarios that are more complex. An example given in the free text comments of a more complex scenario is when lung pathology is the primary reason for the admission. Similarly, nurses ‘step-up’ and make decisions when medical staff are not present. Some ICU’s have protocols and default ventilator settings that are worked out in advance to make decisions or guide decision-making. The survey questions did not ask who is responsible for deciding on the detail of the protocols or default ventilator settings (when they are present). Comments, however, suggest that medical staff

predominantly author protocols. A collaborative approach is sometimes taken that may include nursing staff and technicians<sup>3</sup>.

### Independent titration adjustments made by nurses

Ventilator settings that are independently adjusted by nurses are shown in Table 5. The independent adjustments have been dichotomised into either changed ‘frequently’ (for 50% or more of the time) or ‘infrequently’ (for less than half the time). Dichotomising is consistent with how data were analysed by Rose, Blackwood, Burns et al. and Rose et al. (2011; 2008). From here on, these changes will be referred to as ‘*independent titrations*’. Table 5 shows titrations in ranked order, with oxygen settings (FiO<sub>2</sub>) the most frequently adjusted setting.

**Table 5: Independent titrations**

| Setting change* (n=201-203) | Count | Percentage | 95% CI    |
|-----------------------------|-------|------------|-----------|
| FiO <sub>2</sub> decrease   | 139   | 69.2       | 62.9-75.5 |
| FiO <sub>2</sub> increase   | 133   | 65.5       | 60.0-72.0 |
| Rate                        | 70    | 34.8       | 28.3-41.3 |
| PS decrease                 | 66    | 32.7       | 26.3-39.1 |
| PS increase                 | 61    | 30.0       | 23.7-36.3 |
| TV                          | 56    | 27.7       | 21.6-33.8 |
| PEEP decrease               | 52    | 25.6       | 19.6-31.6 |
| Mode                        | 59    | 29.2       | 23.0-35.4 |
| PEEP increase               | 44    | 21.7       | 16.0-27.4 |
| Pinsp                       | 35    | 17.5       | 12.3-22.7 |

FiO<sub>2</sub>, fraction of inspired oxygen; PS, pressure support; TV, tidal volume; PEEP, positive end expiratory pressure; Pinsp, inspiratory pressure.

\*Ventilator settings adjusted independently by nurses >50% of the time

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<sup>3</sup> ICU technicians in NZ come from a range of professional backgrounds, with several models of employment, responsibility and education required in their work. Some are nurses, respiratory technicians, anaesthetic technicians, scientists or health care assistants (Anderson, Lewandowski, & McGuinness, 2007).

### Use of automated modes

Automated modes are patented and their availability relies on hardware that supports them (Chatburn & Mireles-Cabodevila, 2011), so whether ICU's are able to use automated modes relies on each unit having ventilators with this technology installed. Some units use more than one type of ventilator and there may be more than one automated mode available for use. Although availability of automated modes is not universal in NZ, Table 6 shows the number of nurses who work in units that have these modes available and how many use these modes on a regular basis.

**Table 6: Availability of automated modes and independent titrations**

| Automated Mode<br>(n=186#) | Availability |            | Use >50% of time |            |           |
|----------------------------|--------------|------------|------------------|------------|-----------|
|                            | Count        | Percentage | Count            | Percentage | 95% CI    |
| SmartCare/PS               | 72           | 38.7       | 51               | 27.6       | 21.2-34.0 |
| ASV                        | 60           | 32.8       | 34               | 18.2       | 12.7-23.8 |
| MMV                        | 66           | 35.5       | 25               | 13.5       | 8.6-18.4  |
| PAV                        | 70           | 37.6       | 14               | 7.6        | 3.8-11.4  |

SmartCare/PS™ (Dräger Medical, Lübeck, Germany); ASV, adaptive support ventilation (Hamilton Medical, Bonaduz, Switzerland); MMV, mandatory minute ventilation; PAV, proportional assist ventilation.

#Note the collective counts add up to more than the number of participants as some units have more than one automated mode available.

Participants who have ASV mode available (n=60) were asked how often they adjust %MV. The %MV setting is a fundamental setting, unique to ASV.

Adjusting %MV changes the minimum *volume* of air/oxygen delivered to the patient each minute. Twenty-four nurses (40%) increased this setting more than 50% of the time.

Comparison of the results in Table 7 with Table 5 shows that %MV adjustments follow the top-ranked FiO<sub>2</sub> adjustments in frequency of independent decision-making by nurses. Due to its automated design, ASV runs to a large extent on 'autopilot', however, when adjustments *are* made by clinicians, nurses frequently make adjustments of %MV 36.6-40% of the time.

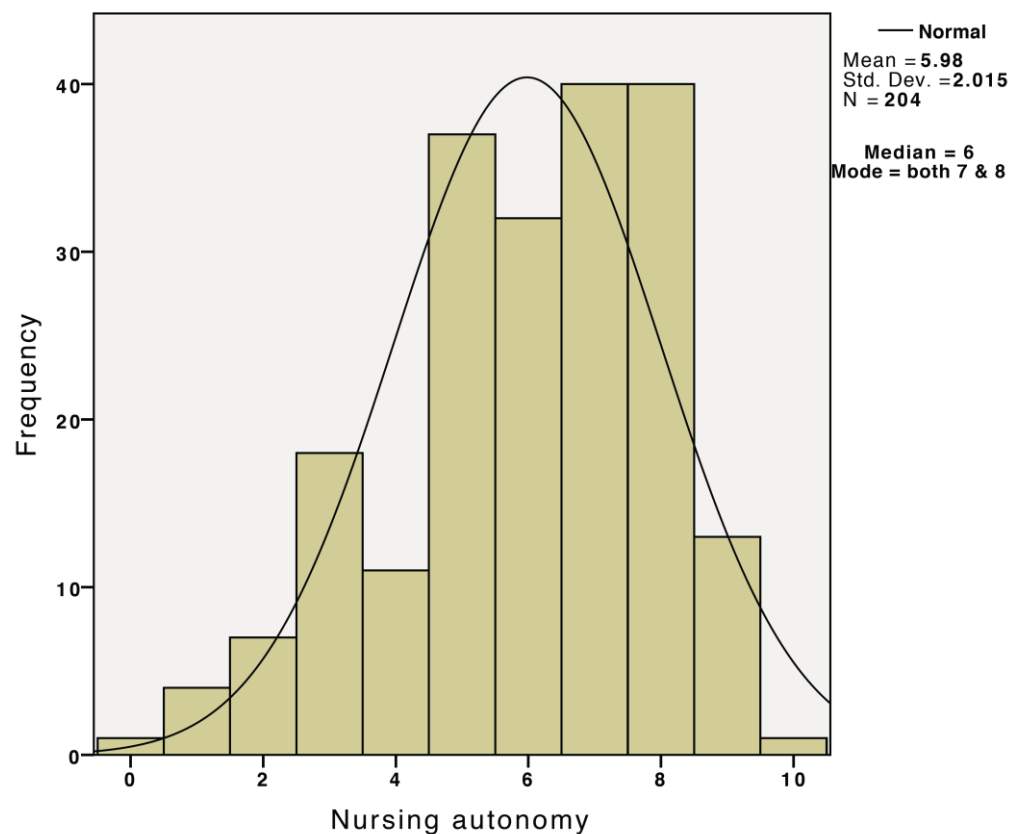
**Table 7: Independent titrations of %MV adjustment**

| Setting change (n=60) | Count | Percentage | 95% CI    |
|-----------------------|-------|------------|-----------|
| %MV increase          | 24    | 40.0       | 27.6-52.4 |
| %MV decrease          | 22    | 36.6       | 24.4-48.8 |

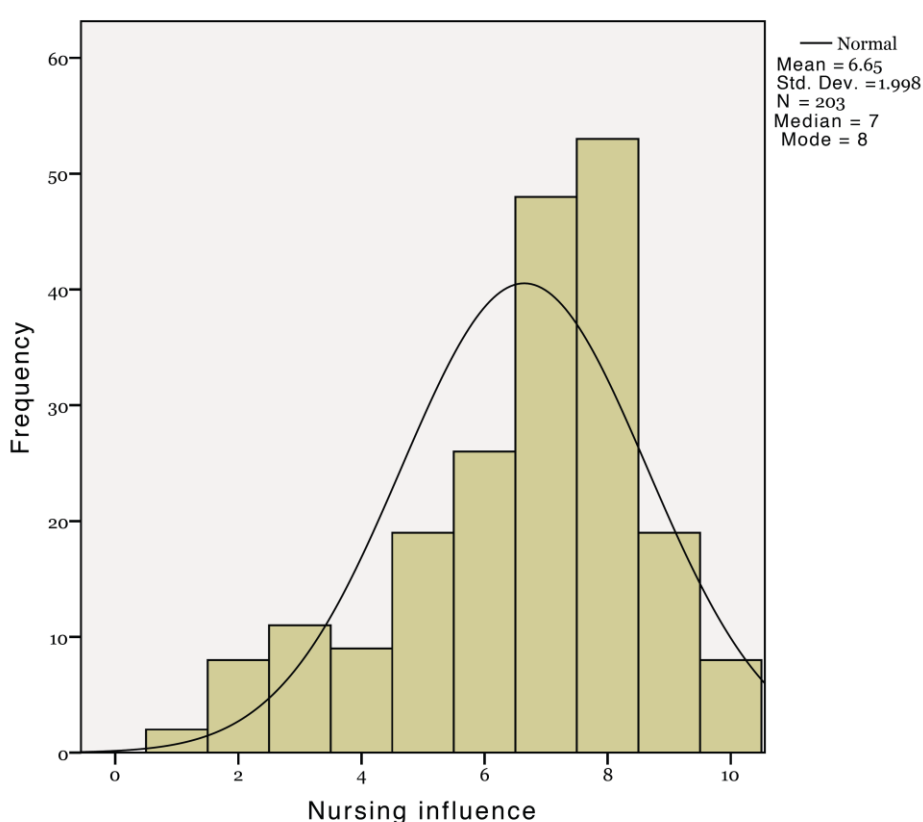
%MV, percentage minute volume.

### Nursing autonomy and influence

Nurses rarely have full responsibility for ventilator-related decisions, however, they have a good sense of autonomy and believe that their contributions influence the decision-making process. Participants were asked to rate their autonomy on an eleven-point scale, with 0 being 'never' and 10 being 'always'. The mean score of nurses' autonomy in ventilation management is 5.98, with a median of 6 (IQR 5-8). Figure 4 shows the distribution is close to a curve of normal distribution, with a slight negative skew (-.579). The defining characteristic of a negative skew is that the mean will have the lowest value, the mode the largest, with the median in between (Pallant, 2010).

**Figure 4: Nursing autonomy**

Participants were asked how often nurses believe they influence ventilator decision-making using the same eleven-point scale. Perceived nursing influence is shown in . The median is 7, with an inter-quartile range (IQR) of 5-8. The histogram indicates a slight negative skew (-0.795) as well as a slightly positive kurtosis (0.174). Kurtosis is the measure of ‘peakedness’ in the distribution (Pallant, 2010). These data suggest that nurses hold a good sense of autonomy in ventilation management and an even greater sense that they contribute to the decision-making process in ventilation management.



**Figure 5: Nursing influence**

Comments regarding perceived autonomy and influence indicate how each ICU culture affects the data. Sometimes nurses work according to their individual education and abilities:

*“Senior nurses with experience and/or qualifications [decide when to stop sedation]” (Participant 141)*

In contrast, nurses can be made to conform with the environment where they work:

*“[There is a] strong medical model of care in the ICU where I work. Little/ no encouragement for nursing involvement ... in fact discouragement to be involved.”* (Participant 69)

*“...very much a medical domain in my current workplace. This is very different to my previous workplace...”. (Participant 124)*

Other units work together, to a point:

*“Nursing autonomy it relatively high however this is dependent on the experience of the nursing looking after that particular patient.”*

(Participant 78)

*“we all work together but with the consultants having the last say”.*

(Participant 192)

The following section presents findings of comparative analysis, beginning with comparing independent titrations with perceived autonomy and influence in decision-making.

