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Nurse staffing, patient falls and medication errors in Western Australian hospitals: Is there a relationship?

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A Thesis Entitled

Nurse Staffing, Patient Falls and Medication Errors in Western Australian Hospitals: Is There a Relationship?

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Submitted as partial fulfillment of the requirements for the Doctor of Philosophy in Nursing

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ABSTRACT

Background: According to the Australian Bureau of Statistics (2013) falls and medication errors in hospitals are among the first twenty leading causes of death. Research on the relationship between nurse staffing, patient falls, and medication errors are limited. Even scarcer are studies that examine this relationship on a nursing shift by shift and ward by ward basis, and no research exists on shift overlap periods and adverse patient outcomes.

Objective: This study examined whether there was a relationship between hospital inpatient falls and medication errors and nurse staffing on a shift by shift and ward by ward basis, including an analysis of patient characteristics and the severity of incidents.

Research Design: Multinomial logistic regression models were used. Data were collected using a secondary analysis of two existing databases: Advanced Incident Management System (AIMS) database and the nursing staff roster database (RoSTAR) over two years (January 2011 to December 2012). The Kane framework of nurse staffing was used to guide the current study.

Setting: The study was conducted in three adult tertiary teaching hospitals in Perth, Western Australia.

Participants: Reports of 7,558 incidents that occurred during the study period from 76 nursing wards and wards (4,677 medical, 2,209 surgical, and 672 critical care wards incidents), and 320,009 nursing shift records in three hospitals, were examined.

Measures: The occurrence and severity of shift-level inpatient falls and medication errors were measured as dependent variables. Independent variables included nursing staff skill-mix, staff experience, and actual nursing hours. Control variables were shift, ward type, and hospital.

Results: This study supports the importance of RN staffing levels in improving patient outcomes. However, it also shows that the relationship between nurse staffing and patient outcomes can be affected by different factors such as patient characteristics, nurse characteristics, and ward type. The number of total clinical incident reports decreased by 7.4% from 2011 to 2012. Falls declined by 4.6% and medication errors declined by 10.8%. The average age of patients who fell or had medication errors was 56.3 years (range of 15 to 100 years) but was more common in patients over 65 years old (57.3%). The number of incidents was highest during the morning shift, less during the evening and lowest during the night shift (28.4%, 27.2%, and 21.8% respectively). Notably, 22.6% of total incidents were reported during the *overlap* period (13:00 pm to 15:29 pm) which is only two and a half hours. Medical wards had the highest incident records followed by surgical wards; fewer incidents occurred in critical care wards (61.9%, 29.2%, and 8.9% respectively). More registered nurses and more experienced staff on the shift were both associated with fewer falls and medication error incidents, as well as less severe injuries. An increase in the actual nursing hours was associated with fewer medication errors but not fewer fall incidents. However, an increase in in the actual nursing hours was associated with less severe falls but not less severe medication errors.

Conclusion: Overall, the fall and medication error incidents in three Perth hospitals decreased over the study period. However, the large variation in the incidents at both the shift and the ward level indicated room for improvement related to fall and medication error prevention. A relationship was identified between both more RNs and more experienced nurses in attendance and fewer incidents and less severe injuries. Further studies are necessary to identify prevention strategies for hospital falls and medication errors in the overlap period. Immediate consideration of the number of incidents that occurred during the overlap period is required. It is necessary to improve communication and teamwork among staff. Actions should be taken to review, implement and evaluate policies and procedures.

DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

(i) Incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;

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Under the direction of his Thesis Advisor, and approved by all Thesis Committee has been presented to and accepted by the Dean of Graduate Research, in partial fulfilment of the requirements for the degree of

PhD. in Nursing

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Prof. Anne Williams
Associate Supervisor
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DEDICATION

The dedication for this research, which has been such a major part of my life, must reflect the contributions and sacrifices made by my family and friends. My family and friends allowed me to sacrifice such precious time to complete this project. This time can never be replaced or revisited and represents the significant contributions that everyone made during this lengthy process to complete this journey. Without their sacrifice and continuous motivation, the final product would never have been complete and achieved. For this, I can never thank them enough.

I dedicate this study to the soul of my mother, Halima, who provided support and encouragement in moving forward with my decision of getting the highest education possible. I also dedicate this to my Father, Adeeb, who supported me through every aspect of life in completing my education and encouraging me to strive for the best.

I would like to express my deepest love and appreciation to my wife, Malak. Thank you for being my number one assistant on this project and always looking after our three kids. It would not have been completed without your support.

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GLOSSARY OF TERMS

ACSQHC: Australian Commission on Safety and Quality in Health Care.

AHPRA: Australian Health Practitioner Regulation Agency.

AIHW: Australian Institute of Health and Welfare.

AIMS: Advanced Incident Management System.

AIN: Assistant in Nursing.

AIRC: Australian Industrial Relations Commission.

ANZFPS: Australian and New Zealand Falls Prevention Society.

ANA: American Nurses Association

CIs: Confidence intervals.

DOH: Department of Health.

ECU: Edith Cowan University.

EN: Enrolled Nurse.

F: Fall.

HCN: Health Corporate Network.

HREC: Human Research Ethics Committee.

IOM: Institute of Medicine.

LOS: Length of Stay.

ME: Medication Errors.

MLR: Multinomial Logistic Regression.

NHMRC: National Health and Medical Research Council.

NHPPD: Nurse Hours Per Patient Day.

Non-RN: Non-Registered Nurse.

NSQHS: National Safety and Quality Health Service.

ORs: Odds Ratios.

RN: Registered Nurse.

SPSS: Statistical Package for the Social Sciences.

WA: Western Australia.

WHO: World Health Organisation.

DEFINITION OF TERMS

Term	Definition
Adult Tertiary Hospital	"Adult tertiary hospitals are defined as those hospitals that provide a full range of patient services except for paediatrics and obstetrics, have teaching hospital status and provide tertiary services for certain specialities" (Twigg, 2009, p.21).
Advanced Incident Management System (AIMS)	"a voluntary reporting system to collect information about adverse events, it was implemented across Western Australian Hospitals in 2001" (Patient Safety Surveillance Unit, 2012, p.1)
Adverse Drug Event	"Noxious and unintended event and occurs at doses used in humans for prophylaxis, diagnosis therapy, or modification of physiologic functions" (Classen, Pestotnik, Evans, Lloyd, & Burke, 1997) p. 302).
Adverse Events	"harm to a patient as a result of medical care or in a health care setting" (Levinson, 2010, p I)
Assistant in Nursing (AIN)	Is trained in a vocational or technical school to assist with the work of RNs and ENs in the care of patients in a variety of settings. "AIN assist in the provision of basic nursing care, working within a plan of care under the supervision and direction of a registered nurse. Entry requirements are Certificate III in Health Services Assistance (Acute Care)" (DOH, 2015).
Critical Care	Critical care wards and intensive care wards (ICU) are those capable of continuous surveillance such as the Cardiac Care Unit (CCU).
Data Custodians	"are responsible for the day-to-day management of data from a business perspective. The Data Custodian aims to improve the accuracy, usability and accessibility of data within the data collection" (Patient Safety Surveillance Unit, 2012, p.9).
Enrolled Nurse (EN)	A graduate of an accredited school of practical nursing and is trained and certified to administer technical nursing procedures. "The main responsibilities of an EN are to work under the supervision of registered nurses to provide patients, from all

Term	Definition
	backgrounds and ages, with basic nursing care. Within their scope of practice, ENs are accomplished in the practical skills of nursing, with advanced skill ENs able to undertake more complex procedures, including observing and measuring vital signs and assisting patients with daily activities. Entry requirements are Diploma of Nursing. ENs must be registered with the Nursing and Midwifery Board of Australia. ENs can complete a conversion degree to become an RN" (DOH, 2015).
Failure to Rescue	"The inability of a hospital to rescue a patient from complications that occur after the patients' admission to the hospital". Alternatively, it is the number of patients who died from an adverse occurrence (Kutney-Lee & Aiken, 2008).
Falls	An event that results in a person coming to rest inadvertently on the ground or floor or another lower level (WHO, 2010).
Five Medication Rights	"the right patient, the right drug, the right dose, the right route, and the right time" (Federico 2014, p. 1).
Hours Worked	Mean nurse hours worked per inpatient day (Kane, Shamliyan, Mueller, Duval, & Wilt, 2007).
Human Research Ethics Committees (HREC)	"protect the welfare and rights of participants involved in research. HREC reviews research proposals that either involves humans directly or require the use and disclosure of personal health information. HREC is responsible for ensuring that research proposals are ethically acceptable and in accordance with relevant standards and guidelines" (Patient Safety Surveillance Unit, 2012, p.9).
Incident	Criteria used to classify adverse events into categories; examples of incidents are medication errors, patient falls (Lee, 2006).
Length of Stay (LOS)	Used to measure the duration of a single episode of hospitalisation. Inpatient days are calculated by subtracting day of admission from the day of discharge (Nelson et al., 2007).

Term	Definition
Medical Error	"failure in the treatment process that leads to, or has the potential to lead to harm to the patient" (McDowel, Ferner, & Ferner, 2009, p. 606).
Medical-Surgical Nurse	An RN who works in a medical or surgical ward; also known as a med-surg nurse (Timby & Smith, 2010).
Medical-Surgical Ward	A ward in which routine nursing care services are provided to medical-surgical patients based on physician orders and nursing care plans (Timby & Smith, 2010).
Medication Error	"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. Such events may be related to professional practice, healthcare products, procedures, and systems, including prescribing, order communication, product labelling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use." National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP, 2016, para. 1).
Nurse to Patient Ratio	The number of patients assigned to an RN for a determined length of time, usually a 4-, 8-, or 12-hour shift (Page, 2004).
Nursing Hours	The total hours of nursing care provided by both RNs and ENs (Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2002).
Nursing Hours Per Patient Day (NHPPD)	A total number of direct patient care nursing hours during a 24-hour period divided by a total number of patients (Needleman et al., 2002; Twigg & Duffield, 2009).
Nursing Workload	The work-related activities provided by a nurse completing direct patient care (Morris, 2007).
Nursing-Sensitive Outcomes	Variable patient or family caregiver state, condition, or perception responsive to nursing intervention (Irvine, Sidani, & Hall, 1998).

Term	Definition
Outcomes	The effect of care on the health of a patient (Donabedian, 1976).
Patient Fall Ratio	The rate per 1,000 patient days on the hospital ward in which a patient has an unplanned descent to the floor (Krauss et al., 2008).
Patient Outcomes	Results of interventions provided on the patient ward from receiving nurse-directed care. These events are often explored to determine if the level of nurse staffing was related to their number to the event (Blegen, Goode, & Reed, 1998; Cho, 2001)
Patient Turnover	The activity on a ward measured as an index of admissions, discharges, and transfers (Patrician et al., 2011).
Registered Nurse (RN)	A nurse who has graduated from a formal program of nursing education (diploma school, associate degree or baccalaureate program) and is licensed by a state board of nursing. "The main responsibilities of an RN range from direct patient care to coordination of care delivery, health promotion, research, and education. RNs can specialise in areas such as Mental Health, Intensive Care, Paediatrics, Community and many other areas. Entry requirements are Bachelor of Science / Nursing. RNs must be registered with the Nursing and Midwifery Board of Australia" Department of Health (DOH, 2015).
RoSTAR	A rostering software package that aids the process of generating timetables for specifying the work shifts of nurses over a given period of time (Edmund, Patrick, Sanja, & Greet, 2004)
Shift Overlap	Anytime between the commencement of the current shift and the completion of the previous one, used for many purposes such as clinical handover, staff training, for coverage of breaks or meetings.
Skill Mix	The number of registered nurses to other clinical nursing staff on the hospital ward (Blegen et al., 1998; Cho, 2001; Needleman et al., 2002).

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CHAPTER I: INTRODUCTION

1.1. Introduction and Background to the Study

According to the World Health Organisation (WHO), one in 10 patients were harmed while receiving care in hospitals around the world (WHO, 2014). It was estimated that around 215,000 patients per year lost their lives to all medical errors in the United States alone (Weeks, 2016). This is equivalent to a commercial jet crashing every day. The Journal of Patient Safety published in 2013 an extensive study by Dr John James, the founder and head of Patient Safety America. The study showed that the number of deaths caused by medical errors in the USA has increased fourfold since the first estimate in 1999; reaching 440,000 deaths in 2013 (James, 2013). In 2008 over 7,000 American patients died specifically because of preventable medication errors (Anderson & Townsend, 2010).

In Canada 9,000 to 24,000 die annually after an avoidable medical error (Baker, 2004), and in England there are approximately 40,000 preventable deaths per year (Hogan et al., 2012). The estimates in Australia are not very different. According to World Health Organisation statistics, 18,000 people may die every year in Australian hospitals through preventable medical errors, 50,000 people suffer from permanent injury annually because of medical errors, and 80,000 Australian patients per year are hospitalised due to medication errors.

In recent years, patient safety has become a national and global priority (Kirwan, Matthews, & Scott, 2013) and has emerged as a primary focus in the delivery of hospital services. In the United States, medical error is the third leading cause of death, after heart disease and cancer (Makary & Daniel, 2016). Healthcare professionals, including nurses, are human beings who inevitably make mistakes for reasons such as inexperience, time pressure, performing insufficient checks, limited memory capacity, fatigue, and stress (Stahel & Clavien, 2015).

Falls and medication errors in hospitals were chosen as the main topics of this study mainly because they have been identified as two of the most common preventable incidents according to the World Health Organisation (WHO, 2011) and the Australian Commission on Safety and Quality in Health Care (ACSQHC, 2013). In the United States (US) the Institute of Medicine (IOM, 2005) reported on the prevalence of life-threatening conditions acquired by patients in hospitals after admission; patient falls were listed as one of eight conditions (Inouye, Brown, & Tinetti, 2009).

Fall injuries are among the 20 most expensive medical conditions (Carroll, Slattum, & Cox, 2005). In the United States the average hospital cost for a fall injury is USD$35,000 (Stevens, Corso, Finkelstein, & Miller, 2006), and depending on the severity of the injury the costs ranged from USD$63,000 to USD$85,984 per fall (Findorff, Wyman, Nyman, & Croghan, 2007). The total treatment costs for patient falls in the United States was USD$19 billion annually: USD$12 billion for hospitalisations, USD$4 billion for emergency department visits only, and USD$3 billion for outpatient care (Stevens et al., 2006). Recent US-based research also reported that the high cost associated with fall-related injuries now totalled over USD$31 billion per year (Burns, Stevens, & Lee, 2016).

In 2010, three million Australians were over 65 years old which equated to 14% of the total population; this is predicted to reach 23% (8.1 million people) in 2050

(Australian and New Zealand Falls Prevention Society [ANZFPS]). Older people who fall are 10 times more likely to be admitted to hospital and eight times more likely to die as a consequence of a fall in comparison to children (Fuller, 2000). The cost of falls is expected to rise to around AUD$1.4 billion annually by 2051. The Australian Department of Health reported that the cost of incidents in Australia was more than AUD$2.2 billion dollars per year (DOH, 2008). The Australian government covered most of the health care expenditure related to patient falls.

Preventing patient falls in the acute care setting has been a goal for many hospitals in recent years. It has been estimated that 30% of hospital-based falls result in some form of serious injury (Hendrich, 2006). Akyol (2007) mentioned four risk factors for falls in the elderly, i.e. increasing age, medication use, cognitive impairment and sensory deficits, and suggested three criteria for any effective fall prevention project: applicability, efficacy, and practicability.

Hendrich (2006) also found environment greatly affected the delivery of safe and effective care. Furthermore, the work environment was found to be associated with risk of mortality and failure to rescue patients from complications that occur after the patients' admission to the hospital (Aiken et al., 2011). Environmental factors such as lighting levels and floor types can add significant risk to patient falls (Barach, 2008).

Medication errors are estimated to cost less than falls (Galanter, Polikaitis, & DiDomenico, 2004) with the average cost of an adverse drug event (ADE) being USD$2000. Medication errors in hospital settings have received considerably more attention in recent years (Tang, Sheu, Yu, Wei, & Chen, 2007).

The cost of treating drug-related injuries in American hospitals is around USD$3.5 billion annually (Aspden et al., 2007). This approximate cost does not include patients losing their incomes or suffering from pain because of medication errors (Aspden et al., 2007). Though most errors do not harm the patient, those that do can be very costly (IOM, 2000). In 2014, the US Department of Health and Human Services/Office of Disease Prevention and Health Promotion found that adverse drug reactions accounted for nearly one-third of all hospital adverse events. This lead to the release of the National Action Plan for Adverse Drug Event Prevention. If these findings are generalised, preventable ADEs cost American hospitals about USD$3.5 billion per year (IOM, 2006). Additionally, adverse events increase patient length of stay (LOS) in the hospitals by 1.7 to 4.6 days (Lucado, Paez, & Elixhauser, 2006).

In Australia, medication errors range from 5% to 20% of all medication orders (ACSQHC, 2013). Barker, Flynn, Pepper, Bates, and Mikeal (2002) examined the medication administration portion of medicine delivery and found 19% contained an error. Medication administration consumes up to 40% of nursing work time (Armitage & Knapman, 2003) and this process has become increasingly complex. Medication errors occur frequently in hospitals; each year it is estimated that more than 1.5 million Australians will experience an adverse event from medication (Roughead & Lexchin, 2006). In Australian hospitals, more than 70,000 admissions per year were due to adverse drug reactions which led to 8000 deaths per year and cost AUD$350 million in direct hospital costs (ACSQHC, 2006; Atik, 2013). Similarly, the IOM reports that medication errors are among the top eight causes of death in the U.S. with around 98,000 deaths in American hospitals per annum (Burke, 2005; Hughes & Ortiz, 2005; Sullivan et al., 2005). Recently the European Commission estimated that adverse drug reactions from prescription drugs caused 200,000 deaths; and about 128,000 patients in the U.S. died from prescription drugs each year (Light, 2014).

