The Self-Rated and Actual Pharmacology Knowledge of Intensive Care Nurses in New Zealand

Elizabeth Johnston

A thesis submitted for the degree of

Master of Health Sciences (Nursing)

at the University of Otago, Christchurch

New Zealand.

May 2012
ABSTRACT

BACKGROUND: Medication administration is a critical aspect of nursing practice, and has significant implications for patient safety. The quality of medication administration depends on the knowledge and attitudes of nurses who are the ones to assess and monitor the therapeutic and adverse response of the patient. Intensive Care is an area that requires staff to manage patients with a wide range of selected medications, often in highly stressful situations. It is essential that nurses have an extensive pharmacology knowledge base in order to understand the complexities of medication management in the critically ill and safely undertake this role.

AIM: The aim of this study is to investigate the self-rated and actual pharmacology knowledge of intensive care nurses in New Zealand.

METHODS: A quantitative study was undertaken for the purposes of investigating the pharmacology knowledge of intensive care nurses. A descriptive correlational design was utilised to determine the level of knowledge nurses have of intensive care medications and to explore if relationships existed between this knowledge and their professional characteristics and confidence in administering these medications. A survey approach was taken using a self-administered questionnaire. Data collection took place over 12 weeks, from September 2010 to December 2010. The sample included 510 intensive care nurses from six public hospital intensive care units in New Zealand. Ethical approval for this study was obtained from the multi-region ethics committee. Data were analysed using the Statistical Package for Social Sciences (SPSS).

RESULTS: Despite study limitations, the findings indicate that pharmacology knowledge is poor. Self-rated knowledge, confidence and actual knowledge were not strongly correlated with nursing or intensive care experience or education level. In addition nurses’ self-ratings of knowledge were often over-estimated. The only significant positive influence on scores was attendance at pharmacology courses or in-service education sessions; as these nurses obtained better tested knowledge scores for each medication as well as self-rating their knowledge and confidence higher.
CONCLUSION: As no previous New Zealand study has investigated the pharmacology knowledge of intensive care nurses, the results of this research offer a valuable insight into the knowledge of this specialist group of nurses and add to a consistent, growing body of literature suggesting that pharmacology knowledge is problematic and needs addressing. Improvement in undergraduate education, competency assessment and continuing education would effectively contribute to the ongoing effort to improve nurses’ knowledge. The findings also establish the need for further nursing research into this important area of nursing knowledge.
DEDICATION

This thesis is dedicated, in loving memory, to my late parents James and Jan and to the late Dr Mary Miles, a friend and mentor.
ACKNOWLEDGEMENTS

It is with immense gratitude that I acknowledge the following people who have contributed in many ways to the completion of this thesis.

I would like to firstly thank my primary supervisor Beverley Burrell, for her guidance, knowledge and encouragement throughout and Henrietta Tripp for her invaluable input and feedback during the final stages. Many thanks also to Dr Patricia Maybee for her advice and support of this project in its early stages.

I extend my deepest appreciation to the nurse managers at the research sites who helped to facilitate data collection and to the many ICU nurses who took the time to participate in this study. The interest and support of my ICU colleagues at Christchurch Hospital was also appreciated.

And last but not least, I would like to thank my dear family and friends for their ongoing love, support and encouragement, which has helped me to achieve this goal.
TABLE OF CONTENTS

ABSTRACT ........................................................................................................................................i
DEDICATION ..................................................................................................................................... iii
ACKNOWLEDGEMENTS ................................................................................................................ iv
TABLE OF CONTENTS ...................................................................................................................... v
LIST OF TABLES ............................................................................................................................. x
LIST OF FIGURES ........................................................................................................................... xi
CHAPTER ONE: INTRODUCTION ................................................................................................... 1
  1.1 AIM OF THE STUDY ................................................................................................................ 2
  1.2 STRUCTURE OF THE THESIS ............................................................................................. 2
CHAPTER TWO: BACKGROUND ..................................................................................................... 4
  2.1 INTRODUCTION .................................................................................................................. 4
  2.2 THE INTENSIVE CARE UNIT ............................................................................................... 4
    2.2.1 The New Zealand Context ............................................................................................. 5
    2.2.2 Intensive Care Nursing ................................................................................................. 6
  2.3 PHARMACOLOGICAL MANAGEMENT OF ICU PATIENTS .............................................. 7
    2.3.1 Sedatives, Opioid Analgesics and Neuromuscular Blocking Agents ......................... 7
      2.3.1.1 Sedation .................................................................................................................... 7
      2.3.1.2 Analgesia ................................................................................................................ 9
      2.3.1.3 Neuromuscular blocking agents ............................................................................ 10
      2.3.1.4 Administration and management ........................................................................... 10
  2.4 MEDICATION ERRORS ....................................................................................................... 11
    2.4.1 The ICU Context ........................................................................................................... 12
      2.4.1.1 Knowledge for safe administration ....................................................................... 13
  2.5 SUMMARY ............................................................................................................................ 14
CHAPTER THREE: LITERATURE REVIEW ................................................................................... 15
  3.1 INTRODUCTION ................................................................................................................ 15
  3.2 PHARMACOLOGY IN NURSING EDUCATION ................................................................... 15
    3.2.1 Pharmacology: Teaching and Learning ....................................................................... 16
      3.2.1.1 Curriculum time ..................................................................................................... 16
      3.2.1.2 Pharmacology: difficulty, knowledge deficits and confidence .............................. 18

v
5.1 INTRODUCTION .............................................................................................................................................42
5.2 THE STUDY RESPONDENTS .............................................................................................................................42
  5.2.1 Response Rate .............................................................................................................................................42
  5.2.2 Demographics ............................................................................................................................................42
  5.2.3 Employment Characteristics ......................................................................................................................43
  5.2.4 Qualification Characteristics of Respondents ...........................................................................................44
5.3 OVERALL PHARMACOLOGY KNOWLEDGE AND IMPORTANCE ..................................................45
  5.3.1 Importance of Pharmacology Knowledge to Practice .............................................................................45
    5.3.1.1 Importance of pharmacology knowledge to practice and demographics ......................................45
  5.3.2 Overall Self-Rated Pharmacology Knowledge .........................................................................................46
    5.3.2.1 Overall self-rated pharmacology knowledge and demographics .................................................47
  5.3.3 Relationship Between Importance and Overall Knowledge .................................................................47
5.4 SELF-RATED PHARMACOLOGY KNOWLEDGE & CONFIDENCE ............................................47
  5.4.1 Self-Rated Knowledge .................................................................................................................................47
    5.4.1.1 Self-rated knowledge and demographics .........................................................................................48
  5.4.2 Self-rated confidence .................................................................................................................................49
    5.4.2.1 Confidence and demographics .........................................................................................................50
  5.4.3 Relationship between Self-rated knowledge and Confidence ...............................................................51
  5.4.4 Frequency of administration ....................................................................................................................51
    5.4.4.1 Self-rated knowledge scores and frequency of administration ....................................................52
    5.4.4.2 Confidence scores and frequency of administration ........................................................................52
5.5 ACTUAL KNOWLEDGE .................................................................................................................................53
  5.5.1 Individual and Total Medication Scores ....................................................................................................53
    5.5.1.1 Individual knowledge scores attained by each respondent ............................................................53
    5.5.1.2 Total knowledge scores attained by each respondent ....................................................................55
  5.5.2 Medication Test Item Responses .............................................................................................................55
  5.5.3 Actual Knowledge and Demographics .....................................................................................................58
  5.5.4 Actual Knowledge and Educational Variables ..........................................................................................58
  5.5.5 Actual Knowledge and Frequency of Administration ..............................................................................59
  5.5.6 Relationship Between Actual Knowledge and Self-Rated Knowledge and Confidence ..................59
5.6 SUMMARY .....................................................................................................................................................59
CHAPTER SIX: DISCUSSION .......................................................................................................................................60
6.1 INTRODUCTION ......................................................................................................................60

6.2 NURSES’ SELF-RATED PHARMACOLOGY KNOWLEDGE ............................................60
  6.2.1 Importance of Pharmacology Knowledge ........................................................................60
    6.2.1.1 Influencing factors ..................................................................................................61
  6.2.2 Self-Rated Knowledge and Confidence ...........................................................................62
    6.2.2.1 Overall self-rated knowledge .................................................................................62
    6.2.2.2 Individual medication self-rated knowledge and confidence ......................................62
    6.2.2.3 Influencing factors ..................................................................................................63

6.3 NURSES’ ACTUAL PHARMACOLOGY KNOWLEDGE .....................................................64
  6.3.1 Overall and Individual Medication Scores ......................................................................64
  6.3.2 Identified Areas of Weakness .........................................................................................65
    6.3.2.1 Medication class, receptor sites and neurotransmitter systems .................................66
    6.3.2.2 Drug actions and effects .........................................................................................66
    6.3.2.3 Onset and duration of action ..................................................................................67
    6.3.2.4 Reversal agents ......................................................................................................68
    6.3.2.5 Side effects ............................................................................................................68
    6.3.2.6 Pharmacokinetics and precautions .........................................................................69
  6.3.3 Frequency of Administration .........................................................................................69
  6.3.4 Experience and Education Level ....................................................................................70
  6.3.5 Pharmacology Courses or In-Service Education ............................................................71

6.4 SELF-RATED VS ACTUAL KNOWLEDGE .........................................................................72
  6.4.1 Correlations Between Self-Rated and Actual Knowledge ...............................................72
  6.4.2 Overestimation of Self-Rated Knowledge and Confidence ............................................73

6.5 LIMITATIONS OF THE STUDY .........................................................................................74

6.6 RECOMMENDATIONS FOR ENSURING MEDICATION COMPETENCE .................76
  6.6.1 Nursing Council Responsibilities ..................................................................................76
  6.6.2 District Health Board Responsibilities ............................................................................77

6.7 RECOMMENDATIONS FOR NURSING EDUCATION ....................................................77
  6.7.1 Undergraduate Education ..............................................................................................78
  6.7.2 Ongoing education in ICU .............................................................................................78
    6.7.2.1 Orientation programmes .........................................................................................79
    6.7.2.2 Continuing education programmes .........................................................................79
LIST OF TABLES

Table 1: Demographics of Respondents ................................................................. 43

Table 2: Employment Characteristics of Respondents........................................... 44

Table 3: Level of Nursing Education of Respondents.......................................... 44

Table 4: Self-Rated Medication Knowledge......................................................... 48

Table 5: Independent T-test for Self-Rated Knowledge and Attendance at Pharmacology Course or In-service Session................................................................. 49

Table 6: Self-rated Medication Administration Confidence.................................. 49

Table 7: Correlations Between Years of Experience and Self-Rated Confidence....... 50

Table 8: Independent T-test for Self-rated Confidence and Postgraduate Qualifications in ICU .................................................................................................................. 51

Table 9: Frequency of Medication Administration.................................................. 51

Table 10: Correlations between Frequency of Rocuronium, Propofol, Midazolam and Morphine Administration and Self-Rated knowledge ............................................. 52

Table 11: Correlations Between Frequency of Administration and Self-Rated Confidence… 52

Table 12: Actual Knowledge Scores....................................................................... 53

Table 13: The Number of Correct Responses to the Knowledge Test...................... 57

Table 14: Independent T-test for Actual Knowledge and Attendance at a Pharmacology Course or In-Service Session................................................................. 58
LIST OF FIGURES

Figure 1: Self-Rated Importance of Pharmacology Knowledge ........................................45

Figure 2: Self-Rated Overall Pharmacology Knowledge ...............................................46

Figure 3: Rocuronium Knowledge Scores .................................................................. 54

Figure 4: Propofol Knowledge Scores ........................................................................ 54

Figure 5: Midazolam Knowledge Scores ..................................................................... 54

Figure 6: Morphine Knowledge Scores ...................................................................... 54

Figure 7: Total Knowledge Scores ............................................................................... 55
CHAPTER ONE: INTRODUCTION

Medication administration is a fundamental part of nursing practice and hence knowledge of commonly used medications and proficiency in medication administration are expectations for all professional nurses in clinical settings (Grandell-Niemi, Hupli, Leino-Kilpi, & Puukka, 2005; Ndosi & Newell, 2009; Raja Lope, Boo, Rohana, & Cheah, 2009; Saethang & Kee, 1998). Indeed, nurses as licensed health-care professionals, have a professional responsibility to ensure they have the knowledge and skill to ensure the quality use of medicines (Health Practitioners Competence Assurance Act 2003; Nursing Council of New Zealand, 2009). Furthermore, they are also required to recognise and, if necessary, challenge inappropriate prescribing (Ives, Hodge, Bullock, & Marriott, 1996). In order to safely and effectively carry out these roles and responsibilities, a good understanding of the scientific principles underpinning medications, and the impact of the patient’s condition upon this, is paramount (Grandell-Niemi et al., 2005; Leathard, 2001; Manias & Bullock, 2002a).

Historically in nursing practice, the administration of medicines has been recognised as one of the highest risk areas of practice, as the consequences of inappropriate or incorrectly administered therapy can be very serious (Armitage & Knapman, 2003; McBride-Henry & Foureur, 2006; Seddon & Merry, 2002). This is particularly the case in a setting such as intensive care. Intensive care is a specialty area that is focused on the care and treatment of acutely and critically ill patients. The intensive care setting is fast-paced, complex, and commonly requires urgent decision-making processes which render patients vulnerable to unsafe medication administration (Rothschild et al., 2005). In addition, patients in intensive care often require complex pharmacological management (Aari, Ritmala-Castrén, Leino-Kilpi, & Suominen, 2004). Therefore a comprehensive understanding of pharmacology is crucial to enable timely and safe care of the patient and to further reduce the risks of medication errors.

Despite the fact that medication administration is a significant part of a nurse’s clinical practice, research over the past 30 years has consistently asserted that nurses’ knowledge of pharmacology is insufficient and inadequate (Ives et al., 1996; Manias & Bush, 1999; 1

---

1 Pharmacology is the science of drugs.
However, most of the literature examining nurses’ pharmacology knowledge has been set within general wards, the community or educational institutions. Only a small number of studies have examined the pharmacology knowledge of nurses employed in the specialised practice setting of intensive care (Arbour, 2003; Erkes, Parker, Carr, & Mayo, 2001; Fothergill-Bourbonnais & Wilson-Barnett, 1992; Loper, Butler, Nessly, & Wild, 1989; Munro & Grap, 2001; Sandie & Heindel, 1999), and to date only one researcher has looked at the pharmacology knowledge of New Zealand nurses (Bray, 1993). Research into the pharmacology knowledge of nurses in the New Zealand intensive care setting is therefore needed.

1.1 AIM OF THE STUDY

The aim of this study is to investigate the self-rated and actual pharmacology knowledge of intensive care nurses in New Zealand. It specifically focuses on the knowledge of common sedative, analgesic and neuromuscular blocking drugs. This study will also explore the level of confidence that nurses’ have in administering these medications and examine whether their pharmacology knowledge (both actual and self-rated) and confidence is related to experience or educational background. Information gained by conducting this research will inform the body of knowledge related to pharmacology knowledge in the New Zealand and the intensive care context. It is only through the accurate assessment of nurses’ knowledge that appropriate strategies can be developed to address their educational needs related to the use of these types of medications in practice. The findings from this study may have implications for policy development, nursing education and reinforcing the skills of practicing nurses in intensive care.

1.2 STRUCTURE OF THE THESIS

The following chapters explore the background, method and findings of this study. Chapter two provides the background for this thesis. It commences with a discussion of intensive care nursing in New Zealand and sets the scene for this study. Medication administration in intensive care is examined and four medications commonly used in intensive care, which are the focus of this study, are introduced. The knowledge required for their safe administration within practice is
reviewed and the implications of a lack of knowledge are discussed, including literature from both here and overseas in relation to medication errors.

Chapter three presents an overview of the relevant national and international literature underpinning this research thesis and includes literature on pharmacology education, tested knowledge, self-rated versus actual knowledge of nurses and knowledge of medications that are used in the intensive care unit (ICU). The sole New Zealand pharmacology study by Bray (1993) is outlined and discussed.

Chapter four describes the methodological approach to this research, outlines and justifies the use of a quantitative method for data collection and discusses the development of the survey tool utilised in this study. Cultural and ethical considerations are also presented.

Chapter five presents the results and analysis of the study, including descriptive data, t-tests and Pearson’s product-moment correlations between knowledge and other variables.

Chapter six provides a discussion of the key findings of this study in relation to the relevant literature and implications for practice. Limitations of the study are presented and discussed. The chapter concludes by suggesting strategies for improving nurses’ pharmacology knowledge through nursing education and recommendations for future research.
CHAPTER TWO: BACKGROUND

2.1 INTRODUCTION

New Zealand intensive care nurses work within a complex and rapidly changing clinical environment. The purpose of this chapter is to present the reader with information about the unique features of the intensive care environment and the specialised medication management of patients in the intensive care settings in which this study took place. Chapter two is presented in three sections. In the first section, intensive care services within New Zealand and the role of intensive care nurses are explored. Secondly, the medications that are crucial to the comfort and treatment of ICU patients will be introduced and discussed, in relation to necessary nursing knowledge required for safe administration. The third section focuses on the potential for adverse drug events in this area, the possible effects on patient outcomes and the impact of pharmacology knowledge upon this.

2.2 THE INTENSIVE CARE UNIT

Critical illness is a life threatening state involving the failure of one or more vital organ systems. Undoubtedly, this condition is the ultimate example of acute, severe physical stress and has the potential to result in significant morbidity and mortality without prompt and appropriate therapeutic intervention (Van den Berghe, 2000). When a patient’s condition deteriorates into critical illness they need a referral for advanced clinical management within an ICU, where they can receive intense support for failing organ systems.

The College of Intensive Care Medicine of Australia and New Zealand (2011) define an intensive care unit as: “...a specially staffed, and equipped, separate and self-contained area of a hospital dedicated to the management of patients with life-threatening illnesses, injuries and complications, and monitoring of potentially life-threatening conditions.” (p.1).
Patients are admitted to ICU for a variety of medication conditions, such as sepsis, hypovolaemic or cardiogenic shock, Systemic Inflammatory Response Syndrome (SIRS), respiratory failure, acute renal failure and metabolic disorders, acute neurological disorders and haematological management or following severe trauma, complex surgery or cardiac arrest. Within ICUs, patients with these complex conditions can benefit from both higher staffing levels, constant close monitoring, living saving support from equipment and/or medication and staff with specialist skills (Davidson, Daly, Romanini, & Elliott, 2001). These critically unwell patients may come from the general wards, both medical and surgical, the Emergency Department, or operating theatres. Their condition can change very rapidly and in an unpredictable way, necessitating the need for constant vigilance. Intensive care services provide essential support to acute care and complex elective surgery within the health care system in New Zealand (Intensive Care Clinical Advisory Group, 2005).

2.2.1 The New Zealand Context

In New Zealand a critical illness requiring admission to a general intensive care unit affects over 17,000 New Zealanders per year. The most recent survey by the Australia and New Zealand Intensive Care Society (ANZICs) Centre for Outcome and Resource Evaluation (2010) reported that in New Zealand in 2009/2010 the annual number of patients treated in public hospital ICUs stood at 17,418. These admissions comprised 2.8% of District Health Board (DHB) inpatient hospitalisations based on 2008/2009 data stating there were 644,826 inpatient discharges in the public sector (New Zealand Ministry of Health, 2011). The latest figures outlined by Drennan, Hart and Hicks (2010) identify 24 public hospital ICU’s in New Zealand, providing 186 available beds\(^2\) and 166 ventilator beds\(^3\). On the basis of the population of New Zealand, DHB ICUs supply 4.39 available beds and 3.91 ventilator beds per 100,000 people (Drennan et al., 2010).

As previously discussed, patients are admitted to ICU when one or more body system cannot maintain physiological homeostatic equilibrium without intensive therapeutic support. However, there are varying degrees of organ failure and levels of intensive care support. Adult intensive

\(^2\) An available ICU bed is one which is configured to intensive care standards and is fully funded and staffed (Drennan et al., 2010).

\(^3\) A ventilator bed is a physical intensive care bed plus ventilator (Drennan et al., 2010).
care units in New Zealand are categorised from level I to level III, depending on the complexity of the patient’s condition and the level of care needed to meet such complexity. In general, smaller hospitals require ICUs that provide basic intensive care at level I or II. Level I ICUs are capable of providing critically ill patients with short term cardio-respiratory support for a period of at least several hours, while Level II ICUs provide a high standard of general intensive care, including complex multi-system life support, for a period of at least several days (College of Intensive Care Medicine of Australia and New Zealand, 2011). Critically ill patients who need comprehensive intensive care management and access to sophisticated investigative facilities are managed in an Level III ICU located in a large tertiary referral hospital (Hawker, 2009). These ICUs are capable of providing complex multi-system life support for an indefinite period (College of Intensive Care Medicine of Australia and New Zealand, 2011). In New Zealand, 58% of available ICU beds are located in Level III ICUs (Drennan et al., 2010). These units are staffed 24 hours a day by consultants, registrars and nurses and provide a varied clinical workload and case-mix of patients to maintain a high level of clinical experience, expertise and education of staff (College of Intensive Care Medicine of Australia and New Zealand, 2011).

2.2.2 Intensive Care Nursing

In New Zealand, intensive care units are exclusively staffed by registered nurses (RNs). The latest available data shows a total of 2,135 RNs working in intensive care/cardiac care which represents 5.04% of the total RN workforce in New Zealand (Nursing Council of New Zealand, 2010b). Intensive care nurses are the primary carer at the bedside and the around the clock constant health professional for critically ill patients and their families, providing one-to-one nursing care. They ensure safety and provide continuity and fine tuning, coordinating and communicating all the elements of treatment and care needed by the patient (Welch & Theaker, 2009). The patient condition in the intensive care setting is critical, rapidly changing, and life threatening compared with patients in other hospital settings. Nurses working within an intensive care unit must undertake continuous complex monitoring and assessment; administer, coordinate and evaluate high intensity therapies and respond promptly to sudden changes in a patient’s condition (British Association of Critical Care Nurses, 2009). The Nursing Council of New Zealand demands that nurses must apply their knowledge and skills in a competent and

---

4 The Nursing Council of New Zealand governs registration and the practices of nurses by setting and monitoring standards of practice, which ensures safe and competent care for the public of New Zealand.
safe way (Nursing Council of New Zealand, 2009). For an intensive care nurse the application of a scientific knowledge base, particularly pharmacology, is crucial to provide proactive, safe and effective care, alongside good clinical assessment and communication skills (Pirret, 2007).

2.3 PHARMACOLOGICAL MANAGEMENT OF ICU PATIENTS

An essential component of intensive care nursing is the administration and monitoring of medications. The pharmacological management of these patients is usually complex and, as such, highly specialised knowledge is required (Smythe, Melendy, Jahns, & Dmuchowski, 1993; Sulosaari, Suhonen, & Leino-Kilpi, 2011). Medication is often needed to improve and maintain adequate cardiovascular/circulatory status/perfusion, respiratory function, renal function and gastrointestinal function and to treat infection. But in addition, intravenous (IV) anaesthetics/sedatives, neuromuscular blocking agents and opioid analgesics medications are required, both as intermittent IV injection and continuous infusions, to facilitate treatments and most importantly, the use of life support equipment such as mechanical ventilation (Foster, Kish, & Keenan, 2002; Fuchs & Von Rueden, 2008; D. L. Jackson, Proudfoot, Cann, & Walsh, 2009; Mehta et al., 2006; Watling, Dasta, & Seidl, 1997). The number of invasively ventilated patients in public hospital ICUs in 2007/2008 was 7,056; representing 39.5% of ICU patients (Drennan et al., 2010), meaning that these particular medications are commonly administered by nurses.