## **Comparative analysis**

### **Autonomy and independence**

Although unit culture can restrict the level of decision-making for individual nurses, independent titrations are an indicator of actual autonomy. To test this assumption, independent samples t-tests were used to compare independent titrations with autonomy and influence, as follows.

Nurses were divided into frequent and infrequent decision makers based on the proportion of independent setting changes for each setting, with nurses who make changes to settings more than 50% of the time compared to those who make changes less often. T-tests were used to clarify whether there was a significant difference in the mean scores of autonomy or influence for these two groups. Table 8 and Table 9 show that those who said they acted more autonomously, or said that they had more influence, did make more independent titrations. A sense of both autonomy and influence are significantly associated with increased adjustment of all twelve independent titrations. Note that all p values show highly significant associations.

**Table 8: Perceived autonomy and independent titrations**

|                                 | Count | Mean perceived autonomy<br>(SD)       |                                         | t     | df      | p             |
|---------------------------------|-------|---------------------------------------|-----------------------------------------|-------|---------|---------------|
|                                 |       | Frequent<br>independent<br>titrations | Infrequent<br>independent<br>titrations |       |         |               |
| <b>Mode</b>                     | 202   | 7.29 (1.274)                          | 5.46 (2.031)                            | 7.696 | 167.973 | <b>0.000*</b> |
| <b>Rate</b>                     | 201   | 7.04 (1.367)                          | 5.43 (2.079)                            | 6.612 | 190.538 | <b>0.000*</b> |
| <b>TV</b>                       | 202   | 7.04 (1.477)                          | 5.59 (2.063)                            | 5.544 | 138.717 | <b>0.000*</b> |
| <b>Pinsp</b>                    | 200   | 7.31 (1.105)                          | 5.67 (2.040)                            | 6.695 | 91.011  | <b>0.000*</b> |
| <b>PS increase</b>              | 203   | 7.03 (1.224)                          | 5.54 (2.126)                            | 6.306 | 184.434 | <b>0.000*</b> |
| <b>PS decrease</b>              | 202   | 6.98 (1.209)                          | 5.49 (2.157)                            | 6.286 | 195.877 | <b>0.000*</b> |
| <b>PEEP increase</b>            | 203   | 7.07 (1.189)                          | 5.69 (2.099)                            | 5.652 | 124.052 | <b>0.000*</b> |
| <b>PEEP decrease</b>            | 203   | 6.98 (1.260)                          | 5.64 (2.118)                            | 5.453 | 150.156 | <b>0.000*</b> |
| <b>FiO<sub>2</sub> increase</b> | 203   | 6.39 (1.783)                          | 5.21 (2.219)                            | 4.100 | 201     | <b>0.000*</b> |
| <b>FiO<sub>2</sub> decrease</b> | 201   | 6.42 (1.802)                          | 5.02 (2.161)                            | 4.805 | 199     | <b>0.000*</b> |
| <b>%MV increase</b>             | 60    | 6.92 (0.881)                          | 5.75 (1.962)                            | 3.126 | 52.104  | <b>0.003*</b> |
| <b>%MV decrease</b>             | 60    | 6.91 (0.9210)                         | 5.82 (1.929)                            | 2.959 | 56.453  | <b>0.005*</b> |

TV, tidal volume; Pinsp, inspiratory pressure; PS, pressure support; PEEP, positive end expiratory pressure;  
FiO<sub>2</sub>, fractional of inspired oxygen; %MV, percentage minute volume.

**Table 9: Perceived influence and independent titrations**

|                               | Count | Mean perceived influence<br>(SD)      |                                         | t     | df      | P             |
|-------------------------------|-------|---------------------------------------|-----------------------------------------|-------|---------|---------------|
|                               |       | Frequent<br>independent<br>titrations | Infrequent<br>independent<br>titrations |       |         |               |
| <b>Mode</b>                   | 201   | 7.90 (1.062)                          | 6.11 (2.073)                            | 8.035 | 190.588 | <b>0.000*</b> |
| <b>RR</b>                     | 200   | 7.73 (1.076)                          | 6.07 (2.143)                            | 7.287 | 197.234 | <b>0.000*</b> |
| <b>TV</b>                     | 201   | 7.70 (1.190)                          | 6.25 (2.110)                            | 6.121 | 172.543 | <b>0.000*</b> |
| <b>Pinsp</b>                  | 199   | 7.71 (0.987)                          | 6.40 (2.083)                            | 5.655 | 108.797 | <b>0.000*</b> |
| <b>PS increase</b>            | 202   | 7.61 (1.187)                          | 6.23 (2.139)                            | 5.853 | 187.994 | <b>0.000*</b> |
| <b>PS decrease</b>            | 201   | 7.58 (1.190)                          | 6.19 (2.167)                            | 5.832 | 196.285 | <b>0.000*</b> |
| <b>PEEP increase</b>          | 202   | 7.55 (1.150)                          | 6.39 (2.117)                            | 5.652 | 124.052 | <b>0.000*</b> |
| <b>PEEP decrease</b>          | 202   | 7.60 (1.089)                          | 6.31 (2.140)                            | 5.554 | 172.843 | <b>0.000*</b> |
| <b>O<sub>2</sub> increase</b> | 202   | 7.11 (1.746)                          | 5.75 (2.172)                            | 4.473 | 114.613 | <b>0.000*</b> |
| <b>O<sub>2</sub> decrease</b> | 200   | 7.08 (1.778)                          | 5.61 (2.139)                            | 4.710 | 97.969  | <b>0.000*</b> |
| <b>%MV increase</b>           | 60    | 7.33 (1.204)                          | 6.31 (2.054)                            | 2.439 | 57.237  | <b>0.018*</b> |
| <b>%MV decrease</b>           | 60    | 7.27 (1.202)                          | 6.39 (2.047)                            | 2.093 | 57.968  | <b>0.041*</b> |

TV, tidal volume; Pinsp, inspiratory pressure; PS, pressure support; PEEP, positive end expiratory pressure;  
FiO<sub>2</sub>, fractional of inspired oxygen; %MV, percentage minute volume.

### Unit size and independent titrations

Independent samples t-tests were used to look at the relationship between mean unit size (measured in bed numbers) and independent titrations made frequently or infrequently. Table 10 illustrates that more frequent independent changes in oxygen and %MV are made in the larger ICUs.

**Table 10: Unit size and independent titrations**

|                               | Count | Mean unit size in<br>beds/unit (SD)   |                                         | t      | df     | p             |
|-------------------------------|-------|---------------------------------------|-----------------------------------------|--------|--------|---------------|
|                               |       | Frequent<br>independent<br>titrations | Infrequent<br>independent<br>titrations |        |        |               |
| <b>Mode</b>                   | 198   | 12.20 (5.732)                         | 11.16 (5.986)                           | 1.138  | 196    | 0.257         |
| <b>RR</b>                     | 197   | 11.94 (5.506)                         | 11.23 (6.054)                           | 0.818  | 195    | 0.414         |
| <b>TV</b>                     | 198   | 11.46 (5.679)                         | 11.54 (6.021)                           | -0.083 | 196    | 0.934         |
| <b>Pinsp</b>                  | 196   | 11.89 (5.614)                         | 11.43 (5.980)                           | 0.414  | 194    | 0.679         |
| <b>PS increase</b>            | 199   | 11.54 (5.452)                         | 11.47 (6.121)                           | 0.077  | 197    | 0.939         |
| <b>PS decrease</b>            | 198   | 11.62 (5.399)                         | 11.49 (6.150)                           | 0.141  | 196    | 0.888         |
| <b>PEEP increase</b>          | 199   | 12.25 (5.719)                         | 11.28 (5.964)                           | 0.963  | 197    | 0.337         |
| <b>PEEP decrease</b>          | 199   | 12.22 (5.515)                         | 11.24 (6.038)                           | 1.013  | 197    | 0.312         |
| <b>O<sub>2</sub> increase</b> | 199   | 12.30 (5.778)                         | 9.91 (5.890)                            | 2.734  | 197    | <b>0.007*</b> |
| <b>O<sub>2</sub> decrease</b> | 197   | 12.22 (5.710)                         | 9.66 (6.090)                            | 2.829  | 195    | <b>0.005*</b> |
| <b>%MV increase</b>           | 60    | 16.08 (3.866)                         | 11.67 (6.099)                           | 3.432  | 57.899 | <b>0.001*</b> |
| <b>%MV decrease</b>           | 60    | 15.91 (3.999)                         | 12.00 (6.103)                           | 2.684  | 58     | <b>0.009*</b> |

TV, tidal volume; Pinsp, inspiratory pressure; PS, pressure support; PEEP, positive end expiratory pressure; FiO<sub>2</sub>, fractional of inspired oxygen; %MV, percentage minute volume.

## Experience and independent titrations

T-tests were used to compare mean experience (measured in years) and independent titrations made frequently or infrequently. Table 11 shows three adjustments were made more frequently by nurses with less experience: increase of PEEP, increase of oxygen and decrease of oxygen.

**Table 11: Experience and independent titrations**

|                               | Count | Mean experience in years<br>(SD)      |                                         | t      | df  | p             |
|-------------------------------|-------|---------------------------------------|-----------------------------------------|--------|-----|---------------|
|                               |       | Frequent<br>independent<br>titrations | Infrequent<br>independent<br>titrations |        |     |               |
| <b>Mode</b>                   | 198   | 14.49 (9.536)                         | 14.45 (8.680)                           | 0.028  | 196 | 0.978         |
| <b>RR</b>                     | 197   | 13.80 (8.844)                         | 14.75 (8.968)                           | 0.818  | 195 | 0.414         |
| <b>TV</b>                     | 198   | 15.25 (8.922)                         | 14.13 (8.903)                           | 0.799  | 196 | 0.425         |
| <b>Pinsp</b>                  | 196   | 16.54 (9.494)                         | 13.96 (8.736)                           | 1.559  | 194 | 0.121         |
| <b>PS increase</b>            | 199   | 13.34 (8.953)                         | 15.01 (8.874)                           | -1.215 | 197 | 0.226         |
| <b>PS decrease</b>            | 198   | 13.57 (9.040)                         | 14.92 (8.873)                           | -1.003 | 196 | 0.317         |
| <b>PEEP increase</b>          | 199   | 11.43 (8.530)                         | 15.37 (8.848)                           | -2.624 | 197 | <b>0.009*</b> |
| <b>PEEP decrease</b>          | 199   | 12.76 (9.273)                         | 15.09 (8.733)                           | -1.617 | 197 | 0.107         |
| <b>O<sub>2</sub> increase</b> | 199   | 13.36 (8.747)                         | 16.75 (8.861)                           | -2.573 | 197 | <b>0.011*</b> |
| <b>O<sub>2</sub> decrease</b> | 197   | 13.57 (8.786)                         | 16.59 (9.000)                           | -2.200 | 195 | <b>0.029*</b> |
| <b>%MV increase</b>           | 60    | 14.17 (10.729)                        | 12.17 (8.122)                           | 0.821  | 58  | 0.415         |
| <b>%MV decrease</b>           | 60    | 14.05 (10.643)                        | 12.34 (8.374)                           | 0.687  | 58  | 0.495         |

TV, tidal volume; Pinsp, inspiratory pressure; PS, pressure support; PEEP, positive end expiratory pressure;  
FiO<sub>2</sub>, fractional of inspired oxygen; %MV, percentage minute volume.

### Unit size/experience and autonomy/influence

Nurses' sense of autonomy and influence was dichotomised above and below their mean. These groups were compared with mean scores of unit size (in beds) and experience (in years) using independent t-tests. No statistically significant differences were found in comparing the means, as shown in Table 12 (autonomy) and Table 13 (influence). The t-tests found no increase in perceived sense of autonomy or influence in decision-making associated with level of experience or the size of ICU they work in.