In 2011, ten National Safety and Quality Health Service (NSQHS) standards were introduced for Australian hospitals to protect the public from harm and to improve the quality of healthcare services. Health service providers were required to comply with these standards by 2013. Standard Four focuses on medication safety: "Clinical leaders and senior managers of a health service organisation implement systems to reduce the occurrence of medication incidents, and improve the safety and quality of medicine use. Clinicians and other members of the workforce use the systems to safely manage medicines" (NSQHS, 2011, p. 34). Standard Ten focuses on falls: "Clinical leaders and senior managers of a health service organisation implement systems to prevent patient falls and minimise harm from falls. Clinicians and other members of the workforce use the falls prevention and harm minimisation systems" (NSQHS, 2011, p. 66).

Currently, few studies across healthcare organisations have specifically explored the relationship between nurse staffing and medication errors and patient falls on a shift-by-shift basis. The two most significant gaps that exist in the literature are the relationships between nurse staffing and specific patient outcomes at ward and shift levels. These relationships would help to reveal the frequency and type of incidents occurring between shifts and wards, and why they happen.

Historically, research has revealed a relationship between patient outcomes and nurse staffing levels and qualifications (Needleman et al., 2002). A systematic review of 28 studies revealed an association between increased registered nurse (RN) staffing, lowered mortality, and fewer adverse patient events (Kane, Shamliyan, Mueller, Duval, & Wilt, 2007). However, only a few national and international studies examined the patient outcomes on a shift-by-shift basis (Needleman et al., 2011; Twigg, Gelder, & Myers, 2015).

Researchers often use cross-sectional designs for hospital-level data when they study nurse staffing and patient outcomes. However, this study has used a longitudinal design to facilitate a more in-depth analysis. It examined the relationships between nurse staffing on a shift-by-shift level and ward-by-ward level with patient falls and medication errors.

1.2. Thesis Approach

This thesis examines administrative data from two years: 2011-2012. Data were derived from records of the Advanced Incident Management System (AIMS) which was a system utilised across all Western Australian government health services to cover the reporting, investigation, analysis and monitoring of clinical incidents. Each time an incident occurs the form is completed and these data are entered into the AIMS database (see Appendix A). This is now recently known as the Clinical Incident Management System (CIMS). The second dataset, the RoSTAR database, is a commercial software program used in West Australian hospitals to efficiently roster large numbers of staff working at multiple levels and in different locations. RoSTAR data are managed by the Health Corporate Network (HCN) in Western Australia. These two datasets were linked to each other by the candidate using a direct data linkage system (same day, shift, ward, hospital). It is noted that original data were collected and entered into these systems by third parties who were subject to the policies, guidelines, and statutes that define such activities and not by the candidate. However, the candidate did solely perform all data linkage, checking, cleaning, manipulation and analysis with advice from Edith Cowan University statisticians.

Chapter II reviews the literature on the relationships between nursing staff and specific patient outcomes, the Australian system for classification of nurses, and discusses the literature gaps investigated in this study.

Chapter III describes the methods used in this study, including the setting within the Western Australian context. Methods of record linkage are introduced, and the use of the multinomial logistic regression statistical method is described.

Chapter IV presents a descriptive analysis followed by the results of the multinomial logistic regression. The relationship between nursing staff and patient outcomes is explored using multinomial logistic regression on a shift-by-shift basis.

Chapter V discusses the results of the analyses in the light of other studies, the conclusions, and recommendations, as well as the limitations of the study.

1.3. Significance of the Study

This study is significant because it used a novel approach to methodology, results, and outcomes. Outcomes were falls and medication errors, the analysis was shift-by-shift over two years and the methodology was a multinomial logistic regression.

This study will contribute to the existing body of nursing knowledge by providing a better understanding of the relationships between nurse staffing and patient falls and medication errors on a shift-by-shift basis. This will enable nurses, nursing leaders, nursing unions, administrators, and policymakers to improve policies for practices and processes regarding nurse staffing and patient safety.

This study offers advantages over the small number of previous studies that have explored this area. This new research provides a foundation for developing further research outcomes. The results will also extend current knowledge about the relationships between nurse staffing at both shift and ward levels, and patient outcomes. This extra knowledge has value for both patients and health care providers in Western Australia and elsewhere.

1.4. Aims and Research Questions

The purpose of this study is to explore the relationship between the reported incidence of patient falls, medication errors, and nursing staff on a shift-by-shift and ward-by-ward basis in Western Australian tertiary hospitals. The study addresses the following research questions:

I. Is there a relationship between patient falls compared to medication errors and nurse staffing on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals?

II. Is there a relationship between nurse staffing and the severity of fall incidents?

III. Is there a relationship between medication errors compared to patient falls and nurse staffing on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals?

IV. Is there a relationship between nurse staffing and the severity of medication error incidents?

1.5. Research Specific Objectives

The first objective of this study was to determine the impact of nursing staff qualifications, actual hours of nursing care provided, and years of experience on patients having a fall or a medication error on a shift-by-shift basis and ward-by-ward level. The second objective was to examine the impact of nursing staff qualifications, actual hours of nursing care provided, and years of experience on the patients and the severity of falls and medication errors.

1.6. Conceptual and Theoretical Framework

The theoretical foundation for this study was the Nurse Staffing and Patient Outcomes Model developed by Kane, Shamliyan, Mueller, Duval, and Wilt (2007).

Kane et al. (2007) proposed a conceptual model to explain the relationship between nurse staffing and outcomes of care. This framework considered several factors that can impact on patient outcomes (Blegen et al., 1998) The relationship between nurse staffing and patient outcomes was affected by patient, hospital, organisation factors and nurse outcomes. The patient length of stay (LOS) was affected by the patient outcomes (see Figure 1).

Kane's model (2007) was based on the US-based health care system, but it is applicable for the Australian care system despite slight differences, for example, shift duration, staff levels. In Kane's model (2007), nurse staffing included nursing hours per patient day, delivered care hours, total paid hours, skill mix, and nurse staffing ratios. Patient outcomes included patient mortality, adverse events, patient satisfaction, and nurse quality outcomes. Nurse characteristics included nurse education, experience, age, use of contract nurses and internationally educated nurses. Patient factors included age, primary diagnosis, patient acuity and severity, comorbidity, and treatment stage. Nurse outcomes included nurse job satisfaction, retention rate, and burnout rate. Hospital factors included hospital size, volume, teaching status, and technology. Organisation factors include clinical wards, duration of shifts, and shift retention.

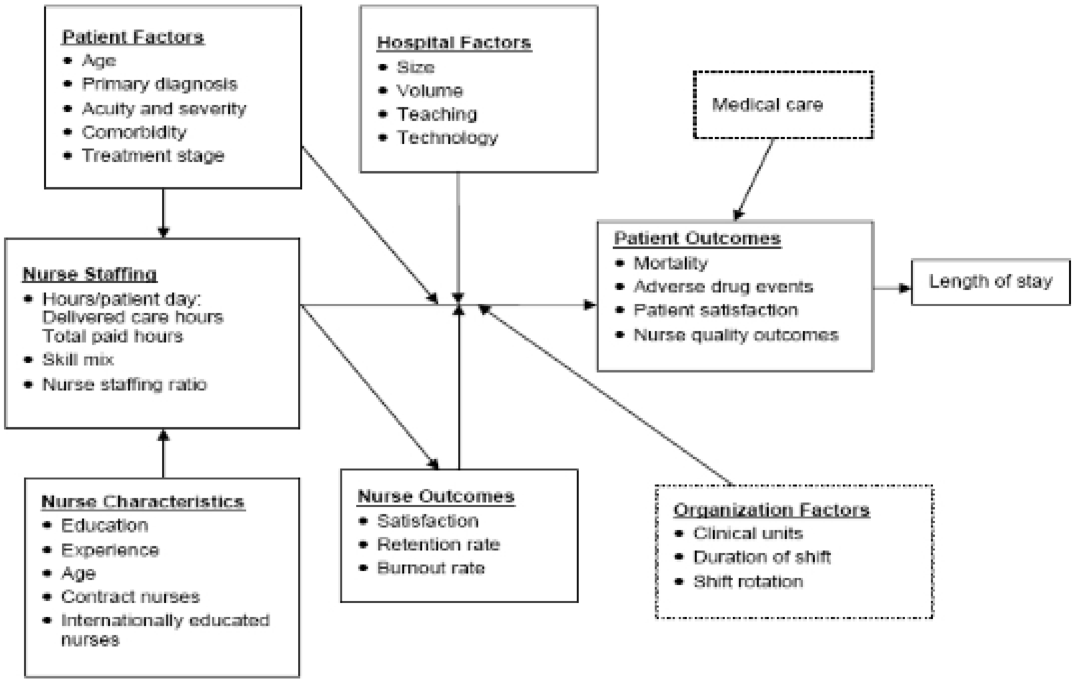


Figure 1: The conceptual framework of nurse staffing and patient outcomes.

Source: Kane, R. L. "Nurse staffing and quality of patient care" (2007), prepared by Minnesota Evidence-based Practice Centre for the Agency for Healthcare Research and Quality, U.S. Dept. of Health and Human Services, Rockville.

For this study, Kane's covariates of interest were modified to reflect the Australian context and available covariates as shown in figure 2. Two groups of factors affecting the relationships between nurse staffing and patient outcomes were included: hospital organisation factors and nurse characteristics. Hospital and organisation factors included the size of participating hospitals, clinical wards type (medical, surgical, critical care), and shift type (morning, overlap, evening, night shifts).

This study proposes that different relationships do exist between the variables of interest as shown in figure 2. Previous research supports the relationship between nurse staffing and outcomes such as patient fall rates (Blegen & Vaughn, 1998; Dunton, Gajewski, Taunton, & Moore, 2004; Krauss et al., 2008; Sovie & Jawad, 2001). Furthermore, other research has investigated and described the effect of hospital factors, nurse characteristics, and patient factors on patient outcomes (Aiken, Clarke, & Sloane, 2002; Aiken et al., 2002). Nurse characteristics that were examined included nursing staff registration status (RN, Non-RN), years of experience in practice, where three staff categories of seniority were calculated and created based on the number of years in practice (level 1 staff: 0 to < 2 years, level 2 staff: ≥ 2 to < 4 years, level 3 staff: ≥ 4 years), and actual hours of care per each group of staff.

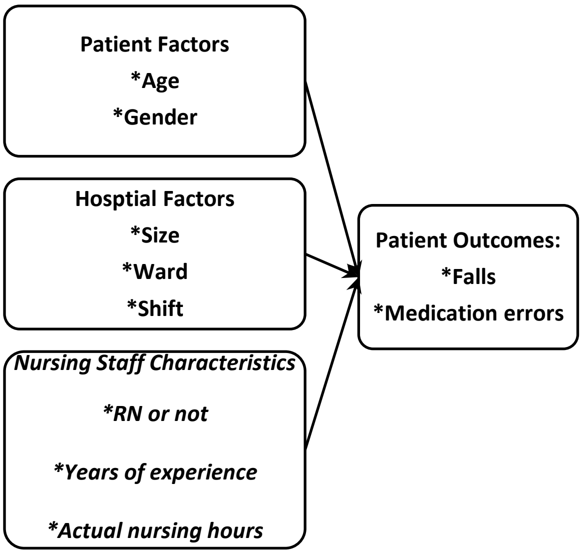


FIGURE 2: the study conceptual model

(Author permission: Kane, R. L., Minnesota Evidence-based Practice Centre & United States Agency for Healthcare Research and Quality (2007). Nurse staffing and quality of patient care. Rockville, MD: Agency for Healthcare Research and Quality, U.S. Dept. of Health and Human Services).

1.7. Summary

The current healthcare environment is focused on ensuring the provision of safe patient care. Consequently, it is essential that nurse administrators and policy makers understand the relationship between structural characteristics such as nurse staffing and patient outcomes such as falls and medication errors. Several studies have been conducted to study this relationship, and these will be reviewed in Chapter II. Although many of the study findings support an inverse relationship between staffing and adverse outcomes, some findings do not. Additional studies have been suggested with careful thought to the limitations of those previous studies already completed and published (Mark, 2006). This current study seeks to add additional information to the growing body of knowledge in the area by studying the effect of nurse staffing on the occurrence of documented patient incidents in an inpatient setting.

CHAPTER II: REVIEW OF THE LITERATURE

This chapter discusses the relationship between nurse staffing and patient outcomes of patient falls and medication errors. The chapter begins with an overview of nurse staffing in Australia, then provides a review of research related to the relationships between nurse staffing, falls, and medication error incidents. The chapter concludes with a discussion of the severity of these outcomes.

The search process included the use of electronic catalogues and databases such as Medline, EBSCO, ERIC, ProQuest, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL). The following keywords were used as search terms: nursing, staff, nursing workforce, RN, EN, AIN, nursing care hours, patient outcomes, falls, medication errors, shifts, wards, nursing years of experience, and shift overlap. The search of the literature was limited to the inclusion of the last 10 years (2006-2016) and identified earlier sentinel studies.

2.1. Nursing Staff in Australia

Nursing staff in Australia involves three categories: registered nurse (RN), enrolled nurse (EN) which are also called licensed practical nurses (LPN) in other countries, and assistant in nursing (AIN). Both RNs and ENs are licensed by the Australian Health Practitioner Regulation Agency (AHPRA). RNs assess patient needs, develop patient care plans, and administer medications and treatments. ENs carry out specified nursing duties under the direction of RNs. AINs typically carry out non-specialised duties and personal care activities. RNs, ENs, and AINs all provide direct patient care.

For RNs, the minimum education requirement is a three-year university degree or equivalent hospital-based program (Australian Institute of Health and Welfare, 2008).

2.2. Nursing Staff and Patient Outcomes

Most of the recent research on hospital structure and patient outcomes has focused on the association between nurse staffing education level, the proportion of RNs and outcomes at the hospital level, which means the researchers have only used one level of analysis. This has mostly been achieved by analysing administrative data. The Agency for Healthcare Research and Quality (2004) reported that hospitals with low nurse staffing tended to have higher rates of poor patient outcomes (Stanton & Rutherford, 2004). Aiken, Clarke, Sloane, Sochalski, and Silber (2002) studied post-surgical mortality and failure to rescue among 232,342 patients discharged from 168 Pennsylvanian hospitals and involving 10,184 nurses through a cross-sectional analysis. It was found that the addition of one patient to an RN’s workload was associated with a 7% increase in mortality over 30 days.

Furthermore, Berney and Needleman (2006) analysed staffing and discharge data from 161 acute general hospitals in New York State, and found an association between overtime and poor rates of six nurse-sensitive patient outcomes or preventable complications. These included urinary tract infection, upper gastrointestinal bleeding, pneumonia, shock, cardiac arrest, sepsis, failure to rescue and mortality.

Griffiths (2009) examined the numbers of registered nurses and patient outcomes in the United Kingdom and found an association between low RN staffing levels and adverse outcomes. Falls was one of these adverse outcomes, however, it was found increases in staff levels alone may not be enough to improve patient care.

Recently, Needleman et al. (2011) conducted a cross-sectional study on 197,961 admissions and 176,696 nursing shifts at Californian state hospitals. Using Cox proportional hazards regression models, they applied a metric derived by taking the target hours of nursing care and comparing them to the actual number of nursing care hours. Target hours of care per shift per ward were derived from a commercially available patient classification system. A difference of eight hours or more below target hours was considered understaffed and was used as the threshold to evaluate the association between staffing of RNs at below target levels and increased mortality. This and many other studies found a statistically significant association between the number of nurse staffing and inpatient mortality (Aiken et al. 2002; Aiken et al., 2011; Aiken et al., 2014; Cho et al., 2003; Diya, Estabrooks, Midodzi, Cummings, Ricker, & Giovannetti, 2005; Liang, Chen, Lee, & Huang, 2012; Needleman et al., 2011; Tourangeau et al., 2007; Tourangeau, Giovannetti, Tu, & Wood, 2002; Van den Heede, Sermeus, & Lesaffre, 2012).

The nursing performance measurement field has benefited from comprehensive and systematic reviews (Blegen, 2006; Kane et al., 2007; Lang, Hodge, Olson, Romano, & Kravitz, 2004; Lankshear, Sheldon, & Maynard, 2005; Needleman et al., 2007). Although there has been an increase in research linking nurse staffing to quality of care, results have yet to yield a consistent foundation to support better nursing ratios, more RNs, stronger practice models, or different processes of care. One reason for the inconsistency may be that the preponderance of evidence to date has only been at the hospital level where it is difficult to attribute poor outcomes to specific structures or processes of care. While this level of analysis gives a better understanding of the relationship between nursing and outcomes, it misses insight as to what happens at the shift and ward level, the sharp edge where patient care is delivered.

Locally, two retrospective analyses investigated nurse staffing and patient outcomes in Western Australia. Twigg et al. (2012) found that nursing skill mix was linked to substantial decreases in eight nursing-sensitive outcomes and increases in three other nursing-sensitive outcomes. In addition, Twigg et al. (2011) noted that after applying a minimum Nursing Hours Per Patient Per Day (NHPPD) policy there were significant decreases at the hospital level in rates of nine nursing-sensitive poor outcomes: mortality, central nervous system complications, pressure ulcers, deep vein thrombosis, sepsis, ulcer /gastritis / upper gastrointestinal bleed, shock/cardiac arrest, pneumonia, and average LOS. At the ward level, significant decreases were also shown in the rates of five poor nursing-sensitive outcomes: mortality, shock/cardiac arrest, ulcer/gastritis/upper gastrointestinal bleed, LOS and urinary tract infections. In New South Wales hospitals, Duffield et al. (2011) conducted a mixed-method longitudinal study which showed that fewer RNs, lesser qualified staff, a heavier workload, and an unstable working environment led to negative and poor patient outcomes including falls or medication errors.

2.3. Nurse-Patient Ratios and Patient Outcomes

In a survey by the American Nurses Association (ANA, 2001), 75% of nurses believed that increased patient loads during the previous two years had adversely affected the quality of care received by patients. This research was further substantiated by Rothberg's (2005) study that found 29% of nurses in Massachusetts knew of a patient death linked to understaffing. Research over the past decade has provided evidence of the effect of nursing hours or skill mix on adverse outcomes such as patient falls (Lake, 2006).