2.3.1 Sedatives, Opioid Analgesics and Neuromuscular Blocking Agents

2.3.1.1 Sedation

Patients who are receiving mechanical ventilation often have pain, anxiety, dyspnoea, and other forms of distress. An integral part of the complex management of this group of patients is the use of sedative agents, to promote tolerance of an endotracheal tube and mechanical ventilation, minimise the discomfort associated with invasive procedures and suctioning, relieve anxiety, control agitation and reduce the risk of accidental self-extubation (Gomers & Bakker, 2008; Park, Lane, Rogers, & Bassett, 2007; Payen et al., 2007; Sessler & Varney, 2008). Sedation also improves synchronisation of a patient’s breathing with mechanical ventilation (I. Egerod, 2002).
Two agents commonly employed for the provision of sedation within the ICU are midazolam and propofol (Fuchs & Von Rueden, 2008). A widely accepted theory regarding the action of both propofol and midazolam is that they interact with the inhibitory γ-aminobutyric acid (GABA) neurotransmitter system, in particular the GABA-A receptors. GABA is the major inhibitory neurotransmitter in the central nervous system. When GABA binds to a GABA-A receptor in the brain, it opens chloride (Cl) channels, resulting in an influx of Cl ions which causes the neuron to be hyperpolarized inhibiting conduction of a neural impulse (Enna, 2007). In addition to the primary binding sites for GABA, the GABA-A receptor has other secondary binding sites for drugs such as midazolam and propofol that enhance the activity of this neurotransmitter system (Noback, Strominger, Demarest, & Ruggiero, 2005).

By attaching to the GABA-A receptor midazolam (a benzodiazepine) increases the frequency of chloride channel opening in response to GABA (Enna, 2007; Rowe & Fletcher, 2008) resulting in anxiolysis, sedative and amnesic effects (Devlin & Roberts, 2009; Fassoulaki, Theodoraki, & Melemeni, 2010; Hall, Schweickert, & Kress, 2009; Young, Knudsen, Hilton, & Reves, 2000). Propofol (an intravenous general anaesthetic) seems to act on the GABA-A receptor at a locus distinct from the site of action of midazolam (Monroe, Hamza, Stocks, Scimeca, & Cowan, 2011) and it is thought it may prolong the duration of chloride channel opening in response to GABA (Enna, 2007). It produces rapid loss of consciousness, exhibits sedative and hypnotic properties at even low doses and has amnesic properties similar to that of the benzodiazepines (Hall et al., 2009; McKeage & Perry, 2003). Propofol’s rapid onset and short duration of action means it is easier to titrate than benzodiazepines, and for these reasons it is the preferred sedative for patients in whom quick awakening is important to facilitate accurate neurological examination or weaning from ventilation (Devlin & Roberts, 2009).

Midazolam and propofol are recommended by the Society of Critical Care Medicine as preferred agents for short-term sedation (Jacobi et al., 2002). Shehabi et al. (2008) conducted a survey to determine sedation practices in Australian and New Zealand intensive care units. Twenty-three predominantly metropolitan, level III Australian and New Zealand intensive care units treating adult patients participated. Midazolam and propofol were found to be the most commonly used sedatives with 52% indicating that midazolam was the primary agent used for sedation and 30% primarily using propofol. In a more recent study which also explored sedative and analgesics
practices in New Zealand intensive care units, propofol was found to be the most commonly used ICU sedative, followed closely by midazolam (O’Connor, Bucknall, & Manias, 2010). This result is congruent with results of previous studies in Australia (Botha & Le Blanc, 2005; Magarey, 1997), Europe (I. Egerod, Christensen, & Johansen, 2006; Payen et al., 2007) and North America (Hong, Mazuski, & Shapiro, 2000; Mehta et al., 2006).

2.3.1.2 Analgesia

Pain is the primary cause of the distress that many ICU patients experience. The predisposing and causative conditions that provoke pain include underlying medication conditions and acute medical or surgical illness, as well as many routine aspects of intensive care such as indwelling tubes and catheters and nursing interventions such as turning (Sessler & Wilhelm, 2008). Opioid analgesic medications, such as morphine, remain the mainstay of therapy for alleviating pain in the ICU patient (Jacobi et al., 2002). This class of agent is also frequently used because of its sedative properties and to facilitate mechanical ventilation given its potent respiratory depressant effects (Devlin & Roberts, 2009). Opioid receptors (mu, kappa and delta) are widely distributed in the brain, spinal cord and peripheral sensory and autonomic nerves. These receptors are normally stimulated by endogenous peptides (for example endorphins), which are produced in response to noxious stimulation and act on the central nervous system to modify nociceptive pathways and reduce the perception of pain (Trescot, Datta, Lee, & Hansen, 2008; Vallejo, Barkin, & Wang, 2011). Morphine, as an opioid agonist, elicits its action through stimulation of the mu, kappa and delta receptors, although the mu receptor is the primary site of opioid activity. Stimulation of the mu receptors leads to inhibition of pain transmission, thus altering the perception and response to pain (Devlin & Roberts, 2009).

Morphine was identified in the Australian/New Zealand study by Shehabi et al. (2008) as the primary analgesic used in the ICUs with 84% of participants indicating that they used morphine in greater than 51% of patients. Furthermore, 54% of sedated patients were reported to receive an opioid (morphine or fentanyl) as well as either midazolam or propofol. Often combined therapy with an opioid analgesic and midazolam or propofol is used to provide synergistic sedation (Luer, 2000; Park et al., 2007).
2.3.1.3 Neuromuscular blocking agents

Neuromuscular blocking agents (NMBAs) are potent paralytic agents that work by blocking impulse transmission at the neuromuscular junction in all skeletal muscles, by competing with acetylcholine at the receptor sites in the post synaptic terminal (Prielipp, 1998). This prevents binding of acetylcholine, which in turn prevents depolarisation, contraction, and muscle movement, prohibiting all voluntary muscle activity including breathing. NMBAs are given to critically ill individuals to facilitate endotracheal intubation and decrease intracranial pressure (Foster et al., 2002; Mehta et al., 2006). They are often also necessary for procedures, such as insertion of central lines and CT scans (Levins, 2002). However, management of mechanical ventilation is the most common reason for on-going NMAB use and may be considered when use of the maximal dosage of sedative and analgesic agents has not achieved the desired goal of compliance with the ventilator (Klessig, Geiger, Murray, & Coursin, 1992; M. J. Murray et al., 2002). This situation occurs most often in patients with persistent severe hypoxemia related to respiratory disease and patients who require complex ventilator modes for when respiratory effort must be controlled (Luer, 2000; van Heerden, 2009).

Non-depolarising agents such as rocuronium are the most commonly used neuromuscular blocking agents in the ICU (van Heerden, 2009). As NMBAs have no sedative, amnesic, anxiolytic, or analgesic properties (Wild, 1991), adequate attention to analgesia and appropriate deep sedation is needed, therefore they must be used in conjunction with sedatives and analgesics such as benzodiazepines and opiates (Phillips & Williams, 2006; Tripathi & Hunter, 2006).

2.3.1.4 Administration and management

Sedative, opioid analgesics and neuromuscular blocking drugs are prescribed in ICU using a range of bolus doses on an ‘as-needed’ basis and/or as continuous infusions, giving the nurse leeway in selecting the dose and frequency or infusion rate (Dasta, Fuhrman, & McCandles, 1994; I. Egerod, 2002; K. Murray, 1997; Slomka et al., 2000). In respect to sedative and analgesic infusions, the nurse increases and decreases the rate of infusion (Magarey, 1997) to achieve target sedation and for NMBAs infusions to achieve ventilator compliance. How sedatives, opioid analgesics and neuromuscular blocking agents are used can have a significant influence on patient outcome (Cullis & Macnaughton, 2007). Incorrect use of these medications,
or incompetent practices related to their assessment and monitoring, can cause harm to the patient (Ryan, Vortherms, & Ward, 1994; Taxis & Barber, 2003).

2.4 MEDICATION ERRORS

Incorrect or inappropriate administration of medications to hospital inpatients represents a major threat to the public’s health. A medication error is one of the most common types of medical errors and is defined as “... any preventable event that may cause or lead to inappropriate medication use or patient harm, while the medication is in the control of the health care professional, patient, or consumer” (The National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP), 2012, para. 1). Medication errors are associated with a substantial increase in patient morbidity and mortality rates (Van den Bemt et al., 2002), and are reported to be the seventh most common cause of death overall (Stelfox, Palmisani, Scurlock, Orav, & Bates, 2006). The latest data from New Zealand District Health Boards reported 25 serious and sentinel events related to medication errors in the 2010/2011 reporting year (Health Quality & Safety Commission, 2012). They represent 7% of the total number of serious and sentinel events (the third largest category), and have increased over the past three years (Health Quality & Safety Commission, 2012).

The literature that explores medication errors frequently links errors to specific professional traits, focusing on individual practitioner’s attributes, skill levels and competencies (McBride-Henry & Foureur, 2006). It is commonly reported that an individual practitioner may contribute to a medication error through a lack of general knowledge about medications (Armitage & Knapman, 2003; Donchin et al., 1995; Kawamura, 2001; Keikkas, 2011; King, 2004; Leape et al., 1995; Meurier, Vincent, & Parmar, 1997; Tissot et al., 2003; Wolf, Hicks, & Serembus, 2006) and studies have suggested that enhanced teaching in the area of pharmacology is vital for patient safety (Barach & Berwick, 2003; Battles & Shea, 2001; Bion & Heffner, 2004; Blue, 1989; Carlton & Blegen, 2006; Deans, 2005). Causes of medication errors according to Cohen, Smeltzer, Tuohy and Kilo (2007) also include inadequate staff orientation and ongoing education.
In their landmark article on systems analysis of adverse drug events, Leape et al. (1995) identified lack of knowledge of the drug as one of the proximal causes of medication errors. The Institute for Safe Medication Practices (ISMP)\textsuperscript{5} recognises that the potential for medication errors and adverse drug events is a reality, and that prevention efforts rely heavily on the knowledge and ability of healthcare professionals. ISMP has identified education as one of the ten key elements that have the greatest influence on safe medication use (Institute for Safe Medication Practices, 2011).

\subsection*{2.4.1 The ICU Context}

Although safety culture has been investigated in New Zealand ICUs (Roberts, 2003), to date no data is available on medication errors. However, an exceptionally high prevalence of medication errors has been reported to occur in the adult intensive care setting overseas (Andrews et al., 1997; Bates et al., 1995). Medication errors have been reported as accounting for 45\% to 78\% of serious medical errors in the ICU (Rothschild et al., 2005; Van den Bemt et al., 2002). The ICU brings together high-risk patients who require urgent, complex interventions in a complex environment where patients are exposed to twice as many medications as those in general medical wards (Kane-Gill, Jacobi, & Rothschild, 2010). Patients who are critically ill are more likely to have life threatening consequences to adverse drug events than any other patient population due to their diminished physiologic reserves (Camire, Moyen, & Stelfox, 2009; Cullen et al., 1997).

The complexity of an ICU patient’s disease (Valentin et al., 2006), the need for sedation and artificial ventilation (Hussain & Kao, 2005) and the fact that potent drugs are given frequently, at times in haste or stress (Kane-Gill et al., 2010; Orser, Chen, & Yee, 2001; Weingart, Wilson, Gibberd, & Harrison, 2000) are all given as reasons for this high number of medication errors. However, the most important risk factor for medication errors in ICU is the greater number of IV medications that these patients receive (Paix, Bullock, Runciman, & Williamson, 2005; Van den Bemt et al., 2002). A study completed by Bates, Vanderveen, Seger, Yamaga and Rothschild

\textsuperscript{5} The ISMP is the USA’s only non-profit health care agency comprising pharmacists, nurses and physicians and is devoted entirely to medication error prevention and safe medication use.
(2005) found that 61% of serious potential medication errors involved IV medications, a finding supported by Kaushal et al. (2001). Given the rapid onset of IV medications, errors that occur in this method of therapy have great potential for patient harm (Hicks & Becker, 2006). In particular sedatives, opioids and neuromuscular blocking agents have been reported to be some of the most common IV medications involved in errors (Calabrese et al., 2001; Kopp, Erstad, Allen, Theodorou, & Priestley, 2006; Raja Lope et al., 2009; Rothschild et al., 2005). In fact sedatives, opioids and neuromuscular blocking agents all make the ISMP list of high alert medications compiled by the ISMP from error reports submitted through their error reporting programme, reports of harmful errors in the literature and input from practitioners throughout the USA (Institute for Safe Medication Practices, 2011). High alert medications are those which have a much higher risk of causing harm when they are used in error (Golembiewski & Wheeler, 2007).

2.4.1.1 Knowledge for safe administration

Given their high-risk status, the wide margin of discretion in dose and frequency of administration that nurses have and the fact that poor knowledge has been reported to contribute markedly to medication errors, it is pertinent that intensive care nurses have thorough knowledge and understanding of the pharmacological profile, actions and effects of sedatives, opioids and NMBAs to ensure their safe and appropriate use. Inadequate sedation and analgesia exacerbates anxiety, agitation and delirium and increases the risk of adverse events such as extubation (Boulain, 1998; D. L. Jackson et al., 2009; Jacobi et al., 2002). It can also stimulate various stress responses, resulting in tachycardia, increased myocardial oxygen consumption, reduced lung volumes and immunosuppression and ultimately increased morbidity and mortality (Fuchs & Von Rueden, 2008; Luer, 2000; Rhoney & Murry, 2003). Conversely, patients receiving these agents may be over-sedated as a result of drug accumulation when doses are administered more frequently than the onset of action (Kane-Gill et al., 2010). Excessive sedation can prolong mechanical ventilation times, increase the risk of nosocomial infection, render neurological assessment difficult and extend length of stay (Pun & Dunn, 2007; Shehabi et al., 2008). Similarly, excessive dosing of NMBAs, or continued unnecessary use, leads to prolonged paralysis and muscle atrophy and can impede weaning from ventilation and prolong the ICU stay (Sladen, 1995; van Heerden, 2009).
Nurses’ awareness of usual dosage, indications for use, pharmacodynamics\(^6\) and pharmacokinetics\(^7\) of these medications is critical to making safe decisions around increasing or decreasing infusion rates, determining appropriate bolus doses and intervals, monitoring therapeutic response and ensuring that appropriate ventilation settings and other supportive measures are in place (Arbour, 2003; Levins, 2002). In addition to this, there needs to be awareness and consideration of how the patient’s clinical condition and co-morbidities impact upon the pharmacodynamics and pharmacokinetics of sedatives, opioids and NMBAs and whether contraindications to administration exist (Davidson et al., 2001; Zagli et al., 2008). This knowledge is also required in order to anticipate, recognise and manage adverse effects, which in the case of midazolam, propofol and morphine can include significant cardio-respiratory depression (Arbour, 2000; Cullis & Macnaughton, 2007; Heeremans & Absalom, 2010; Pandit, 2011), particularly in hypovolaemic, septic or elderly patients (Hubner & Jain, 1996; Soppitt, 2004).

### 2.5 SUMMARY

The critical care environment brings together high-risk patients and high-risk medications in a complex environment with constantly changing personnel over 24 hours. Effective, successful medication management of ICU patients requires safe administration, vigilant monitoring of effects and sound knowledge of pharmacology. The use of opioid analgesics, sedatives and NMBAs are fundamental in the treatment of ventilated ICU patients and specific pharmacology knowledge is essential in ensuring safe and appropriate use of these agents. Drawing from research on critical care settings from New Zealand and other countries identifying the most frequently administered analgesics, sedative and neuromuscular blocking agents in ICUs; propofol, morphine, midazolam and rocuronium were chosen to be the drugs examined in this study.

---

\(^6\) Pharmacodynamics is the biochemical and physiological effects of drugs on the body and their mechanism of actions.

\(^7\) Pharmacokinetics is the movement of drugs within the body and includes absorption, distribution, metabolism and excretion.
CHAPTER THREE: LITERATURE REVIEW

3.1 INTRODUCTION

This chapter provides a review of the nursing literature on pharmacology and is presented in four sections. In the first section, pharmacology education is examined, with a focus on the adequacy of undergraduate pharmacology education, both here and overseas, in preparing nurses for medication administration roles and perceptions of nurses’ abilities to comprehend pharmacology knowledge. Section two introduces and outlines studies which have tested the pharmacology knowledge of nurses working in community and hospital settings, including intensive care. The third section focuses on studies which have looked to compare nurses’ actual and self-rated knowledge. The final section provides an overview of studies examining nurses’ knowledge of opioids, sedatives and NMBAs. To conclude, a summary of the research gaps identified in the literature and the implications of the current study’s research aims are outlined.

3.2 PHARMACOLOGY IN NURSING EDUCATION

The biological sciences, such as physiology, anatomy and pharmacology provide the scientific underpinning for nursing practice necessary for interpreting clinical situations and for complex decision making, and as such are an integral part of nursing education (Drew, 1988; Funnell, Koutoukidis, & Lawrence, 2009; Jordan & Reid, 1997; Meechan, Mason, & Catling, 2011). Although all biological sciences are fundamental in understanding medications, pharmacology is the most important contributor to specific drug knowledge for nurses and as such is an essential core subject in pre-registration nursing programmes (Morrison-Griffiths, Snowden, & Pirmohamed, 2002). Medication administration relies on a thorough knowledge of pharmacology, provided by well delivered and appropriate education in undergraduate courses, both in the classroom and clinical placements. Literature from the last three decades repeatedly suggests that in many instances nurse education has not ensured adequate theoretical knowledge of pharmacology to enable nurses to understand medications or to safely carry out their medication management responsibilities (Banning, 2003; Boggs, Brown-Molnar, & DeLapp, 1988; Jordan & Reid, 1997; Latter, Rycroft-Malone, Yerrell, & Shaw, 2001; Manias & Bullock, 2002a, 2002b; Morrison-Griffiths et al., 2002; Ndosi & Newell, 2009). Armitage and Knapman
propose that 40% of a nurse’s clinical time is involved with the administration of medicines, yet there has been an assertion that the amount of time that nurses spend in medication administration and related activities is not adequately reflected by the amount of time devoted to pharmacology teaching within the clinical area or academic institutions (Ashurst, 1993; Morrison-Griffiths et al., 2002).

3.2.1 Pharmacology: Teaching and Learning

The biological science component of pre-registration nurse programmes has been the focus of much discussion in the literature. An increasing number of nurse academics have raised concerns about the amount of science being delivered in nursing curriculums, with many stating that the amount, level and depth of biological science education is very variable and inadequate (Akinsanya, 1987; Courtenay, 1991; Jordan & Potter, 1999; McVicar & Clancy, 2001; Wharrad, Allcock, & Chapple, 1994). Trnobranski (1993) concludes the move away from the scientific subjects within nursing education has occurred as a result of nursing’s quest to claim a body of knowledge distinct from medicine, with a focus on ‘caring’ rather than ‘curing’. The adoption of the philosophy of holism led to an increasing interest in the behavioural sciences, however over the last three decades there have been concerns that this strong emphasis on the social sciences such as psychology, sociology, ethics and health policy has come at the detriment of the biological sciences such as pharmacology (Clarke, 1995; Courtenay, 2002; Drew, 1988; Manias & Bullock, 2002b; Trnobranski, 1993; N. Wynne, Brand, & Smith, 1997). Ashurst (1993) states that this is producing nurses who have inadequate scientific knowledge to maintain safe clinical practices around medication administration and related activities, and there have been calls by others for increased teaching in this discipline (Banning, 2003; Torrance & Jordan, 1995).

3.2.1.1 Curriculum time

National and international studies canvassing the views of students and clinical nurses consistently report that these groups feel that insufficient time is allocated to the biosciences and express a wish for more education in these areas in order to prepare them for practice (Clancy, McVicar, & Bird, 2000; Davies, Murphy, & Jordan, 2000; Jordan, Davies, & Green, 1999; Nicoll & Butler, 1996). A New Zealand study by Friedel and Treagust (2005) used an interpretative survey strategy to collect both quantitative and qualitative data from nurse educators and nursing students from one New Zealand tertiary institution offering a pre-
registration nursing programme in order to examine bioscience in the pre-registration nursing curriculum. As with the overseas studies, the 155 student participants concurred that there was not enough bioscience in the curriculum, with 81% of students stating they wanted more teaching in this area, although it did not specifically address pharmacology content.

King (2004) whose UK study explored nurses’ perceptions regarding the adequacy of pre-registration pharmacology education, used a qualitative approach to collect data from a purposive sample of 10 qualified nurses from an emergency admissions unit in a city in the north of England. Nine of 10 respondents felt that they did not spend enough time on pharmacology in their pre-registration courses and 4 of 10 respondents felt that this was due to an over-emphasis on other subjects (psychology, sociology and communication studies). The limitation of this study is that it consisted of only a small of participants. Moreover, it was identified by the authors that these participants expressed an interest in this area of nurse education and therefore their views may have been biased. Despite these limitations however, other studies support this view by nurses about the inadequacy of pharmacology curriculum time (Candela & Bowles, 2008; Courtenay, 1991; Davis, 2009; Latter, Rycroft-Malone, Yerrell, & Shaw, 2000; Manias & Bullock, 2002b; Morrison-Griffiths et al., 2002; Wharrad et al., 1994).

Jordan et al. (1999) determined in their survey of 339 pre-registration nursing students and all nursing lecturers (n=73) at a UK university that, in contrast to the majority of students (78%), few lecturers (12%) thought too little time was allocated to pharmacology modules and in fact 18% expressed the view that pharmacology input should be reduced. More recent research however, has revealed opposite opinions. Latter et al. (2001) performed a national survey in England of pharmacology lecturers in 51 institutions delivering pre and post registration nursing education, in order to gain an overview of pharmacology curriculum design. Within the 47 institutions that took part there was a general dissatisfaction among teachers with the amount of pharmacology included within the curricula, with only 25% of respondents considering that there was sufficient time in the curriculum dedicated to pharmacology. Additionally, in a study by Bullock and Manias (2002) of undergraduate nursing lecturers in Victoria, 56% of respondents indicated that they too were dissatisfied with the curriculum time for pharmacology and 34% considered that the graduates had insufficient knowledge for safe practice. Great variation was also found between institutions as to the number of hours devoted to pharmacology; a finding
noted by other researchers (Dilles, Vander Stichele, Van Bortel, & Elseviers, 2011; Morrison-Griffiths et al., 2002).