**Table 12: Autonomy and unit size and experience**

|                           | Count | Mean (SD)     |               | t     | df  | p     |
|---------------------------|-------|---------------|---------------|-------|-----|-------|
|                           |       | High autonomy | Low autonomy  |       |     |       |
| <b>Unit size (beds)</b>   | 199   | 11.88 (5.733) | 10.84 (6.182) | 1.204 | 197 | 0.230 |
| <b>Experience (years)</b> | 199   | 14.66 (8.794) | 14.23 (9.154) | 0.325 | 197 | 0.745 |

**Table 13: Influence and unit size and experience**

|                           | Count | Mean (SD)      |               | t     | df  | p     |
|---------------------------|-------|----------------|---------------|-------|-----|-------|
|                           |       | High influence | Low influence |       |     |       |
| <b>Unit size (beds)</b>   | 198   | 11.93 (5.867)  | 10.82 (5.964) | 1.272 | 196 | 0.205 |
| <b>Experience (years)</b> | 198   | 15.19 (8.808)  | 13.27 (9.045) | 1.465 | 196 | 0.144 |

### Post-graduate ICU qualification

Nurses with a postgraduate (PG) ICU qualification had a significantly higher sense of influence in ventilation management decision-making, and significantly more experience in years working in ICU. There were no significant differences in the size of unit worked or sense of autonomy for those with PG ICU qualifications (see Table 14)

**Table 14: Postgraduate ICU qualification**

|                   | Count | Mean (SD)     |               | t      | df  | p             |
|-------------------|-------|---------------|---------------|--------|-----|---------------|
|                   |       | ICU qual      | No ICU qual   |        |     |               |
| <b>Beds</b>       | 184   | 11.50 (5.881) | 11.54 (6.031) | -0.041 | 182 | 0.968         |
| <b>Experience</b> | 184   | 15.93 (8.395) | 11.08 (9.759) | 3.353  | 182 | <b>0.001*</b> |
| <b>Autonomy</b>   | 187   | 6.07 (2.028)  | 5.59 (1.867)  | 1.488  | 185 | 0.138         |
| <b>Influence</b>  | 186   | 6.84 (1.920)  | 6.20 (1.887)  | 2.064  | 184 | <b>0.040*</b> |

### Education and independent titrations

A chi-squared analysis was used to test for a relationship between level of education and independent titrations. The chi-square test assumption that each cell value is five or higher was violated in every test, so the results were not used (Pallant, 2010). An alternative analysis was to compare independent titrations with nurses that have a PG ICU qualification or not.

A 2x2 chi squared analysis was therefore used with PG ICU qualification (yes/no) and independent titrations (made frequently or infrequently). No significant differences were found across the two PG ICU qualification groups for the 12 variables.

**Table 15: PG ICU qualification and independent titrations**

|                         | Count | Frequent         |           | Infrequent       |           | $\chi^2$ | df | p     |
|-------------------------|-------|------------------|-----------|------------------|-----------|----------|----|-------|
|                         |       | PG Qualification |           | PG Qualification |           |          |    |       |
|                         |       | Yes (%)          | No (%)    | Yes (%)          | No (%)    |          |    |       |
| Mode change             | 174   | 42 (22.7)        | 10 (5.4)  | 92 (49.7)        | 41 (22.2) | 1.970    | 1  | 0.160 |
| RR titration            | 173   | 52 (28.3)        | 14 (7.6)  | 82 (44.6)        | 36 (19.6) | 1.408    | 1  | 0.235 |
| TV titration            | 174   | 43 (23.2)        | 9 (4.9)   | 92 (49.7)        | 41 (22.2) | 2.813    | 1  | 0.094 |
| Pinsp titration         | 172   | 27 (14.7)        | 6 (3.3)   | 107 (58.2)       | 44 (23.9) | 1.136    | 1  | 0.287 |
| PS up                   | 175   | 44 (23.7)        | 12 (6.5)  | 91 (48.9)        | 39 (21.0) | 1.046    | 1  | 0.306 |
| PS decrease             | 175   | 48 (25.9)        | 13 (7.0)  | 86 (46.5)        | 38 (20.5) | 1.347    | 1  | 0.246 |
| PEEP up                 | 174   | 29 (15.6)        | 12 (6.5)  | 106 (57)         | 39 (21.0) | 0.010    | 1  | 0.919 |
| PEEP decrease           | 174   | 37 (19.9)        | 12 (6.5)  | 98 (52.7)        | 39 (21.0) | 0.122    | 1  | 0.727 |
| O <sub>2</sub> up       | 174   | 89 (47.8)        | 35 (18.8) | 46 (24.7)        | 16 (8.6)  | 0.030    | 1  | 0.862 |
| O <sub>2</sub> decrease | 173   | 92 (50.0)        | 36 (19.6) | 41 (22.3)        | 15 (8.2)  | 0.000    | 1  | 0.994 |
| %MV up                  | 57    | 18 (31.6)        | 5 (8.8)   | 21 (36.8)        | 13 (22.8) | 1.049    | 1  | 0.306 |
| %MV decrease            | 57    | 17 (29.8)        | 4 (7.0)   | 22 (38.6)        | 14 (24.6) | 1.586    | 1  | 0.208 |

### Protocol usage

Working in an ICU with a protocol for ventilation management had no statistically significant relationships with nurses' sense of autonomy or influence. The larger units were significantly more likely to have a protocol ( $t(172) = 2.095, p = 0.038$ ), as shown in Table 16.

**Table 16: Protocol in workplace**

|                  | Count | Mean (SD)     |               | t     | df     | p             |
|------------------|-------|---------------|---------------|-------|--------|---------------|
|                  |       | Protocol**    | No Protocol** |       |        |               |
| <b>Beds</b>      | 174   | 11.97 (5.953) | 9.81 (5.375)  | 2.095 | 172    | <b>0.038*</b> |
| <b>Autonomy</b>  | 176   | 6.14 (1.835)  | 5.63 (2.247)  | 1.363 | 61.152 | 0.178         |
| <b>Influence</b> | 175   | 6.86 (1.923)  | 6.28 (2.175)  | 1.654 | 173    | 0.100         |

\*\*Protocol/guideline/policy

### Protocol and independent titrations

A 2x2 chi squared analysis was used to compare presence of a protocol (yes/no) and independent changes (made frequently or infrequently). No significant differences were found across the two protocol groups for the 12 independent titrations.

**Table 17: Presence of a protocol and independent titrations**

| Independent titration   | Count | Frequent  |           | Infrequent |           | $\chi^2$ | df | p     |
|-------------------------|-------|-----------|-----------|------------|-----------|----------|----|-------|
|                         |       | Protocol  |           | Protocol   |           |          |    |       |
|                         |       | Yes (%)   | No (%)    | Yes (%)    | No (%)    |          |    |       |
| Mode change             | 174   | 39 (22.4) | 9 (5.2)   | 92 (52.9)  | 34 (19.5) | 0.863    | 1  | 0.353 |
| RR titration            | 173   | 52 (30.1) | 10 (5.8)  | 78 (45.1)  | 33 (19.1) | 3.245    | 1  | 0.072 |
| TV titration            | 174   | 43 (24.7) | 8 (4.6)   | 89 (51.1)  | 34 (19.5) | 2.199    | 1  | 0.138 |
| Pinsp titration         | 172   | 26 (15.1) | 6 (3.5)   | 104 (60.5) | 36 (20.9) | 0.357    | 1  | 0.549 |
| PS up                   | 175   | 43 (24.6) | 10 (5.7)  | 89 (50.9)  | 33 (18.9) | 0.929    | 1  | 0.335 |
| PS decrease             | 175   | 45 (25.9) | 12 (6.9)  | 86 (49.4)  | 31 (17.8) | 0.353    | 1  | 0.553 |
| PEEP up                 | 174   | 32 (18.3) | 6 (3.4)   | 100 (57.1) | 37 (21.1) | 1.460    | 1  | 0.227 |
| PEEP decrease           | 174   | 36 (20.6) | 8 (4.6)   | 96 (54.9)  | 35 (20.0) | 0.875    | 1  | 0.350 |
| O <sub>2</sub> up       | 174   | 91 (52.0) | 27 (15.4) | 41 (23.4)  | 16 (9.1)  | 0.313    | 1  | 0.576 |
| O <sub>2</sub> decrease | 173   | 92 (53.2) | 30 (17.3) | 38 (22.0)  | 13 (7.5)  | 0.000    | 1  | 1.000 |
| %MV up                  | 52    | 17 (32.7) | 23 (44.2) | 3 (5.8)    | 9 (17.3)  | 0.569    | 1  | 0.450 |
| %MV decrease            | 52    | 16 (30.8) | 24 (46.2) | 3 (5.8)    | 9 (17.3)  | 0.366    | 1  | 0.545 |

### Unit size and experience

Dividing the size of the ICUs into large and small, with a cut-off at the mean of 11.49, allowed for a t-test to compare the means of nursing experience with unit size. There was no significant difference found, as shown below in Table 18.

**Table 18: Size of unit and experience**

|                   | Count | Mean (SD)     |               | t      | df  | p     |
|-------------------|-------|---------------|---------------|--------|-----|-------|
|                   |       | Small unit    | Large unit    |        |     |       |
| <b>Experience</b> | 198   | 14.05 (8.129) | 14.88 (9.596) | -0.646 | 196 | 0.519 |

### Unit size and fundamental decision-making

A chi-squared analysis was conducted to look at the size of unit and fundamental decisions, comparing the medical-only versus collaborative decision-making model. To allow for this comparison, unit sizes were dichotomised by splitting at the median of twelve beds into large and small units. The initial selection of ventilator mode has a significant positive association ( $\chi^2(1, n=182) = 4.988, p=0.026$ ). While medically led decision-making is predominant in the large units, the smaller units are more likely to use a collaborative model.

**Table 19: Unit size and decision-making model**

| Decision              | Count | 0-11 beds   |            | 12+ beds    |            | $\chi^2$ | df | p             |
|-----------------------|-------|-------------|------------|-------------|------------|----------|----|---------------|
|                       |       | Medical (%) | Collab (%) | Medical (%) | Collab (%) |          |    |               |
| Initial selection     | 182   | 25 (13.7)   | 64 (35.2)  | 42 (23.1)   | 51 (28.0)  | 4.988    | 1  | <b>0.026*</b> |
| Titration of settings | 182   | 3 (1.6)     | 82 (45.1)  | 5 (2.7)     | 92 (50.5)  | 0.029    | 1  | 0.725         |
| Stopping sedation     | 186   | 27 (14.5)   | 58 (31.2)  | 29 (15.6)   | 72 (38.7)  | 0.085    | 1  | 0.771         |
| Weaning readiness     | 194   | 13 (6.7)    | 78 (40.2)  | 16 (8.2)    | 87 (44.8)  | 0.002    | 1  | 0.967         |
| Weaning method        | 190   | 23 (12.1)   | 63 (33.2)  | 27 (14.2)   | 77 (40.5)  | 0.000    | 1  | 1.000         |
| Extubation            | 190   | 19 (10.0)   | 71 (37.4)  | 14 (7.4)    | 86 (45.3)  | 1.210    | 1  | 0.271         |

### Experience and decision-making

A chi-squared analysis was conducted to compare experience of nurses with fundamental decision-making, comparing the medical only with a collaborative style. To allow for this comparison, a split was made at the median of 14.5 years

to dichotomise nurses' experience. Table 20 shows the initial selection of ventilator mode has a significant positive association ( $\chi^2 (1, n=204) = 5.486$ ,  $p=0.019$ ) of medically led decision-making with less-experienced staff. Experienced staff were more collaborative in their decision-making than their less experienced peers.