The landmark cross-sectional study by Aiken and colleagues was conducted in four countries (United States, England, Canada, & Scotland), and was widely utilised as evidence to suggest a negative relationship between nurse staffing and patient outcomes (Aiken et al., 2002). The authors found that after adjusting for patient and hospital characteristics, every additional patient per nurse was associated with a 7% increase in the odds of failure to rescue. However, the authors of a later study found no observable association between nurse staffing and failure to rescue (Talsma, Jones, Guo, Wilson, & Campbell, 2014). An important distinction of the Talsma et al. study was that data were obtained at the ward level versus the hospital level and included actual staffing levels versus self-reported staffing levels. An additional feature of this study was that the months of patients' deaths were matched to staffing levels on the ward to also find the impact of staffing on patient mortality.

Zelevinshy (2002) found that when there were fewer RNs caring for patients on medical-surgical wards, there was a higher incidence of poor patient outcomes. Contrary to this, a study by Donaldson et al. (2005) found that mandated ratios did not lead to a significant change in patient fall rates. Donaldson used three approaches to examine nurse-patient ratios in Californian hospitals. The first approach required hospitals to implement nurse-patient ratios based on patient need and held hospitals accountable to maintain these nurse-patient ratios. The second approach was to pass legislation mandating nurse-patient ratios. The third approach combined legislated nurse-patient ratios with a hospital-developed nurse-patient ratios plan. Aiken et al. (2010) compared mandated nurse-patient ratios in Californian hospitals with those in Pennsylvanian and New Jersey and found that nurse-patient ratios mandated in California were associated with lower mortality and more nursing satisfaction.

Increases in nursing workloads and the severity of inpatient illness influence patient hospitalisation across the world. The literature and research suggest that nursing shortages cause adverse events and negative patient outcomes (Aiken et al., 2002; Blegen et al., 2004; Cho et al., 2003; Sochalski, 2004; Unruh, 2003).

Unruh (2003) and Sochalski (2004) concluded that with increases in patient acuity and patient care intensity, a flexible staffing system which allows for adjustments based on patient severity would improve patient outcomes. To sum up, higher nurse-patient ratios are associated with better care quality and patient satisfaction (Aiken et al., 2012).

2.4. Nurse Staffing and Patient Falls

Existing literature was reviewed to identify studies investigating nurse staffing levels and patient falls in the hospital setting. The identified studies primarily investigated the occurrence and severity of falls and the significance of nurse staffing characteristics to patient outcomes. The review also focused on identifying how past studies have aided hospital administrators in improving fall prevention policies and procedures, so that policy implementation and the evaluation of changes in staffing models could help decrease the overall rate of patient falls.

Several studies examined the relationship between nurse staffing and patient falls in hospitals. Consistent with studies using diverse outcomes, these studies included various and alternative measurements of nurse staffing, such as total hours of nursing care per day, total RN hours of nursing care per day, nurse-to-patient ratio, and skill mix. Other studies also measured characteristics of nurse staff such as education, speciality certification, and experience. Consequently, the findings of these studies were conflicting and this is likely due to the type of hospital wards the studies were based on. Some studies separated medical and surgical wards but others combined or included them under one medical-surgical ward. For example, in evaluating total hours of nursing care and patient falls, three studies showed no association (Blegen et al., 1998; Blegen & Vaughn, 1998; Breckenridge-Sproat et al., 2012; Cho et al., 2003). Other studies, however, showed that higher nurse staffing levels were significantly associated with fewer falls on step-down, medical-surgical, and medical wards but interestingly not surgical wards (Dunton et al., 2004). A possible explanation for the conflicting results is that some hospitals are mixing medical and surgical patients in their study samples, whereas others are not.

A relationship between nurse staffing levels and patient falls was also observed in a study by He, Dunton, and Staggs (2012), where wards with lower staffing levels had lower fall rates. This seems counterintuitive, however the researchers suggested that this finding could be attributed to a “diffusion of responsibility” where staff tended to focus more narrowly on their own specific assignments when staffing levels were high, whereas staff assumed more ownership and responsibility for the entire patient population when staffing levels were low.

Using RN skill mix as the independent variable, three studies determined that higher RN skill mix was associated with fewer falls on certain wards (Dunton et al., 2007; He et al., 2012; Patrician et al., 2011). Two studies found no association (Breckenridge-Sproat et al., 2012; Hall et al., 2004); and two studies found a positive association (Grillo-Peck & Risner, 1994; Langemo et al., 2002; Unruh, 2003).

When exploring the incidence rate of falls, studies found that one or more falls were reported in 2% of the patients during the hospitalisation or post-hospitalisation period (Davenport et al., 2009). A higher incidence of fall rate has been attributed to multiple risk factors such as age, history of falls, gait, dizziness, hypotension, and visual impairment (Krauss et al., 2005). Tellingly, the Centres for Disease Control and Prevention (CDC, 2006) released statistics showing a 55% increase in falls for adults 65 years or older between 1993 and 2003.

Generally, fall rates among inpatients have fluctuated from 1.7 to 2.5 falls per 1,000 patient-days depending on the patient ward type (Currie, 2007; Morgan, 1985; & Morse, 1997). Other researchers have estimated higher fall rates from 2.3 to 7 falls per 1,000 patient-days (Halfon, Eggli, Van Melle, & Vagnair, 2001). Similar results were reported by Hitcho et al. (2004) where the highest fall rates at a hospital in Washington D.C. was 6.12 falls per 1,000 patient-days. It seems that as a percentage, patient falls in the acute care setting occurs in 1.9% to 3% of total admissions (Currie, 2007).

In the United States, there are approximately 37 million hospitalisations each year, therefore the resultant number of falls could reach more than one million per year (Agency for Healthcare Research and Quality, 2004). In Australia, there were about 9.7 million total hospitalisations in public and private hospitals according to the Australian Institute of Health and Welfare (AIHW, 2014), with one-third of Australian people aged 65 and over experiencing at least one fall in a year (Gill, 2009; NSW Department of Health, 2010).

Although there is research demonstrating a relationship between patient falls and staffing ratios, limited research has been conducted into how overall nurse-staffing ratios affect the rate of patient falls (Krauss et al., 2005; Schwendimann, 2006). Chiarelli et al. (2009) and Shuto et al. (2010) found a correlation between the incidence of inpatient falls and RN staffing ratios. Furthermore, they found that fall incidences can also be predicted by other risk factors such as Parkinson's disease, stroke, incontinence and vision problems.

A hospital-level study by Cho et al. (2001) investigated the impact of the level of nurse staffing ratios upon patient falls and adverse effects such as pressure ulcers, pneumonia, and sepsis. Cho sampled 124,204 patients at 232 Californian hospitals with 20 Diagnosis-Related Group (DRG) codes between 1998 and 1999. It was found that staffing ratios significantly affected adverse patient outcomes such as pneumonia and pressure ulcers. Although there was a significant inverse correlation found between rates of pneumonia and pressure ulcers and nurse staffing, with more staff leading to better patient outcomes, no significant relationship was found between falls and staffing ratios. Whitman (2002) studied 95 patient care wards across the eastern United States by using a secondary analysis of prospective, observational data and found that an increase in adverse patient outcomes, especially patient falls and medication errors, occurred with a decrease in nurse staffing levels. This finding differs from that of Currie, (2008), whose study demonstrated a significantly higher rate of inpatient falls associated with a decrease in nurse staffing levels. The difference in findings is likely to be related to the different study methods and the sample size.

Lake (2006) also reported that more nurses and more qualified nursing staff in hospitals led to better patient outcomes such as a reduction in the incidence of patient falls and pressure ulcers. Unruh (2003) suggested that although many previous studies have addressed specific relationships involving nurse staffing ratios and patient falls, nurse-patient ratios have not been scientifically determined for specific clinical situations, at least across 215 Pennsylvanian hospitals. Subsequently, Unruh found that in order for healthcare organisations to improve the quality of care, adequate staffing (especially RNs) and balanced workloads were necessary but also costly. These research studies recommended that further investigation of staffing ratios and patient falls was needed to determine if staffing adjustments would have any substantial effect on inpatient hospital falls. However, Dunton (2004) claimed that simply more daily nursing care hours and more RN staff would lead to fewer patient falls and injury.

International studies have involved a mix of ward samples such as medical, surgical, emergency, or critical care (Blegen, Goode, & Reed, 1998; Blegen & Vaughn, 1998; Dang, Johantgen, Pronovost, Jenckes, & Bass, 2002; Mark et al., 2003; Donaldson, 2007; Mark et al., 2008) and a range of nurse-sensitive indicators and outcomes. As noted in an editorial by Needleman (2003), studies have used a blend of administrative data, data abstracted from patient charts, and a range of staffing measures. Several studies have found an association between nurse staffing levels and falls (Blegen & Vaughn, 1998; Mark et al., 2003; Mark et al., 2008; Blegen & Vaughn, 1998; Currie, 2007; Sovie & Jawad, 2001; Unruh, 2002).

However, very few studies have examined the relationship between nurse staffing and adverse patient outcomes such as patient falls on a shift-by-shift or ward-by-ward basis and these studies were only limited to one hospital, for example, in the case of the Needleman (2011) and Twigg et al., (2015) studies. To address this gap in the literature, this study examined and explored this specific aspect on a shift-by-shift and ward-by-ward basis in multiple healthcare organisations.

2.5. Contributing Factors to Patient Falls

Several studies have examined other factors related to patient falls and are presented for contextual purposes. For example, a history of previous falls has been identified as a risk factor for future falls (Mackintosh, Hill, Dodd, Goldie, & Culham, 2006; Stalenhoef, Diederiks, Knottnerus, Kester, & Crebolder, 2002). Other patient-related factors such as age, gender, confusion and delirium, mobility, medications, and toileting along with extrinsic or environmental factors are reviewed.

Patients' Age.

Falls among hospitalised patients tend to occur more frequently for those over 65 years of age (Center for Disease Control and Prevention, 2005). Consequently, many of the studies that explored factors associated with falls limited the study population to adults over a defined older age (Grundstrom, Guse, & Layde, 2012; Stevens & Sogolow, 2005).

Patients' Gender.

Studies examining gender as a risk factor for falls occurring in the hospital setting demonstrated inconsistent results. Three studies found that women fall more often than men (Ackerman et al., 2010; Krauss et al., 2007; Stolze et al., 2004), however only the Ackerman et al. study reached statistical significance. Alternative studies suggested that men fall more often than women (Capone, Albert, Bena, & Morrison, 2010; Halfon, Eggli, Van Melle, & Vagnair, 2001; Hendrich, Bender, & Nyhuis, 2003).

Further, the risk for falling multiple times in a hospital was greater for men than women (Hitcho et al., 2004). Comparing the risk of falling by gender among community-dwelling older adults was significant only for those over the age of 85 years, whereby men were 41% more likely to fall than women. There were also documented gender differences with respect to the consequence of falls. Three studies reported that being female was associated with a decreased risk of injury following a fall (Capone, Albert, Bena, & Tang, 2013; Hitcho et al., 2004; Krauss et al., 2007). Similarly, for 1.64 million total admissions with non-fatal fall related injuries to the emergency departments across the USA, 1.16 million (70.0%) were females. Stevens and Sogolow (2005) found that post-fall hospitalisation rate for women was 1.8 times that for men, and the rate of fractures in females was 2.2 times higher than male patients.

2.6. Time of Falls

Few studies in the literature identified the time of the incident as a predicting factor for adverse patient outcomes. In one very early study, Barbieri (1983) reported the results of a retrospective patient incident report audit and found that the highest incidence of falls among patients aged over 75 years occurred between 06:00am-10:00 am and 04:00pm-08:00 pm. Brown (1983) also found that 50-80-year-old patients had the highest frequency of falls at 03:00 am, whilst Chen (1991) found that falls happened increasingly after 9:00 pm, and reached their highest frequency at midnight, decreasing after 4:00 am. Nearly half (47.5%) of all falls happened during the night shift, followed in order by evening shift (32.7%) and day shift (19.6%). In contrast, the Hill, Johnson, and Garrett study (1988) found that the greatest percentage of falls took place during the 7:30 AM-4:00 PM shift.

Findings from the above studies are contradictory. This lack of consistency in findings may be due to different inpatient samples, different types of hospitals or different types of patient activities during peak periods. To address this gap in the literature regarding predicting and exploring the time of incidents this study used the shift time as one of the covariates in the modelling.

2.7. Falls prevention

Inpatient fall prevention has been an area of nursing concern for many years because all falls are considered avoidable (Currie, 2007). Falls have been associated with consequences such as extended length of stay, increased financial resource utilisation (Zecevic, Chesworth, Zaric, & Huang, 2012), discharge to institutional care, psychological depression (Albert et al., 2014) and/or litigation. As a result, the literature is primarily oriented toward falls prevention and not specifically staffing.

In the domain of acute care hospitals, the research focus has mainly been on the identification of patients at risk, the organisation and evaluation of fall prevention programs (Evans, Hodgkinson, Lambert, & Wood, 2001; Mark et al., 2008), and a particular interest in the elderly population (Agostini, Baker, & Bogardus, 2001). Only one prospective study in a hospital setting was identified that reported falls occurring in all patient age groups (mean= 63.4, range 17-96) (Hitcho et al., 2004).

However, there is no argument that falls in hospitalised patients are costly due to an increased LOS and additional requirements for direct treatment (Bates, Pruess, Souney, & Platt, 1995). Medical costs for an elderly fall event with a serious injury, on average, were approximately three times higher than those with minimal injury (Zecevic et al., 2012). It has been concluded that fall prevention policies have been shown to be beneficial in reducing fall risk (Butt et al., 2013).

2.8. Severity and Consequences of Falls

The outcomes from a fall vary, including fear of falling again, loss of independence and even death. Thirty percent of persons over 65 years of age fall at least once a year, and the quantity rises to 50 percent by age 80 (Markle-Reid et al., 2010). Falling is a substantial cause of injury and death in frail elderly adults. For an assortment of reasons, falls are more likely to cause serious injuries (Vance, 2012). Even non-injurious falls are disabling as the fall can result in activity restriction, isolation, fear of falling, deconditioning, and depression (Albert et al., 2014).

Post fall anxiety syndrome (fear of falling) has been identified as an undesirable outcome of falls (Peel, 2011). This loss of confidence in the capability to walk safely leads to functional decline and feelings of vulnerability, which can lead to limitation of activity, loss of confidence, poor self-esteem, depression, poor quality of life, chronic pain, and functional deterioration (Markle-Reid et al., 2010). Therefore, quality of life is strongly vulnerable to falls and fall-related injuries. Those older individuals who do fall show clinically significant trends towards poorer levels of psychological, social, and physical functioning compared with those who do not fall (Markle-Reid et al., 2010). This finding is consistent with research that shows poor quality of life and function is a common risk factor related to falls (Markle-Reid et al., 2010).

The number of serious injuries reported varied from study to study. Speechley (2011) conducted a historical review study where out of 539 injurious falls, 6% reported serious injuries such as fracture, dislocation, or laceration requiring a suture. One study reported that out of 272 falls, 11% were reported as serious injuries, whereas in another study out of 197 falls, only 3% reported serious injury (Speechley, 2011). A fall does not only affect the individual who falls. Thirty-five percent of caregivers reported having to deal with extra expenses, and 32% needed to change their social activities (Markle-Reid et al., 2010). Twenty percent of caregivers also reported having to change their work arrangements as well (Markle-Reid et al., 2010).

In summary, the literature related to patient falls and nurse staffing consistently appears to be mainly a subset of other studies involving other patient outcomes. Many studies were limited regarding the number of variables examined and did not address any shift by shift patterns. This study has specifically examined the relationship between nurse staffing on patients and the occurrence and severity of falls on a shift-by-shift and ward-by-ward basis, offering new insights into the challenge of falls prevention and improving patients' safety.

2.9. Nurse Staffing and Medication Errors

Adverse drug events (ADEs) are defined by Carlton & Blegen (2006) as any injuries resulting from medical intervention related to a drug and include both inappropriate and appropriate use of a drug (Bates, Boyle, Vander Vliet, Schneider, & Leape, 1995). Medication errors are 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. Such events may be related to professional practice, healthcare products, procedures, and systems, including prescribing, order communication, product labelling, packaging and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use. (NCCMERP, 2016).

Medication errors encompass not only unwanted effects from an appropriately prescribed and administered medication, but also include prescribing errors, patient noncompliance, dispensing and administration errors (Wakefield, Uden-Holman, & Blegen, 1996). Medication errors are more narrowly defined than adverse drug events and include errors of commission and omission. Errors of commission occur when violating one of the six rights of administration: correct drug, patient, dose, route, time, and documentation. Errors of omission occur when the patient does not receive a medication that was ordered (D. S. Wakefield et al., 1999).

Administering medication is a high-frequency activity in nursing; the potential for error increases when the average number of medications administered increases (IOM, 2000). Furthermore, medication delivery is a complex process which is often performed under less than ideal conditions. Combining the frequency and complexity of medicine administration leads to a much higher risk for error (B. J. Wakefield, Wakefield, Uden-Holman, & Blegen, 1998). There is also a tendency to blame individuals rather than the complex administration system. However, most medication errors arise from the orders of physicians, followed by nurse administration. (Carlton & Blegen, 2006).

Medication errors in healthcare are common, costly, and often preventable. Medication-related hospital admissions comprise 2% to 3% of all Australian hospital admissions with an annual cost of AUD $1.2 billion (AIHW, 2013). In the United States, medication-related errors for hospitalised patients cost roughly USD $3.5

billion annually (IOM, 2006). In 1995, a mean of 0.3 medication errors was reported for each patient day or 1.4 errors for every hospital admission in the United States. (Bates, Pruess, Souney, & Platt, 1995). More than a decade later, the IOM (2006) estimated at least one medication error occurs each day for every hospitalised patient, with as many as 1.5 million patients annually experiencing harm from these errors. Medication errors rank third in the list of causes of sentinel events leading to loss of function or death (Pape, 2003).

Barker et al. (2002) conducted a study in 36 facilities in the Georgia and Colorado states, and found that nearly one in five doses administered in their study resulted in error, and that most medication administration reports relied on nurses recognising and reporting the medication errors (D. S. Wakefield, Wakefield, Uden-Holman, & Blegen, 1996) (B. J. Wakefield et al., 1998). Administration of medication at the incorrect time comprised 43% of the errors, followed by omission (30%), wrong dose (17%), and other reasons (10%). Seven percent of the errors were rated potentially harmful which is equivalent to 40 errors per day in a typical 300 patient facility (Carlton & Blegen, 2006).