Nurse educators have also acknowledged problems in their own ability to understand biological sciences (Courtenay, 1991), potentially further affecting how much pharmacology teaching is delivered and contributing to course material being superficial in its content. Friedel and Treagust (2005) found that 69% of the teachers (n=29) in their New Zealand study stated that they would like to have a better knowledge of bioscience and almost half perceived that their science background was not good enough to understand the bioscience currently needed in nursing practice. McVicar et al. (2010) suggest that poor biological knowledge and confidence of clinical nurses’ further limits the opportunities for bioscience learning that are able to be extended to nursing students and new staff by nurse preceptors\(^8\) in the practice setting. The need for more educational support for bioscience within post-registration programmes to help address issues with teaching and learning and hence extend knowledge was highlighted by these researchers.

### 3.2.1.2 Pharmacology: difficulty, knowledge deficits and confidence

It is well reported in the literature that biological sciences are academically difficult subjects for nurses. Students express a high level of concern about studying bioscience, and perceive this to be the most difficult aspect of their nursing programme (Akinsanya, 1987; Barclay & Neill, 1986; Caon & Treagust, 1993; Gresty & Cotton, 2003; Jordan et al., 1999; McKee, 2002; Nicoll & Butler, 1996; Wharrad et al., 1994). In a recent study Fenton (2010), investigated 71 New Zealand nurses’ attitudes to their science education and the use of bioscience in their practice and found that only 51% of those surveyed found the science subjects easy. Similarly, nurse educators and lecturers have also indicated awareness that biosciences are the students most problematic subjects (Chapple, Allcock, & Wharrad, 1993; Clarke, 1995; Jordan et al., 1999; Wharrad et al., 1994). It appears that the lack of consistency across educational programmes and students difficulties in learning science may hinder the acquisition of fundamental pharmacology knowledge (Banning, 2003; Courtenay, 1991; King, 2004; Latter et al., 2001; Manias, 2009).

---

\(^8\) A preceptor is a nurse who assists a practitioner who is new to a practice area, to achieve a competent level of nursing practice (New Zealand Nurse Educators Preceptorship Subgroup, 2010).
Australian research by Manias and Bullock (2002a) undertook to explore the perceptions and experiences that clinical nurses have of graduate nurses’ pharmacology knowledge. Six focus group interviews were conducted with nurse unit managers, clinical nurse consultants and bedside nurses at two metropolitan and two regional public hospitals in Victoria, Australia. Two major themes emerged from the study: First, participants indicated that graduate nurses had an overall lack of depth in their pharmacology knowledge. Secondly, participants perceived there were knowledge deficits relating to specific groups of medications that were commonly used in the clinical area and poor understanding of pharmacology terminology. However, there was also a general perception that all clinical nurses, regardless of experience, had some deficits in their own knowledge of pharmacology.

Manias (2009) a frequently cited author in this field, argues that this lack of education in pharmacology, and the perceived difficulties related to learning pharmacologic principles results in nurses who lack confidence in drug therapy. Courtenay (1991), Hart and Macnee (2007), Manias and Bullock (2002a) and Latter et al. (2001) are supporters of this view. This was a finding identified in student group interviews (n = 87) conducted by Latter et al. (2000) where students indicated that they did not feel confident talking to patients about their medications. More recently in New Zealand, Honey and Lim (2008) undertook a survey of 60 students who had recently completed their final clinical placement. Of the 54 students who responded, there was expression of a lack of confidence in their depth of pharmacology knowledge and their ability to apply this knowledge to clinical practice. A lack of confidence by nurses in how to apply bioscience knowledge to practice has also been noted elsewhere (Clancy et al., 2000; Sturgeon, 2008; Wilkes & Batts, 1998).

Such difficulties in understanding the knowledge taught and lack of confidence have been reported as major sources of anxiety amongst students and nurses (Akinsanya, 1987; Caon & Treagust, 1993; Chapple et al., 1993; Courtenay, 1991; Friedel & Treagust, 2005; Nicoll & Butler, 1996; Race & Holloway, 1992; Sutcliffe, 1993; Wharrad et al., 1994). Mooney (2007) conducted interviews with nurses in Ireland, who had been supernumerary during their pre-registration programme, to explore aspects of the transition from student to staff nurse. Data were gathered using in-depth interviews with 12 nurses who were within one year of qualification. Each respondent expressed concerns about drug administration and felt unable to
match their theoretical and practical pharmacology information. There was also a sense of fear or significant anxiety associated with the lack of knowledge of pharmacology, with a real concern that a mistake may be made. Such studies highlight a need to improve nurses' levels of confidence and their abilities in coping with medication-related issues at pre-registration and post-registration level (Sodha, McLaughlin, Williams, & Dhillon, 2002). Jordan and Hughes (1998) showed that participation in a bioscience course could enhance confidence levels regarding a sufficient knowledge of pharmacology, which is consistent with other recent and relevant research which demonstrates clearly that more pharmacology education correlates with better knowledge (Ives et al., 1996) and confidence in clinical practice (Bullock & Manias, 2002; Jordan & Hughes, 1998; Nicoll & Butler, 1996).

3.2.2 Pharmacology Education: The New Zealand Context

United Kingdom researchers Morrison-Griffiths et al. (2002) suggest that there are insufficient guidelines from nursing regulatory bodies, contributing to much variety in the content and delivery of pharmacology education at nursing schools. Likewise, in New Zealand there is considerable variation between institutions with regards to the amount and delivery of pharmacology education. Some nursing schools teach pharmacology only in the first year of study, while others carry it over into the second or third year (Fenton, 2010; A. G. Lim & Honey, 2006). In addition, many nursing schools teach science curricula, including pharmacology, as discreet subjects (Fenton, 2010), whereas others teach pharmacology in an integrated fashion throughout the undergraduate nursing programme (A. G. Lim & Honey, 2006).

The Nursing Council of New Zealand is the syllabus-setting body, but does not prescribe the curriculum or the content in any detail, leaving the depth and breadth of curriculum content to be determined by each individual nursing education institution. In the Nursing Council of New Zealand’s ‘Education Standards for Registered Nurse Scope of Practice’ (2005), it states that registered nurses require “bioscience, social and behavioural science, pharmacology, pathophysiology, genetics and disease states” (p. 5) in their educational programmes. The content includes pharmacology in order for the students to “achieve the competencies and standards for registration” (Nursing Council of New Zealand, 2005, p.5). In 2008, the nursing council requested that the education programme standards for the registered nurse scope of practice be reviewed to ensure their relevance and effectiveness in preparing safe and competent
new graduate registered nurses. A comprehensive consultation process was initially undertaken within the sector. Clinically based staff considered that pharmacology knowledge and the nursing role in medicine management was increasingly relevant to everyday practice and this area should be increased in the curriculum (Nursing Council of New Zealand, 2010c). In July 2010 new standards were developed which state that: “The programme specifically requires students to demonstrate, in practice at a graduate level,...pharmacology knowledge and medicine management” (Nursing Council of New Zealand, 2010a, p. 6). This was to be implemented by February 2012 and shows a greater commitment to pharmacology education, however it does not detail what specific knowledge or concepts this should include or how it should be assessed. Regardless of the way in which pharmacology education is delivered, Honey and Lim (2008) assert that the curriculum should make explicit the pharmacology content required in the undergraduate nursing programme, that this content should focus more on the fundamental principles of pharmacology in order to facilitate nurses’ understanding and confidence in the use of medications in practice.

3.3 PHARMACOLOGY KNOWLEDGE IN PRACTICE

It is well documented that nurses acknowledge the importance of biological sciences to nursing practice (Courtenay, 1991; Davis, 2009; Friedel & Tregust, 2005; Kinsella, Williams, & Green, 1999; Sutcliffe, 1993). In Fenton’s (2010) New Zealand research, 85% of 71 nurses believed that in-depth knowledge of science was important for them to have. Few studies, however have examined the views on nurses as to the importance of pharmacology knowledge to practice. Davis (2009), in a study of 42 RNs entering a Nurse Prescriber programme reported that 64.3% of respondents indicated they considered pharmacology to be ‘fairly’ or ‘highly’ relevant. In a South African survey by Kyriacos, Jordan and van den Heever (2005), all 54 nurses from a range of clinical hospital settings saw pharmacology as relevant, with 75% perceiving it as essential; however 11 out of 54 nurse respondents (20.4%) felt they only a superficial understanding of pharmacology. Being small sample sizes and undertaken overseas, the results may not be generalisable to the New Zealand context, however they provide an interesting insight into the views of nurses in regards to this area of nursing knowledge.
Authors have repeatedly asserted that comprehensive pharmacology knowledge is critical in order to safely meet the medication management role of clinical nurses (Banning, 2003; Jordan & Reid, 1997; Manias & Bullock, 2002a; Trnobilanski, 1993; Wharrad et al., 1994; White, 1993). Nurses need to ensure that they are fully informed and confident in their knowledge of all aspects of safe pharmacological practice (Bray & Ghose, 1993). To provide optimal patient support in relation to medicines, nurses require sound and comprehensive knowledge of the actions and effects of all medicines being administered to patients in their care (Dreyer, 2007). Although retention of detailed information on all of the individual differences between drug classes is not feasible given the many thousands of medications available, it is reasonable to expect that nurses should have a comprehensive understanding of those medicines that are commonly administer in their particular practice area and the ability to look up appropriate information about others.

3.3.1 Nurses’ Tested Pharmacology Knowledge

Despite serious concerns being raised about the teaching of pharmacology and the understanding of it by nurses for the last 30 years, few studies have sought to test nurses’ pharmacology knowledge in their clinical practice area. Those which have however have comprehensively done so by way of tests and exams. The following section will introduce the national and international literature pertaining to tested knowledge.

In one of the earliest studies in this area, Markowitz, Pearson, Kay and Loewenstein (1981) assessed the medication knowledge of 14 pharmacists, 102 physicians and 100 nurses in a United States (US) hospital. Knowledge of medication was related to six broad areas: drug dosage and administration, drug interactions, adverse drug reactions, interpretation of clinical data and contraindications. All drugs referred to in the questionnaire were commonly used agents. The questions were in either multiple choice or true-false format. Nurses involved in the study included all registered nurses in a position to administer drugs to medical, paediatric and surgical inpatients. The group mean score for the nurses was 72.3 out of 100, compared with 81.3 for the physicians and 85.4 for the pharmacists. The authors reported that nurses had significantly less pharmacology knowledge in all areas than physicians and pharmacists, and that nurses’ knowledge was poor. However, a limitation of this study is the fact that the nurses had to take the same test as doctors and pharmacists, groups that have increased pharmacological
knowledge and roles in medication management that are quite different to nurses. Therefore this may not have been an appropriate tool from which to assess or determine the adequacy of nurses’ knowledge.

Boggs et al. (1988), also in the USA, used a multiple choice exam to test nurses’ knowledge of three commonly administered drugs. Four hundred and fifty nurses were surveyed in four local hospitals, with an overall response rate of 44%. The 36-item multi choice test covered six fundamental areas of pharmacology knowledge: clinical indication, dosage range, mechanism of action, drug interactions, side effects and pharmacokinetics. The nurses’ scores ranged from 8-75% with a mean score of 46.42%, indicating an inadequate level of knowledge. They found that nurses were the least knowledgeable about pharmacokinetics and also scored poorly on questions relating to dosage, mechanism of action and drug interactions. Nurses had greater knowledge in the areas of drug indications and side effects. Experience as an RN was not related to medication knowledge nor was the frequency with which the medications were administered. The authors deemed a drug knowledge exam for new nurses and on-going evaluation as necessary and stated that in-service education was indicated.

The studies by Markowitz et al. (1981) and Boggs et al. (1988) are both dated and differences exist in the nursing curricula between these two countries. Therefore they may not accurately reflect the current pharmacology knowledge of nurses in New Zealand. However, more recent comparable studies within the published literature from the UK, Canada, Australia and NZ, have identified similar themes. A study by O’Donnell (1990) on current practices in resuscitation, saw nurses asked about their knowledge of the drugs used in resuscitation, as part of a questionnaire sent to all the trained nurses in a busy district general hospital in the UK. Of the 155 nurses who responded, knowledge of the drugs used in the treatment of cardiac arrest was found to be poor. Only 6% of the nurses knew the effects of all the drugs given during the treatment of a cardiac arrest, and only 30% were able to identify the mechanism of action of more than half the medications.

Ndosi and Newell (2009) examined the pharmacology knowledge of nurses working in surgical wards of a UK hospital. Data were collected from 42 respondents by structured interview and questionnaire methods. During the interview, the participants made a blinded selection of one of
four drugs they commonly administered and answered seven short answer questions on specific pharmacology knowledge with a score given out of 10. Ndosi and Newell (2009) defined adequate knowledge at 8 or above. The mean knowledge score was six, ranging between two and nine. Only 11 (26.1%) of nurses scored eight or above and the majority 24 (57.2%) scored below seven, indicating inadequate knowledge. Knowledge of the mechanism of action and drug interactions was poor. There were significant differences in the scores obtained by nurses in different grades, with more experienced senior staff achieving higher scores. The limitations to this study included the small sample size which not only limited the use of further comparative tests, but also meant that junior staff members were underrepresented.

In Australia, L.M. Lim, Chiu, Dohrmann and Tan (2010) investigated medication knowledge of registered nurses working in aged care facilities. This exploratory study used a non-randomised pre- and post-test one group quasi-experimental design without comparators. It comprised a 23-item knowledge-based test questionnaire, one-hour teaching session and a self-directed learning package. The volunteer sample was RNs from residential aged care facilities, involved in medication management. Pre-tests showed knowledge deficits in medication management of the elderly and the post-tests showed statistically significant improvement in registered nurses’ knowledge. The findings from this study provide evidence of the importance of continuing professional education on medications.

In Norway, Simonsen, Johansson, Daehlin, Osvik and Farup (2011) carried out a quantitative study in which 212 RNs from two hospitals and three municipalities completed a survey on pharmacology, drug management, and drug dose calculations. In the pharmacology knowledge section multi-choice questions assessed respondents’ knowledge of drug effects, side effects, administration formulas and drug interactions. One hundred and eighty-one (89%) scored 64% or more in pharmacology section of the test. The overall medication knowledge among registered nurses was lower than expected. Postgraduate specialisation was associated with high knowledge.
3.3.1.1 Research from within New Zealand

The only NZ research with a focus on pharmacology knowledge was a descriptive study by Bray (1993) examining nurses’ understanding of, and attitudes to, prescribed medications that they were taking personally. Seventy students and 24 RNs at Otago Polytechnic were surveyed by way of a self-administered questionnaire. Results showed that respondents lacked knowledge about their own medications. Out of the 51 respondents who took a prescribed medication only 61% were aware of potential side effects. The author concludes that there is reason for concern about nurses having responsibility for others medications and offering advice, and cites the need for more pharmacology education for nurses. A limitation to this study is the small convenience sample, however as the only New Zealand pharmacology research study, it provides an important and enlightening view of this area.

3.3.2 Nurses’ Self-Rated versus Actual Knowledge

Research comparing nurses’ actual and self-rated pharmacology knowledge has also been undertaken. Self-reported knowledge is the learner’s own description of the information they possess about a certain subject. In Australia, Ives et al. (1996) studied the actual and self-rated pharmacology knowledge of 363 first year graduate nurses in Victoria using a postal questionnaire. They were asked to self-rate their knowledge of five categories of pharmacology: medication administration, therapeutic effects, adverse effects, patient education and legal aspects of medication administration and to answer questions of the same categories. The survey also obtained data related to aspects of the nurses’ pharmacology education. The findings demonstrated that there was a very wide range of extent of knowledge of pharmacology. The scores of the 363 respondents ranged from 16 to 92%, with a mean score of 56%. Longer experience as an RN was correlated with higher scores, as was participation in a graduate year programme. There was a significant correlation between the groups’ overall self-rating of their knowledge and their total test scores. However, self-rating of knowledge correlated with their test scores only in relation to therapeutic effects. RNs’ self-ratings considerably overestimated their knowledge of drug administration and somewhat overestimated their knowledge of adverse effects, but underestimated their knowledge in relation to client education. Thirty five percent of respondents thought that allocating more time to pharmacology theory would have improved their education in the subject.
Sodha, Williams, Shah and Clegg (2002) sought to compare UK community nurses’ self-rated pharmacology knowledge with their responses to several medication related case studies/scenarios. Of the 59 respondents, 23.7% rated that pharmacology knowledge as poor, 59.3% as average and 14.1% as good. Knowledge on the clinical scenarios was generally poor. There was no correlation between experience and performance in the scenarios, nor was a correlation found between self-rated knowledge and the number of correct responses on the test.

The purpose of a study by Grandell-Neimi et al. (2005) was to investigate self-rated and actual pharmacological skills of registered nurses and graduating nursing students in Finland. The study of 363 registered nurses and 282 graduating nursing students from seven hospitals and five polytechnics in Finland used the Medication Calculation Skills (MCS) Test to gather information on background factors and self-rated pharmacological and mathematical skills and to test actual skills in these areas. The response rate was 68% for nurses and 70% for students. Participants did not find pharmacology an easy subject and self-rated their pharmacology skills as low, especially for pharmacokinetics and pharmacodynamics. Nurses performed better than students on the MCS test. Over half of nurses obtained a score of 79% correct, which the authors deemed quite adequate. Students in general did not perform well, leading the researchers to suggest that learning pharmacology takes place in clinical practice, as concluded also by Morrison-Griffiths et al. (2002). Self-rated scores for both basic and high level knowledge was weakly positively correlated with scores on the basic level, high level and overall test scores. A limitation with this study was that the questionnaires were answered without supervision and therefore some may have referred to text books or the knowledge of others to answer. Those with an interest in pharmacology may also have been more likely to take part.

A cross-sectional study of self-rated and actual knowledge about high alert medications in relation to drug administration and drug regulation, was conducted by Hsaio et al. (2010) in Taiwan using a self-administered questionnaire. Nurses were invited to participate who worked in general hospitals and had the opportunity to administer high alert medications and chemotherapy. A total of 305 nurses took part, giving a 79.2% response rate. Only 3.6% of nurses considered themselves to have sufficient knowledge about high-alert medications, with 21.6% self evaluating their knowledge as insufficient and 5.9% as extremely insufficient. The drug administration part of the multi-choice test had a correct answer rate of 57.8%. Test scores
were positively correlated with nursing experience. There was also a positive correlation between self-rated knowledge and actual knowledge. Results indicated that only 16.7% of respondents had had high-alert medication training and 84.6% claimed to need additional training; therefore the authors highlighted the need for ongoing education about high alert medications.

Fothergill-Bourbonnais and Wilson-Barnett (1992) undertook a study of nurses working in three intensive/cardiac units in two large teaching hospitals and in four hospice-type settings in London. Actual and perceived knowledge of intensive therapy and hospice nurses pertaining to the pharmacological and non-pharmacological aspects of pain and its management was assessed using multiple-choice (MC), short answer and open-ended questions. The sample included 52 intensive therapy and 48 hospice nurses who were grouped into beginner or expert categories. Sixty five percent self-rated their knowledge of analgesics as fair or poor. Hospice nurses self-rated their knowledge of analgesics as higher than ICU nurses, and expert nurses self-rated their knowledge higher than beginner nurses. The findings from the multi-choice test indicated that although the hospice nurses received higher scores than the intensive therapy nurses, both groups demonstrated lack of knowledge, with a mean score of 61%. There was no significant difference between the tested knowledge of beginner and expert nurses. Another study undertaken in the ICU sought to examine critical care nurses knowledge about antibiotic therapy and was carried out in six adult critical care units at a large US hospital (Munro & Grap, 2001). Ninety nurses responded which represented a response rate of 38%. They were asked to self-rate their knowledge of antibiotic therapy and answer a short case study and multiple choice questions designed to test their knowledge of antibiotic therapy. The knowledge test revealed a mean score of 53.8%. Age, educational preparation and years of experience in ICU were not predictive of scores on the objective knowledge test. Self-perception of knowledge was also not predictive of performance on the antibiotic therapy knowledge test and nor were comfort levels. However comfort levels regarding knowledge of antibiotics were positively correlated with self-perception of knowledge. These findings support the belief that nurses have difficulty accurately assessing their own knowledge levels. Limitations of the studies include the use of convenience samples and the relatively small number of respondents.
Sandie and Heindel (1999) undertook a survey of intensive care nurses, as part of a larger group that also included surgical and post anaesthesia care unit nurses in a US military hospital, to examine their knowledge and attitudes regarding postoperative epidural analgesia. As well as testing their knowledge about the mechanism of action and adverse effects of epidural opioids by way of true/false and multiple-choice questions, they also assessed the nurses’ attitudes towards their knowledge level. Of the 200 nurses who were eligible, 85 (43%) took part in the study. In the true/false sections a 70% score was attained by participants on the basic pharmacology questions and 74% on the epidural pharmacology questions. A 30% overall correct score was achieved in the pharmacology section of the multiple choice questions. More experience as an RN and receipt of pain education in undergraduate teaching were both associated with higher scores in tested knowledge section of the survey. Only a quarter of the respondents rated their knowledge as ‘good’, with the majority stating it was ‘fair.’ Those who had received epidural in-service education rated their knowledge as ‘good’ more often than those who had not received such education. Nurses who responded that their self-rated knowledge was ‘good’ also scored higher on the knowledge test. All respondents stated that more education on opioid epidural analgesia should be provided by their hospital.

3.3.3 Knowledge of Opioids

Studies documenting pain control repeatedly identify the cause of inadequate treatment to be due to lack of knowledge about drugs. There have been several studies that have investigated nurses’ knowledge of opioid analgesics as part of broader studies on pain assessment and management, and significant knowledge deficits have been documented. In one such study on nurses’ knowledge and attitudes of pain management, Erkes, Parker, Carr & Mayo (2001) surveyed 30 medical/surgical intensive care nurses in a large metropolitan hospital in the USA. The survey was administered before and after an educational intervention. Pre-test knowledge deficits were shown regarding the long term use of opioids, with less than half (46.6%) correctly identifying that morphine has no ceiling effect and only 63% knowing that the side effects of opioids decrease over the amount of time that they are prescribed. The authors found these results surprising because of the fact that opioids are regularly dispensed. Retesting after the education programme revealed a significant increase in scores related to pharmacology knowledge. No

---

9 A ceiling effect in analgesia refers to a dose beyond which an increase in dose will not result in increased pain relief (McCaffery & Ferrell, 1992).
correlations were found between the baseline knowledge scores and years of nursing experience or the type of nursing qualification.

Tapp and Kropp (2005) investigated nurses’ knowledge and attitudes toward pain management, pain medication side effects and pharmacologic management in a surgical unit at a US community teaching hospital. Of 32 nurses sampled, 23 nurses completed the survey. It was reported that nurses knew only just over half of the 15 questions pertaining to the pharmacologic management of pain. As a result, a need for education about the pharmacology of opioids was identified.

The small sample sizes are limitations of the studies by Erkes et al. (2001) and Tapp and Kropp (2005); however other larger studies have reported similar findings. Furstenberg et al. (1998) examined the knowledge and attitudes of physicians, nurses, and pharmacists towards cancer pain in the state of New Hampshire, USA. Two hundred and forty eight nurses took part in the statewide survey. The questions addressed five major areas relevant to managing cancer pain, with one section containing nine questions relating to knowledge of opioid pharmacology. They found that many nurses lacked adequate knowledge of the fundamental facts of opioid pharmacology, including choice of drug, routes, and schedules, drug tolerance and opioid ceiling effects.