**Table 20: Nurses' experience and decision-making model**

| Decision                             | Count | 0-14yrs     |            | 15+yrs      |            | $\chi^2$ | df | p             |
|--------------------------------------|-------|-------------|------------|-------------|------------|----------|----|---------------|
|                                      |       | Medical (%) | Collab (%) | Medical (%) | Collab (%) |          |    |               |
| <b>Initial selection of settings</b> | 204   | 44 (24.2)   | 52 (28.6)  | 24 (13.2)   | 62 (34.1)  | 5.486    | 1  | <b>0.019*</b> |
| <b>Titration of settings</b>         | 204   | 6 (3.3)     | 89 (48.9)  | 2 (1.1)     | 85 (46.7)  | 0.919    | 1  | 0.282         |
| <b>Stopping sedation</b>             | 204   | 35 (18.8)   | 62 (33.3)  | 21 (11.3)   | 68 (36.6)  | 2.871    | 1  | 0.090         |
| <b>Weaning readiness</b>             | 204   | 17 (8.8)    | 82 (42.3)  | 12 (6.2)    | 83 (42.8)  | 0.469    | 1  | 0.493         |
| <b>Weaning method</b>                | 204   | 31 (16.3)   | 66 (34.7)  | 19 (10.0%)  | 74 (38.9)  | 2.687    | 1  | 0.101         |
| <b>Extubation readiness</b>          | 204   | 16 (8.4)    | 81 (42.6)  | 17 (8.9)    | 76 (40.0)  | 0.018    | 1  | 0.894         |

Where the medical-only model of decision-making was strong, animosity was expressed in some of the explanatory comments made:

*“Medical and some nursing staff keep our ICU in the dark age. The other argument is the need to teach the registrars.” (Participant 197)*

## Comparison with previous studies

Findings of this study were then compared with the findings of two studies (Rose, Blackwood, Burns, et al., 2011; Rose et al., 2008) where data are available to statistically compare. Caution should be exercised when making comparisons because both of these previous studies employ some fundamental differences in their design. As previously discussed, these studies collected data from the unit managers rather than directly from nurses. Where one response in the earlier studies represents one ICU, it is unknown exactly which units are represented in this study and how many nurses represent each unit. Parameters explored in the following section were staff ratios, use of protocols, PG ICU

qualifications, decisional responsibility, independent decision making, use of automated modes and perceived autonomy/influence.

### **Nurse-to-patient ratios**

Like the present findings, Rose et al. (2008) also reported 100% of ventilated patients in New Zealand receiving a 1:1 nursing ratio. Both these results compare favourably to ratios reported in the European units (Rose, Blackwood, Burns, et al., 2011). Although more than half of the ICU's in four countries reported a 1:1 ratio (UK 93%; Norway 90%; Denmark 73%; Switzerland 61%), for the remainder (Germany, Netherlands, Greece and Italy) a ratio of 1:2 was the most common.

Rose et al. (2008) reported that 71% of units (n=14 units) in NZ provided a 1:2 staffing ratio for patients receiving non-invasive ventilation. Whether the remainder were less or more was unreported. Based on the assumption that the remainder of these units (29%) provided a ratio of 1:1, findings in this study would indicate that ratios have significantly improved in NZ. Nurses who reported a 1:1 ratio in this study totalled 51.5%, and 45% reported 1:2 (n=204 nurses). Chi square analysis for goodness of fit was used to compare these, with the results,  $\chi^2 (1, n = 200) = 55.95, p = 0.000$  showing a significant change in reported ratios.

### **Use of protocols**

Rose et al. (2008) reported usage of a protocol only specifically for ventilator weaning. Of the participating units in Australia and NZ, 24% had such a protocol (n=54 units). As 89 nurses in this study (43.8%, n=204) have a protocol available on ventilation weaning, there is a strong indication of an increased availability of ventilator-related protocols. Although data regarding protocol usage was collected in the European study (Rose, Blackwood, Burns, et al., 2011), it was not reported.

### Post graduate nursing study

Rose et al. (2008) reported the median percentage of nursing staff per NZICU who hold a post-graduate qualification relating to the intensive care specialty as 54% (n=14 units). These results have significantly increased with the 69.7% (n=195 nurses) found in this study, indicating post graduate ICU qualifications have increased to the previous Australian median (70%) as reported earlier by Rose et al. A chi-squared goodness-of-fit test indicates there was a significant difference in the proportion of NZICU nurses identified in the current sample (69.7%) as compared with the value of 54% that was obtained by Rose et al.,  $\chi^2(1, n = 195) = 26.40, p < 0.000$ . Post graduate qualification data was not collected in the European study (Rose, Blackwood, Burns, et al., 2011).

**Table 21: Postgraduate ICU qualification completed**

|                              | Count      | Percentage completed |
|------------------------------|------------|----------------------|
| Rose et al. (2008) NZ        | 14 units   | 54                   |
| Rose et al. (2008) Australia | 40 units   | 70                   |
| This study                   | 195 nurses | 69.7                 |

### Responsibility of fundamental decisions

Responsibilities for fundamental decisions in NZICUs are comparable to data from Germany and the Netherlands (Rose, Blackwood, Egerod, et al., 2011), with a strong model of collaborative decision-making and medical staff making most of the non-collaborative decisions. Switzerland and the UK were generally stronger in the nurses-only and collaborative models; Denmark, Greece, Norway and Italy had increasingly stronger medical-only decision-making models.

Table 22 shows there are low numbers of NZ ICU nurses making autonomous fundamental decisions, with proportions only measuring as high as 2%. These low figures are shared to a greater or less extent internationally, with nurses taking a collaborative approach to fundamental decision-making, rather than acting independently.

**Table 22: International decisional responsibility**

| Country                                 |                | NZ<br>(204 nurses) | Switzerland<br>(n=73) | UK<br>(n=115) | Germany<br>(n=201) | Netherlands<br>(n=71) | Denmark<br>(n=41) | Greece<br>(n=12) | Norway<br>(n=39) | Italy<br>(n=34) |
|-----------------------------------------|----------------|--------------------|-----------------------|---------------|--------------------|-----------------------|-------------------|------------------|------------------|-----------------|
| <b>Initial ventilator settings</b>      | Collaborative  | 117 (57.4)         | 55 (85)               | 90 (78)       | 134 (67)           | 40 (56)               | 22 (54)           | 5 (42)           | 14 (36)          | 11 (32)         |
|                                         | Med staff only | 69 (33.8)          | 13 (18)               | 23 (20)       | 49 (24)            | 32 (45)               | 18 (44)           | 7 (58)           | 25 (64)          | 23 (68)         |
|                                         | Nurses only    | 4 (2.0)            | 4 (6)                 | 1 (1)         | 18 (9)             | -                     | -                 | -                | -                | -               |
|                                         | Other          | 14 (6.9)           | 1 (1)                 | -             | -                  | 1 (1)                 | -                 | -                | -                | -               |
| <b>Titration of ventilator settings</b> | Collaborative  | 178 (87.3)         | 63 (86)               | 112 (99)      | 176 (88)           | 66 (93)               | 37 (90)           | 11 (92)          | 34 (87)          | 19 (56)         |
|                                         | Med staff only | 8 (3.9)            | 3 (4)                 | -             | 8 (4)              | 3 (4)                 | 2 (5)             | 1 (8)            | 3 (8)            | 15 (44)         |
|                                         | Nurses only    | 4 (2.0)            | 5 (6.8)               | 1 (1)         | 15 (8)             | 2 (3)                 | 1 (2)             | -                | 2 (5)            | -               |
|                                         | Other          | 14 (6.9)           | 2 (3)                 | 1 (1)         | -                  | -                     | -                 | -                | -                | -               |
| <b>Readiness to wean</b>                | Collaborative  | 169 (82.8)         | 65 (89)               | 111 (97)      | 172 (82)           | 59 (83)               | 39 (95)           | 4 (33)           | 32 (82)          | 16 (47)         |
|                                         | Med staff only | 30 (14.7)          | 5 (7)                 | 4 (4)         | 25 (12)            | 11 (16)               | 1 (2)             | 8 (67)           | 7 (18)           | 18 (53)         |
|                                         | Nurses only    | 0 (0.0)            | 2 (3)                 | -             | 3 (2)              | -                     | -                 | -                | -                | -               |
|                                         | Other          | 5 (2.5)            | 1 (1)                 | 4 (4)         | -                  | 1 (1)                 | -                 | -                | -                | -               |
| <b>Method of weaning</b>                | Collaborative  | 144 (70.9)         | 59 (81)               | 104 (90)      | 131 (71)           | 49 (69)               | 31 (76)           | 6 (50)           | 27 (69)          | 9 (27)          |
|                                         | Med staff only | 50 (24.6)          | 5 (7)                 | 10 (9)        | 37 (18)            | 20 (28)               | 10 (24)           | 6 (50)           | 11 (28)          | 25 (74)         |
|                                         | Nurses only    | 2 (1.0)            | 4 (6)                 | -             | 22 (11)            | 1 (1)                 | -                 | -                | -                | -               |
|                                         | Other          | 7 (3.4)            | 5 (7)                 | 6 (5)         | -                  | 1 (1)                 | -                 | -                | -                | -               |
| <b>Readiness to extubate</b>            | Collaborative  | 161 (79.7)         | 56 (77)               | 98 (85)       | 152 (76)           | 36 (49)               | 32 (78)           | 5 (42)           | 25 (64)          | 14 (41)         |
|                                         | Med staff only | 34 (16.8)          | 17 (23)               | 15 (13)       | 45 (22)            | 35 (49)               | 9 (22)            | 7 (58)           | 13 (33)          | 20 (59)         |
|                                         | Nurses only    | 1 (0.5)            | -                     | -             | 2 (1)              | -                     | -                 | -                | -                | -               |
|                                         | Other          | 6 (3.0)            | -                     | 2 (2)         | -                  | -                     | -                 | -                | -                | -               |

All data are n (%). For NZ data, n=number of participants. For European data, n=number of units. Note some % do not add up to 100 due to missing data. Other: includes physiotherapists or specialized ventilator practitioners who may also hold a nursing qualification.

### **Independent titrations**

While data on independent titrations has been collected in both NZ (Rose et al., 2008) and Europe (Rose, Blackwood, Egerod, et al., 2011), only the European study presented the data as figures. Nurses working in Europe reported comparable levels of independence to their New Zealand colleagues in this study in oxygen and PEEP titration. Nurses working in Europe reported greater independence in titration of the remainder of these settings. A chi-squared goodness-of-fit test supports there is no significant difference in levels of independence in oxygen and PEEP titration. These data are presented in Table 23 overleaf.

### **Automated modes**

Use of automated modes in European ICUs was reported by Rose, Blackwood, Egerod, et al. (2011). Of the 586 participating European units, 319 (50-59, 55%) use a form of automated ventilation. Of these modes, the most frequently used (>50% of the time) was ASV at roughly 16%, followed by SmartCare at approximately 12% (these percentages are estimations from the published bar graph). NZICU's frequent usage (>50% of the time) of SmartCare (27.6%) is more than ASV (18.2%). In this study and Rose et al., SmartCare and ASV are the main two modes used.

**Table 23: Independent titrations in NZ and Europe**

| Independent titration**   | NZ (n=201-203 nurses) |            |           | Europe (n=579-582 units) |            |       | Comparison |    |               |
|---------------------------|-----------------------|------------|-----------|--------------------------|------------|-------|------------|----|---------------|
|                           | Count                 | Percentage | 95% CI    | Count                    | Percentage | 95%CI | $\chi^2$   | df | p             |
| FiO <sub>2</sub> decrease | 139                   | 69.2       | 62.9-75.5 | 392                      | 68         | 64-71 | 0.12       | 1  | 0.0726        |
| FiO <sub>2</sub> increase | 133                   | 65.5       | 60.0-72.0 | 386                      | 67         | 63-70 | 0.58       | 1  | 0.448         |
| Rate                      | 70                    | 34.8       | 28.3-41.3 | 290                      | 50         | 46-54 | 18.51      | 1  | <b>0.000*</b> |
| PS decrease               | 66                    | 32.7       | 26.3-39.1 | 317                      | 55         | 51-59 | 40.68      | 1  | <b>0.000*</b> |
| PS increase               | 61                    | 30.0       | 23.7-36.3 | 321                      | 55         | 51-59 | 51.06      | 1  | <b>0.000*</b> |
| TV                        | 56                    | 27.7       | 21.6-33.8 | 251                      | 44         | 40-48 | 21.72      | 1  | <b>0.000*</b> |
| PEEP decrease             | 52                    | 25.6       | 19.6-31.6 | 162                      | 28         | 25-32 | 0.57       | 1  | 0.449         |
| Mode                      | 59                    | 29.2       | 23.0-35.4 | 231                      | 40         | 36-44 | 9.80       | 1  | <b>0.002*</b> |
| PEEP increase             | 44                    | 21.7       | 16.0-27.4 | 147                      | 25         | 22-29 | 1.20       | 1  | 0.274         |
| Pinsp                     | 35                    | 17.5       | 12.3-22.7 | 229                      | 40         | 36-44 | 42.19      | 1  | <b>0.000*</b> |

FiO<sub>2</sub>, fraction of inspired oxygen; PS, pressure support; TV, tidal volume; PEEP, positive end expiratory pressure; Pinsp, inspiratory pressure.