Some hospital level studies examined the relationship between the use of contract nurses and patient outcomes and showed an associated increase in medication errors (Roseman & Booker, 1995) and other negative patient outcomes with an increased number of contract nurses (Jackson, Chiarello, Gaynes, & Gerberding, 2002; Roseman & Booker, 1995). However, few studies have been conducted at the ward level (Breckenridge-Sproat, Johantgen, & Patrician, 2012; Breeding et al., 2013; Duffield et al., 2011).

In summary, the preponderance of literature to date has mostly focused on the following areas: determining the incidence and prevalence of errors, developing classification systems, identifying steps that are most vulnerable to errors, and evaluating the impact of technology such as computerised order entry systems. However, the literature has been lacking medication error causality, acknowledged to be attributed to underreporting or failure to recognise errors (Wakefield, et al., 1996; Wakefield et al.,1998; Wakefield et al., 1999; Barker, Flynn, Pepper, Bates, & Mikeal, 2002; Blegen et al., 2004; IOM, 2004). Also, the impact of the nurses' work environment on patient safety was studied by many researchers (Lamb, 2007; Mark, 2006; Needleman, Kurtzman, & Kiser, 2007), but despite the literature supporting a variety of outcomes associated with nursing-sensitive indicators, there is still a failure to find consistent results.

Several studies found that higher numbers of RNs were associated with fewer medication errors (Frith, Anderson, Tseng, & Fong, 2012; Hall et al., 2004; Patrician et al., 2011) as were higher total hours of care (Blegen et al., 1998; Whitman, Kim, Davidson, Wolf, & Wang, 2002).

In contrast, the use of non-RNs to administer the medications was associated with more medication errors (Breckenridge-Sproat et al., 2012; Patrician et al., 2011). This study looked at the nursing staff levels and experiences on both the incident and the severity of medication errors.

2.10. Relationship Between (8 or 12-hour Shifts) and Medication Errors

"How long and how much are nurses now working?" is the question asked by Trinkoff, Geiger-Brown, Brady, Lipscomb, & Muntaner (2006). The answer of "too long, too much" causes concern given that the Institute of Medicine (IOM) recommends nurses work no more than twelve hours in a 24-hour period (Trinkoff et al., 2006). Trinkoff et al. (2006) defined an extended work schedule as, "a schedule that varies from the standard one of eight hours per day, 35 to 40 hours per week". Trinkoff studied 2,273 randomly selected nurses residing in two American states. The researchers found that more than a quarter of the sample reported that they are typically working more than twelve hours per day, which goes against the recommendations of the IOM.

Do 12-hour shifts affect patient safety? Two separate studies, Rogers, Hwang, Scott, Aiken, & Dinges (2004), and Scott, Rogers, Hwang, & Zhang, (2006) used logbooks to collect error data associated with nurses. Both studies examined the logbooks to consider if work hours influenced the safety of the patient. In the first study, Rogers et al. (2004) used a broad sample of 393 full-time hospital staff nurses, who were working over 40 hours a week. Log books were used to collect information including the number of hours worked and questions regarding medication errors by each nurse. The researchers stated that log books were used rather than incident reports to collect medication errors, for logbooks had been used in earlier field studies to collect data. Of the 30% of nurses that were scheduled to work a 12-hour shift, 39% of the shifts were over 12.5 hours long. It was found that of all the errors recorded in the log book, 58% were directly related to medication errors. Additionally, the results revealed that

1.6 % of the nurses working 8.5 hours or less had reported making one or more error, whereas 5% of nurses who worked 12.5 or more hours had one or more reported medication errors. When a nurse worked 12.5 hours or more in a shift, the risk of making a medication error significantly increased.

In the second study conducted by Scott et al. (2006), the random sample consisted of critical care nurses who were members of the American Association of Critical Care Nurses. The logbooks of 502 full-time CCU nurses were used to collect information regarding hours worked. Of the 44 % of nurses scheduled 12.5 hours, 62 % of the shifts were actually 12.5 hours or more. The authors reported that for nurses working eight and half hours or less; 2 % reported making at least one medication error. Whereas, for nurses working 12.5 hours or more per shift; 4 % reported making at least one medication error. It was evident that working longer hours increased the chances of making errors. When nurses worked 12.5 hours or more, the risk of making a medication error almost doubled. It is safe to conclude that long work hours pose serious threats to patient safety. Both studies above revealed that a nurse who worked 12.5 hours or more a day was at increased risk of making a medication error. This supports the IOM recommendations of nurses limiting work hours to no more than twelve hours in a 24-hour time period.

In the study conducted by Rogers et al. (2006), for the 393 hospital nurses that logged their errors, the occurrence of medication errors did not increase until the shifts exceeded 8.5 hours per day. The logbooks revealed that nurses working 8.5 hours or less consisted of 543 shifts (9%). Of these 543 only 11 (2 %) reported making at least one medication error, but it seems no matter the length of the shift, nurses are still at risk of making a medication error. However, Rogers found no significant relationship between the nurses who worked 8.5 hours a day and medication errors. A limitation of this study, as reported by the researchers, was the inability to detect the effects of work hours on medication errors for nurses that were scheduled to work less than 12.5 hours a day.

In comparison, another study on staff nurse fatigue and patient safety reported that of 11,387 shifts examined, only 15.7 % of the nurses left at the end of their scheduled shift. Working only 8-hour shifts significantly decreased the risk of making errors. There was no differentiation in the risk of errors if they worked hours that were scheduled hours, mandatory overtime, or voluntary overtime (Rogers, 2008).

Mark & Belyea conducted a study in 2009 to examine the relationship between nurse staffing hours and medication errors. The sample for this study included data collected from 284 medical-surgical nursing wards in 145 hospitals. The data was collected from 911 RN's working eight-hour shifts. This was a longitudinal study to examine the effects of nurse staffing hours on patient safety by the number of medication errors documented in incident reports. Mark & Belyea (2009) defined medication errors as an error in medication administration for wrong patient, drug, dose, time, or route. The data obtained by this study indicates there was only weak evidence to indicate a relationship between work hours and medication errors. One of the limitations the authors stated in this study was that the data concerning medication errors were obtained from incident report data which was likely to underreport errors (Mark & Belyea, 2009).

Researchers have made important discoveries regarding the relationship between the long hours worked by nurses and medication errors. Many early studies show that long work hours pose serious threats to patient safety, however, it is not obvious so far that there is a relationship between twelve-hour shifts and the incidence of medication errors. Finally, a 12 European Countries study by Griffiths et al., 2014 concluded that RNs who worked 12 hours or more report lower quality and safety and more unfinished care.

This study was conducted in Western Australia where the longest shift nursing staff work was typically the 10-hours night shift, a time where more errors were expected as the staff began to tire, but more likely to be discovered and reported in the morning shift following a night shift.

2.11. Nursing Shift Overlap

Western Australian hospitals have three standard shifts: morning from 07:00 am to15:30 pm (8 hours) including the (2.5 hours) overlap period from 13:00 pm to15:30 pm, evening shift from 13:00 pm to 20:59 pm (8 hours), and finally the night shift from 21:00 pm to 06:59 am (10 hours).

The only study that clearly mentioned the mid-day overlap shift was conducted by Hawley & Stilwell in 1993 in Wales to examine the length of the afternoon overlap period which varied from one hour to three and a half hours over 14 different wards. The study stated that hospitals were trying to find ways to reduce labour costs by reducing the nursing shift overlaps (Hawley & Stilwell, 1993). The study also showed that the length of time that extra staff were on duty did not differ greatly between wards with either long or short overlap periods. It was also found that there was often less staff on the ward during the overlap because of a lot of activities happening in this period, for example, meal breaks, staff development and teaching seminars or courses. The authors concluded a shortened overlap was better and called it the "myth of the midday shift overlap". There were no other international or Australian studies identified that had explored the nursing shift overlap.

2.12. Summary

Previous research does not clearly determine a relationship between staffing and patient falls and medication errors. There were few national or international studies that address this issue on a shift-by-shift or ward-by-ward level. Also, very few longitudinal studies have been conducted on the impact of nursing staff levels and years of experience on patient outcomes. There were no studies identified that addressed the relationship between shift overlap periods and patient adverse outcomes. This study explored the effect of nurse staffing levels, nursing experience and shifts, including the overlap period, on the occurrence and severity of falls and medication error incidents.

CHAPTER III: RESEARCH METHODS AND DESIGN

3.1. Introduction

The intent of this study was to investigate the relationship between nursing staff on patients and selected outcomes (patient falls and medication errors). A quantitative multilevel method was implemented, consisting of (a) a data collection of reported incidents and nursing staff rostering information (RoSTAR) and (b) linking the two datasets together. The purpose of this method was to allow for an exploration of the impact of nursing staff on patient who had falls and medication errors across shift, ward, and hospital levels.

This chapter discusses the methods used in the study. It contains a description of the following: (1) research questions, (2) research design, (3) appropriateness, (4) settings and samples, (5) procedures for collecting and cleaning data for analysis, (6) ethical considerations, and (7) data management.

3.2. Research Questions

This study sought to answer four research questions:

I. Is there a relationship between patient falls compared to medication errors and nurse staffing on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals?

II. Is there a relationship between nurse staffing and the severity of fall incidents?

III. Is there a relationship between medication errors compared to patient falls and nurse staffing on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals?

IV. Is there a relationship between nurse staffing and the severity of medication error incidents?

These questions specified the central variables of interest in this study. The dependent variables were specific patient outcomes (falls, medication errors and severity of each). The independent variables were nurse staffing characteristics (education levels, years of experience, actual nursing hours). It is noted the demographical data for nurses such as nurses' age, gender, and background were not available. Additional independent variables included in the modelling were patients' age and gender. Furthermore, hospital, ward, and shift were included as control level variables.

This design consisted of identifying hospitalisations in which incidents had already occurred (documented incident) and matching them with nursing RoSTAR data for the same time period (same patient, same hospital, same ward, same shift). A direct merging technique in Statistical Package for the Social Sciences (SPSS) was used to match the incident and the RoSTAR data by creating an identical "link number" in both datasets. This provided a clear picture regarding every single incident of how the incident happened, where it took place (in which hospital/ward) when (on which shift), and actual nursing hours and what were their qualifications and experience when the incident occurred. This will be discussed later in the chapter (see Section 3.9). Multinomial logistic regression analyses were conducted on the sample of 7,558 incidents to explore patient and nurse characteristics that might predict the impact on patients having the incidents. The various steps and considerations that characterised the design of this study are described in greater detail in this chapter (see Section 3.11).

3.3. Overview of Methods and Design

The study was a retrospective, longitudinal, and nonexperimental design using multinomial logistic regression modelling to provide a secondary analysis of two existing databases from three tertiary hospitals. The data from these databases are classified as secondary data as they were originally collected for different purposes. The data were then matched and linked to answer the pertinent research questions.

This approach was appropriate for the research because it is known that secondary data analysis is a rich source of answers to nursing research questions (Nicoll & Beyea, 1999), analysis of administrative data is becoming common, and this method has been utilised by researchers worldwide (Andrews, Higgins, Andrews, Lalor, 2012; Smith, 2008; Smith et al., 2011). Health care records are created to be multi purpose therefore they represent a valuable resource for secondary data analysis (Magee, Lee, Giuliano, & Munro, 2006).

There are numerous advantages of secondary data analysis: it is inexpensive, flexible, data can be obtained with little effort, they can be analysed quickly, and sample sizes can be large enough to enable the researcher to draw meaningful conclusions. Secondary data are often longitudinal, allowing the researcher to look for trends and changes over time. Disadvantages of secondary data include indirect measures of problems or concerns, potential problems with data accuracy and, while many statistical tests can be significant, the results may not be clinically meaningful (Nicoll & Beyea, 1999). It is noted, however, in some cases the results may not be statistically significant but clinically significant.

This study examined the impact of nurse staffing on patients and the occurrence and severity of patient falls and medication errors. The incidents took place during a two-year period (January 1, 2011, to December 31, 2012) at three adult tertiary teaching hospitals located in metropolitan Perth, in the state of Western Australia. For privacy purposes, the hospitals are named Hospital A, Hospital B, and Hospital C in this study. The participating hospitals had a total bed capacity of 1,883 beds.

Data for this study were collected from two in-use databases: (i) The Advanced Incident Management System (AIMS) which collects data from the standard incident form that was filled out by the staff when an incident occurred in Western Australian hospitals, and (ii) the RoSTAR database which contain rostering information such as staff numbers, levels, shifts, experience, and allocations. Patient incident reports and nurse staffing data were extracted from these Department of Health databases for the two-year period. These data were selected by the researcher because they contained the necessary elements to conduct the current study. It is noted that neither hospital bed occupancy, admissions nor midnight census data were available during the data collection period. As a result, the researcher was unable to calculate ratios or proportions of patients who had incidents compared to total number patients.

3.4. Research Design Appropriateness

The outcomes of interest in this study were patient fall and medication error incidents after being admitted to the hospital, and the severity of the same incidents. Multinomial logistic regression modelling was used in this study to identify nurse characteristics that predict the probability of impacting on patients with these incidents. Multinomial logistic regression is defined as a characterisation methodology that generalises logistic regression to multiclass problems, i.e. with more than two conceivable discrete results (Greene, William, 2012).

Multinomial logistic regression is a widely used methodology within the health care discipline (Bagley, White, & Golomb, 2001). Logistic regression analysis consists of applying logistic regression with the intention of determining whether the independent predictor variables are associated with the dependent categorical variable (Hosmer & Lemeshow, 2000).

Multinomial logistic regression was selected for its predictive ability. Logistic regression allows one to predict a discrete outcome such as group membership from a set of variables that may be continuous, discrete, dichotomous, or a mix (Tabachnick & Fidell, 2001). Furthermore, logistic regression has no assumptions about the distributions of the predictor variables; in logistic regression, the covariates do not have to be normally distributed, linearly related, or of equal variance within each group (Tabachnick & Fidell, 2001). Logistic regression applies maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of the dependent occurring or not). In this way, logistic regression estimates the probability of a certain event occurring (Garson, 2014). In other words, the linear regression equation is the natural log (logit) of the probability of being in one group divided by the probability of being in the other group (Tabachnick & Fidell, 2001).

Logistic regression can be used to predict a dichotomous dependent variable based on either continuous or categorical independent variables (Kleinbaum, Kupper, Muller, & Nizam, 1998). The dependent variables in this study were falls and medication errors. In addition, logistic regression can determine the percent of the variance in the dependent variable explained by the independent variables, rank the relative importance of independents, assess interaction effects and understand the impact of covariate control variables (Garson, 2014).

In this study, multinomial logistic regression modelling was used to assess the likelihood that independent variables of nurse staffing characteristics impact on patients reported having fall and medication error incidents. As the data only contains incidents, there are no contrast data so all modelling was performed comparing falls against medication errors and vice versa. Significant results reported will reflect the likelihood of an independent variable contributing to an event and not the likelihood of that event itself. Given that the 95% confidence interval will be used in the analysis, it is inferred that significant results will be meaningful within the context of the analysis.

For research questions one and three, the dependent variables were fall and medication error incidents. The primary independent variables of nursing staff characteristics were registration status (RNs, Non-RNs), years of experience, and the actual number of nursing care hours (in a ward-by-ward and shift-by-shift level). The primary independent variables of patients' characteristics were gender and age. The control variables were shift, ward and admitting hospital. For research questions two and four, the dependent variables were the severity of falls and medication error incidents.

The regression design was appropriate for the study due to its multilevel nature. Four specific analysis levels were used: patient, shift, ward, and hospital levels. Thus, this quantitative research method was appropriate for this study because the method involved measuring and analysing variables of interest to determine the strength of relationships existing between predictor and outcome variables. Four models of multinomial logistic regression have been performed to address the research questions: (model one) covariates for fall incidents, (model two) covariates for severity fall incidents, (model three) covariates for medication error incidents, and (model four) covariates for severity of medication error incidents.

3.5. Research Hypothesis

The research hypothesis is a tentative prediction of the relationship between two or more variables based on the research questions. The following study hypotheses were tested.

Fall Hypotheses

- ***Alternative Hypothesis**:* there is a relationship between nurse staffing and the likelihood or the severity of patients who had fall incidents compared to patients who had medication error incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals.

Hypothesis HA1: *at the patient level*: there is a statistically significant difference in the occurrence of falls based on the patients' gender.

Hypothesis HA2: *at the patient level*: there is a statistically significant difference in the severity of falls based on the patients' gender.

Hypothesis HA3: *at the patient level,* there is a statistically significant difference in the occurrence of falls based on patients' age.

Hypothesis HA4: *at the patient level,* there is a statistically significant difference in the severity of falls based on patients' age.

Hypothesis HA5: *at the shift level*, there is a statistically significant difference in the occurrence of falls based on shift time.

Hypothesis HA6: *at the shift level*, there is a statistically significant difference in the severity of falls based on shift time.

Hypothesis HA7: *at the ward level*, there is a statistically significant difference in the occurrence of falls between medical, surgical, and critical care wards.

Hypothesis HA8: *at the ward level*, there is a statistically significant difference in the severity of falls between medical, surgical, and critical care wards.

Hypothesis HA9: *at the hospital level,* there is a statistically significant difference in the occurrence of falls based on the hospital.

Hypothesis HA10: *at the hospital level,* there is a statistically significant difference in the severity of falls based on the hospital.

Hypothesis HA11: there is a statistically significant difference in the occurrence of patient falls based on nursing staff registration status.

Hypothesis HA12: there is a statistically significant difference in the severity of patient falls based on nursing staff registration status.

Hypothesis HA13: there is a statistically significant difference in the occurrence of patient falls based on the nursing staff years of experience.

Hypothesis HA14: there is a statistically significant difference in the severity of patient falls based on the nursing staff years of experience.

Hypothesis HA15: there is a statistically significant difference in the occurrence of patient falls based on the actual nursing hours.

Hypothesis HA16: there is a statistically significant difference in the severity of patient falls based on the actual nursing hours.

Medication Errors Hypotheses

- ***Alternative Hypothesis:*** there is a relationship between nurse staffing and the likelihood or the severity of patients who had medication error incidents compared to patients who had fall incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals.

Hypothesis HA17: *at the patient level*: there is a statistically significant difference in the occurrence of medication errors based on the patients' gender.