Brown, Bowman and Eason (1999) surveyed 1000 practicing RNs in North Carolina, USA on their knowledge and attitudes regarding pain, with 260 nurses participating (26% response rate). Twenty of the 35 items on the questionnaire related to pharmacologic issues, including potentiators of opioid analgesics, duration of action, equi-analgesic dosages of oral and IV opioids, mechanism of action of NSAIDs, routes of administration, dosing schedules, and side effects. This pharmacologic knowledge section of the questionnaire was a primary area of concern, with a lack of knowledge demonstrated. There was no significant difference in scores based on years of experience or educational background. Hamilton and Edgar (1992) also found that nurses lacked knowledge about some principles of opioid pharmacology (ceiling effect, dosing, and side effects) in their survey of 318 staff nurses at an acute care teaching hospital in Montreal, Canada. As with Brown et al’s (1999) study, no statistically significant differences were found in the scores by level of educational preparation or years of experience. These
studies all show consistent problems with knowledge regarding opioids, but as completion of the questionnaires were not supervised it is possible that nurses may have used learning materials to assist them in answering questions; potentially affecting reliability of the results.

However two further studies on opioids undertaken in controlled environments have demonstrated similar knowledge deficits. McCaffery and Ferrell (1992) sought to determine nurses’ knowledge about opioid analgesics. Two thousand one hundred and thirty five nurses completed a pretest questionnaire at continuing education programmes on pain conducted by the authors. The questionnaire included questions on addiction, equi-analgesic doses and a ceiling on morphine analgesia. Knowledge was found to be lacking and only half of the sample recognised that there is no ceiling on the analgesia of morphine. A descriptive study by Watt-Watson (1987) focused on knowledge of pain assessment and opioid administration. Data were collected via questionnaires from 207 subjects (106 graduate nurses and 101 baccalaureate students) who were attending pain presentations. In relation to opioid pharmacology, a lack of knowledge was evident for questions about opioid administration, potential side effects and duration of action. The results indicate that nurses require education on the appropriate actions and uses of drugs.

### 3.3.4 Knowledge of Sedation and NMBAs

There is little information available regarding the degree of understanding of sedatives, and neuromuscular blocking drugs by nurses and in fact to date no studies have been found that examine knowledge of propofol, rocuronium or midazolam. However, recent studies of sedative drugs suggest variability in prescribing patterns (Dasta, Fuhrman, & McCandles, 1995) and there is some evidence of misunderstanding of the pharmacologic actions of sedatives and NMBAs by some nurses. Loper, Butler, Nessly and Wild (1989) surveyed 258 critical care nurses as to their understanding of the benzodiazepine, diazepam and the neuromuscular blocker, pancuronium. Approximately 40% of nurses thought diazepam had analgesic properties and a similar number thought pancuronium was an anxiolytic. Furthermore, 10% of nurses endorsed the use of pancuronium for analgesia.
In a study by Arbour (2003) practice concerns associated with nurses’ administration and monitoring of sedatives, analgesics and neuromuscular blocking agents were identified by the clinical nurse specialist (CNS) within a surgical ICU of a US tertiary hospital. The CNS used multiple data sources, which included chart review, listening to the shift report, walking rounds and reviewing the clinical bedside examination. Data collection revealed that multiple patients were paralysed without adequate sedation and analgesia. In addition, Arbour found that many staff members received inconsistent education in sedation, analgesia and neuromuscular blockade therapies. Within the critical care areas of the study institution, there was no formal, consistent educational programming in these areas. These educational deficiencies in the appropriate clinical use of sedatives, analgesics and neuromuscular blocking agents often caused inconsistent clinical practice.

3.4 SUMMARY

This chapter has provided an overview of the current literature pertaining to pharmacology education, nurses’ and students views of the difficulties in learning and applying pharmacology knowledge and the self-rated and actual pharmacology knowledge of nurses in clinical practice. The literature strongly supports the importance of education to address deficits in nurses’ pharmacology knowledge and confidence. While commentary and qualitative studies on lecturers, students and nurses’ views of pharmacology education and application of knowledge are common, there is a lack of empirical research specifically focusing on nurses’ tested knowledge and self-rated knowledge of pharmacology. Of those that have examined both tested and self-rated medication knowledge, many deficiencies are highlighted. However, few of these have addressed critical care or specifically neuromuscular blocking agents, analgesics or sedatives. Additionally, there is no New Zealand research on nurses’ knowledge of medicines in the context of clinical roles in hospitals. By exploring the pharmacology knowledge of New Zealand Intensive Care nurses, this study will help to fill this gap in the literature. The following chapter will present the methodological approach used in the current research.
CHAPTER FOUR: METHODOLOGY

4.1 INTRODUCTION

This chapter outlines the methodological approach taken in the collection and analysis of data for this thesis and provides a rationale for the research process utilised. Included is a description of the setting, sample, the instrument, rigour of the instrument, and processes related to how the data were collected, managed and analysed. Ethical and cultural considerations identified throughout the process are also detailed.

4.2 METHODOLOGICAL APPROACH

Quantitative methods and procedures were determined to be the most appropriate for examining nurses’ self-rated and actual pharmacology knowledge. Quantitative research is a systematic and objective process by which numerical data are collected, tabulated and analysed, in order to obtain information and answer research questions (N. Burns & Grove, 2005; Levine, 2011). It is a commonly used methodology in nursing research from which to generate knowledge, identify and describe variables and establish the relationships among variables (N. Burns & Grove, 2005; Polit & Beck, 2006). In order to accurately measure, report and describe the demographic characteristics, attitudes and knowledge of nurses in this study and communicate the degree to which these variables were related, a descriptive correlational design was utilised.

4.2.1 Descriptive Correlational Design

Descriptive correlational studies measure and describe variables and the relationships that occur between and among them (N. Burns & Grove, 2005). Both the descriptive and correlational strategies are non-experimental approaches to research. This means that there is no attempt to manipulate or control the variables, rather they are identified and measured as they exist naturally (Mitchell & Jolley, 2010).
4.2.1.1 Descriptive research

Descriptive research is used to provide a factual and accurate description of the population being studied, to measure and describe an event or variable(s) and determine the frequency with which they occur (Mitchell & Jolley, 2010; Singh, 2007). In describing the existing phenomena, it can also identify problems or make evaluations of current knowledge, perceptions, beliefs or practices (Kelley, Clark, Brown, & Sitzia, 2003; Polit & Beck, 2006). A descriptive research design fitted with this study which aims to examine nurses’ current level of knowledge (both self-rated and actual) of common sedative, analgesic and neuromuscular blocking drugs and perceptions of their level of confidence about using these drugs. Descriptive research is a good way of building up knowledge about a topic and is often used when little research has been undertaken in an area and hence little is known about it (Tarzian & Cohen, 2006). By examining the degree to which nurses perceive that they are knowledgeable about medications and testing this knowledge, this study sheds light on an area of practice that has not been adequately studied.

4.2.1.2 Correlational research

In correlational research, the goal is to establish whether a relationship exists between the variables. It is conducted to examine relationships between two or more variables and to determine the type (positive or negative) and degree (strength) of the relationship (N. Burns & Grove, 2005; Taylor, Kermode, & Roberts, 2006). In this study the correlational method was used to determine whether nurses’ pharmacology knowledge (self-rated and actual) was related to experience or educational background and to examine the relationship between self-rated knowledge, confidence and actual test scores.

4.3 RESEARCH METHOD

In order to undertake this descriptive correlational study, an objective, rigorous, and systematic approach for examining the issues and generating data was required. Descriptive correlational research can be accomplished by a variety of data collection methods, which include surveys, case studies and observation. The method chosen for this research was survey.
4.3.1 Survey Research

Survey research is a valuable and applicable method for conducting research on nursing related issues. Survey research methods are used to gather self-reported data and can measure how people report that they act, think or feel (Mitchell & Jolley, 2010). They are an invaluable and accessible research tool for studying the knowledge, attitudes, beliefs and practices of clinicians for relatively little money (Boswell & Cannon, 2011; Passmore, Dobbie, Parchman, & Tysinger, 2002; Rubenfeld, 2004). Survey research enhances the generalisability of the results from a sample to a population, leading to the ability to deduce some characteristics and behaviours of the population (Cohen et al., 2007). One advantage of the survey method over the other descriptive correlational methods, such as observational or case study research, is that it is not limited by geography and allows researchers to gather a lot of information on a large population (S. L. Jackson, 2011; Mitchell & Jolley, 2010). One of the limitations of surveys as a research technique is that they can only provide information on the questions asked and that respondents may not provide accurate or honest answers (Polit & Beck, 2006).

Several options exist for survey administration, including telephone interviews, self-administered questionnaires, and face-to-face interviews. A formal structured, self-administered questionnaire was the tool used to collect the quantitative data from the respondents within this study. Questionnaires can be used not only to assess individuals’ attitudes, opinions or thoughts about a particular topic, but can also include ability or achievement tests which can be used to measure an individual’s knowledge or competence in an area. This made a self-administered questionnaire an appropriate choice. A further advantage was the ability of it to be anonymous, allowing collection of data on such sensitive issues as self-rated and actual knowledge.

4.4 SURVEY INSTRUMENT

After a review of the available literature and research on the topic area, no valid tool could be found that canvassed this issue of interest and so a new 65 item questionnaire was developed\(^\text{10}\). The questionnaire consisted of three sections and utilised the closed question format that gives a uniform frame of reference for respondents to decide their answers. These were felt to be the

\(^{10}\) Refer to Appendix 2 for a copy of the survey questionnaire.
most suitable, as they are quick for respondents to answer and reduce the time needed to complete the questionnaire, thus increasing the likelihood of participants taking part and completing the questions (Houser, 2008). The other benefit is that they are easy to analyse using statistical techniques, enabling comparisons to be made across groups (Lewin, 2011).

Section one of the questionnaire ascertained socio-demographic and professional/educational characteristics of the respondents and utilised binary (yes/no) and nominal measurement formats. These questions were presented first to ease respondents into questionnaire completion (K. E. A. Burns et al., 2008). Section two contained questions in which the nurses were asked to self-rate their knowledge of and their confidence in using rocuronium, propofol, midazolam and morphine and how frequency they administered each medication. The responses to each question were arranged on a 5 point Likert scale. Likert scales can be used to measure respondents' attitudes and other factors. This type of response option was chosen because it allows scaling of an individual’s attitude to an issue and is more sensitive to the full range of possible attitudes or responses than a simple dichotomous agree/disagree option (Rattray & Jones, 2007).

In section three, which tested actual knowledge, questions were designed to assess knowledge of indications of use, pharmacokinetics, pharmacodynamics, dosing, side effects and contraindications. Questions were formatted as multiple-choice and true/false with each question worth one mark, giving an overall test score for each drug. The true/false questions also contained an answer choice of “don’t know”. The inclusion of an indecisive response options, such as “don't know” acknowledges uncertainty (Stone, 1993). In this case it was used to reduce the likelihood of respondents guessing the answer, so that their actual knowledge could be more accurately determined. In order to determine knowledge scores “don’t know” answers were treated as incorrect. An unanswered question was coded to indicate no response.

### 4.4.1 Questionnaire Development

The development of this instrument occurred in stages. The content and questions were initially developed and modified by the researcher from pharmacology textbooks and pharmacology test banks. The data collection tool was then examined by an expert panel of two nurse academics, two practice educators, and an ICU pharmacist based at the second largest tertiary ICU unit in
NZ to assess for appropriateness, accuracy, clarity, readability, face validity, and page design. Revisions and adjustments were made to reflect their recommendations. A few other minor modifications, based on the pharmacist’s feedback were made to some of the questions and response alternatives prior to distribution of the questionnaire to the pilot group.

4.4.2 Pilot Study

A pilot study was undertaken to test the instrument and evaluate the success of the data collection technique (De Vaus, 2002). This involved a penultimate draft of the questionnaire being given to respondents who were similar to the sample (Bowden, Fox-Rushby, Nyandieka, & Wanjau, 2002). Five nurses who no longer worked as bedside nurses in ICU, but had previously worked in a level III unit within the last two years formed the pilot group, ensuring subjects as similar as possible to those planned for the main study (Stone, 1993). The respondents were asked to examine the questionnaire with regard to its flow, effectiveness of instructions, clarity of the questions, time required to complete it and administrative ease. The subjects did not have any problems with the wording, length and format of the questionnaire and no-one reported problems with the usability of the tool. All questions were answered and no clarification of the questions was required. The researcher determined that it would take twenty minutes to complete the questionnaire.

4.4.3 Internal Consistency of the Questionnaire

Cronbach’s alpha reliability estimates were computed on the whole sample to examine the internal consistency of the self-rated knowledge, confidence and actual knowledge scales. Reliability estimates were .84, .74 and .65 respectively, suggesting adequate reliability (DeVellis, 2003).

4.5 SETTING OF THE STUDY

The study was carried out in six public hospital level III adult ICUs. These were located in both the North and South Islands. Level I and II ICUs were excluded from the study as it was considered unlikely that all four of the study medications, particularly neuromuscular blocking agents, would be commonly administered by staff. This is because there is little likelihood that all nurses in these units would care regularly for ventilated patients, as patients needing complex
ventilatory care or prolonged ventilation would be transferred to a tertiary unit. The decision was made to sample at multiple units, as conducting the study solely in the level III unit in which the researcher was employed would potentially risk exposing participants to confidentiality issues, as it may have been possible to identify staff through the demographic information. By also sampling staff at five other tertiary units, these participants were masked within this greater sample.

4.6 SAMPLING METHOD

Sampling is a process of selecting a portion of the population of people with whom to conduct a study (N. Burns & Grove, 2005). An alternative to sampling is to take a census, where the researcher surveys each member of the population of interest (Singh, 2007). This study utilised this method and was a census of all bedside nurses working in the Level III ICUs. This technique may be used when the realistic population is not too large, as was the case in this study. It was administratively the simplest way to obtain data and enabled a wide representation of New Zealand ICU nurses in relation to levels of experience and/or education, as it was not possible to stratify in advance to ensure this occurred. However, although a census was attempted, the fact that the response rate was not high (28%) means that it could be considered more of a self-selected sample.

4.6.1 Inclusion Criteria

The study’s inclusion criteria were clearly defined and specific to include RNs working full or part time who were involved in direct patient care roles. Nurses that were excluded were those who were not directly involved in patient care such as Clinical Nurse Educators, Clinical Charge Nurses and Clinical Nurse Managers.

4.6.2 Sample Size

All of the nurse managers provided information on the number of eligible staff working in each unit. Based on this information, 510 questionnaires were distributed to the 6 level III ICUs throughout NZ. The target population thus consisted of all nurses working during the sampling period of Sept-Dec 2010 that met the inclusion criteria. A final total of 142 responses were received; a response rate of 28%.
4.7 DATA COLLECTION PROCEDURES

Nurse Managers were contacted and informed about the study. Following each telephone call, emails were sent which provided further information about the aims of the study, intended procedures, and the inclusion criteria. A copy of the questionnaire was also sent for the nurse managers to read, along with the information sheet. The researcher visited each unit, meeting with the nurse managers and educators, as it was felt that this personal contact may help to increase response rate; a common problem with mail surveys (N. Burns & Grove, 2005; McColl et al., 2001). The questionnaires were provided to the managers at these meetings and the data collection procedure was explained. The questionnaires, along with an information sheet for participants\(^\text{11}\) were then distributed to eligible staff through the nurse managers. The information sheet explained the purpose of the research and how the results from the questionnaire would be used. On completion, respondents were requested to seal the questionnaire in an attached pre-addressed postage paid envelope. A collection box was placed in each clinical area where the completed questionnaires could be left and posted by the nurse manager. Two weeks after the questionnaires were to be distributed by each of the nurse managers, follow up calls were made. Data collection took place over twelve weeks from September to December 2010 at the different sites. The extended timeframe ensured that all possible questionnaires were collected; thereby ensuring the best response rate could be achieved.

4.8 ETHICAL CONSIDERATIONS

Prior to conducting the study, ethical approval was obtained from the Health and Disability Ethics Committee (Multi Region)\(^\text{12}\). Institutional approval was sought and received from the Auckland DHB Research Review Committee\(^\text{13}\). Verbal approval for this study was obtained from the Nurse Managers of each unit.

\(^{11}\) Refer to Appendix 1 for a copy of the information sheet for participants
\(^{12}\) Refer to Appendix 3 for a copy of ethics approval letter
\(^{13}\) Refer to Appendix 4 for a copy of Auckland DHB Research review committee approval
4.8.1 Right to Self-determination and Privacy

People have the right to be autonomous and determine for themselves whether or not to partake in research studies (N. Burns & Grove, 2005). Participants’ right to self-determination was ensured by fully informing them of the study, emphasising that participation was purely voluntary and that they could discontinue participation at any time without penalty and providing information about who to contact for answers to questions about the research (De Vaus, 2002). Participants were free to complete the questionnaire in their own time and at a place convenient to them, thereby protecting their privacy. Prospective research participants must be fully informed about the procedures involved in a study and give their consent to participate (N. Burns & Grove, 2005). In this study they were advised that consent was implied by the return of the questionnaire.

4.8.2 Right to Anonymity and Confidentiality

There are two standards that are applied in order to help protect the privacy of research participants. The research subject has the right to anonymity and the right to assume the data collected will be kept confidential. Complete anonymity exists if the subject remains anonymous throughout the study – even to the researchers themselves (N. Burns & Grove, 2005). To ensure anonymity of the respondents to the researcher, the Centre for Postgraduate Nursing Studies was enlisted as a third party to receive the returned questionnaires. An administrator within the centre handled receiving of the completed questionnaires. Each questionnaire was given an individual identification number, which was recorded at the bottom left hand corner of the questionnaire and related to the hospital that it was from. The identification was for the purpose of monitoring the return of questionnaires and the geographical centre they originated from. This allowed the administrator to identify the response rate of each hospital and convey this information to the researcher for follow up to occur. The codes were removed before the researcher received the questionnaires for analysis, thus masking the identity of individuals taking part and their location. Confidentiality is the researcher’s management of private information shared by a subject. The confidentiality of participants was protected by way of the collected data being stored in a locked secure environment during the research and subjects were informed that on completion of the study and written report, all raw data will be destroyed in accordance with University of Otago guidelines.
4.8.3 Treaty of Waitangi

It was essential that this research demonstrate commitment to partnership, protection and participation with Māori, consistent with the Treaty of Waitangi and the University’s research policy (University of Otago, 2003). In order to meet these obligations, Māori consultation took place. A meeting with Elizabeth Cunningham, Research Manager - Māori for the University Of Otago Christchurch School Of Medicine, occurred in January 2010. After reviewing the research proposal it was determined that there were no ethical implications for Māori, nor were there any procedures or questions that could affect Māori cultural protocol. In terms of ethnicity data collection, she felt that information on the number of Māori working in ICUs would be of interest for workforce development strategies. Therefore, support for the research was given, and a report on the conclusion of the study was requested.

4.9 DATA ANALYSIS

SPSS® software (version 20.0) was used for descriptive and inferential statistical analysis of the data. Descriptive statistics (means, standard deviations, percentages) were used to describe the characteristics of the nursing population in the study as well as their self-rated and actual knowledge and confidence. All percentages were determined based on the number of respondents for a given question, not the total sample size. Responses on the Likert scales were treated as numerical data as opposed to ordinal, as is common in the social sciences (Maurer & Pierce, 1998; Norman, 2010; Veney, Kros, & Rosenthal, 2009).

Pearson product-moment correlations were used in order to determine relationships between tested variables and demographic data. T-tests were undertaken to analyse differences in mean scores between groups within the population. Because of the small number of Likert categories utilised and the fact that the distribution of data was not always symmetrical, the underlying assumptions of bivariate normality for correlations and normality of distribution for t-tests were not met in the self-rated section. However, as both the Pearson product-moment correlation coefficient and t-test are robust to violations of distribution assumptions, parametric statistics such as these can be used with Likert data (Gaito, 1980; Havlicek & Peterson, 1976; Norman, 2010). Furthermore, the usual nonparametric alternatives (Spearman’s rank-order correlation, 14 Refer to Appendix 5 for a copy of letter regarding Maori Consultation
Mann-Whitney U test and Wilcoxon matched-pairs signed-ranks test) are problematic as with only a small number of categories there are many ties.

4.10 SUMMARY

This chapter has described the research methodology and methods chosen to best meet the aims of this descriptive correlational study. Justification was made for the survey approach and the use of a self-administered questionnaire. The content and development of the survey tool were outlined as were establishing the reliability and validity of the instrument. The data analysis process was described. Ethical and cultural considerations that were addressed in order to proceed with this study were described. The results from this study are outlined and discussed in the following chapter.
CHAPTER FIVE: RESULTS

5.1 INTRODUCTION

This chapter presents the results of the study that was designed to determine the level of nurses’ actual pharmacology knowledge and its relationship to self-rated knowledge, confidence and personal demographic factors. In accordance with the layout of the questionnaire, the results have been presented in three sections. The first part of this chapter contains a detailed description of the participants involved in the study, outlining their experience and educational background. Collection of descriptive data facilitates analysis and comparison later in the chapter. Section two will present results of the questions about the importance of pharmacology to practice, self-rated knowledge and frequency of use in relation to the four medications. The third section will examine and describe the nurses’ tested knowledge. Both sections two and three include the identification and description of any relationships between the variables and comparisons between groups. Tables and graphs have been used to present descriptive statistics, comparison scores, and correlations.

5.2 THE STUDY RESPONDENTS

5.2.1 Response Rate

Of the 510 questionnaires distributed, 142 questionnaires were returned giving a response rate of 28 percent. Response rates of 25-30% are common for mailed questionnaires (N. Burns & Grove, 2005) and, in this case, could be attributed to several factors, which are outlined in the discussion chapter.

5.2.2 Demographics

Of the 142 participants, 115 (81%) were female and 25 (17.6%) were male. Male representation was higher than the 10.7% of male nurses reported to be working in ICU nationally (Nursing Council of New Zealand, 2010b). Two respondents did not identify their gender. There were respondents in all age categories from 20-29 to 60+. The two largest groups were those aged 30 to 39 years (n =45, 31.7%) and 40 to 49 years (n=46, 32.4%). This is similar to the latest
national workforce figures which show that 64.3% of nurses working in critical care are between 30 and 49 years of age (NCNZ, 2010b). Fifty nine percent of the respondents (n=84), recorded an ethnicity of New Zealand European. Maori made up only 2.8% (n=4) of respondents, with several other minority groups also represented (Table 1). This is slightly higher than the figure of 2.3% of RNs practicing in acute district health board (DHB) settings who identify as Maori (NCNZ, 2010b). One third of respondents (n=42) reported themselves as ‘Other’, with British (10.6%) the most common in this category.