\*\*Ventilator settings adjusted independently by nurses >50% of the time

### Autonomy and Influence

Autonomy results in this study are lower than previously estimated by NZICU nurse management, however, perceived influence results are higher (Rose et al., 2008). Autonomy and influence in Australia is perceived as higher than NZ in both studies. Europe reports higher perceived autonomy than this study, with comparable perceived influence in decision-making.

**Table 24: Autonomy and influence**

|                              | Count      | Autonomy<br>median | Influence<br>median |
|------------------------------|------------|--------------------|---------------------|
| Rose et al. (2008) NZ        | 14 units   | 6.5                | 6.5                 |
| Rose et al. (2008) Australia | 40 units   | 7                  | 7.7                 |
| Rose et al. (2011) Europe    | 586 units  | 7                  | 7                   |
| This study                   | 204 nurses | 6                  | 7                   |

To compare medians in autonomy or influence, the one-sample Wilcoxon signed rank test was used. Autonomy and influence was rated by European ICU's, resulting in a median of 7 for both variables (Rose, Blackwood, Egerod, et al., 2011). In New Zealand, Rose et al. (2008) reported a median of 6.5 for both variables. The Wilcoxon signed rank test was used to compare these results against data in this study and found all but one of these medians to be significantly different. This allows a null hypothesis (that there is no relation between unit size and autonomy/influence) to be rejected in these three cases.

Europe (2011): Autonomy ( $p=0.000$ )\* and influence ( $p=0.057$ ).

NZ (2008): Autonomy ( $p=0.006$ )\* and influence ( $p=0.028$ )\*.

### Summary

This chapter has presented the results of the data analysis data according to the processes outlined in the methodology chapter. This included descriptive data, decisional responsibilities, use of automated modes and participants' perceived autonomy and influence in making decisions. Variables were compared, mainly using either t-tests or chi-square analysis. Data from this study were then

compared with international and historical NZ data. The results are discussed in the next chapter.

The data supports some findings of Rose et al. (2011; 2008). New Zealand ICUs have high nurse to patient ratios compared to their European colleagues. Nurses in NZ continue to have similar reported levels of independent decision-making. Data also brings to light some features that differ from or extend previous ventilation management knowledge about New Zealand. Post-graduate education has increased, ventilation protocol availability has increased and nurses are making similar use of automated modes of ventilation management to European ICU nurses. Nurses in this study had lower perceived autonomy and influence into decision-making than their managers reported previously.

## **Chapter 5**

### **Discussion**

#### **Introduction**

The previous chapter analysed data about the role of NZICU nurses in ventilation management. This chapter discusses the data in relation to the internationally published research.

While the research question has been asked before (Rose et al., 2008), this study differs in two significant ways. First, it asks nurses to self-report their role in ventilation management rather than asking their supervisors. Second, this survey was conducted online, using Survey Monkey, where the original studies were carried out by postal survey. The online survey allowed for access to a large and geographically dispersed population, whilst working within a tight budget. While the study uses Rose et al. (2011) as a starting point and builds on their dataset, it also treads previously unmapped territory to better understand the role of nurses in ventilation management in New Zealand's ICUs. As participants answer as individuals and provide demographic data, findings are likely to have a high degree of accuracy, reflecting what actually happens in practice and not just what is thought to happen. In addition, this study describes the role of automated ventilation modes in NZ for the first time.

This chapter will discuss the principle findings in the context of the international literature, noting areas of consistency with previous research, before examining comparisons of unit size and experience; autonomy and experience; collaboration and autonomy; education and independence. Implications and recommendations for the nursing workforce of NZICUs that are raised from this study are discussed and study limitations are acknowledged.

The evidence that data from this study is comparable with work done by Rose et al. (Rose, Blackwood, Egerod, et al., 2011) lies in the similarities of certain questions. Most of the questions are taken directly from the 2011 survey. As

described in the methodology chapter, modifications were made to use local names of professional roles. Questions were included that enquire of personal data, like experience and education, while questions aimed at management, like hospital type and unit speciality were not included.

## **Comparing the sample**

### **Clinical experience**

Participants in this study work mainly in clinical roles, where ventilation management is part of their everyday work. Data comes from a sample that makes up approximately<sup>4</sup> 23% of NZICU nurses (n=204). This cohort collectively works more than 6,000 hours per week. Although it is not possible to compare experience directly with the Nursing Council of New Zealand (NCNZ) national workforce data (Nana et al., 2013), the sample offers a spread of clinical experience, ranging from 0-42 years. Participants in this study have a range of ICU experience work, measured in years (M=14.5, SD=8.9). In comparison, Rose et al. (2008) gathered data from a representative in 14 of the 23 NZICUs.

### **Size of unit**

Sizes of the ICUs where nurses work are measured in number of ICU beds. To preserve anonymity, the survey did not ask for detail of ICU location or level of care provided. However, the data distribution suggests that the full range of units are represented, both in size and tertiary or secondary level of care. Based on bed number allocation and email addresses, this study collected 204 responses from at least 25 of the 29 ICUs reported in the ANZIC's 2014 annual report (Turner, 2014), compared with previous data collection (Rose et al., 2008) where 14 responses by nurse managers represented 14 ICUs.

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<sup>4</sup> As mentioned in the methodology chapter, it is difficult to ascertain the exact number of ICU nurses working in NZ due to the combination of cardiac care nurses with ICU nurses in NCNZ data categories.

Nurses in large units<sup>5</sup> behave differently than those in smaller units. T-tests comparing unit size with independent titrations showed that nurses working in larger units make significantly more changes in oxygen and %MV changes ( $p < 0.05$ ). The level of care (secondary or tertiary) provided by different sizes of units may well explain some of these distinctions, although the majority of data came from large units. While larger units provide tertiary level care and look after patients with all levels of acuity, smaller units transfer the patient out to tertiary units for higher level or long-term care. Short-term care requires less ventilation changes, as the aim is to provide stability rather than recovery. Nurses in larger units are no more likely than those who work in smaller units to have difference in experience ( $p = 0.519$ ), perceived autonomy ( $p = 0.230$ ) or perceived influence in decision-making ( $p = 0.205$ ), but they do make more changes in oxygen and %MV.

### **Protocols**

Protocols aim to provide nurses with a level of independence, albeit guided or prescribed independence, especially in weaning patients from ventilation. Although protocols for ventilation management were more likely to be provided in the larger ICUs ( $p = 0.038$ ), there were no significant differences found in the role of nurses who work with protocols, either in number of independent titrations made ( $p = \text{greater than } 0.05$  in all twelve titrations)<sup>6</sup>, the perceived level of autonomy ( $p = 0.178$ ) or perceived influence in decision-making ( $p = 0.100$ ). These findings support the proposal that protocols are largely redundant in a skilled and supportive environment such as NZICUs (Crocker & Scholes, 2009; Rose et al., 2007, 2008).

### **Expertise and nurses' experience**

Nurses in this study with less experience more frequently increase PEEP, increase oxygen and decrease oxygen without checking with a doctor ( $p < 0.05$ ). While frequent independent oxygen management is reported across the sample,

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<sup>5</sup> Large and small units are divided at the mean of 11.49 ICU beds.

<sup>6</sup> Refer to Table 17 for more detail.

change of PEEP is not. Changes in PEEP are, in fact, important decisions. PEEP adjustments affect oxygenation by means of physical support using positive airway pressure (Caramenz et al., 2009). Inappropriate changes of PEEP can lead to trauma of the alveoli, either through their derecruitment and collapse or an excess of positive pressure. The prospect of indiscriminate increase of PEEP amongst less experienced nurses is concerning. Findings in this study suggest nurses with less experience act with added boldness in some independent titrations, which may not be in the patient's best interest.

Nonetheless, nurses with differences in experience have no significant difference in how they perceive their autonomy ( $p=0.745$ ) or influence ( $p=0.144$ ) in making ventilation decisions. While more experience affects decision-making (notably less frequent increase of PEEP), perceived autonomy ( $p=0.745$ ) and influence ( $p=0.144$ ) are not significantly different.

Expertise is fundamental to ventilation management. In research about effective ventilation weaning management by nurses, Crocker and Scholes (2009) found that 'knowing the patient' was the central theme for nurses who weaned patients from mechanical ventilation, with pre-requisites of expertise and continuity of care. Expertise cannot be calculated in number of years. As nurses gain experience, wisdom is not automatically acquired, however, as knowledge is added nurses should increase in competence (Uhrenfeldt & Hall, 2007).

## **Education**

Nurses working in NZICUs are increasingly a well-educated group, with 69.7% ( $n=200$ ) holding a postgraduate critical care specialty qualification. This contrasts with previous data where Rose et al. (2008) found a median of 54% ( $n=14$  units represented) of ICU nurses in NZ held such a qualification. The rise reported in this study in qualifications brings NZICU nurses up to where Rose et al. measured Australian ICU nurses at 70% in 2008. The increase is most likely to be associated with an initiative from Health Workforce New Zealand to concentrate funding of postgraduate study for nurses (Barnhill, McKillop, & Aspinall, 2012). The authors undertook a small postal survey and asked NZ nurses working in a range of acute settings ( $n=57$ ) about the impact of this

increase of nurses undertaking postgraduate study. All participants agreed that furthering nurses' education had improved their practice in the following four areas: application of knowledge, critical thinking, impact on patient care and communication in the workplace.

Nurses in this study with a post-graduate ICU qualification are more experienced ( $p=0.001$ ) and perceive that they are more influential in decision-making ( $p=0.040$ ), however, they feel no more autonomous ( $p=0.138$ ). It is unclear why perceived autonomy and influence are different. A possible explanation is that autonomy is determined to a greater extent by unit culture and norms. Perceived influence in contrast, may be seen as negotiated by the individual nurse. In comparing this cohort with nurses without a post-graduate ICU qualification, there are no significant differences in initiating independent titrations ( $p = \text{greater than } 0.05$  in all twelve titrations). Rose et al. (2011; 2008) have not published findings at this level, so it is unknown if the experience is shared with European or Australian ICUs.

### **Automated modes**

This study provides data concerning usage of automated ventilation modes in NZICU's and how often nurses independently adjust a key parameter in ASV mode, %MV. As this is the first time this data has been collected, it cannot be compared with previous NZ data. Where traditionally the role of the nursing and medical staff are compared (Rose et al., 2008), use of automated modes brings a third participant into the arena of decision-making; the ventilator itself. Although discussion has commenced about the role that software brings to this area of practice (Mireles-Cabodevila et al., 2012; Rose et al., 2014), the only data that has been gathered to date on usage of these modes, apart from this study, is by Rose, Blackwood, Egerod et al. (2011).