Hypothesis HA18: *at the patient level*: there is a statistically significant difference in the severity of medication errors based on the patients' gender.

Hypothesis HA19: *at the patient level*, there is a statistically significant difference in the occurrence of medication errors based on patients' age.

Hypothesis HA20: *at the patient level*, there is a statistically significant difference in the severity of medication errors based on patients' age.

Hypothesis HA21: *at the shift level*, there is a statistically significant difference in the occurrence of medication errors based on shift time.

Hypothesis HA22: *at the shift level*, there is a statistically significant difference in the severity of medication errors based on shift time.

Hypothesis HA23: *at the ward level*, there is a statistically significant difference in the occurrence of medication errors between medical, surgical, and critical care wards.

Hypothesis HA24: *at the ward level*, there is a statistically significant difference in the severity of medication errors between medical, surgical, and critical care wards.

Hypothesis HA25: *at the hospital level*, there is a statistically significant difference in the occurrence of medication errors based on the hospital.

Hypothesis HA26: *at the hospital level*, there is a statistically significant difference in the severity of medication errors based on the hospital.

Hypothesis HA27: there is a statistically significant difference in the occurrence of patient medication errors based on nursing staff registration status.

Hypothesis HA28: there is a statistically significant difference in the severity of patient medication errors based on nursing staff registration status.

Hypothesis HA29: there is a statistically significant difference in the occurrence of patient medication errors based on the nursing staff years of experience.

Hypothesis HA30: there is a statistically significant difference in the severity of patient medication errors based on the nursing staff years of experience.

Hypothesis HA31: there is a statistically significant difference in the occurrence of patient medication errors based on the actual nursing hours.

Hypothesis HA32: there is a statistically significant difference in the severity of patient medication errors based on the actual nursing hours.

3.6. The Study Population and Sample Size

The population for this study included all hospitalised patients within the AIMS database who met the inclusion criteria listed in table 1. The sample for the current study was drawn from a population of 11,155 incidents where 7,558 met the three inclusion criteria. Data were also collected from the RoSTAR database consisting of all nursing staff at the three study hospitals who worked during the two-year study period. There were approximately 300,000 nursing shift records.

3.6.1. Setting

The study was conducted in Perth, the capital city of Western Australia (WA), which is the largest state in Australia (see Figure 3). The population of WA was approximately 2.5 million on 31 December 2014 (Australian Bureau of Statistics, 2014). Perth's metropolitan area in WA accounts for 72% of the state's residents (Regional Population Growth Australia, 2012-13).

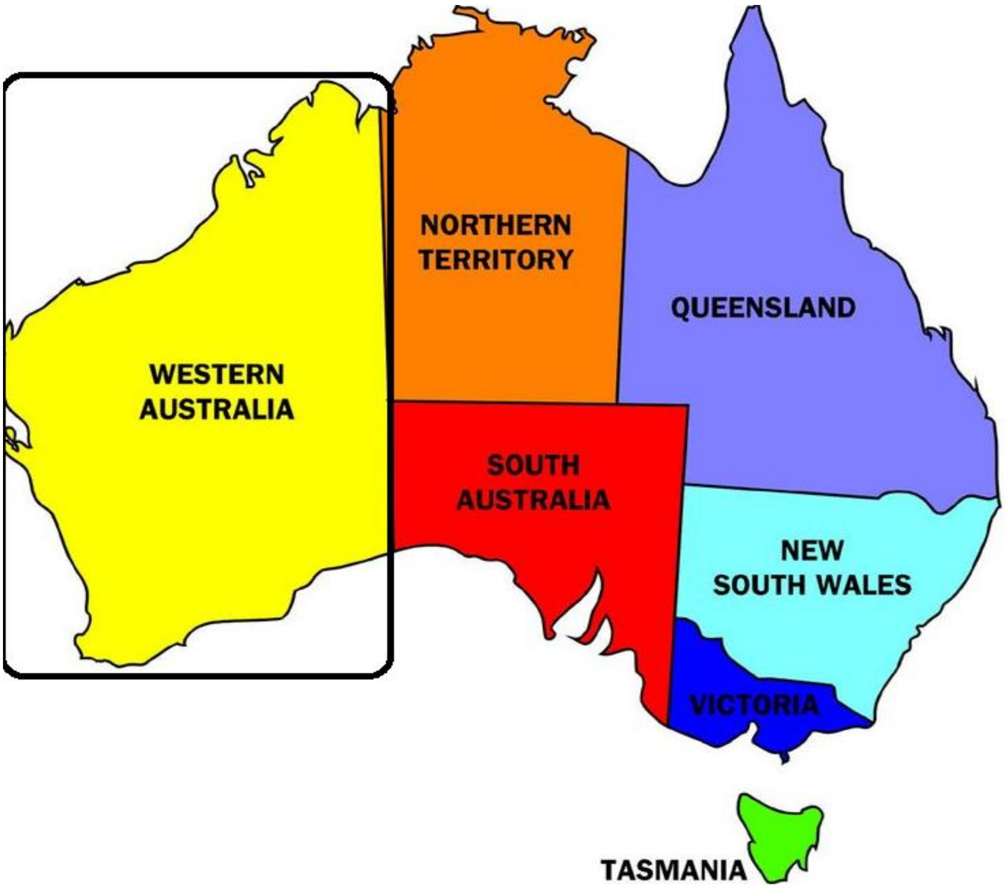


Figure 3: The study setting: Western Australia

Extracted from Australian Bureau of Statistics website: http://www.abs.gov.au/

3.6.2. Sampling method

This study used a convenience sampling method. The target population were inpatients who had a documented fall or medication error between January 1, 2011, and December 31, 2012, within the hospital setting. The RoSTAR system provided detailed information about the nurses who worked at the three participating hospitals during the study period.

3.6.3. Sample inclusion and exclusion criteria

The sample criteria were non-exclusive with respect to gender, ethnicity, diagnosis, or hospital treatment plan. The target population for this study included two population groups: nurses and patients (see Table 1).

Nurses: the study included all RNs, ENs, and AINs with direct patient care responsibility in all wards regardless of the type of employment such as part-time, full-time, contract, or agency.

Exclusion criteria for the nurses' group included: all nurses with non-direct patient care responsibilities: nursing managers, supervisors, coordinators, or educators, plus any incidence reports lodged by other professionals, for example, doctors, pharmacists, etc.

Patients: sample inclusion criteria consisted of (1) being a hospitalised patient, (2) being over 15 years of age. Exclusion criteria for the patients' group were: any patient under 15 years old at the time of admission, the young teenager under 16, child and newborn were not eligible for treatment and admission to the hospitals in this study.

Table 1

Sample Inclusion and Exclusion Criteria

Patient inclusion criteria (n=7,558)	Patient exclusion criteria (n=4,076)
Hospitalised patient	Non-hospitalised patient
Age > 15 years	Age ≤ 15 years
Had a fall reported	
Had a medication error reported	
Hospitalised during this period 1/1/ 2011 to 31/12/ 2012	
Staff inclusion criteria	**Staff exclusion criteria**
RNs with direct patient care	Nursing managers
ENs with direct patient care	Nursing administrators
AINs with direct patient care	Nursing educators
Worked during this period 01/01/ 2011 to 31/12/ 2012	Other medical staff, including doctors, physiotherapists Non-medical staff

3.7. Data Collection Procedure

Data were sourced from the Health Corporate Network (HCN), WA Department of Health (WA Health) for this study. HCN is WA Health's corporate shared service centre that provides services to all employees working for WA Health. HCN consists of four main service areas: supply, finance, human resources (RoSTAR) and reporting. With approximately 650 staff, HCN processes up to 6,000 transactions daily for WA Health. HCN identified that to efficiently and effectively manage all transactions they would need to introduce the concept of automated workflows and information management, hence the RoSTAR database.

It is a WA Health requirement to notify them of all clinical incidents. As such all clinical incidents within public hospitals are to be notified via the Advanced Incident Management System (AIMS). WA Health's Clinical Management Policy 2015 is based on the following principles of clinical governance: transparency, accountability, probity/fairness, patient/consumer centred care, open 'just' culture, obligation to act, and prioritisation.

To be effective, clinical incident management requires a 'no blame' reporting culture. Responsibilities of all staff are to notify clinical incidents, participate in investigations, and implement recommendations. On the other hand, hospitals are required to take immediate action when a clinical incident occurs to ensure the patient receives appropriate treatment and report the clinical incident to AIMS. Also, an initial investigation of the clinical incident is undertaken within 48 hours to identify critical human error and system failures and implement preliminary actions to prevent harm to further patients.

For confidentiality reasons, information from both databases were de-identified after completion of ethical clearance processes. These data represent a unique dataset, extracted specifically for the analyses in this research by specialised custodians. Each patient and nurse in both datasets were allocated a unique ID number which was recorded on the AIMS and RoSTAR form for de-identification purposes. AIMS data is government owned, nonprofit data. According to the Australian Institute of Health and Welfare (AIHW, 2012), the occupancy rate in the three target hospitals was 90- 95% at the time of data collection.

In 2008, the Performance Activity and Quality Division of the Western Australian Department of Health released a new policy called the Sentinel Event reporting policy, which is now the governance system for safety and quality in Western Australia. This policy was used to draft the Western Australian Strategic Plan for Safety and Quality in Health Care 2013–2017.

Incident outcome levels were classified on a scale of 1-8, with the eight nationally endorsed sentinel event categories shown in table 2. An outcome level of 1-2 is defined as a "near miss" resulting in no harm. It is noted that level 1 data was not provided by the Department of Health and there were very few level 2 cases in this study. Outcome Levels 3-8 refer to events of increasing severity that directly affect the patient ranging from no harm (outcome level 3) to significant or severe harm, i.e. permanent disability or death (outcome level 8).

According to the 2008 policy, incidents resulting in an outcome of level 3 to 8 are to be notified to WA Health. The purpose of this protocol is to ensure that data is accessible and available for the purposes of quality improvement and to prevent or reduce future harm to patients, identify and treat hazards before they cause harm, take preventative actions and share lessons learned (The Clinical Incident Management Policy, 2011).

In 2011 the AIMS Policy was modified to require only the mandatory reporting of level 8 clinical incidents, those that resulted in severe patient harm or death. These were a very small percentage of the total incidents and were withheld by the Department of Health for confidentiality reasons. These cases were directly dealt with by WA Health with a different process to AIMS and as such, this data was not available to the researcher. Further, no level one records were in the sample because level one incidents were potential (not actual) incidents only.

Table 2

Advanced Incident Management System Outcome Levels

Outcome Level	Description/Example
Level 1	Dangerous state/potential for harm e.g. understaffed ICU, torn floor covering.
Level 2	Intercepted prior to causing harm e.g. wrong medication drawn up but not given, medication allergy identified so medication not given, bed rails not in place.
Level 3	No harm occurred. No change in condition or treatment e.g. harmless medication given to the wrong patient.
Level 4	Minor harm occurred not requiring treatment. Reviewed by a doctor, extra observations or monitoring, minor harm.
Level 5	Moderate harm occurred. Minor diagnostic investigations undertaken (e.g. blood test, x-ray, and urinalysis), minor treatment (e.g. dressings, cold pack, and analgesia), security or emergency services attendance, allied health review.
Level 6	Moderate harm occurred. Diagnostic investigations (e.g. MRI, CT, surgical intervention), cancellation or postponement of treatment, transfer to another area not requiring increased length of stay, treatment with another medication.
Level 7	Significant harm occurred. Increased length of stay, hospital admission, readmission, transfer to ICU, CPR/resuscitation, secure ward management, seclusion, fractured neck of femur, morbidity which continued at discharge.
Level 8	Severe harm occurred. Permanent disability or death

*Note: *Extracted from Performance Activity and Quality Division, Western Australian Department of Health, 2012, p.48.*

3.8. Data Cleaning

Both datasets were extracted and cleaned separately as follows:

3.8.1. AIMS Data Cleaning

The preliminary sample consisted of 11,634 incidents, 7,558 of which were included in the study. The remaining 4,076 incidents were excluded because they were reported by other professionals (pharmacists, physiotherapists, etc.) and automatically were not linked to nursing staff data, or the patient was 15 years old or younger. The results of the data cleaning are displayed in figure 4.

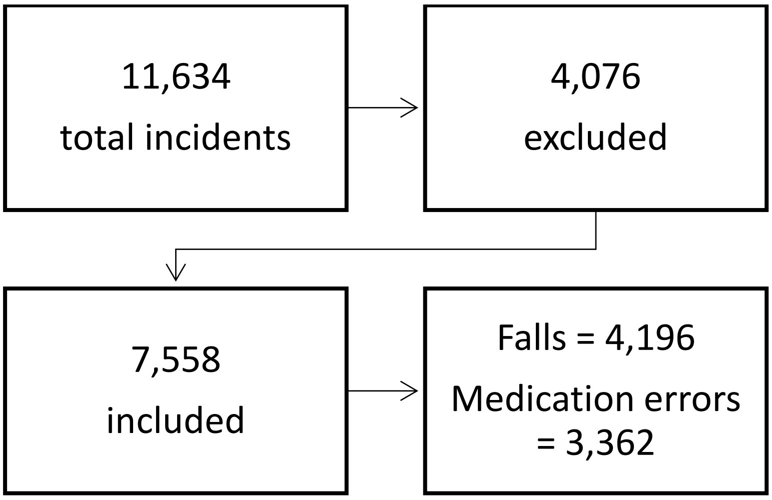


Figure 4: Data cleaning and sample reduction stages

3.8.2. RoSTAR Data Cleaning

More than 300,000 shift records were received from the three target hospitals for every ward during the study period (3 shifts per day × 365 days × 2 years). Any ward not recognised as an "actual nursing ward" was excluded, such as the outpatient clinic and physiotherapy ward. Any "non-nurse" staffing on the RoSTAR database, for example, clerks and secretaries, were excluded. Nurse staffing variables from each ward were extracted directly from HCN databases, variables including the total number of nursing staff per shift, nursing staff registration status, staff seniority according to a number of years of experience and other nursing staff variables were calculated and created by the researcher. Other researchers have in the past only calculated the total number of hours worked (shift end time - shift start time = total hours worked/staff member/shift), however, in this study actual hours worked by each staff member per shift (sum (exact nursing hours worked by staff – break time) per shift)) were calculated as a more accurate variable. Example syntax used the Statistical Package for the Social Sciences (SPSS) software can be found in Appendix H.

3.9. Data Linkage

Data linkage is a complex technique for connecting data records within and between datasets using demographic data (e.g. name, date of birth, address, gender, medical record number) and is also known as 'Record Linkage' according to the Data Linkage Western Australia website. Record linkage is also defined as the bringing together in a single file, records derived from different sources, but relating to the same individual or event (Hobbs & McCall, 1970). The linkage of health records has been used for many purposes, including public health surveillance, primary prevention research, 15

natural history and prognostic research, and the utilisation, adverse effects, and outcomes of health services (Holman et al., 1999). Many researchers now use linkage technique for both health and non-health information to create new de-identified research datasets (Pavis & Morris, 2015).

In this study, the data linkage technique was used to connect staff information to patient information; for every recorded incident, it was important to know how many and what type of staff members were in the same ward at the same time in that particular hospital. In both datasets, a unique “link number” was created consisting of a concatenation of shift, date, ward, and hospital data. This way a direct matching could be performed between the files using the SPSS merge function. If the “link number” in the AIMS database equaled the “link number” in the RoSTAR database, then the information was merged. The final file contained patient incidents data plus staff data (see Figure 5). The steps taken to link patients’ records and nurse’s records within the two years of the study were:

Step 1: Set Linkage Parameters (same shift, same date, same ward, and same hospital).

i. Linkage by matched incidents on shift, date, ward, and hospital.

ii. Linkage by matched staff on shift, date, ward, and hospital.

Step 2: Generate (link number) in both dataset.

Step 3: Run Linkage Syntax.

Step 4: Check if Patients Records to Nurses Records have been linked.

Step 5: Generate one dataset containing both datasets.

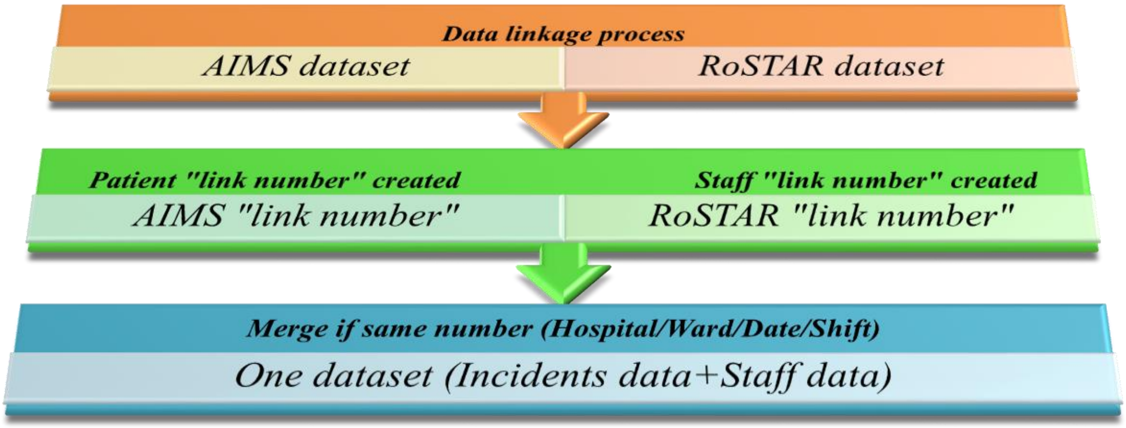


Figure 5: Data linkage process

3.10. Variables Selection

Variables selected in the current study included categorical and continuous variables: patients' age in 10 year categories, patients' gender (two categories: male, female), the number of falls and medication errors reported, the contributing factors of both kind of incidents, where the fall occurred and primary medical speciality or the type of ward where the incident took place (three categories: medical, surgical, critical care). Other variables included the day of the week (indicated whether the incident occurred on a weekday or weekend), shift (incident occurred during morning [07:00 - 12:59], overlap [13:00 - 15:29], evening [15:30 - 20:59], or night [21:00 to 06:59] shifts), and the outcome level of injury (eight levels varied from no harm to severe harm) for both fall and medication incidents. There was an only small number of severity eight cases involving death over the study period, but these were subject to coronial inquiries and as such, could be re-identified so were excluded from the study datasets by WA Health.