Table 1

<table>
<thead>
<tr>
<th>Demographics of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Not stated</td>
</tr>
<tr>
<td><strong>Age</strong></td>
</tr>
<tr>
<td>20-29</td>
</tr>
<tr>
<td>30-39</td>
</tr>
<tr>
<td>40-49</td>
</tr>
<tr>
<td>50-59</td>
</tr>
<tr>
<td>60+</td>
</tr>
<tr>
<td>Not stated</td>
</tr>
<tr>
<td><strong>Ethnic Group</strong></td>
</tr>
<tr>
<td>NZ European</td>
</tr>
<tr>
<td>Maori</td>
</tr>
<tr>
<td>Chinese</td>
</tr>
<tr>
<td>Indian</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Not stated</td>
</tr>
</tbody>
</table>

**5.2.3 Employment Characteristics**

The majority of the respondents were employed 0.8-1.0 FTE (n=111, 78.2%), with 23 (16.2%) working 0.5-0.7 FTE and only 8 nurses (5.6%) working less than 0.5 FTE. Just under half of all respondents (45.8%) had greater than 16 years nursing experience, with the lowest frequency (2.1%) being reported in the range of 1 to 2 years (n=3). In terms of the years of ICU experience, the greatest number of respondents reported having worked in the area for >16 years.
(n=37, 26.1%), with the lowest representation (n=12, 8.5%) in both the <1 year and 11-15 year range (Table 2).

Table 2

Employment Characteristics of Respondents

<table>
<thead>
<tr>
<th>Years of RN Experience</th>
<th>n (=142)</th>
<th>(%)</th>
<th>Years of ICU Experience</th>
<th>n (=142)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 year</td>
<td>4</td>
<td>(2.8)</td>
<td>&lt;1 year</td>
<td>12</td>
<td>(8.5)</td>
</tr>
<tr>
<td>1-2 years</td>
<td>3</td>
<td>(2.1)</td>
<td>1-2 years</td>
<td>20</td>
<td>(14.1)</td>
</tr>
<tr>
<td>3-5 years</td>
<td>17</td>
<td>(12.0)</td>
<td>3-5 years</td>
<td>35</td>
<td>(24.6)</td>
</tr>
<tr>
<td>6-10 years</td>
<td>31</td>
<td>(21.8)</td>
<td>6-10 years</td>
<td>26</td>
<td>(18.3)</td>
</tr>
<tr>
<td>11-15 years</td>
<td>22</td>
<td>(15.5)</td>
<td>11-15 years</td>
<td>12</td>
<td>(8.5)</td>
</tr>
<tr>
<td>&gt;16 years</td>
<td>65</td>
<td>(45.8)</td>
<td>&gt;16 years</td>
<td>37</td>
<td>(26.1)</td>
</tr>
</tbody>
</table>

5.2.4 Qualification Characteristics of Respondents

For 66.9% of respondents their primary education leading to nursing registration was undertaken in New Zealand. Most of the participants (69%) were educated at bachelor’s degree level or higher (Table 3). The largest group was those with a postgraduate certificate or diploma (n=49, 34.5%). Fifty five percent stated that they had postgraduate qualifications in Intensive Care Nursing. In terms of ongoing pharmacology education, 34.5% reported that they had attended pharmacology courses or in-service education sessions and 10.6% stated that they had undertaken postgraduate study in pharmacology.

Table 3

Level of Nursing Education of Respondents

<table>
<thead>
<tr>
<th>Highest level of nursing education</th>
<th>n (=142)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing Certificate</td>
<td>11</td>
<td>(7.7)</td>
</tr>
<tr>
<td>Nursing Diploma</td>
<td>30</td>
<td>(21.1)</td>
</tr>
<tr>
<td>Bachelor of Nursing Degree</td>
<td>39</td>
<td>(27.5)</td>
</tr>
<tr>
<td>Postgraduate Certificate or Diploma</td>
<td>49</td>
<td>(34.5)</td>
</tr>
<tr>
<td>Master of Nursing (or equivalent)</td>
<td>10</td>
<td>(7.1)</td>
</tr>
<tr>
<td>PhD</td>
<td>0</td>
<td>(0.0)</td>
</tr>
<tr>
<td>Not stated</td>
<td>3</td>
<td>(2.1)</td>
</tr>
</tbody>
</table>
5.3 OVERALL PHARMACOLOGY KNOWLEDGE AND IMPORTANCE

This section describes the findings for the questions that examined the nurses’ opinions on the importance of pharmacology knowledge and their overall self-rated pharmacology knowledge. Pearson product-moment correlations and t-tests were performed to determine what relationships, if any, the responses (scores) may have with other data sets such as education or years of service. As there was an inadequate sample size of nurses who had undertaken postgraduate pharmacology study, this variable was excluded from further analysis.

5.3.1 Importance of Pharmacology Knowledge to Practice

The respondents views on the importance of pharmacology knowledge to their clinical practice (Figure 1) were measured on a 5-point Likert scale (1 = unimportant to 5 = very important). All rated pharmacology knowledge as moderately important or above, with a mean score of 4.39 (SD = .695). In fact just over half of the nurses (n=72, 51%) stated that they felt it was very important.

![Figure 1. Self-rated importance of pharmacology knowledge (n=141).](image)

5.3.1.1 Importance of pharmacology knowledge to practice and demographics

There was no correlation found between age, level of education, years as an RN and self-rated importance of pharmacology knowledge. However, there was a small negative correlation (r = -.211, n = 141, p = .01) in relation to the number of years of ICU experience; with more ICU experience associated with lower perceived importance of pharmacology knowledge to practice.
Independent samples $t$-tests were also conducted to compare the self-rated importance of pharmacology to the other educational characteristics of the sample. There was no significant difference in scores for those whose undertook their primary nursing education in New Zealand and those who did not. There was a significant difference however in the self-rated scores for those with postgraduate qualifications in ICU (Mean = 4.27, SD .755) and those without (Mean = 4.53, SD .590; $t$(139) = -2.23, $p = .02$, two-tailed; mean difference = -.26, 95% CI: -.48 to -.04). These results showed that those with postgraduate ICU qualifications did not rate the importance of pharmacology knowledge as highly as those without. A significant difference in scores was also found between those who had undertaken pharmacology courses or in-service education sessions (Mean = 4.57, SD .577) and those who had not (Mean = 4.29, SD .734; $t$(120) = 2.47, $p = .02$, two-tailed; mean difference = .28, 95% CI: .06 to .50); with those who had undertaken a pharmacology course or in-service education session rating pharmacology knowledge as more important to practice than those who had not undertaken such continuing education.

### 5.3.2 Overall Self-Rated Pharmacology Knowledge

The subjects were asked to rate their current overall pharmacology knowledge as either very poor, poor, average, good or excellent. Despite viewing pharmacology knowledge as important to clinical practice, the majority of the nurses’ (62%) self-rated their overall pharmacology knowledge as average (Figure 2). Responses ranged from poor to good, with a mean score of 3.15 (SD .597) and 11% self-rated their knowledge as poor.

![Figure 2. Self-rated Overall Pharmacology Knowledge (n=141).](image)

Figure 2. Self-rated Overall Pharmacology Knowledge (n=141).
5.3.2.1 Overall self-rated pharmacology knowledge and demographics

There was no correlation found between age, level of education, years as an RN or years in ICU and overall self-rated pharmacology knowledge. Independent-sample t-tests were conducted to compare overall self-rated pharmacology knowledge with the different educational characteristics of the sample. There were no significant differences in scores for those who undertook their primary nursing education in New Zealand and those who did not, or those who had postgraduate qualifications in ICU. However there was a significant difference in scores for those who had completed pharmacology courses or in-service education (Mean = 3.35, SD .561) and those who had not (Mean = 3.04, SD .591; t(139) = 2.95, p = .004, two-tailed; mean difference = .30, 95% CI = .10 to .51), with those who had undertaken courses/in service sessions rating their overall knowledge higher.

5.3.3 Relationship Between Importance and Overall Knowledge

The relationship between nurses’ perceived importance of pharmacology to practice and overall self-rated pharmacology knowledge was investigated using Pearson’s product-moment correlation coefficient. There was a weak, positive correlation between the two variables, r = .255, n = 141, p = .002, with higher levels of perceived importance associated with higher levels of perceived knowledge.

5.4 SELF-RATED PHARMACOLOGY KNOWLEDGE & CONFIDENCE

The findings for the questions that examined the nurses’ self-rated pharmacology knowledge of rocuronium, propofol, midazolam and morphine and their confidence in using these medications are now presented. Pearson’s product-moment correlations and t-tests were undertaken to examine relationships between the responses and other data sets such as demographics and frequency of administration.

5.4.1 Self-Rated Knowledge

Responses to the self-rated knowledge questions for each drug can be found in Table 4. Rocuronium knowledge was rated the lowest of the four medications, with 40% of respondents rating their knowledge as poor or very poor and 60% as average to good (Mean 2.61 on 1-5 scale with higher score meaning more knowledgeable). Self-ratings of average or better were
given by 88% of nurses’ for midazolam (Mean 3.29) and 94% for propofol (Mean 3.52). Morphine received the highest self-rating with 100% stating their knowledge was average or better (Mean 3.87).

Table 4

**Self-Rated Medication Knowledge**

<table>
<thead>
<tr>
<th>Medication</th>
<th>Score*</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Rocuronium</td>
<td>2.61</td>
<td>0.819</td>
</tr>
<tr>
<td>Propofol</td>
<td>3.52</td>
<td>0.723</td>
</tr>
<tr>
<td>Midazolam</td>
<td>3.29</td>
<td>0.713</td>
</tr>
<tr>
<td>Morphine</td>
<td>3.87</td>
<td>0.683</td>
</tr>
</tbody>
</table>

* Scores are based on 5-point likert scale (1=very poor to 5=excellent)

5.4.1.1 Self-rated knowledge and demographics

Self-rated knowledge scores for each medication did not positively correlate with any of the demographic variables except in the case of midazolam, where scores showed a weak positive correlation with years of RN experience ($r = .225$, $n = 141$, $p = .007$) and years of ICU experience ($r = .188$, $n = 141$, $p = .03$); with more experience associated with higher self-rated knowledge.

As with overall self-rated pharmacology knowledge, the only significant difference in scores when looking at each of the four medications was between those who had completed pharmacology courses or in-service education and those who had not (Table 5). Those who had completed such sessions scored their self-rated knowledge as higher than those who had not.
Table 5

Independent T-test for Self-rated Knowledge and Attendance at Pharmacology Course or In-Service Session

<table>
<thead>
<tr>
<th>Medication</th>
<th>Course or in-service</th>
<th>Mean Score*</th>
<th>Std. Deviation</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)</th>
<th>Mean difference</th>
<th>95% CI of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocuronium</td>
<td>Yes</td>
<td>2.83</td>
<td>.859</td>
<td>2.32</td>
<td>138</td>
<td>.02</td>
<td>.33</td>
<td>.05 to .62</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2.50</td>
<td>.777</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propofol</td>
<td>Yes</td>
<td>3.79</td>
<td>.804</td>
<td>2.92</td>
<td>139</td>
<td>.004</td>
<td>.36</td>
<td>.12 to .61</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3.39</td>
<td>.645</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midazolam</td>
<td>Yes</td>
<td>3.57</td>
<td>.736</td>
<td>3.43</td>
<td>89</td>
<td>.001</td>
<td>.43</td>
<td>.18 to .68</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3.14</td>
<td>.656</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morphine</td>
<td>Yes</td>
<td>4.06</td>
<td>.689</td>
<td>2.42</td>
<td>140</td>
<td>.02</td>
<td>.29</td>
<td>.05 to .52</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3.77</td>
<td>.662</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Scores are based on 5-point likert scale (1=very poor to 5 = excellent)

5.4.2 Self-rated confidence

Responses to the confidence questions for each drug can be found in Table 6. On a 1-5 Likert scale (higher score meaning more confident), only 40% of respondents indicated that they felt quite confident or completely confident administering rocuronium, compared with 79.6% of respondents for midazolam, 92.2% for propofol and 96.5% for morphine. Rocuronium was the only medication to score in the ‘not at all confident’ category.

Table 6

Self-Rated Medication Administration Confidence

<table>
<thead>
<tr>
<th>Medication</th>
<th>Mean</th>
<th>SD</th>
<th>Score*</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Not at all confident</td>
<td>Not very confident</td>
</tr>
<tr>
<td>Rocuronium</td>
<td>3.07</td>
<td>1.04</td>
<td>8.5</td>
<td>20.4</td>
</tr>
<tr>
<td>Propofol</td>
<td>4.32</td>
<td>.625</td>
<td>0.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Midazolam</td>
<td>3.94</td>
<td>.717</td>
<td>0.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Morphine</td>
<td>4.45</td>
<td>.566</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

* Scores are based on 5-point likert scale (1=not at all confident to 5 = completely confident)
5.4.2.1 Confidence and demographics

In evaluating the relationship between personal and professional characteristics and confidence scores for each drug, several significant correlations were found. There were weak to moderate positive correlations between confidence in administering the medications and both years of RN and ICU experience (Table 7), with more years of experience associated with higher reported confidence in administering the medications.

Table 7

Correlations Between Years of Experience and Self-rated Confidence

<table>
<thead>
<tr>
<th></th>
<th>Rocuronium</th>
<th>Propofol</th>
<th>Midazolam</th>
<th>Morphine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of RN experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.159</td>
<td>.262**</td>
<td>.374**</td>
<td>.285**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.06</td>
<td>.002</td>
<td>&lt;.001</td>
<td>.001</td>
</tr>
<tr>
<td>N</td>
<td>140</td>
<td>141</td>
<td>142</td>
<td>142</td>
</tr>
<tr>
<td>Years of ICU experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.210*</td>
<td>.375**</td>
<td>.383**</td>
<td>.224**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.01</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.007</td>
</tr>
<tr>
<td>N</td>
<td>140</td>
<td>141</td>
<td>142</td>
<td>142</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Nurses who completed their primary nursing education outside New Zealand scored significantly higher for confidence for both midazolam (Mean = 4.16, SD .479) and morphine (Mean = 4.64, SD .487) than New Zealand trained nurses (Mean = 3.83, SD .794; t(128) = 3.01, \( p = .003 \), two-tailed; mean difference = .33, 95% CI: .11 to .54) and (Mean = 4.38, SD .587; \( t(137) = 2.53, \ p = .01 \), two-tailed; mean difference = .26, 95% CI: .06 to .46). Those who had undertaken a pharmacology course scored significantly higher only for confidence in using propofol (Mean = 4.49, SD .582) than those who had not attended such sessions (Mean = 4.23, SD .631; \( t(139) = 2.41, \ p = .02 \); mean difference = .26, 95% CI: .07 to .48). Those who had completed a postgraduate qualification in ICU all scored significantly higher in confidence across all four drugs that those who had not (Table 8).
Table 8

Independent T-test for Self-Rated Confidence and Postgraduate Qualifications in ICU

<table>
<thead>
<tr>
<th>Medication</th>
<th>PG ICU qualifications</th>
<th>Mean Score*</th>
<th>Std. Deviation</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)</th>
<th>Mean difference</th>
<th>95% CI of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocuronium</td>
<td>Yes</td>
<td>3.35</td>
<td>.984</td>
<td>3.65</td>
<td>138</td>
<td>&lt;.001</td>
<td>.62</td>
<td>.29 to .96</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2.73</td>
<td>1.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propofol</td>
<td>Yes</td>
<td>4.45</td>
<td>.526</td>
<td>2.81</td>
<td>139</td>
<td>.006</td>
<td>.29</td>
<td>.09 to .49</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>4.16</td>
<td>.700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midazolam</td>
<td>Yes</td>
<td>4.09</td>
<td>.563</td>
<td>2.78</td>
<td>107</td>
<td>.006</td>
<td>.34</td>
<td>.10 to .58</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3.75</td>
<td>.836</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morphine</td>
<td>Yes</td>
<td>4.56</td>
<td>.499</td>
<td>2.69</td>
<td>140</td>
<td>.008</td>
<td>.25</td>
<td>.07 to .44</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>4.31</td>
<td>.614</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Scores are based on 5-point likert scale (1=not at all confident to 5 = completely confident)

5.4.3 Relationship between Self-rated knowledge and Confidence

Each respondent’s confidence and self-rated knowledge scores were averaged across the four medications. Overall, nurses reported higher confidence than self-rated knowledge, with an average confidence score over the four medications of 3.94 (SD=.573) and average knowledge score of 3.29 (SD=.566). There was also a strong positive correlation noted between the average confidence and knowledge scores across the four medications, $r = .663$, $n = 139$, $p = <.001$, with higher levels of confidence associated with higher self-rated knowledge.

5.4.4 Frequency of administration

In response to questions about the frequency with which the studies medications were administered by the respondents (Table 9), rocuronium was found to be administered the least, with only 9% of nurses reporting to use it often to frequently, compared with 37% for midazolam, 70% for morphine and 95% for propofol.

Table 9

Frequency of Medication Administration

<table>
<thead>
<tr>
<th>Medication</th>
<th>Never (%)</th>
<th>Rarely (%)</th>
<th>Occasionally (%)</th>
<th>Often (%)</th>
<th>Frequently (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocuronium</td>
<td>10.6</td>
<td>38.7</td>
<td>40.8</td>
<td>7.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Propofol</td>
<td>0.0</td>
<td>1.4</td>
<td>2.8</td>
<td>16.2</td>
<td>78.9</td>
</tr>
<tr>
<td>Midazolam</td>
<td>0.0</td>
<td>11.3</td>
<td>51.4</td>
<td>33.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Morphine</td>
<td>0.0</td>
<td>0.0</td>
<td>30.3</td>
<td>52.1</td>
<td>17.6</td>
</tr>
</tbody>
</table>

Rarely = 1-5% of patients; Occasionally = 6-25% of patients; Often = 26-50% of patients; Frequently = >50% of patients.
5.4.4.1 Self-rated knowledge scores and frequency of administration

In evaluating the relationship between frequency of use and knowledge scores, several significant correlations were found. There were weak to moderate positive correlations between frequency of administration and self-rated knowledge for rocuronium, midazolam and morphine, with higher frequency of use associated with higher self-rated knowledge (Table 10).

Table 10  

Correlations Between Frequency of Rocuronium, Propofol, Midazolam and Morphine Administration and Self-Rated Knowledge

<table>
<thead>
<tr>
<th>Frequency of medication administration</th>
<th>Self-rated knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rocuronium</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.429**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>N</td>
<td>140</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).  
* Correlation is significant at the 0.05 level (2-tailed).

5.4.4.2 Confidence scores and frequency of administration

There were weak to moderate positive correlation between frequency of administration and self-rated confidence for all four medications, with higher frequency of use associated with higher self-rated confidence (Table 11).

Table 11  

Correlations Between Frequency of Administration and Self-rated Confidence

<table>
<thead>
<tr>
<th>Frequency of medication administration</th>
<th>Self-rated confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rocuronium</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.469**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>N</td>
<td>140</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).  
* Correlation is significant at the 0.05 level (2-tailed).
5.5 ACTUAL KNOWLEDGE

Respondents' knowledge of the pharmacodynamics, pharmacokinetics, side effects, precautions and other considerations of each of the four medications (rocuronium, propofol, midazolam and morphine) was assessed with multiple choice and true/false questions. A score out of 10 was calculated for each of the four medications and a total knowledge score was calculated for the 40 items. To determine what relationships, if any, the tested knowledge scores may have had with self-rated knowledge and confidence or with other data sets such as education or years of service, Spearman’s rank order correlations and t-tests were performed.

5.5.1 Individual and Total Medication Scores

The test scores attained by the respondents for each medication ranged from 1 to 10 for rocuronium, 3 to 10 for both propofol and midazolam and 2 to 10 for morphine. Table 12 is an overview of the mean scores for each. For analysis and discussion purposes 80% was set as an acceptable score to achieve for the knowledge tests, as has been the case in previous research (Brown et al., 1999). Any score below 80% was considered an indication of inadequate knowledge and evidence of a knowledge deficit. All of the mean scores fell below this competency indicator. Propofol had the highest mean score of 62.4%, followed by midazolam (61.7%), rocuronium (59.4%) and morphine (53.2%).

Table 12

<table>
<thead>
<tr>
<th>Medication</th>
<th>N</th>
<th>Mean Score *</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocuronium</td>
<td>127</td>
<td>5.94</td>
<td>1.74</td>
</tr>
<tr>
<td>Propofol</td>
<td>134</td>
<td>6.24</td>
<td>1.57</td>
</tr>
<tr>
<td>Midazolam</td>
<td>122</td>
<td>6.17</td>
<td>1.71</td>
</tr>
<tr>
<td>Morphine</td>
<td>128</td>
<td>5.32</td>
<td>1.63</td>
</tr>
</tbody>
</table>

*maximum score = 10

5.5.1.1 Individual knowledge scores attained by each respondent

In the rocuronium test only 18.9% of the nurses (n=24) achieved the competency indicator of 80% with a score of 8 or more out of 10. Fifty one nurses (40.1%) scored 6-7 and 40.9% (n = 52) scored 5 or less. Only one respondent correctly answered all 10 questions (Figure 3). Propofol scored similarly with 28 respondents (20.9%) achieving a score of 8 and above.
Nearly half of the nurses’ (n = 63, 47%) scored between 6 and 7 and 32.1% (n = 43) scored 5 or below (Figure 4). A quarter of the respondents (24.6%, n = 30) had a score of 8 and above in the midazolam test, with 41.0% (n = 50) achieving between 6 and 7 and 34.4% (n = 42) correctly answering 5 or less questions (Figure 5). Only 6.3% (n=8) of the nurses’ achieved a score of 80% or more for morphine, while 49 (38.3%) scored 60-70% and the majority of the respondents (n = 71, 55.5%) scored 5 or below (Figure 6). No respondents correctly answered all the questions in the propofol, midazolam or morphine tests. Between 8 and 20 participants failed to answer all the questions in each test, therefore total scores for each test could not be tabulated for all respondents.

Figure 3. Rocuronium knowledge scores (n=127).

Figure 4. Propofol knowledge scores (n=134).

Figure 5. Midazolam knowledge scores (n=122).

Figure 6. Morphine knowledge scores (n=128).
5.5.1.2 Total knowledge scores attained by each respondent

The total knowledge scores for the questionnaire ranged from 14 (35%) to 39 (97.5%), with a mean score of 23.72 (59%). Only 6.1% (n=7) met the competency indicator of 80% with a score of 32 or more. Only one respondent scored higher than 34 out of 40. Of the remainder, 64.9% (n=74) scored 50-79% and 21.9% (n=25) of nurses scored less than 50% correct (Figure 7). Twenty eight participants failed to answer all four medication tests in totality, therefore a total knowledge score could only be given for 114 respondents.