Usage of automated modes in NZICUs is similar to European ICUs. It is likely that increase will be seen over a short time, due to the uptake of this technology in the ventilator market. Usage is up in NZ (2014) compared to Europe (2011). In both studies, SmartCare (27.6% in NZ; 12% in Europe) and ASV (18.2% in NZ; 16% in Europe) are the main automated modes used on a frequent basis. It

is now commonplace in NZICUs to use ventilators with automated modes that adjust ventilator settings based on software-based algorithms. Increase in usage is likely to continue as the technology is embedded into practice.

### **Ventilation prescriptions**

Whether ventilator settings are a prescription depends on who is asked.

Oxygen is, strictly speaking, a prescription medicine, except in emergency situations or perhaps under a standing order. In some units, protocols may cover oxygen usage and in others, more strict ‘standing orders’ are provided on a case-by-case basis. While delegation of oxygen therapy is a grey area, whether volume, pressure and timing of ventilation are components that require prescription is even less clear. Some NZICUs utilise protocols and guidelines to bring clarity to the roles, however, comments provided in this study explain that how much management is delegated depends on unit culture, the approach of medical staff and whether they trust the nurse. Some of the comments gathered in this study indicate that nurses see ventilation as a prescription that can be ‘tweaked’ or ‘titrated’ to a certain extent, but fundamental changes needing to be ‘checked’ with a doctor, either prior to, or soon after the change is made.

Nurse practitioner registration allows for an expansion in the nursing role, including (for ICU nurses) greater autonomy in ventilation management (Niezen & Mathijssen, 2014). Only two (1%) participants identified themselves as nurse practitioners. These are, in fact the only two nurse practitioners in NZICUs (NCNZ, 2013). By contrast, the neonatal ICU (NICU) environment has nine nurse practitioners employed (NCNZ, 2013). NICUs, although similar to ICU, were not included in this research. Other than the two nurse practitioners in this study, none of the nurses have prescribing authority.

### **Fundamental decisions in ventilation management**

Fundamental ventilatory decisions provide turning points in the overall plan of care, including when to administer, when to reduce and when to stop providing ventilator support. These fundamental decisions are discussed as follows.

Titration-level decisions are discussed in the subsequent section.

### **Perceived autonomy and influence in fundamental decisions**

Nurses' perceived autonomy in NZICUs in relation to fundamental ventilatory decisions is minimal. With respect to these decisions, there is a low level of nursing autonomy. Although a model of collaboration with medical staff is a conservative and safer pathway, only four nurses (2%) of the sample (n=204) acted independently to make these decisions.

Initial selection of ventilator settings was the only fundamental decision that was significantly different depending on unit size and nurses' experience. Less experienced nurses and nurses working in larger units were more likely to be led by medical staff in the initial selection of ventilator settings. Using a medically led model is a logical approach when nurses are less experienced. Prevalence of medically led initial selection of settings in the larger units would possibly be accounted for by an increased use of protocols in larger units that include setup guidelines. Protocols sometimes include the default mode and settings that are used on commencing ventilation.

Nurses' autonomy adapts depending on the acuity of the patient. Nurses in this study suggest in comments that they are independently involved with clinically 'routine' cases, while medical staff act more independently to make decisions regarding more 'complex' cases, especially when lung pathology is a key part of the patient's disease process. Despite the majority of NZICU admissions being 'routine' (Rose et al., 2009), the majority of fundamental decisions are still made collaboratively. While nurses readily titrate settings independently for routine patients.

Nurses' autonomy also adapts according to availability of medical staff. Nurses in this study comment about 'stepping-up' into a more independent role when medical staff are not present. Although the survey tool did not ask whether the place of work was in the public or private sector, these comments reflect the management structure of both private healthcare, where specialists are employed without junior doctors to delegate responsibility and of provincial units where staffing is less resourced as tertiary centres. Although nurses who

work in any environment may act with greater autonomy when medical staff are not present, the comments that reflect this were made by nurses working in units with six or less ICU beds, well below the mean of 11.49 beds in this study. Delegation of autonomy in these cases would appear to be circumstantial, in that either the situation demands extended delegation or it is expedient for medical staff to allow it. There is no evidence in this study to suggest that nursing staff are any more or less experienced, qualified or educated in areas with extended delegation.

Fundamental decision responsibilities of ventilation management in NZ are comparable to data collected in Germany and the Netherlands (Rose, Blackwood, Egerod, et al., 2011), with a strong model of collaborative decision-making. Switzerland and the UK report stronger independence in nursing staff, while nurses in Denmark, Greece, Italy and Norway are less independent. Medical-staff independently make most of the decisions that are not made collaboratively in both studies. While NZICU nurses are not the most independent nurses within this body of work, their work is largely collaborative, rather than led by medical staff only.

### **Automated modes and fundamental decisions**

Automated modes also make fundamental decisions regarding ventilation management. As mentioned in the literature review, ASV and IntelliVent-ASV™ modes automatically commence weaning by reducing the support pressure as soon as diaphragmatic effort is detected. Although this can be overridden by clinical staff, it would require a change of %MV to almost twice the usual setting to take effect (Wu et al., 2010). Delay of weaning can also be achieved in ASV by keeping the patient either deeply sedated or (chemically) paralysed, in which case the decision to wean or stop sedation becomes a decision to wean by default. On stopping paralysis or sedation, the patient can resume breathing and consequently, on detecting this effort, ASV will start weaning support. In the survey, when asked who decides when a patient is ready to wean, none of the participants acknowledged the role of the ventilator. In fairness, 'the ventilator' was not given as a categorical answer, so participants were required to use the 'other' option to provide this information. Nevertheless, perhaps the fact that

neither the researcher nor any participants suggested this response conveys a lack of awareness regarding the ventilator's involvement in decision-making. Given the abundance of literature regarding ventilation management that centres on weaning, the addition of a third 'player in the game' signals a significant change in ventilation management.

The finding of oversight in acknowledgment of clinical role echoes recent work, where contributors of decision-making were not acknowledged. When Rose and Presneill (2011) surveyed ANZ intensivists (n=164) about predictors for weaning and extubation readiness, only one participant (0.006%) identified the bedside nurse as a contributor to these decisions. Similarly, nursing staff were not listed as categorical answers in the survey, so the answer offering recognition of nurses' contribution would require thinking 'outside the box' of the survey tool. Acknowledging the roles that team members play in the workplace is a necessary part of building/maintaining staff morale and interdependence (Coombs, 2003; Rose, 2011). It appears that although ventilator software plays a significant role in ventilation management, the role is not acknowledged by nursing staff.

## **Titration of ventilator settings**

Independent titrations were referred to in the survey as 'titration of settings' and represent adjustments or titrations within the framework of ventilation management, rather than turning points in the fundamental approach. Much of the analysis in this study uses these independent titrations to measure, describe and compare nurses' role.

### **Perceived autonomy and influence in titration of settings**

Perceived autonomy and influence in decision-making were shown to be good indicators for increased independence in the titration of ventilation settings. The principle reason for conducting the t-tests was to verify consistency in participants' reporting. Making the comparison verified whether nurses who said they exercised autonomy and have influence in decision-making also reported more frequent titrations of ventilator settings. The process resulted in

significant positive associations in all 24 t-tests ( $p < 0.05$ ) with mean perceived autonomy and influence levels significantly higher for frequent decision-makers. The positive association verified consistency and reliability in reporting. Independent titrations, autonomy and influence were then compared other variables.

### **Extent of delegation and titrations**

According to comments provided in this study, how a 'fundamental change' is understood may depend on the culture of the unit, the perspective of the physician and their level of trust in the individual nurse. Although a level of delegation of tasks to nurses may occur, final responsibility of ventilation management lies with the physicians. Delegation of tasks and the power dynamic have long been discussed within nursing literature as the profession develops from its subservient origins into a profession with ever-extending roles (Coombs, 2003; Niezen & Mathijssen, 2014). Data from this study indicates that the majority of fundamental decisional responsibilities that cover the over-all strategic changes involved in providing ventilation management are decided collaboratively. In contrast, the ventilator independent titrations that provide the more piecemeal detail of adjustments made are frequently managed independently by nurses. Question 23 in this survey asks how frequently these settings are independently titrated. This question was asked by Rose et al. (2008) and Rose, Blackwood, Egerod et al. (2011), with the addition of two parameters; increase and decrease of %MV. If the significance of these settings are measured according to how often they are in fact adjusted, oxygen titration is a simple decision, whilst change of pressure is more advanced. In this way, the demarcation of responses of participants confirms that the fundamental parameters suggested by Rose, Blackwood, Egerod et al. are in fact higher level decisions and the titrations are lower level decisions. Nurses make low-level decisions independently while more fundamental decisions are predominantly decided by collaboration.

Amongst the setting changes that nurses make independently, the most liberally adjusted parameter is the concentration of oxygen. Oxygen is routinely (>75% of the time) adjusted independently by around half the participants (48% increase

oxygen and 50.5% decrease oxygen). The high representation found of oxygen titration compared to the other parameters in this data is consistent with other research as a low-level, frequently titrated parameter (Pirret, 2007; Rose, Blackwood, Egerod, et al., 2011; Rose et al., 2007, 2008). Rose et al. (2011) suggest that nurses maintaining a near-continuous presence in the bedspace ideally positions them for titrating ventilation settings and oxygen is the most likely to be titrated.

### **Balancing autonomy with collaboration**

A balance of autonomy and collaboration is suggested to achieve improved quality of care, patient safety and outcomes (D'Amour, Goulet, Labadie, San Martin-Rodriguez, & Pineault, 2008; Kerfoot, Rapala, Ebright, & Rogers, 2006; Zwarenstein & Reeves, 2006). Autonomy is traditionally seen as a pathway to build the nursing profession (Briggs, 1991; Elander & Hermeren, 1991). Briggs formerly expressed nurses' need to "fight for nursing autonomy and a professional status" (p. 228). Although autonomy may be seen as inconsistent with teamwork, Rose (2011) suggests that collaborative team members can lead to autonomy of a team, rather than autonomy of individuals. Nurses have the opportunity to strengthen the team, not by individual autonomy alone, but by applying themselves as a strong partner in a collaborative team. Concerns have been raised regarding the increased pressure experienced by the NZ health system, due to a proportionately aging population and increased life expectancy among the general population (Nana et al., 2013). Authors who discuss increased future workforce nursing requirements tend to focus on either supply (Nana et al., 2013; NCNZ, 2013) or skill (Lim, North, & Shaw, 2014; Pirret, 2013). It is yet to be seen how workforce challenges affect NZICU nursing, however, nurses may be well advised to strengthen their role in contributing to collaborative teamwork in fundamental decisions, rather than treading the same ground with low-level decisions.

### **Quality of the research**

Quality criteria were discussed in the methodology chapter using generalisability, validity and reliability as indicators. Despite a non-probability

sample, the strengths of this study and the steps that have been taken to address quality indicators in the study design are as follows.

Generalisability examines whether findings are transferable beyond the sample (Polit & Beck, 2011). Steps were taken to maximise the sample and increase generalisability in the research. The sample frame is made up of NZICU nurses, most of whom work clinically in NZICUs. Utilising the professional group encouraged a large sample capture and the method of online survey allowed for a wide geographical sample. Advertising in the NZNO monthly publication Kai Tiaki prompted participation. A group email invited further participation by the NZCCCN, with a follow up reminder sent three weeks later. The final sample of 204 made up 26.3% of the NZCCCN membership, which in turn make up the majority of NZICU nurses.

The original survey tool did not undergo formal testing beyond face validity and sensibility assessment. Nevertheless, the survey tool has now been applied in two studies apart from this one (Rose, Blackwood, Egerod, et al., 2011; Rose et al., 2008) and thus is well established in the body of research that explores roles in ventilation management. The survey was reviewed by the principle author of the original studies (Rose, Blackwood, Egerod, et al., 2011), resulting in a change to question order. The survey was piloted by four NZICU nursing experts, resulting in the addition of a question related to stopping sedation. Further input was invited from the NZCCCN committee, with no amendments requested. These steps were taken to improve validity.

The survey design gave opportunity for participants to give context to their categorical answers, offering 'other' as an option, followed by a free-text box. This design feature was included to encourage accuracy in answers and therefore to increase reliability in the data.