Other studies have used NHPPD to transform the total number of hours worked per shift per staff into an approximate value that would enable comparison with findings from other studies (Kirby, 2015; Twigg et al., 2011; Twigg et al., 2012). This current study used RoSTAR data to calculate actual nursing hours. This was calculated by summing exact hours worked by each staff member on all shifts minus staff breaks. This variable was then used as one of the independent variables in modelling. The calculation for actual nursing hours is as follows:

Actual nursing hours = sum (exact nursing hours worked by staff – break time) per shift

In this study, the researcher was able to calculate the exact and actual nursing hours of direct care per shift which is more accurate than using the approximate daily metric NHPPD used by other researchers as mentioned earlier.

3.10.1. Dependent Variables

The data used in this study included four dependent variables: falls and medication errors including the severity outcomes of these incidents.

3.10.2. Independent variables

Three main independent variables of interest were selected for this study, the first being whether the staff were registered nurses or not. Registered nurses are registered with the Australian nursing board and usually hold a Bachelor Degree in Nursing or above. The second variable was the years of experience in practice, where three staff categories of seniority were calculated and created based on the number of years in practice (see Figure 6). The third variable was actual hours worked on the shift. Additional independent variables included in the modelling were patient characteristics (age, gender).

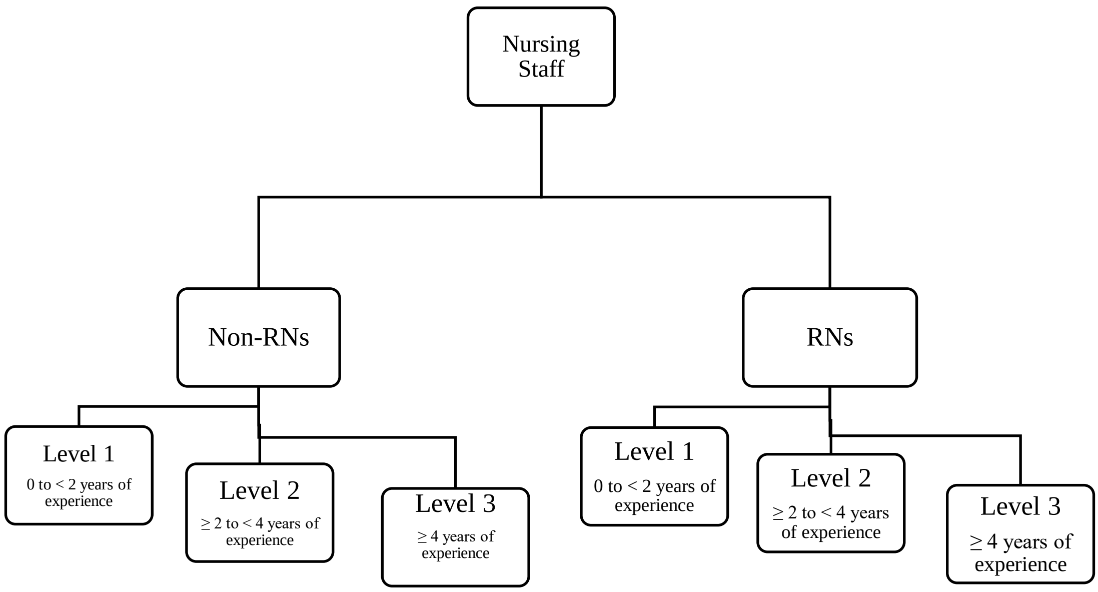


Figure 6: Nursing staff levels

3.10.3. Control Variables

Multinomial logistic regression used control variables to fit all levels of analysis, namely shift, ward, and hospital. The hospital was included as a control variable due to each hospital in the study having different characteristics, for example, variation in hospitals bed capacity, technology, and the number of employees. Ward types included in the study were medical, surgical, and critical care. The ward type was controlled in the study to account for the different type of patient care provided. It is noticed that shift lengths were standard in all participating hospitals in this study.

3.11. Data Analysis

The IBM software package, SPSS version 23.0, was used for analyses with statistician guidance. Data were checked for errors and outliers. Descriptive statistics were used to describe and summarise the results of the study. Frequency distributions, percentages, proportions were used to describe the categorical variables of the year, hospital, and ward type. Descriptive statistics included:

- Frequencies and percentages of patients' characteristics: age, gender.
- Frequencies and percentages of nurse characteristics: educational level, years of experience, shifts and hours worked.
- Frequencies and percentages of patient outcomes: falls, medication errors.

One of the major novelties of this study is that three levels of analysis were applied, not just hospital and ward but also shift by shift. The majority of previous research has utilised either hospital or ward level data but few have modeled on a shift by shift basis.

Using ward level analysis in nurse staffing research is preferred over other approaches such as the hospital level, because it aggregates different types of patients with different levels of illness. Also, modelling on the ward is preferable for the severity of incidents (Blegen et al. ,1998).

As the research was considered exploratory in nature, the *p*-value was set at 0.05, meaning that an acceptable false-positive rate, or chance of concluding that the finding was significant when in reality it was not, was 5%. Confidence intervals (CIs) surrounding Odds Ratios (ORs) of 95% are reported. CIs represent the range of values that are not significantly different from the reported value. If the 95% CI included l.0, then the odds ratio included unity and so the finding would not be considered statistically significant (Altman, Machin, Bryant, & Gardner, 2013).

The investigator used multilevel models with the hierarchal procedure in SPSS (Pallant, 2010) to analyse the relationships among the variables of the study (see Figure 7).

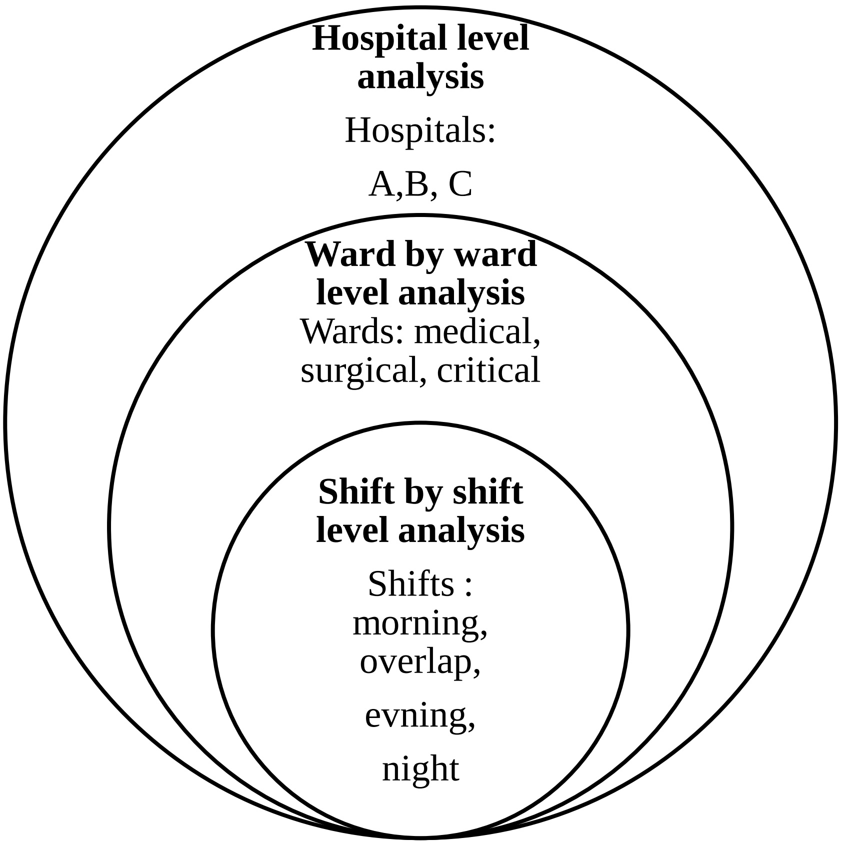


Figure 7: Multilevel structure per shift, ward, and hospital

This study was conducted over a period where the system encouraged staff who witnessed a clinical incident to report it using a clinical incident form. Each report included a description of the incident and whether this was witnessed or not, and extensive analysis of the report text fields was undertaken to try and ascertain this. Manual review of every record was not possible due to the availability of resources and logistical constraints, so syntax was developed to query these fields for key words that indicated a witnessed incident.

3.12. Ethical Considerations

The study adhered to the ethical practices and guidelines of the Human Research Ethics Committee at Edith Cowan University and the Australian National Health and Medical Research Council (NHMRC), so permission was obtained from the Department of Health (DOH) in Western Australia to use data (Appendix B). Additionally, Human Subjects Review forms describing the study were completed by the investigator and submitted to the HREC at each of the three target hospitals (see Figure 8). The study was approved by all three hospital HRECs (after the study was approved by the Human Research Ethics Committee at Edith Cowan University (Appendix B).

A database custodian at the WA Department of Health extracted the requested data from the AIMS database. The data custodian performed validity checks on the newly transported data to ensure accuracy and completeness and placed them into SPSS files. A unique (patient identification number) was provided by the DOH (WA) to prevent anyone from looking up other patient-related information and protecting the patients' confidentiality and anonymity (Kaiser, 2009).

This quantitative study presented no potential harm, discomfort and/or inconvenience (NHMRC, 2009) to the researcher, staff or patients because there was no direct contact between the researcher, the patients or staff. There were no monetary costs to the three hospitals and the hospitals did not receive any payment for taking part in this study.

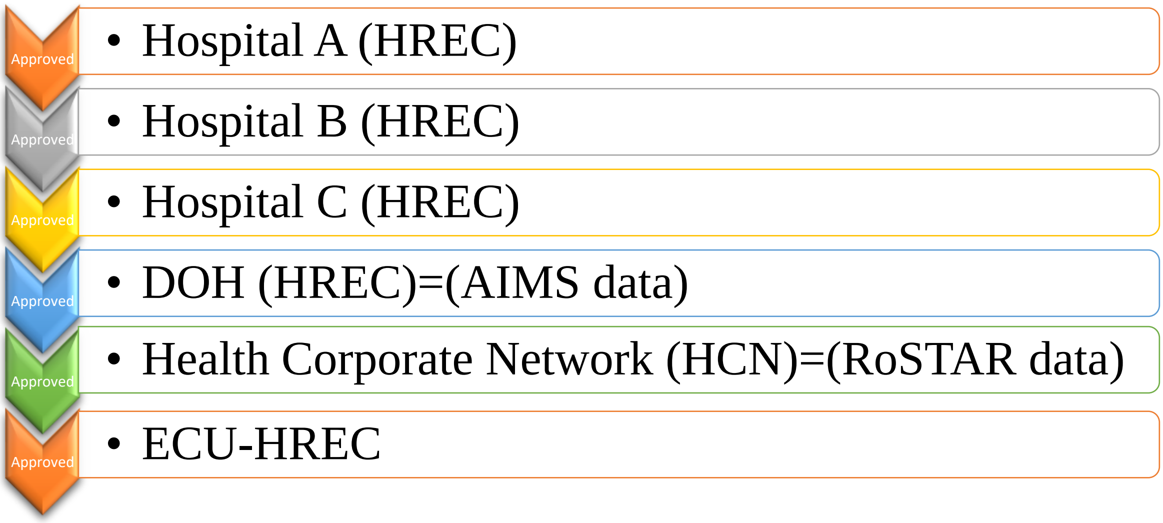


Figure 8: Ethical approval process

3.13. Data Management and Security

The data for the current study and code numbers for the hospitals were stored in a secure area (i.e. a locked filing cabinet), to protect confidentiality, anonymity, and privacy. An electronic backup copy of the data was created and stored within a different locked cabinet within the same suite at Edith Cowan University, with the back-up stored separately from the primary data. Access to the data was limited to the investigator, the supervisors, and a statistician. The data were used by the investigator only within the confines of this suite of offices and were not removed from the premises for use in other locations. The identity of the patients whose clinical and administrative data were used in this study was protected in several ways: a) patient names were not present in the data and b) the patient identification numbers were assigned afterwards and according to the hospital they were in and these numbers were created by the database custodian and so the investigator was blind to identifying information.

3.14. Summary

A retrospective, longitudinal design was used to examine the impact of nurse staffing on the occurrence of specific patient outcomes. A convenience sample was drawn from three major hospitals in Western Australia for a total of 7,558 incidents. Data were generated from a secondary analysis of existing databases over a two-year period from the beginning of 2011 to the end of 2012. The databases were checked for missing and outlying data. Three groups of variables were explored, including measures of nurse staffing, patient outcomes, and control variables. The multilevel model analysis was used to answer the research questions.

CHAPTER IV: RESULTS

4.1. Introduction

This study explored two aims related to nurse staffing and adverse events. The first aim was to determine the relationship between nursing staff characteristics (nursing staff qualification, actual hours of nursing care provided, and years of experience) and patients with falls and medication errors on a shift-by-shift and ward-by-ward basis. The second aim was to examine the impact of nursing staff, hospital, ward, and shift characteristics on the patients' severity of falls and medication error incidents.

The first section of this chapter describes the results of aim number one which examined the relationship between nurse staffing, falls and medication error incidents. The second section describes the findings from aim number two which explored the impact of nurse staffing on the severity of these incidents. To achieve these aims, four models of multinomial logistic regression have been performed to test the relationship between nurse staffing, patient falls, and medication errors as follows: (model one) covariates for fall incidents, (model two) covariates for severity fall incidents, (model three) covariates for medication error incidents, and (model four) covariates for severity of medication error incidents.

Chapter four begins with a description of the results in relation to patients' characteristics, shifts, ward types, hospitals and nurse staffing characteristics, the actual nursing hours, and an overview of the incidents. This is followed by the statistical analyses used to test each of the four hypotheses as following:

1. ***Null Hypothesis***: there is no relationship between nurse staffing and the likelihood or the severity of patients who had fall incidents compared to patients who had medication error incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals.
2. ***Alternative Hypothesis****:* there is a relationship between nurse staffing and the likelihood or the severity of patients who had fall incidents compared to patients who had medication error incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals.
3. ***Null Hypothesis***: there is no relationship between nurse staffing and the likelihood or the severity of patients who had medication error incidents compared to patients who had fall incident on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals.
4. ***Alternative Hypothesis****:* there is a relationship between nurse staffing and the likelihood or the severity of patients who had medication error incidents compared to patients who had fall incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals.

4.1.1. Clinical Incidents 2011 to 2012

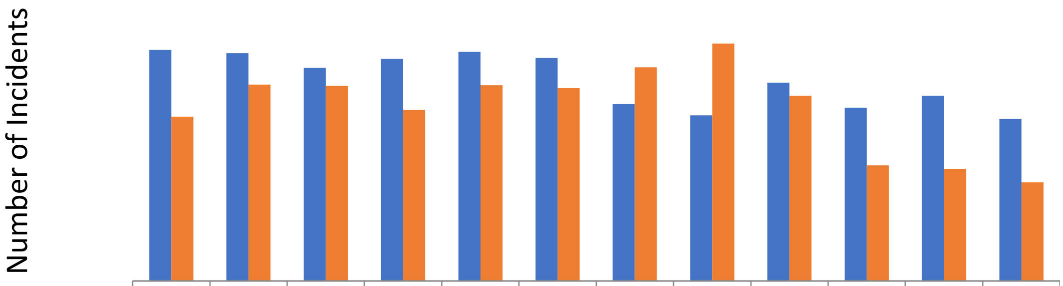
A total of 7,558 clinical incidents were reported across three Perth hospitals within a two-year period (2011–2012). Clinical incidents were categorised as either patient falls or medication errors. A total of 4,196 patients falls and 3,362 medication errors occurred during this time. The number of reported clinical incidents overall dropped from 4,056 in 2011 to 3,502 in 2012; a decrease of 7.4%. The number of falls declined by 4.6% and the number of medication errors declined by 10.8% (see Table 3).

Table 3

Total Number and Trend of Clinical Incidents Per Year (2011–2012)

Incident type	Year		Total	Trend
	2011	2012		
Falls	2,195	2,001	4,196	↓4.6%
Medication errors	1,861	1,501	3,362	↓10.8%
			7,558	

An exploration of the patterns of incidents reported each month during the two-year period revealed a decrease in reported incidents in the months of July and August in 2011; in 2012 decreases occurred in November and December (see Figure 9). There was no significant difference in the total number of incidents over the months of the year for the study period (χ^2=20, df (11), p=0.36).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	389	384	359	374	386	376	298	279	334	292	312	273
2012	277	331	329	288	330	325	360	400	312	195	189	166

Month

Figure 9: Comparison of total incidents as reported per month and year

Patterns of incidents occurring by day of the week were also explored; the lowest number of incidents occurred on Sundays, and the highest number of incidents occurred on Mondays (see Figure 10). However, there was no significant difference in the total number of incidents over the weekday for the study period (χ^2=3.6, df (6), p=0.690).

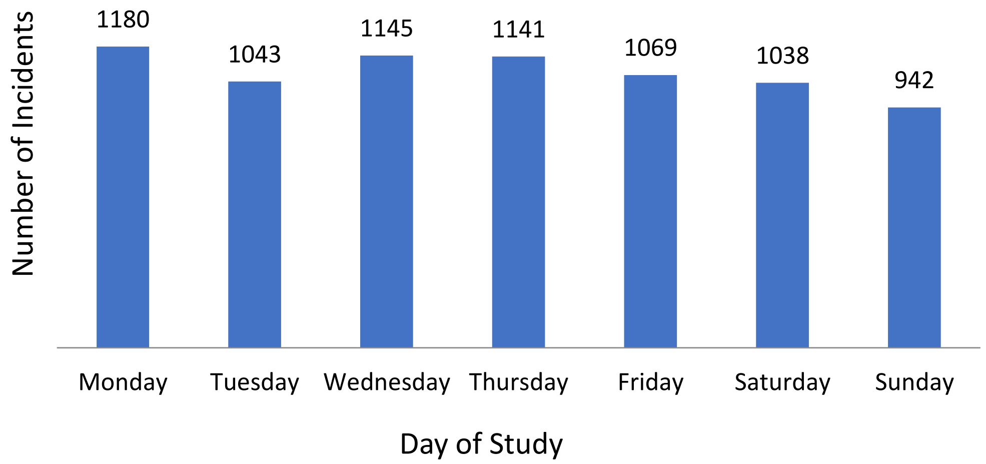


Figure 10: Comparison of total incidents as reported per day

Incidents by shift

Figure 11 shows the patterns of incidents occurring on different nursing shifts. The highest number of total incidents happened during the morning shift (07:00–12:59), followed by the evening shift (15:30–20:59) then night shift (21:00–06:59), 28.4%, 27.2% and 21.8 % respectively. Interestingly, 22.6 % of incidents were reported in the two and half hour overlap period (13:00 to 15:29), more than the 21.8 % reported in the 10-hour night shift.