![Figure 7. Total knowledge scores (n=114).](image)

5.5.2 Medication Test Item Responses

The percentage of nurses answering correctly each item of the knowledge test is provided in Table 13. The number of correct responses for each medication ranged from 26.2% to 83.7% for rocuronium, 29.6% to 97.9% for propofol, 13.8% to 87.2% for midazolam and 9.9% to 99.3% for morphine. Only 18 questions were answered by all the respondents, with non response to the other questions varying at between 1 and 16 nurses. The questions which were most often not answered were the same for each of the four drugs and were those concerning neurotransmitter systems and receptor sites of action.
There were no questions answered correctly by all the respondents. Knowledge was high (>80% correct) for 6 items across the whole knowledge test, with these high scoring topics varying between each medication. Propofol had the most questions in this category (3). Seventeen questions scored between 60-80% and 17 questions scored less than 60% correct. Of these, 7 were identified as areas that demonstrated very poor knowledge by less than 30% of the respondents answering correctly. The lowest rates of correct answers were obtained in the areas of knowledge of drug effects, onset of action, receptor sites and drug excretion. Knowledge of duration of action and reversal agents was poor to moderate, with the exception being morphine, where the reversal agent was correctly identified by 99.3%; the highest score for any of the questions. Interestingly, although the morphine test had the question with the highest score, it also had the lowest score of 9.9%. In fact 5 of the 10 questions scored under 60% correct, with 3 scoring under 30%, the poorest overall result for any of the medications.
Table 13

*The Number of Correct Responses to the Knowledge Test*

<table>
<thead>
<tr>
<th>Medication</th>
<th>Question #</th>
<th>Topic</th>
<th>% Correct</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocuronium</td>
<td>26</td>
<td>Functional class</td>
<td>71.7</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>Neurotransmitter system</td>
<td>78.9</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Receptor site of action</td>
<td>66.4</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>Duration of action</td>
<td>52.6</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Reversal agent</td>
<td>54.5</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>Precautions</td>
<td>79.1</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>Drug effects</td>
<td>52.5</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>Drug excretion</td>
<td>26.2</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>Onset of action</td>
<td>83.7</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>Drug effects</td>
<td>27.0</td>
<td>141</td>
</tr>
<tr>
<td>Propofol</td>
<td>36</td>
<td>Functional class</td>
<td>97.9</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>Neurotransmitter system</td>
<td>63.4</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>Onset of action</td>
<td>29.6</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>Mechanism of action</td>
<td>80.3</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Precautions</td>
<td>84.4</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>Adverse effects</td>
<td>67.6</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>Drug effects</td>
<td>31.0</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>Drug effects</td>
<td>47.2</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>Drug tolerance</td>
<td>61.3</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>Metabolism</td>
<td>59.9</td>
<td>142</td>
</tr>
<tr>
<td>Midazolam</td>
<td>46</td>
<td>Functional class</td>
<td>87.2</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>Neurotransmitter system</td>
<td>65.6</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>Receptor site of action</td>
<td>45.2</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>Duration of action</td>
<td>76.5</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Reversal agent</td>
<td>72.3</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>Precautions</td>
<td>13.8</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>Metabolism/Excretion</td>
<td>66.2</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>53</td>
<td>Drug effects</td>
<td>69.0</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>Side effects</td>
<td>57.7</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>Drug effects</td>
<td>69.0</td>
<td>142</td>
</tr>
<tr>
<td>Morphine</td>
<td>56</td>
<td>Functional class</td>
<td>70.7</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>57</td>
<td>Receptor site</td>
<td>31.3</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>Onset of action</td>
<td>22.0</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>59</td>
<td>Reversal agent</td>
<td>99.3</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>Mechanism of action</td>
<td>72.9</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>61</td>
<td>Side effects</td>
<td>25.7</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>62</td>
<td>Drug effect</td>
<td>50.0</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>63</td>
<td>Metabolism/Excretion</td>
<td>76.8</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>64</td>
<td>Side effects</td>
<td>9.9</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>Drug effects</td>
<td>66.9</td>
<td>142</td>
</tr>
</tbody>
</table>

* See appendix 2 for the questionnaire
5.5.3 Actual Knowledge and Demographics

Actual knowledge scores for propofol, midazolam and morphine did not correlate with level of education, age, years of RN experience or years of ICU experience. Significant but weak positive correlations were found however between the number of correct answers on the rocuronium test and number of years of RN ($r = .223, n = 127, p = .01$) and ICU experience ($r = .284, n = 127, p = .001$). That is, the more years of experience the respondents had, the better their tested knowledge. Similarly, total knowledge scores correlated weakly with RN experience ($r = .245, n = 114, p = .001$) and ICU experience ($r = .193, n = 114, p = .04$).

5.5.4 Actual Knowledge and Educational Variables

There was no significant difference in scores for any of the four medications in regards to whether respondents had undertaken their nursing education in New Zealand or not. Nor were there any significant differences in scores for morphine in regards to whether respondents had a postgraduate ICU qualification or had attended a pharmacology course/in-service session. There was however a significant difference in scores on the rocuronium test between those who had a postgraduate ICU qualification (Mean = 6.26, SD = 1.54) and those who did not (Mean = 5.61, SD = 1.89; $t(125) = 2.13, p = .035$, two-tailed; mean difference = .65, 95% CI: .05 to 1.26). And those who had attended a pharmacology course or in-service session achieved a significantly higher mean score for midazolam, propofol and total overall knowledge (Table 14).

Table 14

<table>
<thead>
<tr>
<th>Course or in-service session</th>
<th>Mean Score</th>
<th>Std. Deviation</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)</th>
<th>Mean difference</th>
<th>95% CI of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propofol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>6.70</td>
<td>1.65</td>
<td>2.48</td>
<td>132</td>
<td>.01</td>
<td>.70</td>
<td>.14 to 1.25</td>
</tr>
<tr>
<td>No</td>
<td>6.00</td>
<td>1.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midazolam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>6.70</td>
<td>1.70</td>
<td>2.43</td>
<td>120</td>
<td>.02</td>
<td>.79</td>
<td>.15 to 1.43</td>
</tr>
<tr>
<td>No</td>
<td>5.91</td>
<td>1.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>24.95</td>
<td>4.48</td>
<td>2.04</td>
<td>112</td>
<td>.04</td>
<td>1.87</td>
<td>.06 to 3.68</td>
</tr>
<tr>
<td>No</td>
<td>23.08</td>
<td>4.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.5.5 Actual Knowledge and Frequency of Administration
There were no correlations found between the frequency with which the respondents administered rocuronium, propofol, midazolam and morphine and their tested knowledge.

5.5.6 Relationship Between Actual Knowledge and Self-Rated Knowledge and Confidence
There was a weak positive correlation between nurses self-rated knowledge and actual knowledge of propofol \((r = .269, n = 133, p = .002)\) and midazolam \((r = .188, n = 121, p = .04)\), with a higher self-rating of knowledge associated with a higher score. There was also a weak positive correlation between overall self-rated knowledge and the total test score \((r = .209, n = 114, p = .03)\). There was a weak positive correlation between actual knowledge of rocuronium and confidence \((r = .270, n = 125, p = .002)\) with a higher self-rating of confidence associated with a higher score. However there were no correlations between confidence and actual knowledge for the other medications.

5.6 SUMMARY
This chapter has presented the results of this descriptive correlational study. The data obtained from the three sections of the questionnaire has provided informative and descriptive insights into nurses’ knowledge of four important ICU medications and their self-rated knowledge and confidence in using these medications. Pearson product-moment correlations and \(t\)-tests have also identified relationships that exist between knowledge (self-rated and actual), experience and educational background. Correlations between nurses’ self-rated knowledge, confidence and actual knowledge have also been identified and described. These findings will be discussed in the following chapter.
CHAPTER SIX: DISCUSSION

6.1 INTRODUCTION

The requirement for registered nurses to have a sound knowledge of pharmacology is self-evident, as nurses perform key roles in the implementation and evaluation of drug therapy, especially in the intensive care unit. It is clear from the literature however that there are deficits in nurses’ general pharmacology knowledge which have the potential to put patients at risk of harm. By examining the degree to which intensive care nurses perceive that they are knowledgeable about medications and testing their knowledge, this study sheds light on an area of practice that has not been studied in New Zealand. The following chapter examines the key results, identifies and discusses the implications for practice, with reference to previous pharmacology research. Limitations of this study are then addressed, before recommendations for nursing education and future research are outlined.

6.2 NURSES’ SELF-RATED PHARMACOLOGY KNOWLEDGE

6.2.1 Importance of Pharmacology Knowledge

Pharmacology, as part of the biological sciences, represents a substantial part of the knowledge base required for competent nursing practice. Nurses recognition as to the considerable relevance of pharmacology to their work was previously identified by Davis (2009) and Kyriacos et al. (2005). Nurses’ attitudes towards the importance of pharmacology knowledge in the current study similarly reflect this view that it is an integral part of nursing practice. However, while it is indeed positive that all respondents in the current study reported pharmacology to be at least ‘moderately important’ to their practice, the fact that not all the nurses saw it as ‘very important’ is concerning, in view of the fact that medication administration is a fundamental part of intensive care nurses’ work. In order for them to consider seeking and retaining knowledge of anaesthetic, analgesic and neuromuscular blocking drugs as crucial, they need to regard the contribution of pharmacology to their practice as highly important.
6.2.1.1 Influencing factors

No researchers have examined the relationship between professional characteristics and nurses’ views on the importance of pharmacology knowledge. However, Manias and Bullock (2002a) reported in their Australian study that experienced clinical nurses expressed concern at the lack of pharmacology knowledge of new staff, indicating that they themselves obviously placed a high value on this knowledge in practice. Hence, it was particularly surprising that in the current study the more intensive care experience the nurses had, the lower they perceived the importance of pharmacology knowledge to practice. One possible explanation could be the intensive care environment itself, where there is much greater collaboration between nursing and medicine than in other areas of acute care (Fairman & Lynaugh, 1998) with registrars present at all times. This close working relationship means that the pharmacology knowledge of doctors is readily available to nurses, which perhaps over time may cause nurses to feel that it is less important for them to have this knowledge themselves and potentially lead to apathy towards pharmacology. A further striking finding was that those with postgraduate ICU qualifications did not rate the importance of pharmacology knowledge as highly as those without. Of the 55% of respondents who had undertaken postgraduate study in intensive care nursing, only 10 nurses stated that they had undertaken postgraduate study in pharmacology. The remainder had obviously focused on other areas or aspects of intensive care delivery. The content of this postgraduate study has the potential to have influenced what knowledge they saw as important to their role and could therefore explain a devaluation of the contribution that pharmacology makes to their practice.

Whatever the reasons, both of these findings are of concern when one considers that it is the most senior and well qualified staff that undertake roles around orientation, and hence have the potential to influence the attitudes or practices of new staff to ICU and/or direct where their continuing education should occur. Indeed, Arbour (2003) in his study of clinical practice in the areas of sedation, analgesia and neuromuscular blockade, reported that many staff revealed that in these areas of knowledge they had been instructed by preceptors, or learned by watching the practices of other staff.

Interestingly, the single positive variable impacting on nurses’ views was having attended pharmacology courses or in-service education sessions. Nurses who partook in such activities
rated pharmacology knowledge as more important to practice than those who had not. Whether it was attendance at these sessions that increased the nurses’ awareness of the importance of pharmacology knowledge, or their recognition of its importance in their practice that encouraged them to seek out and attend such sessions, is difficult to establish. A lack of research means there are no other studies with which to compare this result.

6.2.2 Self-Rated Knowledge and Confidence

6.2.2.1 Overall self-rated knowledge

In the current study there was a positive correlation between perceived importance of pharmacology knowledge and overall self-rated knowledge, however this correlation was weak and generally awareness of the importance of pharmacology knowledge did not appear to translate into self-rated knowledge. Whilst all respondents viewed pharmacology knowledge as ‘moderately important’ to ‘very important’ to clinical practice, no nurses rated their knowledge as excellent and in fact 11% self-rated their knowledge as poor. This is consistent with findings of Sandie and Heindel (1999) in which 13% of nurses self-rated their knowledge of epidural analgesia as poor, and Sodha, Williams, et al. (2002), where the majority of community nurse respondents (59.3%) believed their overall degree of knowledge to be average, closely aligning to the 62% in the current study who viewed their knowledge the same way. The results were better however than the findings of Kyriacos et al. (2005) in which 20.4% of the respondents felt that they only had a superficial understanding of pharmacology and Fothergill-Bourbonnais and Wilson-Barnett (1992) where 45 (86.5%) of 52 ICU nurses self-rated their knowledge of pain management as fair or poor. Similar results were also reported by Grandall-Neimi et al. (2005) in their study of nurses and nursing students, where only one third of participants agreed that their own pharmacology skills and knowledge were sufficient for practice.

6.2.2.2 Individual medication self-rated knowledge and confidence

When looking at each medication individually there were several interesting findings. There was a spread of mean scores, with rocuronium scoring lowest for self-rated knowledge (Mean = 2.61 on 5 point Likert scale) and morphine scoring highest (Mean = 3.87). The order in which each medication was ranked for both knowledge and confidence were the same, however confidence was rated higher than knowledge for each of the four medications. This could suggest that nurses’ confidence in using these medications was not impacted solely by how
knowledgeable they felt, but rather by how familiar these medications were to them and how often they were used in their practice. This appears to be backed up by the fact that greater frequency of use of the medications was correlated with higher confidence scores for all four medications and higher self-rated knowledge scores for rocuronium, midazolam and morphine. Interestingly though, confidence and knowledge was more strongly correlated with frequency of administration in the cases of rocuronium and midazolam; the two medications which nurses rated as those they were least knowledgeable and confident about and used the least frequently. This indicates that perhaps higher use increases confidence and knowledge more markedly when a drug is used little, but in the case of more familiar medications such as morphine and propofol, where self-rated knowledge and confidence are mostly reported to be average or greater, confidence and self-rated knowledge is not increased by administering the medication more frequently.

6.2.2.3 Influencing factors

The only relationship found between self-rated knowledge and years of RN and ICU experience, was a weak positive correlation found for midazolam, hence not indicating a clear pattern of increasing-self-reported knowledge with experience. This supports the findings of Munro and Grap (2001), who determined that years of experience in ICU or nursing were not predictive of self-rated knowledge, but differs from Fothergill-Bourbonnais and Wilson-Barnett (1992). In their examination of hospice and ICU nurses’ pharmacological management of pain, expert nurses rated their knowledge of analgesics higher than beginner nurses. More experience in ICU nursing was however positively correlated with higher confidence in using all four medications, differing from the results of Munro and Grap (2001) and supporting the finding of Manias (2009) who reported that new nurses, due to limited practical knowledge and experience, felt less confident in their use of medications. Those who had undertaken postgraduate study in ICU also reported higher confidence in the current study; a somewhat surprising result considering that this same group placed a lower value on pharmacology knowledge in practice that those without ICU qualifications.

Munro and Grap (2001) found that educational preparation was not predictive of self-perception of knowledge and a similar finding was reported in the current study, with no correlation identified between nurses’ education level and self-rated knowledge or confidence. However,
although there were no statistically significant findings, there were noticeably lower self-rated knowledge scores shown by nurses with higher levels of education for all four medications and hence a larger sample of nurses may have revealed a statistically significant correlation between self-rated knowledge and level of nursing education. This observed trend of self-rated knowledge being lower in those with higher levels of education is congruent with findings of Sandie and Heindel (1999) who reported that a “good” self knowledge rating was significantly higher for diploma holders (71%) than for associated degree holders (30%) or those with a bachelors of science in nursing degree (11%). It is possible that the more educated group may have reported lower self-rated knowledge because they were more self-aware and hence conscious of their knowledge deficits.

The one factor that had a positive influence on self-rated knowledge for each of the four medications was pharmacology courses or in-service education sessions, with nurses who had undertaken such continuing education reporting higher knowledge than nurses who had not. It is doubtful that in each case the medications from the current study would have been covered, but clearly the content or concepts of pharmacology that were discussed in these sessions either encouraged the nurses to feel more confident in their knowledge, or stimulated their interests and/or foundational knowledge, thereby encouraging them to seek out information about the medications in question. The positive impact of in-service education on self-rated knowledge and confidence levels has been previously reported elsewhere (Jordan & Hughes, 1998; Sandie & Heindel, 1999).

6.3 NURSES’ ACTUAL PHARMACOLOGY KNOWLEDGE

6.3.1 Overall and Individual Medication Scores
An expectation of any intensive care nurse is that they actively acquire and maintain current critical care knowledge and an integral part of that knowledge is ICU medications. However, this study has exposed an overall deficit in all aspects of medication knowledge. The mean overall score on the knowledge test was 59%, with a mean score of 59.4% for rocuronium, 62.4% for propofol, 61.7% for midazolam and 53.2% for morphine. These scores are similar to those obtained by Ndosi and Newell (2009) for nurses in surgical wards (60%), Ives et al. (1996) for first year registered general nurses (55.8%) and Markowitz et al. (1981) for medical,
surgical and paediatric nurses (62.3%), but considerably higher than scores reported by Boggs et al. (1988) for general nurses (46.4%) and Sandie and Heindel (1999) for post anaesthetic care unit, intensive care unit and surgical nurses (30%). The finding that morphine was the lowest scoring medication was very unexpected, not only because it was reported as being administered frequently, but also because it is the only drug in the group of four that is administered regularly throughout hospitals, and therefore one that respondents would have had experience in administering prior to working in ICU. A possible explanation for this finding could be that nurses’ familiarity with this drug has caused them to be over confident of their knowledge and less likely to check the accuracy of, or update, their knowledge.

Rocuronium, propofol, midazolam and morphine are high risk drugs with the potential for harm if administered incorrectly and patients in ICU are particularly vulnerable due to their already compromised physiological condition associated with critical illness (Arbour, 2000; Cohen et al., 2007; Devlin & Roberts, 2009). Given the importance of these medications in the treatment and care of ICU patients, the regularity with which they are used and their potential for harm, stringent criterion was applied to define adequate knowledge at an achievement of a total score of at least 80%. Under this criterion, only 24.6% achieved an adequate score for midazolam, compared with 20.9% for propofol, 18.9% for rocuronium and 6.3% for morphine. However, when examining the overall score the results were far worse, with only 7 (6.1%) of the 114 nurses who completed all forty test questions, being found to have adequate knowledge with a score of 32 or higher, while the majority of the nurses (93.9%) had insufficient pharmacology knowledge. The fact that the number who achieved an adequate overall score is lower than that for each of the medications individually indicates that where a nurse may have done well on one drug test they did not do well on others. These findings are consistent with previous studies where nurses’ performances in medication knowledge tests were below the expected standards (Boggs et al., 1988; Bray, 1993; Grandell-Niemi et al., 2005; Ives et al., 1996; Markowitz et al., 1981; Ndosi & Newell, 2009; Simonsen et al., 2011; Sodha, Williams, et al., 2002).

6.3.2 Identified Areas of Weakness

The item-by-item analysis revealed serious gaps in knowledge and in fact there was not one area of pharmacology knowledge where nurses consistently performed well across the four medications.
6.3.2.1 Medication class, receptor sites and neurotransmitter systems

More than 70% of the nurses did correctly identify the functional class of each of the medications, making it score the most favourably of the test questions; however one could expect that all nurses should be capable of identifying the classes to which specialty medications from their practice area belong. Particularly surprising was the fact that 30% of respondents failed to recognise that morphine was an opioid agonist, instead stating it was an opioid antagonist. Difficulties in answering questions on agonists and antagonists were also a finding of Grandell-Niemi et al. (2005). Terms such as ‘agonist’ and ‘antagonist’ are important pharmacological concepts; therefore these findings highlight deficits in understanding of basic principles of pharmacology. Grandell-Niemi et al. (2005) found that correctly identifying the role of cell receptors in drug action was problematic for respondents. Similarly, questions about receptor sites of action and neurotransmitter systems were areas that nurses struggled with in the current study. Furthermore, these were also the questions that were most often left unanswered. If one assumes that these were left unanswered because respondents were unsure of the answers, then potentially knowledge may have been lower than the results would indicate. Knowledge and understanding of functional/chemical class, receptor sites and neurotransmitter systems are crucial so that nurses’ can comprehend how drugs act and hence anticipate and monitor responses.

6.3.2.2 Drug actions and effects

Knowledge of the mechanism of action was another weak area for the nurses and has previously been identified as poor in studies by Boggs et al. (1988), King (2004) and Ndosi and Newell (2009). In O’Donnell’s (1990) study of hospital nurses’ knowledge of resuscitation practices, only 6% of respondents were able to correctly report the actions and effects of all the medications given during resuscitation. Uncertainty about knowledge of drug actions was also noted in research undertaken by Clancy et al. (2000). In terms of the intensive care environment, problems in understanding the actions of neuromuscular blocking agents have also been reported. Loper et al. (1989) stated that 40% of nurses thought the neuromuscular blocking agent pancuronium was an anxiolytic and that 10% of the respondents endorsed the use of pancuronium for analgesia, a finding backed up by Levins (2002) who states that too many nurses wrongly believe that neuromuscular blocking agents have sedative or analgesic properties. In fact the same confusion was found to exist in this study. Forty seven percent
incorrectly stated that the statement “Rocuronium has no effect on pain threshold, but does cause unconsciousness” was true, when in fact rocuronium does not cause unconsciousness, and hence the administration of sedation prior to a dose of rocuronium being given is required (Phillips & Williams, 2006; Tripathi & Hunter, 2006). Administration of neuromuscular blocking agents without sedatives means that patients could perceive a sensation of paralysis and experience pain and anxiety with no means of communicating these perceptions (Luer, 2000) potentially resulting in post-traumatic stress disorder (Lowson & Sawh, 1999). If nurses wrongly believe that neuromuscular blocking agents affect consciousness, then there is a high likelihood that they will not administer sedation first. Arbour (2003) recognised this issue in his clinical quality improvement study, where he observed that multiple patients had been paralysed without adequate sedation and analgesia.

Another concept from this study that has previously been addressed by other researchers examining knowledge of analgesia, is that of a ceiling effect for morphine. When asked to respond to the statement ‘beyond a certain dosage of morphine, increases in dosages will not increase pain relief”, 50% of respondents in the current study incorrectly answered ‘true’. This finding was similar to studies by McCaffery et al (1992), Hamilton and Edgar (1992) and Erkes et al. (2001), but significantly worse than the finding of Furstenberg et al. (1998) in which only 16% of nurses did not have this knowledge. If nurses believe there to be a ceiling, this may limit the amount of analgesia that they make available to patients in pain. Adequate analgesia is of particular importance in ICU patients as adverse effects of pain in this population include increased blood pressure, heart rate, and respirations, decreased pulmonary function, compromised weaning from ventilation, and can increase morbidity and length of stay (Arbour, 2000; Fuchs & Von Rueden, 2008).

6.3.2.3 Onset and duration of action

Because rocuronium, morphine, midazolam and propofol are all medications that ICU nurses administer on a “PRN” basis, knowledge about onset of action is vital to ensure that the appropriate supports are in place to facilitate care. Knowledge about duration of action is required so that nurses can make appropriate clinical assessments and decisions about when it is safe to administer the next dose. If this is not known there is potential for overdose or drug accumulation to occur (Arbour, 2003). However, nurses in the current study scored
inconsistently on questions around onset and duration of action. More than half of the sample did not correctly identify the duration of action of rocuronium. The lack of knowledge on duration of action amongst nurses is consistent with findings from several US studies (Brown, Bowman, & Eason., 1999; Edgar & Hamilton., 1992) where in both cases more than half of the nurses sampled did not know the duration of action of meperidine, a commonly used opioid in the study hospitals, while Erkes et al. (2001) reported that only 20% of medical/surgical ICU nurses were aware of its usual duration of action. When looking specifically at morphine knowledge, Watt-Watson (1987) found that 51% of the graduate nurse respondents did not know the duration of action of morphine. Although there wasn’t a question on duration of action of morphine in the current study, only 22% were able to correctly identify it’s onset of action and only 50% of the nurses were able to recognise the correct duration of action for propofol.