In summary, the strengths of this study are as follows. The survey tool appears to measure what it is intended to measure. The survey was piloted with amendments made. The number of participants of the NZICU population participated in the study was maximised through various means, rather than

generating a randomised sample. Comment boxes provided clarification, if needed. While steps were taken to mitigate common challenges in the provision of reliable, valid and generalisable data, limitations were present in the research, as follows.

## **Limitations of this study**

This study has a number of limitations including the potential for selection bias, self-report bias and as discussed, a lack of generalisability. Data were based on self-report, and accordingly offers an estimation of practice. The sample is limited to NZCCCN members with up-to-date email addresses, leading to selection bias within this cohort (Malone, Nicholl, & Tracey, 2014). Nurses more interested in ventilation were probably more likely to participate, increasing selection bias. Participants' answers may reflect the practice of the unit where they work, rather than their own personal practice. Inferences based on personal experience/education may not be as significant as those based on unit size.

Although self-report bias may influence participants to answer in ways that make them look as good as possible (van de Mortel, 2008), the data gathered in this study is no more vulnerable to this influence than any of the studies it is compared with (Rose, Blackwood, Egerod, et al., 2011; Rose et al., 2008). Participants were limited to nurses. Further research using the same survey, but including medical staff as participants, has been conducted in Norway (Haugdahl et al., 2014). Comparison of nurse manager and medical directors reports found that nurse managers perceived nurses as more autonomous, influential and collaborative in ventilation management than medical directors perceive them to be. It is not known who is best placed to accurately describe the role of nurses, however, an assumption of this study is that nurses are.

This study describes a sample of NZICU nurses and is not intended to represent populations beyond this cohort. The method used non-probability sampling whereby invitations were extended to the current NZCCCN database. As a random sample was not selected for this study, parametric tests such as t-tests

should be treated with a level of caution. Breadth of geographical location, size of units, experience of participants and numbers of participants who engage with ventilation as part of their daily routine are likely to represent an adequate cross-section of the population.

Data gathered from different sources is compared in statistical tests. Rose et al. gathered data from nurse managers and this study compares this with responses from all nurses. Readers need to consider the comparability of results between data collected from managers on behalf of nurses and nurses on behalf of themselves.

## **Summary**

This cross-sectional survey of NZICU nurses suggests some consistency with previous data gathered in NZ (Rose et al., 2008) and in Europe (Rose, Blackwood, Egerod, et al., 2011). In all three studies, fundamental decisions in ventilation management and weaning are predominantly managed collaboratively, with both nursing and medical staff involved in these decisions. Nurses were independently involved in low-level decision-making on a regular basis and make frequent titrations to ventilator settings. ICU nurses are reliant on a level of decisional responsibility to be delegated by medical staff. ICU nurses in NZ are, in the most part, given significant freedom to titrate settings, rather than make fundamental decisions independently.

Automated modes are increasingly used in the clinical setting, with nursing staff frequently involved in adjusting parameters within ASV. As in Europe, ASV and SmartCare are the most common automated modes in NZICUs. Participants did not acknowledge the role that automated modes have in decision-making and ventilation management.

## **Chapter 6**

### **Conclusion**

#### **Introduction**

This thesis poses the question ‘what is New Zealand intensive care nurses’ role in ventilation management?’ The question has been asked before, however, the answers were collected from nurse managers, on behalf of nursing staff (Rose et al., 2008). The study builds on the work of Rose et al. with some modifications, as outlined in the introduction chapter and detailed in the methodology chapter. What follows is a concluding account of the research process with pivotal findings. This chapter additionally offers suggestions for further possible research and a final conclusion.

Knowledge of the role of NZICU nurses has been updated with a detailed examination of some of the variables affecting the role, including a nurses’ education, experience, FTE, role, perceived autonomy and perceived influence in ventilation management. Workplace data collected included number of ICU beds, availability of guidelines, staffing ratios, use of automated modes and in-service education offered. Role in ventilation management was examined within two main categories of fundamental decisions and ventilator titrations.

#### **Literature**

The review of literature revealed Rose as the lead researcher in the investigation of nurses’ role in ventilation management (Haugdahl et al., 2014; Rose, Blackwood, Burns, et al., 2011; Rose, Blackwood, Egerod, et al., 2011; Rose et al., 2007, 2008; Rose et al., 2009). These studies collect data from nurse managers on behalf of nurses, so cover a much broader geographical area, but without the detail offered in this study. Use of protocols feature heavily in literature within the discussion of autonomy and role of nurses in ventilation management. Although safe and effective use of automated modes is increasingly investigated in literature, data collection of the clinical use of automated modes remains scant.

## Implications and key findings

Findings in this study were congruent with previous work (Rose et al., 2008), with detail added and data updated for NZ. Detail added includes the effect that education, experience and unit size have on clinical practice in decision-making, perceived autonomy and influence in decision-making. Use of automated modes in NZICUs has now been updated to match data gathered internationally (Haugdahl et al., 2014; Rose, Blackwood, Egerod, et al., 2011). This study contributes to preliminary discussion in literature regarding the role of the ventilator *managing itself*. How ventilator automation affects the role of clinicians, particularly nurses, is yet to be seen. However, since nurses' main independent contribution to decision-making is within the realm that automated modes control, the implications are notable.

Numbers of NZICU nurses with postgraduate NZICU education and availability of ventilation protocols has significantly increased since this data was last collected (Rose et al., 2008). Neither of these two variables had a significant effect on practice, measured in this study as the level of titrations made independently.

Perceived autonomy and influence in ventilation decision-making is less than previously estimated by nurse managers (Rose et al., 2008). This dissonance of perceived roles between the disciplines is further substantiated by findings gathered in Norway, where doctors' perception of nurses' autonomy and influence in ventilation management were less than the nursing managers perceived them (Haugdahl et al., 2014). An assumption in this study is that the professionals best positioned to describe the nurses' role are nurses.

Nurses with less experience made more frequent oxygen titrations and increases in PEEP. Although involvement at this level of complexity with PEEP adjustment, coupled with less experience may seem counterintuitive, boldness can accompany lack of experience and may explain this finding.

The adaption of nurses' autonomy, depending on the clinical acuity and the availability of medical staff is a new issue raised in participants' comments.

Discussion of this adaptability in role definition has not featured in the literature on ventilation management and could warrant further investigation. These findings were collected from the smaller ICUs where medical cover is not consistent around the clock.

Participants failed to acknowledge the role of the ventilator in making fundamental decisions; although in fairness, the survey did not offer 'ventilator' as a categorical option within the answers. Nevertheless, it was not raised in the comments section, indicating the ventilator is not viewed as a 'team-member', at this stage at least. Clearly, when ASV mode is applied, the decision of when to commence weaning is made by the ventilator, unless it is specifically set to not wean. The exception to this is when the patient is either deeply sedated or (chemically) paralysed, in which case the decision to stop sedation or paralysis medication usually becomes a decision to wean ventilation. The role of the ventilator and how automation affects clinical roles is only starting to be explored.

Autonomy may not be the future of nursing in ventilation management. Much of the literature that discusses the development of the nursing profession promotes greater autonomy in the traditional sense of working independently. With automated modes taking a responsibility in the titrations of ventilator settings, there is a strong indication that nurses will need to re-evaluate their contribution to ventilation management. Nurses already make a strong contribution to the collaborative fundamental decision-making. This study suggests that nurses may not find autonomy in independence so much as developing a more valid contribution to collaborative decisions, as independent titrations are increasing taken up by automated ventilation.

To strengthen the role of contributing to the inter-professional decision-making, Pirret (2007) suggests ICU nurses develop their knowledge and ability to articulate contributions. Suggested solutions include developing a greater clinical depth offered in education, a better understanding of formal language and a shift from intuitive thought processes to analytical practice.

It is yet to be seen how workforce challenges affect NZICU nursing, however, if nurses' role in ventilation management becomes increasingly automated and less supported in staffing, nurses may be well advised to strengthen their role in contributing to collaborative teamwork in fundamental decisions, rather than treading the same ground with low-level decisions.

## **Further research**

Findings in Norway (Haugdahl et al., 2014) raise the question of who is best placed to describe the nurses' role. Further work that includes medical staff and clinical nursing staff would broaden knowledge in promoting inter-professional collaboration, as most of the data in this body of work draws on nurse managers.

Studies investigating NZICU nurses' competency in ventilation management have not been conducted beyond an earlier study by Pirret (2007), assessing nurses' knowledge of respiratory physiology. Pirret raised several barriers that impede nurses' progress in the articulating and applying principals of respiratory physiology in their practice. This study did not investigate barriers to contributing to ventilation management, beyond delegation from medical staff.

The impact of artificial intelligence in the form of automated ventilation modes has not been closely investigated. Research investigates safety and efficacy of automated modes. This study answers how often automated modes are used in NZICUs and how often %MV is independently titrated by nurses. It is not known how practitioners decide whether these modes should be used or not. It is not known how these modes are used or how practitioners learn how to use them. It is not known if they are used well or even how best to maximise their use clinically.

## Conclusion

This study set out to clarify the role of NZ ICU nurses in ventilation management. The aim has been fulfilled, updating previous data, providing detail not previously explored and establishing a dataset of automated mode use.

Fundamental decisions are decided in the most part collaboratively, with results comparable to findings in Germany and the Netherlands. Ventilator settings are readily titrated independently by NZICU nurses. While oxygen titration in NZ is similar to European ICUs, the other settings are titrated less often than in Europe.

Use of automated ventilation modes was considerably higher than data collected in Europe. It is difficult to know how comparable the datasets are. The rapid uptake of this technology makes the data time-sensitive and the time-lapse in datasets may explain the difference. Nevertheless, a dataset for usage in NZICUs has now been established.

Availability of protocols has significantly increased since data was collected last in NZICUs. While Pirret received mixed views of the value of protocols from NZICU nurses, the clinical effect was not measured as significant in this study.

The key message in this study is the comparability between decisions currently made by nursing staff and those made by the ventilator in automated modes. It seems clear that ICU nurses will need to re-evaluate their contribution to decision-making in ventilation management, given the increase in uptake of this technology in recent years.

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## Appendix A: Permission from MUHEC



MASSEY UNIVERSITY  
TE KUNENGA KI PŪREHUROA

17 April 2013

COPY FOR YOUR  
INFORMATION

Mark Henderwood  
64 Severn Street  
Island Bay  
WELLINGTON 6230

Dear Mark

**Re: HEC: Southern A Application – 13/10**  
**Decisional responsibility for mechanical ventilation and weaning in New Zealand**  
**Intensive Care Units**

Thank you for your letter dated 15 April 2013.

On behalf of the Massey University Human Ethics Committee: Southern A I am pleased to advise you that the ethics of your application are now approved. Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Brian Finch, Chair  
Massey University Human Ethics Committee: Southern A

cc **Dr Jill Wilkinson**  
School of Nursing  
WELLINGTON

A/Prof Annette Huntington, HoS  
School of Nursing  
WELLINGTON

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Massey University Human Ethics Committee  
Accredited by the Health Research Council  
Research Ethics Office

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## Appendix B: Permission to use survey tool

**From:** [Louise Rose](#)  
**To:** [Henderwood, Mark](#)  
**Cc:** [Wilkinson, Jill](#)  
**Subject:** RE: ANZ ICU workforce profile study  
**Date:** Thursday, 2 August 2012 9:30:00 a.m.

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Hi Mark

I am very interested to hear that Wellington ICU is using ASV as the default mode – I am in the final stages of a Cochrane review on automated systems – one of the reasons why we added questions on use of these types of modes. Happy for you to modify the survey, can you send me a copy of your final modified version?