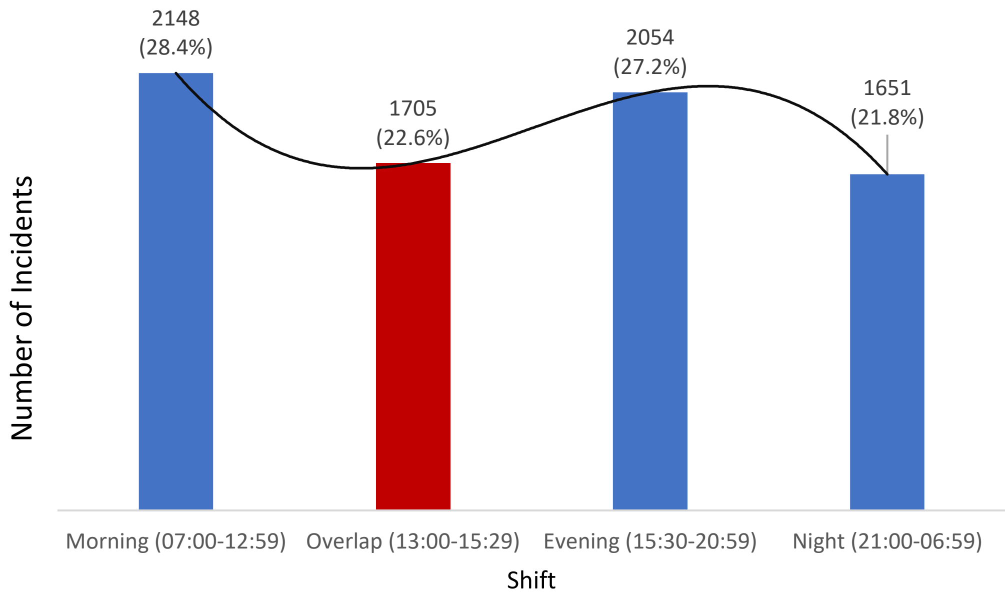


Figure 11: Comparison of incidents as reported per shift

Incidents by hour

There is a clear peak in the number of reported incidents during the overlapping period, where nearly a quarter of all incidents (22.6%) occurred in just two and half hours during the shift overlap period. More specifically, the time between 13:30 and 14:00 pm equaled the total number of incidents occurring in the entire ten-hour period of the night shift.

It was observed that although fall incidents had one peak time around 14:00 pm, medication errors had more than one peak time and coincided with the times of the medication administration rounds (8:00 am, 14:00 pm, and 20:00 pm), which is expected (see Figure 12).

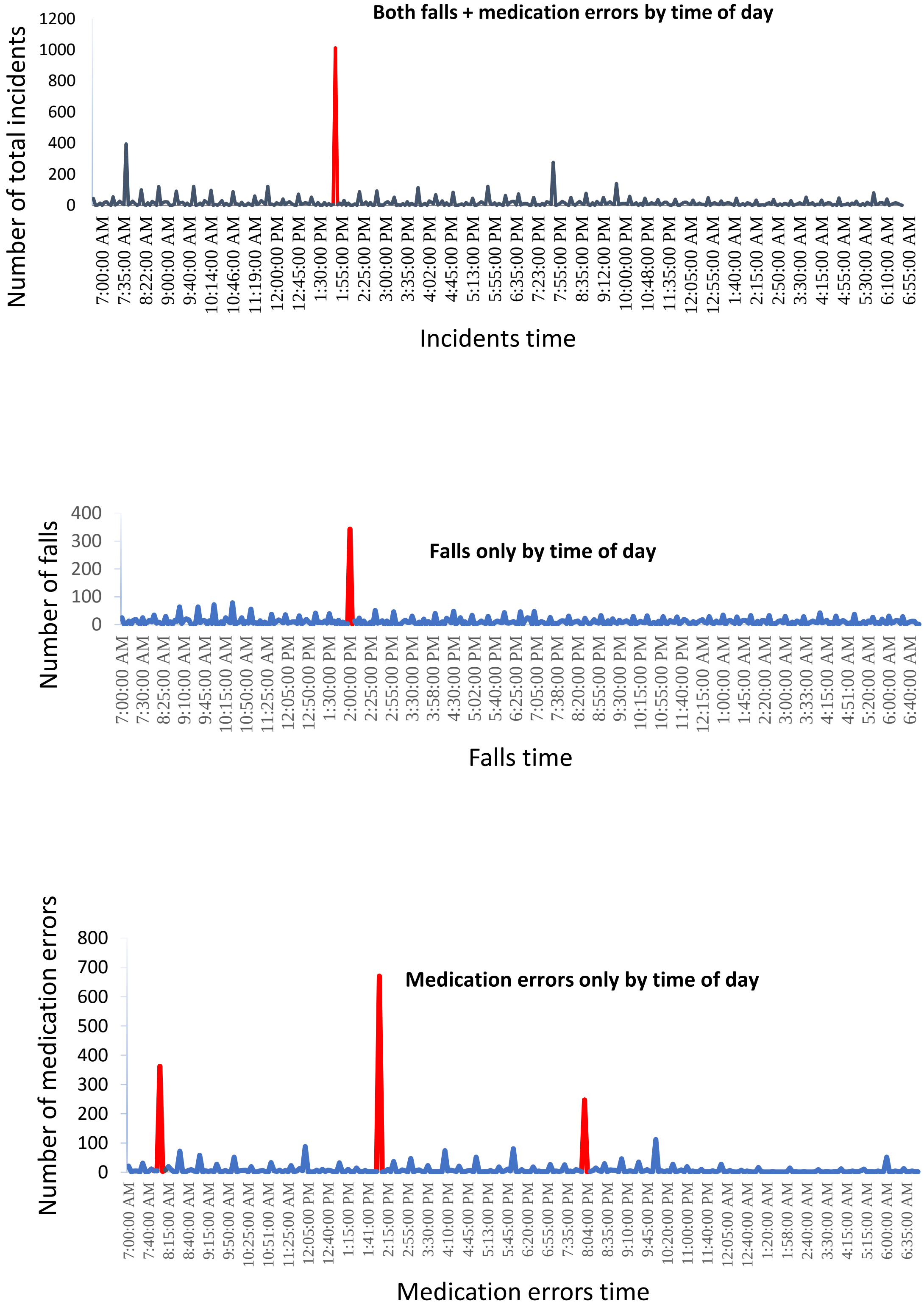


Figure 12: Incident trends over 24 hours

This study found that only 27.2 % of total incidents had a description of the incident and were witnessed, so the majority of falls and medication error incidents were unwitnessed by the staff. It is assumed that for unwitnessed incidents, the incident time in the data was the reporting time, but not the actual incident time.

4.1.2. Descriptive Characteristics of Patients Who Experienced an Incident

Table 4 presents a description of patient characteristics. Some patients had more than one incident during the study period. The greatest number of multiple incidents for an individual patient was 21.

Table 4

Study Sample by Gender and Age

Gender		Age Groups									Total
		15-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years	85-94 years	95- 100 years	
Female	**n**	124	170	252	390	491	623	697	663	70	3,480
	(%)	(3.6)	(4.9)	(7.2)	(11.2)	(14.1)	(17.9)	(20.0)	(19.1)	(2.0)	(46)
Male	**n**	121	198	318	451	720	805	934	504	27	4,078
	(%)	(3.0)	(4.9)	(7.8)	(11.1)	(17.7)	(19.7)	(22.9)	(12.4)	(0.7)	(54)
Total	n	245	368	570	841	1,211	1,428	1,631	1,167	97	7,558
	(%)	(3.2)	(4.9)	(7.5)	(11.1)	(16.0)	(18.9)	(21.6)	(15.4)	(1.3)	(100)

Males appear to dominate across all age groups except the very old, 85+ years age group (see Figure 13). Slightly more than half (54%) of the incidents were recorded for male patients during their hospitalisation. Females comprised 46% of the incidents. The number of clinical incidents observed from 2011 to 2012 differed between females (n= 3,480) and males (n= 4,078). There was a significant difference in gender and the incidents ($\chi 2=21$, df (15), p = 0.000). The study included adult patients only in Perth where patients' ages ranged from 15 years to over 100 years. Patients younger than 15 years were eligible for treatment and admission to pediatric hospitals, however, most of the participants were relatively old (mean = 56 years; sd = 19.03 years).

Patients aged 65 years and over accounted for the majority (57.2%; n= 4,323) of reported clinical incidents (see Figure 13), whilst the highest percentage of incidents reported were among patients aged 75 to 84 years in both genders (20% of the female; and 22.9% of male patients). There was a significant difference in age over 65 years and the number of incidents ($\chi 2 = 166.68$, p = 0.000).

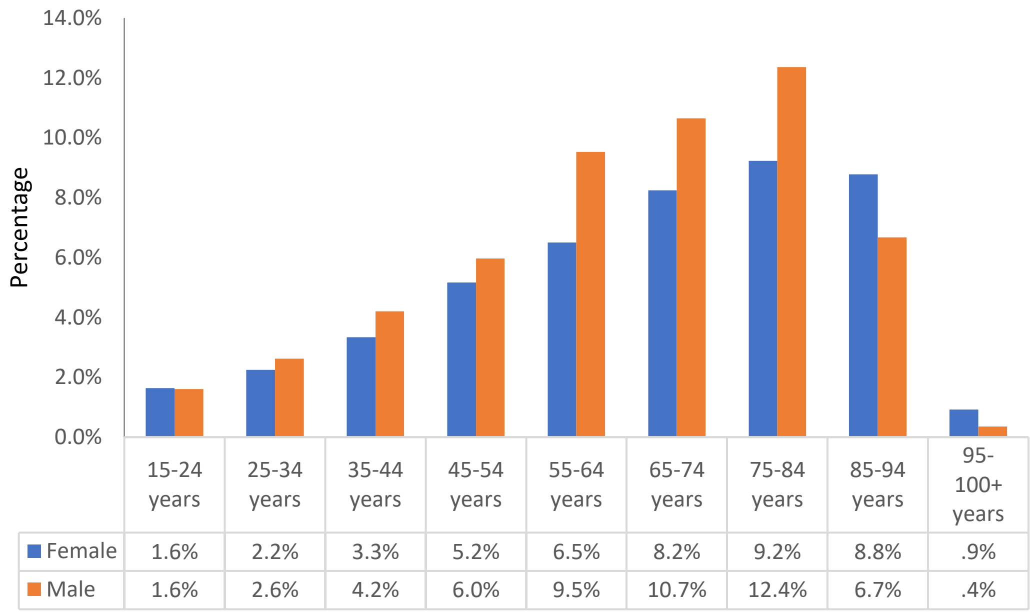


Figure 13: Study sample by age groups and gender

4.1.3. Ward Characteristics

Two-thirds of the reported incidents occurred with patients who were admitted to a medical ward (n=4,677). Fewer incidents were reported in surgical wards (n= 2,209), and even fewer incidents (n= 672) occurred in critical care wards. Figure 14 identifies in which ward type incidents occurred.

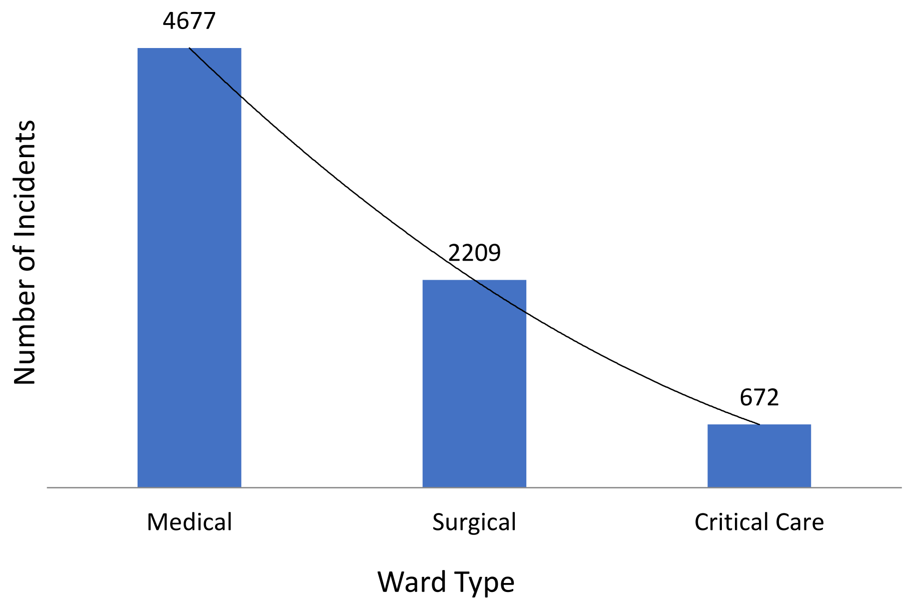


Figure 14: Study sample by ward type

4.1.4. Hospital Characteristics

Three hospitals were selected (A, B, C) as illustrated in Table 4. The study was restricted to only metropolitan, teaching, government-owned, non-profit tertiary hospitals. Hospital B had the highest number of incidents at 37.5%; the largest hospital in size "C" had the second highest level (35.3%) followed by the smallest hospital "A", 27.2%). No significant difference was found between the hospitals and falls

($\chi 2=14$, df (1), p=0.08), however, a significant difference was found between the hospitals and medication errors ($\chi 2=7.7$, df (2), p=0.02). All hospitals included medical, surgical and critical care wards.

Table 5

Study Sample by Hospital

Hospital	Falls (n)	Percentage	Medication Errors (n)	Percentage	Number of incidents (n)	Percentage
A	1,002	23.9%	1,052	31.2%	2,054	27.2%
B	1,677	39.8%	1,159	34.6%	2,836	37.5%
C	1,517	36.3%	1,151	34.2%	2,668	35.3%
Total	4,196	100.0%	3,362	100.0%	7,558	100.0%

4.1.5. Fall Incident Findings

From January 1, 2011, to December 31, 2012, a total of 4,196 falls were reported. Falls were the most common type of incident reported per year in all hospitals.

Nature of falls

Falls can happen anywhere in the hospital setting and the severity of injury often depends on the nature of the fall. In 2011 to 2012, a fifth (n= 921, 21.9%) of all reported falls were associated with a fall on the same level, for example, while walking or standing (see Figure 15). Notably, 18.7% of all falls were of unknown origin, which means that these falls were unwitnessed or the staff did not know how the fall occurred. The next most common nature of falls was from the bed or cot (16.5%), in the shower or bathroom (9.9%), from chair or wheelchair (8.7%) and getting to or from the toilet (7.9%).

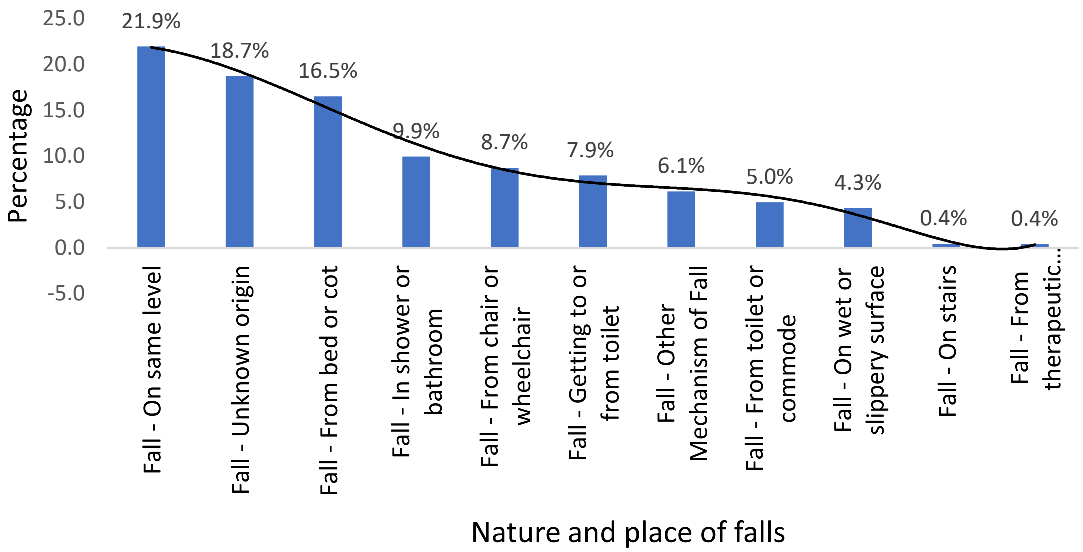


Figure 15: Nature and place of falls

Some very interesting results were evident when falls were examined by shift (Table 6). Falls on the same level was approximately the same for all shifts, including the number of falls being almost the same for the overlap period. Falls of unknown origin were almost the same across all shifts, except for night shift, which was double the number of falls than the other shifts. This may be due to the fact there are often less staff and hence less patient oversight during the night shift to witness events. Notably, falls from the bed during the night shift were triple that of falls from the bed during the morning shift and more than double that of the overlap and evening shifts. Also, falls when the patient was getting to or from the toilet during the night shift were more than triple that of falls during the morning shift or evening shift.