6.3.2.4 Reversal agents
In addition, knowledge of reversal agents for midazolam and rocuronium was also identified as being poor, raising significant issues around safety. Although it should be noted that rocuronium and midazolam were the least frequently administered medications, with some nurses saying they never or infrequently gave them, other benzodiazepines or non depolarising neuromuscular blocking agents that nurses would likely give instead use the same reversal agents, therefore they should still have been familiar to them. The morphine reversal agent (naloxone) was well known, but due to the prevalence of morphine’s use as an analgesic throughout the hospital, naloxone is generally well known to all nursing staff and even nursing students.

6.3.2.5 Side effects
Boggs et al. (1988) found that nurses tended to have better knowledge of side effects than other areas of pharmacology; however Bray (1993), in her New Zealand study, found that respondents lacked knowledge about the side effects of medications they were taking personally and raised concerns about nurses having responsibility for others medications and offering advice. Similarly, knowledge of side effects was problematic in the current study. Seventy five percent of respondents failed to recognise that an increase in biliary pressure is a side effect of morphine and only 54% correctly identified that nausea and vomiting are uncommon side effects of
midazolam. In the study by Sandie and Heindel (1999) difficulties in distinguishing between the adverse effects of epidural local anaesthetics and epidural opioids were also noted, with correct response rates of only 6% and 5% respectively. Familiarity with opioid side effects was also an issue noted by Erkes et al.’s (2001) ICU study in which only 63% knew that the side effects of opioids decrease over the amount of time they are given. Interestingly the most poorly answered question of the survey highlights a problem not in identifying a common side effect, but the physiology behind it. Ninety percent of the nurses incorrectly agreed with the statement that morphine causes nausea and vomiting though stimulation of the hippocampus, when in fact nausea and vomiting occurs as a result of stimulation of the chemoreceptor trigger zone: The hippocampus is involved only in memory. Concerns about other aspects of nurses’ bioscience knowledge, including pathophysiology, have been discussed in recent literature alongside pharmacology (Banning, 2003; Friedel & Treagust, 2005).

6.3.2.6 Pharmacokinetics and precautions
Questions around pharmacokinetics of the four medications were found to be problematic for nurses, with correct response rates ranging between 26 and 77%. Grandell-Niemi et al. (2005) have previously reported nurses’ difficulties in understanding pharmacokinetics, as have Boggs et al. (1988). Sound knowledge of pharmacokinetics is particularly important within the context of intensive care, as many critically ill patients will need dose adjustment and careful monitoring of drug effects as a result of the impact of failing organs on the metabolism and excretion of the medications. Similarly, awareness of precautions around sedatives, analgesics and NMBAs is paramount, and although these were generally well recognised for propofol and NMBAs, they were very poor for midazolam. One could reasonably expect all nurses to be familiar with patient groups for whom careful consideration needs to occur prior to administering these medications.

6.3.3 Frequency of Administration
Interestingly, there were no correlations between nurses’ actual knowledge and how often they administered each medication in the current study, a finding also reported by Boggs et al. (1988). This differs markedly from the findings in relation to self-rated knowledge and confidence where increased use of the medications correlated in most cases with an increase in scores. Clearly, increased medication use in practice does not mean that those administering the
medication are any more knowledgeable than those who use it infrequently, reinforcing the view that perhaps staff get comfortable with a medication and do not check the accuracy of their knowledge.

6.3.4 Experience and Education Level

The positive correlation in this study between years of RN and ICU experience and overall test score is consistent with previous findings than senior staff obtained higher total knowledge test scores (Hsaio et al., 2010; Ives et al., 1996; Ndosi & Newell, 2009; Sandie & Heindel, 1999). However, when knowledge for each drug in this study was examined separately, test scores for propofol, midazolam and morphine did not correlate at all with years of ICU experience or RN experience, and rocuronium knowledge was only weakly correlated with RN and ICU experience, hence also concurring with studies by Markowitz et al. (1981), Watt-Watson (1987), Boggs et al. (1988), Hamilton and Edgar (1992), Fothergill-Bourbonnais and Wilson-Barnett,(1992); Brown et al. (1999), Jordan et al. (1999), Erkes et al. (2001), Munro and Grap (2001) and Sodha, Williams et al. (2002), which found no significant differences in drug knowledge between nurses with differing levels of experience.

Results on the effect of level of education on nursing knowledge has previously been mixed, with Watt-Watson (1987), Hamilton and Edgar (1992), Brown et al. (1999) and Sandie and Heindel (1999) and Munro and Grap (2001) determining that no association existed between level of education and overall pharmacology knowledge, but conversely Boggs et al. (1988) reporting that pharmacology knowledge was increased with educational background. The findings of the current study were congruent with those of Ives et al. (1996) with no correlation found for either nurses’ overall test scores or their scores for each medication. The study by Ndosi and Newell (2009) indicated that nurses with postgraduate qualifications were more knowledgeable than their undergraduate counterparts and Simonsen et al. (2011) found that postgraduate specialisation was associated with higher knowledge. Rocuronium was the only medication in the current study where knowledge was better for those with postgraduate qualifications in ICU than those without and there were no significant differences in scores for the other three medications or for overall score, therefore the findings of both Ndosi & Newell...
(2009) and Simonsen et al. (2011) are not supported here. No determination was able to be made about nurses with postgraduate pharmacology qualifications, because the small number of nurses in this category meant no analysis could be carried out.

6.3.5 Pharmacology Courses or In-Service Education

Sandie and Heindel (1999) postulated that a lack of in-service education may have substantially accounted for nurses’ poor performance in the knowledge test in their study. Considering that in the current study only 34.5% had attended pharmacology courses or in-service education compared to the 54% that Sandie and Heindel (1999) reported, this could well be a contributing factor here also. The fact that a positive relationship emerged in this study between attendance and knowledge scores goes further towards reinforcing the value of continuing education on knowledge. Those who had attended a pharmacology course or in-service education session had significantly better results for overall score, midazolam and propofol than those who had not. Although the increase in scores was not statistically significant for rocuronium and morphine, they were still slightly higher in the in-service group. Attendance at courses or sessions has previously been identified by Watt-Watson (1987) and L.M. Lim et al. (2010) as having a positive effect on drug knowledge. Tapp and Kropp (2005) showed that an educational intervention led to an increase in nurses’ knowledge of pain medication, as did Erkes et al. (2001), who also found that it was the senior nurses’ whose knowledge was most improved from pretest to posttest. In a study of organisational factors associated with the effectiveness of continuing education in long term care, Stolee et al. (2005) emphasise the importance of workplace environments that supported staff efforts to try improving their knowledge and skills. All these findings lend support to calls that have been made over the last thirty years for pharmacology knowledge to be addressed by way of well-conceived, regular in-service education programmes (Boggs et al., 1988; Bray, 1993; Fothergill-Bourbonnais & Wilson-Barnett, 1992; Manias & Bullock, 2002a; Markowitz et al., 1981). Ndosi and Newell (2009) point out that it is unreasonable to expect nurses to know every drug used in practice, but rather state that emphasis should be placed on in-service education for commonly used drugs, a view shared by Honey and Lim (2008).
6.4 SELF-RATED VS ACTUAL KNOWLEDGE

6.4.1 Correlations Between Self-Rated and Actual Knowledge

A strong positive association between self-assessed and actual knowledge would demonstrate accurate self-assessment and provide reassurance that nurses can identify knowledge gaps (Dunning, Heath, & Suls, 2004). In the current study, correlations were found between self-rated knowledge and actual knowledge for midazolam and propofol and between overall self-rated pharmacology knowledge and total knowledge score, but while these correlations were positive, namely, higher self-rated knowledge was associated with higher test scores, the critical result is that all were weak ($r = .188$ to .269). In addition, no correlation was found between self-rated knowledge and actual knowledge for rocuronium or morphine.

Prior pharmacology studies examining whether or not self-assessment of knowledge correlates with actual objective knowledge, have had similar mixed finding that are consistent with the current study in some areas but not others. Sodha, Williams et al. (2002) in their study of community nurses, reported no significant correlation was found between self-rated knowledge and the number of correct responses on the test, whereas the study by Grandall-Niemi et al. (2005) found a weak positive correlation between self-rated and total knowledge scores, consistent with Hsaio et al. (2010), who reported that nurses who felt more knowledgeable about high-alert medications also achieved higher overall test scores and vice versa. Ives et al’s (1996) study identified a weak positive correlation between respondents’ overall test scores and their overall self-rated pharmacology knowledge, however when the nurses’ self-rating was separated out into five categories of medication knowledge, it was only accurate for therapeutic effects. Sandie and Heidel (1999) noted that nurses’ who perceived their knowledge as ‘good’ scored better on the test than those that stated their knowledge was ‘poor’. However, no mention is made of whether this was a statistically significant result or just an observed trend. The results from this study and the others on pharmacology are perhaps not unexpected, as Dunning et al. (2004) and Regehr and Eva (2006) state that when researchers correlate self-assessments of knowledge and skill against objective performance, the relationship they find is rarely strong, with it most often weak and sometimes null. These weaknesses in self-assessment have also been reported in other areas of nursing literature for a number of years (Drass, Muir-Nash, Boykin, Turek, & Baker, 1989; G. Wynne, Marteau, Johnston, Whiteley, & Evans, 1987).
6.4.2 Overestimation of Self-Rated Knowledge and Confidence

The more concerning aspect of this study was the considerable disparity between perceived knowledge and the actual knowledge of medications used in ICU, with a significant overestimation of self-rated knowledge. Despite only 6.1% having adequate knowledge in relation to the total test score, the majority of the respondents failed to recognise their poor knowledge, with 88.7% reporting their overall self-rated pharmacology knowledge as average or good. Not only was this evident in terms of the overall results, but also for each of the four medications, with in fact the highest rated medication receiving the lowest score. A self-rating of average or better knowledge was given by 100% of the respondents for morphine, but only a staggering 6.3% gained a passing score. Self-rated knowledge for the other three medications was also overestimated, with average or better self-ratings given by 59.2% of respondents for rocuronium, 88% for midazolam and 93.6% for propofol, while knowledge scores of 80% or more were only obtained by 18.9%, 24.6% and 20.9% of respondents respectively. None of the other pharmacology studies that have examined self-rated and actual knowledge have discussed this overestimation, but it is in the health domain that divergences between self-perceptions of knowledge and reality have been most commonly documented (Dunning et al., 2004) and several studies have reported that nurses are most likely to overestimate their abilities (Colthart et al., 2008; Gordon, 1991; Regehr & Eva, 2006; Ward, Gruppen, & Regehr, 2002).

An additional concern was that with the exception of rocuronium, confidence in using the medications was correlated not with actual knowledge but rather self-rated knowledge, consistent with the findings of Munro and Grap (2001). The fact that self-rated knowledge was either not or only weakly correlated with actual knowledge and that the nurses overestimated their abilities, suggests that self-ratings of confidence may not be a good predictor of clinical performance.

These are worrying finding as those who overestimate their self-rated knowledge and confidence have failed to recognise their own knowledge deficits and this has potential for serious consequences when it comes to assessing medication competence. The New Zealand Nursing Council (NZNC) define competence as “the combination of skills, knowledge, attitudes, values and abilities that underpin effective performance as a nurse” (Nursing Council of New Zealand, 2011, p. 12). Central to the demonstration of competence in the New Zealand
nursing environment is self-assessment of the individual’s nursing practice against the relevant regulatory standards/competencies for practice (Nursing Council of New Zealand, 2011). Using self-assessment as an integral part of demonstrating competence involves an implicit assumption that there is a strong relationship between self-assessed competence and actual competence and hence that nurses are capable of accurately determining that their knowledge is adequate (Eva, Cunnington, Reiter, Keane, & Norman, 2004; Ward et al., 2002) which has not been demonstrated to be the case in the current study or that of others (Drass et al., 1989; Ives et al., 1996; Munro & Grap, 2001; Sodha, Williams, et al., 2002). Clearly, the failure of nurses in this study to accurately self-assess knowledge brings the validity of self-assessment as a way of demonstrating competency in medication administration into question, and raises a need for specific assessment of medication knowledge whereby deficits are identified and corrective strategies implemented.

6.5 LIMITATIONS OF THE STUDY

There are several potential limitations to this study, which require discussion. The first is the poor response rate of 28%. This response rate resulted despite careful attention to follow-up strategies. Although low response rates such as this are common for self-reported questionnaires (N. Burns & Grove, 2005; McColl et al., 2001), the response rate could be further explained by the topic of the study. Some individuals may have had a limited interest in pharmacology and therefore may not have wanted to spend time completing the survey. There is also the possibility that the knowledge test may have been too difficult for some or that individuals who did not know the answers may have chosen not to take part. Surveys containing questions of a sensitive nature are also less likely to be returned (Edwards et al., 2002) and evaluation of pharmacology knowledge could be viewed by some nurses as a sensitive area.

In addition to the small sample size which gave rise to smaller subgroups, thereby restricting the use of some tests, data for this study were collected from tertiary ICUs only, and therefore care should be exercised when generalising findings to other New Zealand ICU units. A more comprehensive study involving other public and private ICUs would yield more conclusive data. However, the sample did include nurses from six different tertiary ICU settings with a wide
range of experience and educational backgrounds. In fact, the sample compared well to the national nursing statistics in terms of being representative of the larger ICU nursing population. So, although the survey return rate was not optimal and only tertiary ICUs were sampled, these results may still provide a realistic view of nurses’ pharmacology knowledge in critical care in New Zealand.

A further limitation is that this study utilised a self-reported questionnaire, which carries with it the risk of inaccurate responses as a result of carelessness, poor memory or misinterpretation of a question (Polit & Beck, 2006). In addition there is the well documented problem with self-reported questionnaires that people will try to answer in a socially acceptable way which is otherwise known as ‘response bias’ (N. Burns & Grove, 2005). People like to present a favourable image of themselves and therefore tend to misrepresent their responses by giving answers that are congruent with prevailing social morals (Polit & Beck, 2006). It is possible in the self-reported knowledge and confidence sections of the questionnaire that respondents were self-rating higher for this reason. However, the fact that respondent anonymity was ensured in this study should have encouraged frankness of survey participants. Also, respondents were free to complete the questionnaire at a time and place that allowed privacy, which should have further encouraged accurate data reporting by the participants.

The negative aspect of allowing a private environment for completion of the questionnaire in this study is that it was uncontrolled and as such some of the respondents could have accessed literature to answer the knowledge test or cooperated with other nurses. However, this suspicion was not confirmed by the results, which showed a great spread of scores, with few high scores and no consistent patterns indicating sharing of answers.

Finally, the characteristics and knowledge levels of non-respondents remain unknown and because participation was on a voluntary basis, it was not possible to determine if the subjects were truly representative. Those who completed the survey may have been more interested in the topic or more active members of the staff. They may also have been more highly motivated to answer and more knowledgeable than non-respondents. One would expect that both of these characteristics would result in a greater knowledge level than those who chose not to complete the survey. Hence, the results of this study may in fact, overestimate the actual level of ICU
nurses’ knowledge. But if it is assumed that only the most confident persons volunteered for such an examination, it is rather discouraging that, in reality, the level of knowledge is possibly even lower than this study shows.

6.6 RECOMMENDATIONS FOR ENSURING MEDICATION COMPETENCE

The poor ongoing results from studies examining nurses’ pharmacology knowledge over the last 30 years means that changes to the assessment of competency in medication administration and knowledge needs to take place. Professional organisations and employers need to take some responsibility in terms of identifying, facilitating and supporting continued competence (Campbell & MacKay, 2001).

6.6.1 Nursing Council Responsibilities

Brown (1991) states that the ability to accurately recognise knowledge deficits is just part of a valid self-assessment for the purposes of proving competence and that having appropriate criteria against which knowledge can be judged is equally important. The Health Practitioners’ Competence Assurance Act (2003) requires the Nursing Council of New Zealand, as the body that regulates the practice of nursing, to ensure the continuing competence of practitioners to protect the health and safety of the public. As such, it is their responsibility to lay out clear competencies to ensure that the required knowledge and skills are clearly communicated to nurses. However, currently the indicators in the scope of practice against which nurses are expected to demonstrate competence in relation to medications are very vague, stating only that a nurse “(U)pdates knowledge related to administration of interventions, treatments, medications and best practice guidelines within area of practice” (Nursing Council of New Zealand, 2009, p. 22). For a proper determination of competency around medications to be made, assessment standards and necessary knowledge (such as indications for use, principles of pharmacodynamics and pharmacokinetics, side effects) need to be made explicit. Not only will stringent indicators around medication competencies go some way towards helping nurses to make a more accurate determination of their knowledge deficits (Dunning et al, 2004) but also most importantly ensure that nurses recognise what specific pharmacology knowledge it is expected of them and hence start viewing obtaining and retaining this as a priority in their practice.
6.6.2 District Health Board Responsibilities

There is a need for employers to ensure that nurses meet the requirements of their scope of practice and demonstrate competence in the clinical environment. Currently there is an expectation in district health boards that nurses undergo regular assessment and testing of knowledge related to falls assessment, accessing IV devices, fire training and CPR; the results of this study suggest that the same needs to be considered for medication administration. However, the use of generic medication knowledge assessment tool across the DHB would not take into account the specific context and medication knowledge required to practice in a specialist environment such as ICU (Sulosaari et al., 2011). Therefore quality assurance assessment programmes and formal testing (through multiple choice questions, written and oral tests for example) should be developed for each clinical area, to check the understanding of commonly used medications and important pharmacology concepts (Mason, Fletcher, McCormick, Perrin, & Rigby, 2005). This formal testing and feedback should occur alongside self-assessment to promote a connection between identified and actual knowledge weaknesses and provide a more complete appraisal of competence in nursing practice (Colthart et al., 2008).

6.7 RECOMMENDATIONS FOR NURSING EDUCATION

The finding that ICU nurses performed poorly on a knowledge test examining drugs specifically used in their area of practice has implications for nurse educators in both undergraduate education and continuing education. Although this study did not question the nurses about their experiences of undergraduate education, previous research has revealed the dissatisfaction of teachers, students and nurses in relation to the lack of pharmacology in the curriculum (Bullock & Manias, 2002; Friedel & Treagust, 2005; King, 2004; Latter et al., 2001) and others have indicated difficulties in learning pharmacology (Honey & Lim, 2008; Jordan, et al., 1999; McKee, 2002; Wharrad et al., 1994). The weaknesses that nurses’ in the current study had regarding basic pharmacology concepts serves to reinforce these concerns and highlights the need for content and knowledge acquisition in undergraduate pharmacology education to be addressed. The fact that specific ICU medication knowledge was also poorly understood highlights a need to identify important knowledge, to educate new staff to ICU and to ensure ongoing continuing education occurs around medications that are fundamental to the treatment of critically ill patients. Not only will this improve nurses’ actual knowledge of medications,
but Kruger and Dunning (1999) report that an increase in knowledge by way of educational input also in turn improves the accuracy of self-rated assessment of knowledge or skills.

6.7.1 Undergraduate Education
National processes ensure that pharmacology is included in nursing curricula, but no standard has been set for required drug knowledge, or how and by whom it is taught. There should be a review of the nursing curricula to examine the breadth and depth of pharmacology in the undergraduate curriculum and the content needs to be examined critically for relevance and accuracy. Applied pharmacology should be presented to undergraduate students as a set of skills and knowledge that require self-direction and life-long learning (Latter et al., 2000; A. G. Lim & Honey, 2006), thus ensuring that students recognise the importance of pharmacology in their daily nursing roles. The amount of time devoted to pharmacology must also be evaluated carefully and further research needs to take place around whether pharmacology should be taught as a separate or integrated subject. Fundamental pharmacologic principles and knowledge areas of pharmacokinetics and pharmacodynamics, need particular attention because these areas have previously been identified as the most poorly understood and the most difficult concepts to understand (Boggs et al., 1988; Bray, 1993; Grandell-Niemi et al., 2005; Honey & Lim, 2008; L. M. Lim et al., 2010; Watt-Watson, 1987) and yet they are so fundamental to nurses understanding of medications use in practice (Simonsen et al., 2011).

6.7.2 Ongoing education in ICU
Undergraduate education is not the only place where teaching and learning should be occurring. It is critical that the practice area provides teaching on medications and ensures that nurses have a thorough knowledge base from which to make appropriate decisions and provide safe care (Hanley & Higgins, 2005). Because educational efforts directed at nurses have contributed to improving their knowledge in this study and others (L.M Lim et al., 2010; Tapp & Kropp, 2005) there is justification for putting in place material for nurses covering basic principles to develop familiarity with pharmacological terminology, as well as education that is directly relevant to the specific high risk intensive care drugs with which they are regularly working. This should be addressed in new employee orientation and ongoing continuing education programs.
6.7.2.1 Orientation programmes

Because many ICU drugs, including three of the four from this study, are not used by nurses outside of the ICU, new staff members have no prior experience in administering them, nor do they often have any knowledge on the pharmacological profiles of the medications, potentially causing anxiety and impacting upon their ability to safely administer them to patients. It is therefore reasonable to expect that education around these medications would be a priority and the focus of in house teaching for new staff. Nurses new to intensive care receive an individualised orientation programme, which includes a mutually agreed supernumerary period of experience and this is a good opportunity to teach important pharmacology knowledge by way of a formal, consistent education programme. Unless new nurses to ICU are well educated and informed, they will act on the practices and processes they observe, which may include inadequate understanding of drugs and inappropriate attitudes to pharmacology.

6.7.2.2 Continuing education programmes

Nurses’ difficulties in accurately self-rating their pharmacology knowledge have serious consequences when it comes to professional development and continuous education. For in New Zealand most nurses select their continuing education on the basis of their self perceived needs. In fact the NZNO critical care section states that “The nurse identifies his/her own learning needs” (Critical Care Nurses’ Section of NZNO, 2002, p. 13). If nurses are lacking insight into their weaknesses, they will not seek out appropriate learning appropriate opportunities (Colthart et al., 2008). In addition self-directed learning requires a willingness to address knowledge gaps when they are identified by the individual. Regehr and Eva (2006) suggest that it is overly optimistic to assume that people, upon recognising their gaps, will possess sufficient self-control to raise themselves to the minimum standard. In view of these findings, mandatory education around pharmacology is vital, rather than relying entirely on the nurse’s internal motivation or awareness of deficits to do address knowledge deficits. This education should include dosage, receptor sites of action, pharmacodynamics, duration of action, onset of action, pharmacokinetics, antagonists, dosage and important side effects, precautions and drug interactions for each of the commonly used ICU medications.
6.7.2.3 Teaching strategies

A priority of educators needs to be development of well structured in service education sessions and regular updates on ICU medications in collaboration with unit managers and pharmacists. Post in-service education testing and periodic, ongoing evaluation should also occur to gauge the effectiveness of educational strategies and to maintain the focus on pharmacology knowledge as an important institutional clinical priority. A number of other strategies should also be implemented to provide information to nurses. These could include case studies or unit educational posters, and encouragement of staff to identify a medication of interest to present to their colleagues. In addition, whenever unit educators and/or doctors provide updates or refresher information to staff about procedures or care of patients with selected conditions, pharmaceutical treatment should be an integral part of the discussion. Making medication knowledge a part of each and every educational intervention will emphasise the priority that it holds in the delivery of quality care.