Louise

**Dr. Louise Rose**

Lawrence S. Bloomberg Limited Term Professor in Critical Care  
Lawrence S. Bloomberg Faculty of Nursing, University of Toronto  
Adjunct Scientist and Director of Research, Provincial Centre of Weaning Excellence, Toronto  
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## Appendix C: Information letter



### Decisional responsibility for mechanical ventilation and weaning in New Zealand Intensive Care Units

#### -INFORMATION SHEET-

Hello, my name is Mark Henderwood. As a part of my Masters degree I am undertaking research about ventilator management in NZ ICUs.

The project aims to describe responsibility for key ventilation and weaning decisions and to examine organisational characteristics associated with nurse involvement.

#### An invitation

As a member of the Critical Care Nurses Section (CCNS) of the New Zealand Nursing Organisation you are invited to participate in an online survey. The questions will be about role responsibility for ventilator management. I expect it will take about fifteen minutes to complete. The survey will be available online for three weeks from [date]. If you have any questions, please do not hesitate to contact me or my supervisor. In the event that you work concurrently in two different tertiary ICU's, please answer the questions with reference to the ICU that you spend the most time in.

At the end of the survey there will be an invitation to answer further questions if you choose. These questions will be used to provide clarification on the same topic. Questions to be asked will depend on the nature of the survey responses.

#### Your rights as a participant.

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- Decline to participate in the survey
- Decline to answer any particular question;
- Withdraw from the survey at any time;
- Ask any questions about the study at any time during participation via email as below;
- Provide information on the understanding that your name will not be used or any identifying details, as your identity will not be known to me;
- Be given access to a summary of the project findings via the CCNS when it is concluded.

#### Potential risks and benefits from participation

There are few risks to you as a participant in this study other than the very minimal risk that you could be identified by your written responses. I will take every step to minimise this risk, but you need to be aware of the possibility. Otherwise you will remain anonymous in your participation unless you wish to offer your email contact at the end of the survey.

The benefits of participation in this survey are that you will have the opportunity to report your experience of working with ventilators in the context of your workplace and demographics. Research by others has involved asking these questions of nurse managers; this will be your chance to contribute directly. The survey will help provide information about nurses' involvement in ventilation management and how best to support nurses in this aspect of ICU care.

A reminder notice will be sent to you all from CCNS a week before closing, as I will not know who has and who has not responded. All data will only be available to me and my research supervisor (Dr Jill Wilkinson). It will be stored on a password protected computer, and will be held for 5 years after completion of this study at which time it will be destroyed.

Thank you for taking the time to consider participating.

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*This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 13/10. If you have any concerns about the conduct of this research, please contact Dr Brian Finch, Chair, Massey University Human Ethics Committee: Southern A telephone 06 350 5799 x 84459, email [humanethicsoutha@massey.ac.nz](mailto:humanethicsoutha@massey.ac.nz).*

## Appendix D: Survey

(The information sheet was repeated on the first page on the survey)

### 1. Who determines the INITIAL SELECTION of ventilator settings?

- ☐ Medical staff only
- ☐ Nurses only
- ☐ Medical staff and nurses in collaboration
- ☐ Other (please specify)

### 2. Identify the seniority of medical staff responsible for INITIAL SELECTION of ventilator settings

- ☐ Consultants only
- ☐ Registrars and above
- ☐ House officers and above
- ☐ Other (please specify)

### 3. If applicable, identify the seniority of nurses responsible for INITIAL SELECTION of ventilator settings

- ☐ Senior nurses only (e.g. clinical nurse specialists, nurse managers, educators)
- ☐ Nursing staff who have completed an ICU specialty qualification
- ☐ All nursing staff (once oriented to the ICU environment)
- ☐ Other (please specify)

### 4. Who evaluates the patient's response to mechanical ventilation and TITRATES SETTINGS if required?

- ☐ Medical staff only
- ☐ Nurses only
- ☐ Medical staff and nurses in collaboration
- ☐ Other (please specify)

**5. Identify the seniority of medical staff responsible for TITRATION of ventilator settings**

- ☐ Consultants only
- ☐ Registrars and above
- ☐ House officers and above
- ☐ Other (please specify)

**6. If applicable, identify the seniority of nurses responsible for TITRATION of ventilator settings**

- ☐ Senior nurses only (e.g. clinical nurse specialists, nurse managers, educators)
- ☐ Nursing staff who have completed an ICU specialty qualification
- ☐ All nursing staff (once oriented to the ICU environment)
- ☐ Other (please specify)

**7. If applicable, who determines when a patient's sedation is stopped?**

- ☐ Medical staff only
- ☐ Nurses only
- ☐ Medical staff and nurses in collaboration
- ☐ Other (please specify)

**8. Identify the seniority of medical staff responsible for determining when a patient's sedation is stopped**

- ☐ Consultants only
- ☐ Registrars and above
- ☐ House officers and above
- ☐ Other (please specify)

**9. If applicable, identify the seniority of nurses responsible for determining when a patient's sedation is stopped**

- ☐ Senior nurses only (e.g. clinical nurse specialists, nurse managers, educators)
- ☐ Nursing staff who have completed an ICU specialty qualification
- ☐ All nursing staff (once oriented to the ICU environment)
- ☐ Other (please specify)

**10. Who decides when a patient is READY TO WEAN?**

- ☐ Medical staff only
- ☐ Nurses only
- ☐ Medical staff and nurses in collaboration
- ☐ Other (please specify)

**11. Identify the seniority of medical staff responsible for determining WEANING READINESS**

- ☐ Consultants only
- ☐ Registrars and above
- ☐ House officers and above
- ☐ Other (please specify)

**12. If applicable, identify the seniority of nurses responsible for determining WEANING READINESS**

- ☐ Nurses only (e.g. clinical nurse specialists, nurse managers, educators)
- ☐ Nursing staff who have completed an ICU specialty qualification
- ☐ All nursing staff (once oriented to the ICU environment)
- ☐ Other (please specify)

**13. Who decides the METHOD OF WEANING from mechanical ventilation?**

- ☐ Medical staff only
- ☐ Nurses only
- ☐ Medical staff and nurses in collaboration
- ☐ Other (please specify)

**14. Identify the seniority of medical staff responsible for determining the METHOD OF WEANING**

- ☐ Consultants only
- ☐ Registrars and above
- ☐ House officers and above
- ☐ Other (please specify)

**15. If applicable, identify the seniority of nurses responsible for determining the METHOD OF WEANING**

- ☐ Senior nurses only (e.g. clinical nurse specialists, nurse managers, educators)
- ☐ Nursing staff who have completed an ICU specialty qualification
- ☐ All nursing staff (once oriented to the ICU environment)
- ☐ Other (please specify)

**16. Who decides when a patient is READY TO EXTUBATE?**

- ☐ Medical staff only
- ☐ Nurses only
- ☐ Medical staff and nurses in collaboration
- ☐ Other (please specify)

**17. Identify the seniority of medical staff responsible for determining READINESS FOR EXTUBATION**

- ☐ Consultants only
- ☐ Registrars and above
- ☐ House officers and above
- ☐ Other (please specify)

**18. If applicable, identify the seniority of nurses responsible for determining READINESS FOR EXTUBATION**

- ☐ Senior nurses only (e.g. clinical nurse specialists, nurse managers, educators)
- ☐ Nursing staff who have completed an ICU specialty qualification
- ☐ All nursing staff (once oriented to the ICU environment)
- ☐ Other (please specify)

**19. What is the usual nurse-to-patient ratio for patients receiving mechanical ventilation in your ICU?**

- ☐ 1:1 ratio
- ☐ 1:2 ratio
- ☐ 1:3 ratio
- ☐ Other (please specify)

**20. What is the usual nurse-to-patient ratio for patients receiving non-invasive ventilation in your ICU?**

- ☐ 1:1 ratio
- ☐ 1:2 ratio
- ☐ 1:3 ratio
- ☐ Other (please specify)

**21. How would you rate nursing autonomy in regards to mechanical ventilation practices?**

Please select the number on the scale below

0 No autonomy    1    2    3    4    5    6    7    8    9    10 Complete autonomy

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Please comment (optional)

**22. How often do nursing contributions influence decisions made regarding mechanical ventilation?**

Please select the number on the scale below

0 Never    1    2    3    4    5    6    7    8    9    10 Always

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Please comment (optional)

**23. How often do nurses make and implement the following decisions independently?  
(without prior direct consultation with medical staff)**

|                                   | Never<br>(0%)         | Seldom<br>(1-25%)     | Frequently<br>(26-50%) | Often<br>(51-75%)     | Routinely<br>(>75%)   | Uncertain or<br>N/A   |
|-----------------------------------|-----------------------|-----------------------|------------------------|-----------------------|-----------------------|-----------------------|
| Change of mode                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Titration of respiratory rate     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Titration of tidal volume         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Titration of inspiratory pressure | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Increase of pressure support      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Decrease of pressure support      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Increase of PEEP                  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Decrease of PEEP                  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Increase of FiO <sub>2</sub>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Decrease of FiO <sub>2</sub>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Increase %MV                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Decrease %MV                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**24. In your ICU, do you have a guideline/policy/protocol for weaning from mechanical ventilation?**

- ☐ Yes
- ☐ No
- ☐ Uncertain

**25. If Yes, does it contain information on management of patients failing weaning?**

- ☐ Yes
- ☐ No
- ☐ Uncertain

**26. In your ICU, do you have a guideline/policy/protocol for management of non-invasive ventilation (NIV)?**

- ☐ Yes
- ☐ No
- ☐ Uncertain

**27. In your ICU, do you have a guideline/policy/protocol for management of mechanical ventilation?**

- ☐ Yes
- ☐ No
- ☐ Uncertain

**28. Are any of the following automated weaning modes used in your ICU?**

|                                       | Never<br>(0%)         | Seldom<br>(1-25%)     | Frequently<br>(26-50%) | Often<br>(51-75%)     | Routinely<br>(>75%)   | Uncertain             |
|---------------------------------------|-----------------------|-----------------------|------------------------|-----------------------|-----------------------|-----------------------|
| SmartCare/PS                          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Adaptive support ventilation (ASV)    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Mandatory minute ventilation (MMV)    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Proportional assist ventilation (PAV) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**29. Do nurses receive education on ventilation during ICU orientation?**

- ☐ Yes

☐ No

☐ Uncertain

If YES, please describe (optional)

**30. Are opportunities available in your ICU for ongoing professional development related to mechanical ventilation?**

☐ Yes

☐ No

☐ Uncertain

If YES, please describe (optional)

**31. Do you hold a post-graduate critical care specialty qualification?**

☐ Do you hold a post-graduate critical care specialty qualification? Yes

☐ No

☐ No, but I'm currently enrolled in such a programme

☐ Other (please specify)

**32. Is this qualification associated with a university?**

☐ Is this qualification associated with a university? Yes

☐ No

☐ Other (please specify)

**33. What is the highest level of education you have completed?**

☐ What is the highest level of education you have completed? Hospital Certificate in Nursing

- ☐ Diploma in Nursing (Polytechnic)
- ☐ Diploma in Nursing (University)
- ☐ Bachelor of Nursing
- ☐ Post graduate certificate
- ☐ Post graduate diploma
- ☐ Masters
- ☐ PhD
- ☐ Other (please specify)

**34. Please list the names of any postgraduate papers you have COMPLETED at university**

**35. Please list the names of any postgraduate papers you are currently ENROLLED IN at university**

**36. What is your MAIN role in ICU?**

- ☐ Staff nurse
- ☐ Enrolled nurse
- ☐ Nurse educator
- ☐ Nurse specialist
- ☐ Nurse practitioner
- ☐ Nurse technician
- ☐ Research nurse
- ☐ Outreach/PAR nurse
- ☐ Nurse co-ordinator/charge/ACNM
- ☐ Nurse manager
- ☐ Other (please specify)

**37. Number of ICU beds in your unit**

**38. Please identify how many years (in total) you have worked in the ICU environment.**  
(Please include working in different units and countries)

**39. On average, how many hours a week do you work in ICU?**

**40.** There is a chance that we would like to contact you further about this study.

If you would be interested in contributing please include your email in the box below.

Thank you so much for contributing to this research!

Keep up the great work :)

Mark Henderwood