Select interested nurses who have undertaken postgraduate study in pharmacology could become ‘pharmacology resource nurses’ and work collaboratively with other clinical services, such as pharmacy, to improve understanding of regularly used medications among their colleagues. These nurses, in conjunction with nurse educators, could also form a pharmacology practice group to help target specific education efforts based on individual unit needs, prepare and distribute guidelines for the use of a variety of medications and create an atmosphere where medication knowledge is valued as an important domain of nursing and the focus of appropriate critical thinking and ongoing education.

6.8 RECOMMENDATIONS FOR FUTURE RESEARCH

Findings from the survey suggest that specialist areas such as ICU may not be different from others with respect to knowledge about medications, although comparison was limited by the poor response rate. Further research examining these and other commonly used critical care medications in primary and secondary ICUs is required in order to draw more accurate conclusions about the knowledge of this group of nurses. A larger sample would also include larger sub groups of nurses in relation to experience and education to enable more conclusive comparative testing. Further research also needs to be undertaken with ICU nurses to establish
where they learn about the medications they administer, what stops them from increasing their knowledge, and to find out the best way of providing ongoing learning opportunities.

It is likely that the deficiencies found in this study exist in other areas of practice in New Zealand, therefore research also needs to be undertaken to examine the level of pharmacological knowledge in other clinical areas. A cross-country hospital wide study would help identify nurses’ awareness of, perceptions of, competencies in, and barriers to integrating pharmacology knowledge in nursing practice in New Zealand. This would allow a more comprehensive understanding of the issues and potentially provide more evidence for changes in medication competence assessment and delivery of pharmacology education to take place.

In addition to this, research on the pharmacological learning environment in undergraduate education is needed. Student nurses and clinical nurses views on the adequacy of this education is needed in order to enable evaluation of the undergraduate curriculum and the problems to be addressed.

6.9 CONCLUSION

Despite the limitations of this descriptive correlational study, it provides valuable baseline data that describes New Zealand nurses’ self-rated and actual knowledge of pharmacology in ICU; a specialist setting in which there has previously been no New Zealand and little overseas pharmacology research. The findings from this study suggest that nurses have a limited understanding of basic pharmacology concepts and identified significant gaps in their knowledge of neuromuscular blocking agents, analgesics and sedatives. Nurses had difficulty in recognising this poor knowledge, with their self-rated knowledge and confidence for each medication most often overestimated. These results are consistent with the deficits in pharmacology knowledge that have been reported in many different clinical areas in the literature over the last 30 years and clearly indicate a need for improving nurses’ knowledge.

Nurses would benefit from greater emphasis on pharmacology content in the undergraduate curriculum and specific nursing competencies that would allow them to more accurately assess what knowledge is required and improve their ability to identify their own deficits. Regular
formal assessment of this knowledge must occur to ensure competence around medication administration is met. In the practice setting nurses would benefit from collaborative, structured and unstructured pharmacology education focusing on the common medications they administer and finally, further New Zealand research to explore the nature and issues around nurses clinical pharmacology knowledge is needed. All of these interventions are necessary to ensure safer practices around medication administration. For while knowledge itself is not enough to guarantee a reduction in the potential for drug errors and harm, this risk is not going to be reduced in the absence of education, nor will knowledge improve.


Health Practitioners Competence Assurance Act 2003.


Soppitt, A. J. (2004). Sedation and neuromuscular paralysis in the ICU. *Anaesthesia & Intensive Care Medicine, 5*(1), 32-34. doi:10.1383/anes.5.1.32108


APPENDIX 1: PARTICIPANT INFORMATION SHEET

Information Sheet

Research Title: The Self-Rated and Actual Pharmacology Knowledge of Intensive Care Nurses.

Researcher: Elizabeth Johnston: Centre for Postgraduate Nursing Studies, University of Otago.

I am a Master’s student in the Centre for Postgraduate Nursing Studies at the University of Otago, Christchurch. As part of this degree I am undertaking research under the supervision of Beverley Burrell, Senior Lecturer. I am researching the self-rated and actual pharmacology knowledge of nurses working in New Zealand Level III Intensive Care Units (ICU).

It is recognised that nurses play an important role in medication management and that an adequate knowledge of pharmacology and the scientific principles underpinning medications is necessary in order for nurses to undertake this role safely. However there have been no published studies examining the pharmacology knowledge of nurses employed in specialised practice settings such as critical care. Therefore, to extend the knowledge base, this study aims to evaluate nurses’ pharmacological knowledge from an ICU perspective by focusing on four drugs commonly used in this setting: Ropivacaine, Midazolam, Morphine and Propofol.

Only registered nurses whose primary role involves direct patient care are eligible to take part in this study. If you fit this criterion I would appreciate it if you would complete the attached questionnaire. The success of this survey depends on your contribution and it is therefore important that you answer the questions as accurately as you can. Please do not refer to books or discuss any of the questionnaire items with your colleagues before you have completed and returned your response. After completion, please put it into the envelope, seal it and return it to the box in your department no later than 2 weeks after you have received the questionnaire.

This study received ethical approval on March 12th 2010 from the Multi-region Ethics Committee. Responses to this questionnaire are entirely anonymous and all information that you provide through your participation in this study will be kept confidential. Individuals will not be identified in the thesis or in any report. There are no known or anticipated risks to participation in this study. By completing the following survey it is undertaken that you have consented to be in the study.

If after receiving this letter, you have any questions about this study, or would like additional information about the research to assist you in reaching a decision about participating, please contact me at (03)338 2636 or my supervisor, Ms Beverley Burrell, at the Centre for Postgraduate Nursing Studies, University of Otago, P.O. Box 4345, Christchurch, phone (03) 364 3850.

Thank you in advance for your co-operation in my research. Your participation in this study is valued and appreciated.
For questions 1-11 please tick the applicable box.

1. How old are you?
   20-29.......................................................... □
   30-39.......................................................... □
   40-49.......................................................... □
   50-59.......................................................... □
   60+.......................................................... □

2. Are you
   Male.......................................................... □
   Female...................................................... □

3. Which ethnic group do you belong to? *(Mark the space or spaces which apply to you)*
   NZ European............................................. □
   Māori....................................................... □
   Samoan..................................................... □
   Cook Island Maori...................................... □
   Tongan..................................................... □
   Niuean..................................................... □
   Chinese................................................... □
   Indian..................................................... □
   Other *(e.g. Dutch, Japanese)*. Please state__________ □

4. Highest level of Nursing Education
   Nursing Certificate...................................... □
   Nursing Diploma........................................ □
   Bachelor of Nursing Degree........................ □
   Postgraduate Certificate or Diploma............... □
   Master of Nursing (or equivalent).................. □
   PhD......................................................... □

5. Was your primary education leading to nursing registration undertaken in New Zealand?
   Yes.......................................................... □
   No........................................................... □
6. Years of RN Experience
   < 1 year.................................................................☐
   1-2 years...........................................................☐
   3-5 years...........................................................☐
   6-10 years.........................................................☐
   11-15 years......................................................☐
   >16 years.........................................................☐

7. Years of Intensive Care Nursing Experience
   <1 year......................................................................☐
   1-2 years..................................................................☐
   3-5 years..................................................................☐
   6-10 years............................................................☐
   11-15 years............................................................☐
   >16 years...............................................................☐

8. Your current FTE status
   0.8 – 1.0 FTE..........................................................☐
   0.5 – 0.7 FTE..........................................................☐
   <0.5 FTE.................................................................☐

9. Do you have any postgraduate qualifications in Intensive Care Nursing?
   Yes...........................................................................☐
   No...........................................................................☐

10. Have you attended any pharmacology courses/in-service pharmacology education sessions?
    Yes...........................................................................☐
    No...........................................................................☐

11. Have you undertaken any postgraduate study in pharmacology?
    Yes...........................................................................☐
    No...........................................................................☐
For questions 12-25 please tick your preferred option.

12. How important do you think pharmacology knowledge is to your clinical practice?

<table>
<thead>
<tr>
<th>Unimportant</th>
<th>Of little Importance</th>
<th>Moderately Important</th>
<th>Important</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

13. How would you rate your overall pharmacology knowledge?

<table>
<thead>
<tr>
<th>Very Poor</th>
<th>Poor</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

14. How regularly do you administer Rocuronium in your intensive care unit?

<table>
<thead>
<tr>
<th>Never</th>
<th>Rarely (1-5% of patients)</th>
<th>Occasionally (6-25% of patients)</th>
<th>Often (26-50% of patients)</th>
<th>Frequently (&gt;50% of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

15. How would you rate your pharmacology knowledge of Rocuronium?

<table>
<thead>
<tr>
<th>Very Poor</th>
<th>Poor</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

16. How confident are you in administering Rocuronium?

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Not very Confident</th>
<th>A little Confident</th>
<th>Quite Confident</th>
<th>Completely Confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
17. How regularly do you administer Propofol in your intensive care unit?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Never</th>
<th>Rarely (1-5% of patients)</th>
<th>Occasionally (6-25% of patients)</th>
<th>Often (26-50% of patients)</th>
<th>Frequently (&gt;50% of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

18. How would you rate your pharmacology knowledge of Propofol?

<table>
<thead>
<tr>
<th>Knowledge Level</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

19. How confident are you in administering Propofol?

<table>
<thead>
<tr>
<th>Confidence Level</th>
<th>Not at all confident</th>
<th>Not very Confident</th>
<th>A little Confident</th>
<th>Quite Confident</th>
<th>Completely Confident</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

20. How regularly do you administer Midazolam in your intensive care unit?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Never</th>
<th>Rarely (1-5% of patients)</th>
<th>Occasionally (6-25% of patients)</th>
<th>Often (26-50% of patients)</th>
<th>Frequently (&gt;50% of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

21. How would you rate your pharmacology knowledge of Midazolam?

<table>
<thead>
<tr>
<th>Knowledge Level</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
### 22. How confident are you in administering Midazolam?

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Not very confident</th>
<th>A little confident</th>
<th>Quite confident</th>
<th>Completely confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

### 23. How regularly do you administer IV Morphine in your intensive care unit?

<table>
<thead>
<tr>
<th>Never</th>
<th>Rarely (1-5% of patients)</th>
<th>Occasionally (6-25% of patients)</th>
<th>Often (26-50% of patients)</th>
<th>Frequently (&gt;50% of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

### 24. How would you rate your pharmacology knowledge of Morphine?

<table>
<thead>
<tr>
<th>Very Poor</th>
<th>Poor</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

### 25. How confident are you in administering Morphine?

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Not very confident</th>
<th>A little confident</th>
<th>Quite confident</th>
<th>Completely confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
For questions 26-31 please circle the correct response.

26. Rocuronium is a:
   a. Benzodiazepine
   b. Non depolarizing neuromuscular blocking agent
   c. Anti-cholinergic drug
   d. Depolarising neuromuscular blocking agent

27. Rocuronium competes with which neurotransmitter?
   a. Acetylcholine
   b. Noradrenaline
   c. Serotonin
   d. Dopamine

28. At what receptor site does Rocuronium act?
   a. Cholinergic receptors at the motor plate end (skeletal muscle)
   b. Beta 2 receptors in the lungs, brain and skeletal muscle
   c. Serotonin receptors in the Central Nervous System (CNS)
   d. Muscarinic receptors at smooth muscle

29. What is the duration of action of Rocuronium?
   a. 1-2 mins
   b. 5-10 mins
   c. 20-40 mins
   d. 1-2 hours

30. Overdose of Rocuronium is treated with:
   a. Acetylcholine
   b. Naloxone
   c. Neostigmine
   d. Flumazenil

31. In what group of patients should Rocuronium be used with extreme caution?
   a. Orthopaedic trauma
   b. Myasthenia Gravis
   c. Head Injuries
   d. Pneumonia
For the following statements, please circle True, False or Don’t know:

32. Rocuronium has no effect on pain threshold, but does cause unconsciousness

33. Biliary excretion is an important route of elimination of Rocuronium

34. Rocuronium can provide intubation conditions within 60 seconds of administration

35. The sequence of muscle paralysis following administration of Rocuronium is as follows:
   Eyes/face/neck → Limb/abdomen/trunk → Intercostal muscles/diaphragm
For questions 36-41 please circle the correct response.

36. Propofol is a:
   a. Sedative/hypnotic
   b. Analgesic
   c. Barbiturate
   d. Benzodiazepine

37. Propofol appears to act by enhancing which neurotransmitter system:
   a. Glutamate system
   b. Gamma aminobutyric acid (GABA) system
   c. Dopamine system
   d. Noradrenaline system

38. What is the onset of action of Propofol?
   a. 5-10 secs
   b. 10-20 secs
   c. 30-50 secs
   d. 2-5 mins

39. Propofol infusion is associated with?
   a. An increase in tidal volume and respiratory rate
   b. A reduction in cerebral blood flow and intracranial pressure (ICP)
   c. An increase in blood pressure
   d. Analgesic effects

40. In what group of patients should Propofol be used with extreme caution?
   a. Hypovolaemic
   b. Hyperthyroid
   c. Hypertensive
   d. Diabetics

41. Which of the following is not an adverse effect of Propofol?
   a. Respiratory depression
   b. Hypotension
   c. Hypertriglyceridermia
   d. Diplopia
For the following statements, please circle True, False or Don’t know:

42. Propofol has antiemetic and anticonvulsant properties

43. Propofol can substantially reduce cardiac output because it is both a negative inotrope and negative chronotrope

44. Prolonged sedation with Propofol has been associated with the development of tolerance

45. Propofol is eliminated via hepatic metabolism to inactive metabolites
For questions 46-51 please circle the correct response.

46. Midazolam is a:
   a. Barbiturate
   b. Opioid
   c. Benzodiazepine
   d. Neuromuscular blocking agent

47. What is the primary receptor system implicated in the action of Midazolam?
   a. Adenosine system
   b. Glutamate system
   c. Gamma-aminobutyric acid (GABA) system
   d. Cholinergic system

48. Midazolam appears to act by:
   a. Increasing the affinity of the GABA binding site for GABA
   b. Inhibiting the release of GABA
   c. Increasing the affinity of the Glutamate receptor for glutamate
   d. Inhibiting the release of noradrenaline

49. What is the duration of action of IV Midazolam?
   a. 1-4 hours
   b. 6-8 hours
   c. 10-14 hours
   d. 24 hours

50. Overdose of Midazolam is treated with:
   a. Naloxone
   b. Flumazenil
   c. Disulfiram
   d. Neostigmine

51. In what group of patients may Midazolam be eliminated more slowly?
   a. Renal failure
   b. Liver failure
   c. Renal and liver failure
   d. Renal, liver and congestive heart failure
For the following statements, please circle True, False or Don’t know:

52. Midazolam is metabolized primarily in the liver and excreted in the urine
   True  False  Don’t know

53. Midazolam possesses analgesic properties
   True  False  Don’t know

54. Nausea and vomiting are uncommon side effects of Midazolam
   True  False  Don’t know

55. Recovery is more prolonged if a Midazolam infusion exceeds 24 hours
   True  False  Don’t know
For questions 56-61 please circle the correct response.

56. Morphine is a:
   a. Strong pure opioid agonist
   b. Benzodiazepine
   c. Agonist-antagonist opioid
   d. Pure opioid antagonist

57. Which opioid receptor(s) does morphine interact with?
   a. Mu, kappa & delta
   b. Mu
   c. Mu and delta
   d. Kappa and delta

58. What is the onset of action of IV morphine?
   a. < 1 min
   b. 2-3 mins
   c. 5-10 mins
   d. 20 mins

59. Overdose of morphine is treated with:
   a. Naloxone
   b. Nalbuphine
   c. Methylene blue
   d. Methadone

60. Which of the following is not a mechanism of action of morphine?
   a. Reduces anxiety
   b. Decreases venous return (preload)
   c. Increases systemic vascular resistance (afterload)
   d. Decreases myocardial oxygen demand

61. Which of the following is a side effect of morphine?
   a. Pupillary dilation
   b. Decrease in ICP
   c. Increase in Biliary pressure
   d. Diarrhoea
For the following statements, please circle True, False or Don't know:

62. Beyond a certain dosage of morphine, increases in dosage will not increase pain relief.  True  False  Don't know

63. Morphine undergoes hepatic metabolism and is excreted in the urine  True  False  Don't know

64. Morphine causes nausea and vomiting through stimulation of the hippocampus  True  False  Don't know

65. When morphine is given intrathecally, analgesia can persist for 24 hours  True  False  Don't know

Thank you for completing this questionnaire
APPENDIX 3: COPY OF ETHICS APPROVAL

Multi-region Ethics Committee
Ministry of Health
133 Molesworth Street
PO Box 5013
Wellington 6145
Phone (04) 470 0655
(04) 470 0648
Fax (04) 496 2340
Email: multiregion_ethicscommittee@minhealth.govt.nz

Health and Disability Ethics Committees

12 March 2010

Ms Elizabeth Johnson
Canterbury District Health Board
103 Lincoln Road
Addington
Christchurch

Dear Elizabeth

Ethics ref: MEC/10/10/EXP
Study title: The self-rated and actual medication knowledge of Intensive Care Nurses
Investigators: Ms Elizabeth Johnson
Locallities: Christchurch Hospital - University of Otago, Centre for Postgraduate Nursing
Studies

The above study has been given ethical approval by the Multi-region Ethics Committee.

Approved Documents
Protocol Version. 1 dated 2nd of March 2010
• Questionnaire, version 1, dated February 2010
• Statistics Letter describing study, dated 8th of February 2010
• Information Sheet, version 2, dated March 2010
• Māori Consultation Letter from Research Manager – Elizabeth Cunningham, dated 11th of February 2010

Certification
The Committee is satisfied that this study is not being conducted principally for the benefit of the manufacturer or distributor of the medicine or item in respect of which the trial is being carried out.

Accreditation
The Committee involved in the approval of this study is accredited by the Health Research Council and is constituted and operates in accordance with the Operational Standard for Ethics Committees, April 2006.

Progress Reports
The study is approved until 1 March 2012. The Committee will review the approved application annually and notify the Principal Investigator if it withdraws approval. It is the Principal Investigator’s responsibility to forward a progress report covering all sites prior to ethical review of the project by the 12 March 2011. The report form is available on http://www.ethicscommittees.health.govt.nz. Please note that failure to provide a progress report may result in the withdrawal of ethical approval. A final report is also required at the conclusion of the study.

Requirements for SAE Reporting
The Principal Investigator will inform the Committee as soon as possible of any of the following untoward medical occurrences at any dose that:

Administered by the Ministry of Health  Approved by the Health Research Council  http://www.ethicscommittees.health.govt.nz

117
• involves a fatal reaction, or
• involves a life-threatening reaction, or
• results in persistent or significant disability or incapacity, or
• results in a congenital abnormality...

Where the application is for a study with a data monitoring committee SAEs must be reporting by the principal investigator to the ethics committee where they

• are unexpected because they are not outlined in the investigator’s brochure, and
• are not defined study end—points(e.g. death or hospitalisation) and
• occur in patients located in New Zealand, and
• if the study involves blinding, result in a decision to break the study code.

There is no requirement for the individual reporting to ethics committees of SAEs that do not meet all of these criteria.

SAEs should be individually reported within the time-frames for expedited reporting set out in ICH guidelines.

Amendments
All amendments to the study must be advised to the Committee prior to their implementation, except in the case where immediate implementation is required for reasons of safety. In such cases the Committee must be notified as soon as possible of the change.

Please quote the above ethics committee reference number in all correspondence.

The Principal Investigator is responsible for advising any other study sites of approvals and all other correspondence with the Ethics Committee.

It should be noted that Ethics Committee approval does not imply any resource commitment or administrative facilitation by any healthcare provider within whose facility the research is to be carried out. Where applicable, authority for this must be obtained separately from the appropriate manager within the organisation.

We wish you well with your study.

Yours sincerely

Claire Lindsay
Administrator
Multi-region
Email: claire_lindsay@moh.govt.nz
APPENDIX 4: AUCKLAND DHB RESEARCH APPROVAL

Date 13 September 2010

Ms Elizabeth Johnston-Walker
103 Lincoln Road
Addington
Christchurch

Dear Elizabeth

Re: Research project A+4889 (Ethics MEC 10/10/EXP) The self-rated and actual medication knowledge of Intensive Care nurses

The Auckland DHB Research Review Committee (ADHB-RRC) would like to thank you for the opportunity to review your study and has given approval for your research project.

Your Institutional approval is dependant on the Research Office having up-to-date information and documentation relating to your research and being kept informed of any changes to your study. It is your responsibility to ensure you have kept Ethics and the Research Office up to date and have the appropriate approvals. ADHB approval may be withdrawn for your study if you do not keep the Research Office informed of the following:

- Any communication from Ethics Committees, including confirmation of annual ethics renewal
- Any amendment to study documentation
- Study completion, suspension or cancellation

More detailed information is included on the following page. If you have any questions please do not hesitate to contact the Research Office.

Yours sincerely

On behalf of the ADHB Research Review Committee
Dr Mary-Anne Woodnorth
Manager, Research Office
ADHB
11 February 2010

Ma Beverley Burrell
Centre for Postgraduate Nursing Studies
University of Otago, Christchurch

Mā te rangahau hauora e tautoko te whakapiki ake te hauora Māori
All health research in Aotearoa New Zealand benefits the hauora (health and wellbeing)
of tangata whenua

Tena koe, Bev

Thank you to you and Elizabeth Johnston for taking the time to meet with me at the University of Otago,
Christchurch on Wednesday 10th February 2010, to discuss your research study titled:

The self-rated and actual medication knowledge of intensive Care nurses

I note that the multi-centred research is a Masters thesis to access “medication knowledge” of registered
nurses working in Intensive Care in New Zealand.

It is always challenging for me to comment on a survey questionnaire before the data has been obtained.
However the objectives outlined are important to the health care of patients and health professionals.
The nurses knowledge, experience or educational background could highlight (or not) the need to ensure
safe practice given the constant changes of medication.

It would be interesting in terms of workforce development the number of Maori nurses working in
Intensive Care given the question of ethnicity is required in your questionnaire.

It is a requirement of the ethics approval process that a final report be submitted when the research is
complete. A copy of the report should be provided to me at that time as findings from this project may
contribute to the development of future research hypotheses or projects. It is therefore important that
appropriate Maori organisations, Maori health professionals and Maori researchers are aware of your
findings. The Research Office of the University of Otago, Christchurch and in particular myself as the
Research Manager of Maori health would be willing to assist in the dissemination of your findings once
your project has reached a successful conclusion.

My suggestions do not necessarily relate to ethical issues with the research, including methodology.
Other committees may also provide feedback in these areas. I hope this letter will suffice in terms of the
application. Please contact me should you need any other information that may not have been included
in the letter relevant to our conversation.

I wish you well in your research.

“Mo tatou a mo ka uri a muri ake nei” Ngai Tahu 2025

Ka nui tonu nga mihi

Elizabeth Cunningham
Research Manager - Maori

Research Office, Department of the Dean
University of Otago, Christchurch
PO Box 3345, Christchurch Mail Centre, Christchurch 8140, New Zealand
Tel +64 3 364 0237 • Fax +64 3 364 0525 • Email research.uoc@otago.ac.nz
www.uoc.otago.ac.nz