Table 6

Nature of Falls by Shift

Nature of fall	Morning	Overlap	Evening	Night	Total	Percentage
On same level	289	167	223	242	921	21.9%
Unknown origin	142	147	165	331	785	18.7%
From bed	108	125	133	327	693	16.5%
In shower or bathroom	143	79	90	105	417	9.9%
From chair or wheelchair	140	93	99	34	366	8.7%
Getting to or from toilet	53	38	61	179	331	7.9%
Other mechanism of fall	52	42	50	114	258	6.1%
From toilet or commode	90	27	42	49	208	5.0%
On wet or slippery surface	74	35	20	53	182	4.3%
On stairs	8	6	1	3	18	0.4%
From therapeutic equipment	6	7	3	1	17	0.4%
Total (n)	1,105	766	887	1,438	4,196	100.0%

Falls were also examined by level of severity. As explained earlier (see Section 3.7), there was no level one incidents in the dataset as these did not result in a fall, and only 1% of falls were level 2. Level 1 and 2 severity describes a potential fall and staff do not always report this kind of incidents. Less than 4% (n=163) of all falls were reported as “no harm or injury” (outcome level 3), and almost half (48.9%; n= 2,095) the reported falls were associated with “minor harm” (outcome level 4). Less than 2% (n= 70) of all fall incidents were associated with significant harm (outcome level 7). In summary, 95% of all reported falls were associated with either minor or major injury (see Figure 16).

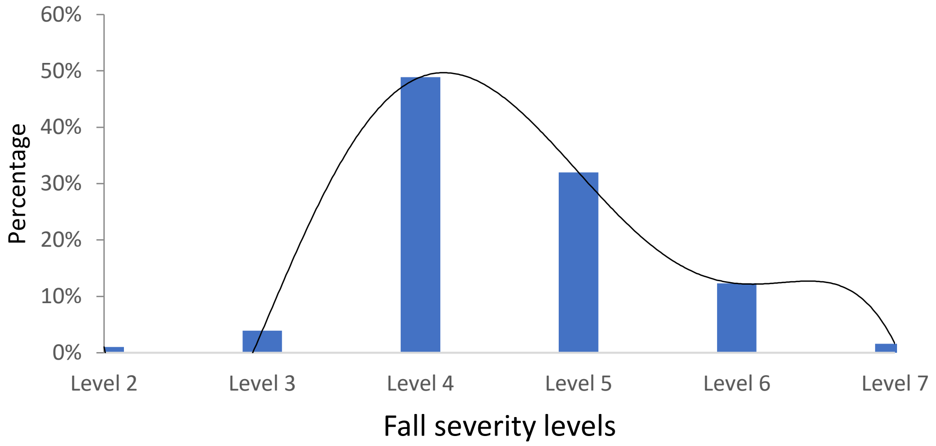


Figure 16: Falls severity levels

As shown in table 7, male patients had a significantly higher number of falls compared to female patients ($\chi 2=118.7$, df (1), $p<0.001$)

Table 7

Falls by Gender

Gender		Falls count	Percentage
	Female	1,848	44%
	Male	2,348	56%
	Total	4,196	100%

Older patients fall more than younger patients. Two-thirds of falls were sustained by patients aged 65 years and older (63.8%; n= 2,677) (see Figure 17).

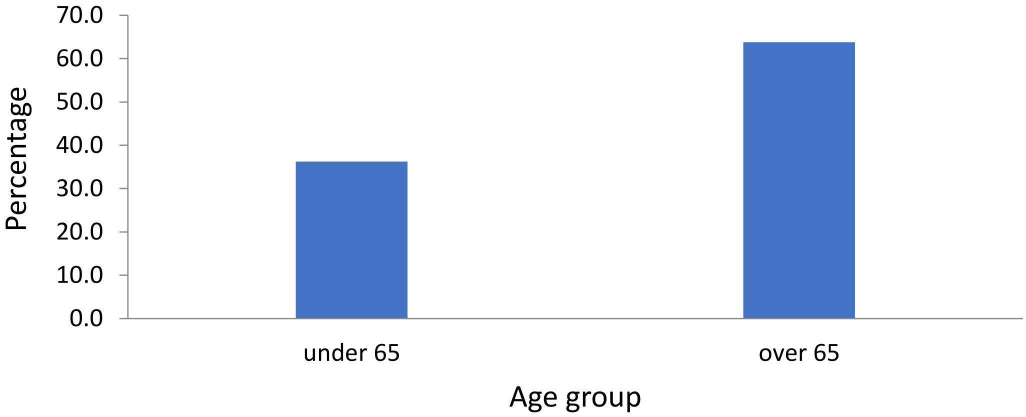
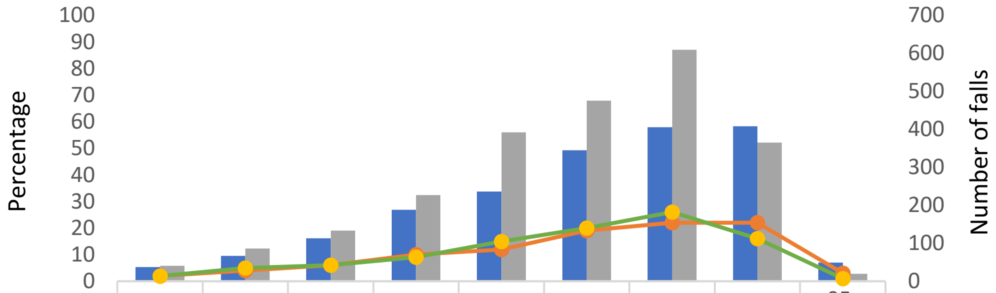


Figure 17: Falls among patients over or under 65 years' old

The percentage of adults who fell increased with age, with 9.9% of patients aged 45–54 years, 19.5% of patients aged 65–74 years and 18.4% of patients aged ≥85 years. A quarter of total falls (24.2%) occurred amongst patients 75-84 years. Males had more falls across all age groups except 85+ years. The highest percentage of fall incidences occurred in the 80+ year age group (see Figure 18).



	15-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years	85-94 years	95-100+ years
Female N	37	67	113	188	236	345	405	408	49
Male N	41	86	133	227	392	475	609	365	20
Female %	2	4	6	10	12	19	22	22	3
Male %	2	5	6	9	15	20	26	16	1

Figure 18: Falls by age groups and gender

The highest number of fall incidents occurred in the night shift, where a third of all falls (34.8%, n= 1,438) were reported in the 10-hours night shift between 21:00 pm and 06:59 am. However, a fifth of all falls occurred in the two and half hours' overlap period (18.3%, n= 766). The highest rate of falls was reported in this overlap period (13:00 to 15:30 pm), almost double the rate of falls per hour than in the night or evening shift. In summary, the night shift had the highest number of falls yet the lowest hourly rate, however, the overlap period had the lowest number of falls and highest hourly rate, approximately double that of other shifts (see Figure 19).

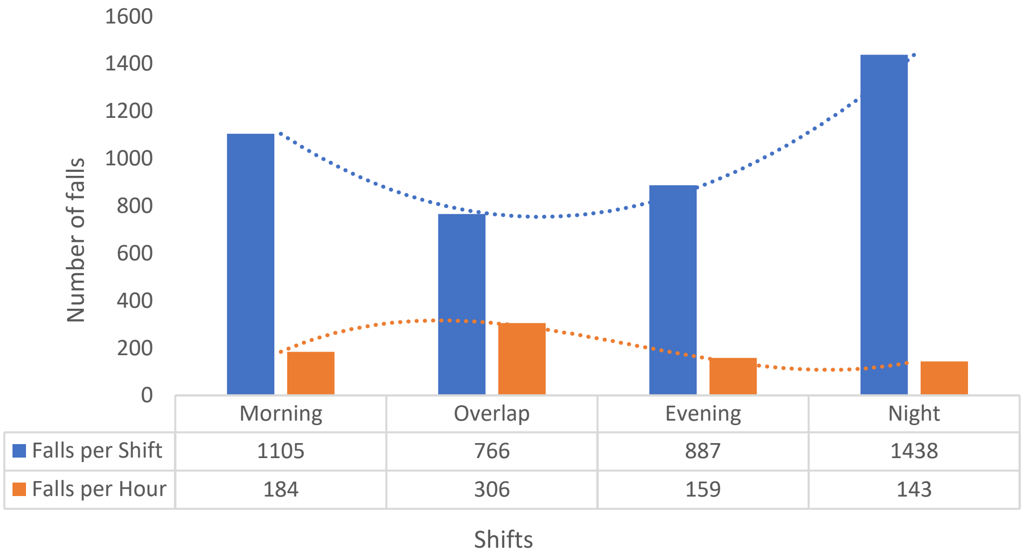


Figure 19: Falls per shift and per hour

Staff-related contributing factors were also identified for each fall incident. Table 8 shows that almost a quarter of all falls (23%) were related to miscommunication between nursing staff. This was followed by poor teamwork (13%) or the staff were busy (13%). When considered together, approximately a quarter of all falls (22%) occurred because the staff either did not have adequate knowledge or experience or there was insufficient staffing on the shift.

Table 8

Number and Percentage of Falls Incidents by Type of Staff Contributory Factors

Staff factor	Number	Percentage
Communication problem	961	23%
Poor teamwork	544	13%
Busy	543	13%
Inadequate knowledge and/or inexperience	531	12%
Insufficient or inadequate staff	419	10%
Distraction or inattention	373	9%
Failure to follow policy or procedure	329	8%
Failure to follow advice or instructions	208	6%
Fatigue or stress or unwell	205	4%
Misread or did not read documentation	83	2%

4.1.6. Medication Incident Findings

Over the study period, 3,362 medication errors were reported. One-quarter of total reported medication errors (26.4%, n= 886) were due to omission (missed doses), followed by medication overdose (22.9%, n= 771), which means that missed dose and overdose errors represented almost half of total medication errors (see Figure 20). Wrong medications and other medications involved in the incident accounted for a further quarter (26.4 %) of all medication errors.

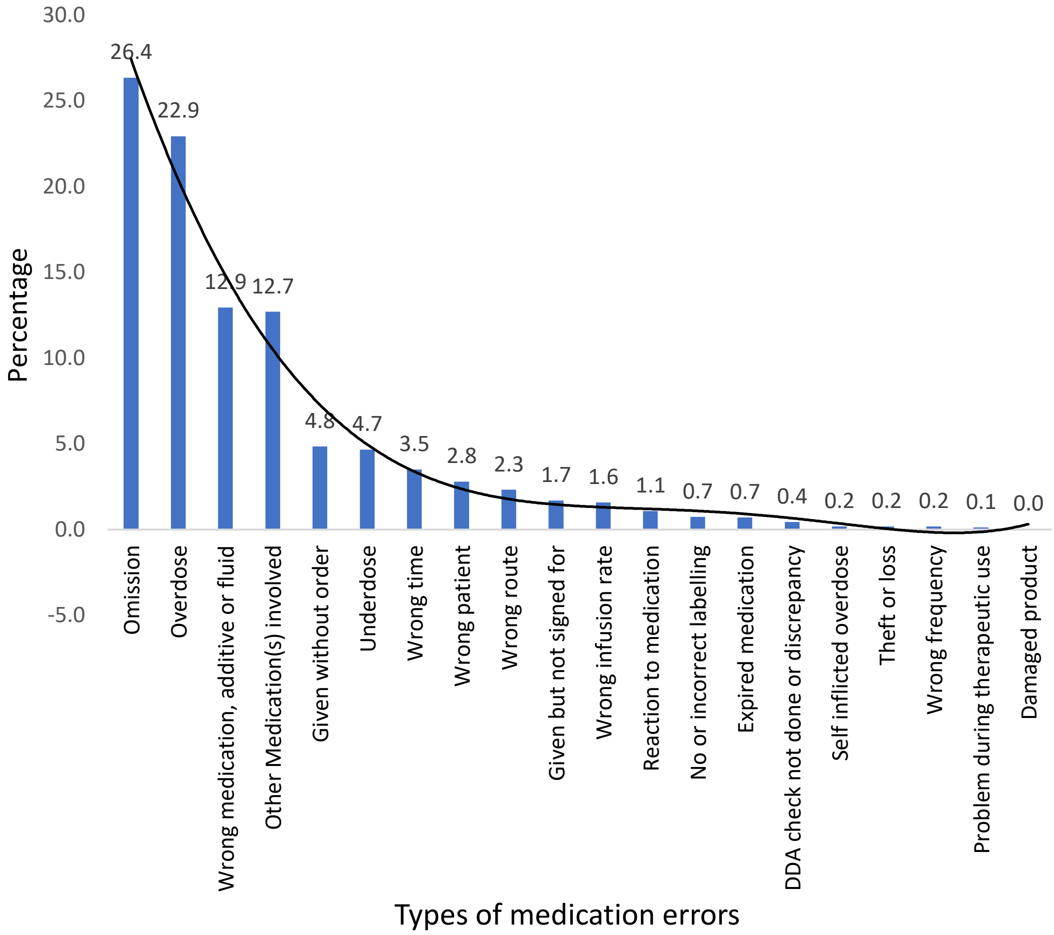


Figure 20: Medication error types

According to the reporting frequency, the top medications involved in clinical incidents were anticoagulants like warfarin and heparin, which together contributed to 17.2% of all medication errors. Dosages of these drugs continually change according to regular blood test results, with increased potential for errors of calculation and dispensing. The second most common drug involved in medication errors was oxycodone (5.8%), which is also expected as oxycodone is a widely-used analgesia, has sedative effects, can alter conscious state and increases the risk of falls (see Table 9).

Table 9

Number and Percentage of Most Common Medications Involved in Incidents

Medication	Medication class	Number of incidents	Percentage
Warfarin sodium	Anticoagulant	431	12.8%
Oxycodone hydrochloride	Opioid analgesic	197	5.8%
Heparin	Anticoagulant	149	4.4%
Insulin	Anti-diabetic	118	3.5%
Paracetamol	Analgesic	94	2.8%
Vancomycin hydrochloride	Antibiotic	55	1.6%

In the AIMS reporting system, medication error outcomes are also categorised according to the severity level from 1 to 8. A little less than half of the total reported medication errors (41.8%) were without harm (level 2) or were associated with minor harm (levels 3). Nearly a third of medication errors (32.9%) resulted in minor harm not requiring treatment (level 4) and a quarter (24.7%) resulted in moderate harm (levels 5 and 6). Less than 1% of all medication error incidents were associated with severe harm (outcome level 7) (see Figure 21).

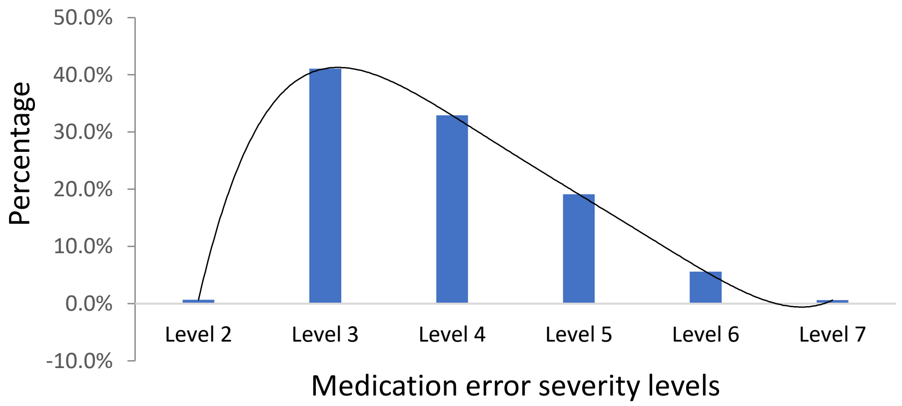


Figure 21: Medication errors severity levels

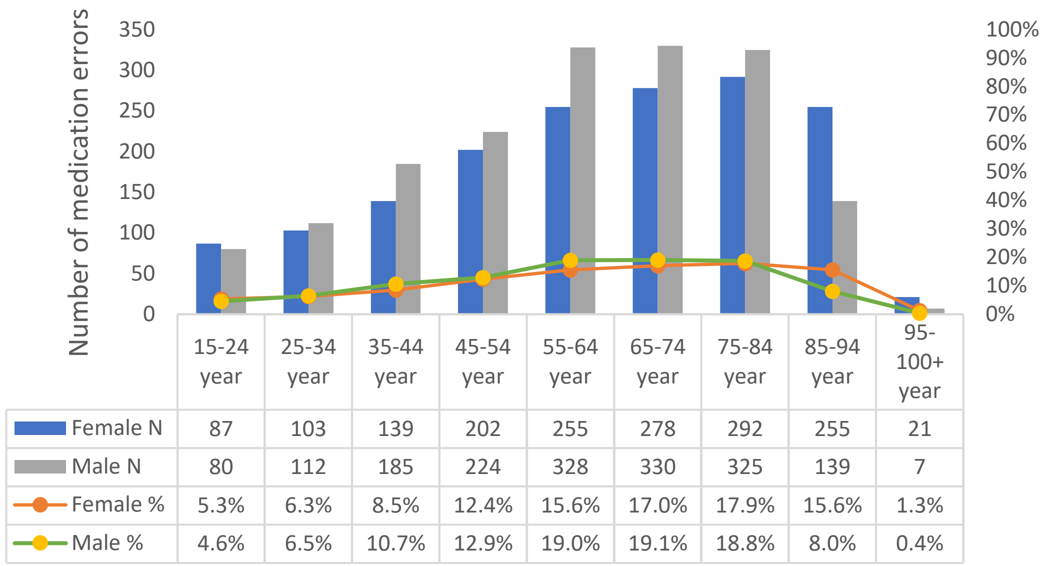
As shown in Table 10 female patients had a higher incidence of medication errors than male patients by 3% ($\chi2=5.6$, df (1), p=0.02). Male and female patients had approximately the same percentage across all age groups except 85-94 years, where females had double the percentage of medication errors than among males (see Figure 22).

Table 10

Medication Errors by Gender

Gender	Medication errors count	Percentage
Female	1,632	48.5
Male	1,730	51.5
Total	3,362	100%

More than 50% of total medication errors were reported mainly between the age of 55 to 84 years (see Figure 22), whereas falls mainly start to peak in the age groups 65 years plus.



	15-24 year	25-34 year	35-44 year	45-54 year	55-64 year	65-74 year	75-84 year	85-94 year	95-100+ year
Female N	87	103	139	202	255	278	292	255	21
Male N	80	112	185	224	328	330	325	139	7
Female %	5.3%	6.3%	8.5%	12.4%	15.6%	17.0%	17.9%	15.6%	1.3%
Male %	4.6%	6.5%	10.7%	12.9%	19.0%	19.1%	18.8%	8.0%	0.4%

Figure 22: Medication errors by age groups and gender

Unlike fall incidents, slightly more than half of the medication errors occurred among patients aged 65 years or less (51%; n= 1,715) (see Figure 23).

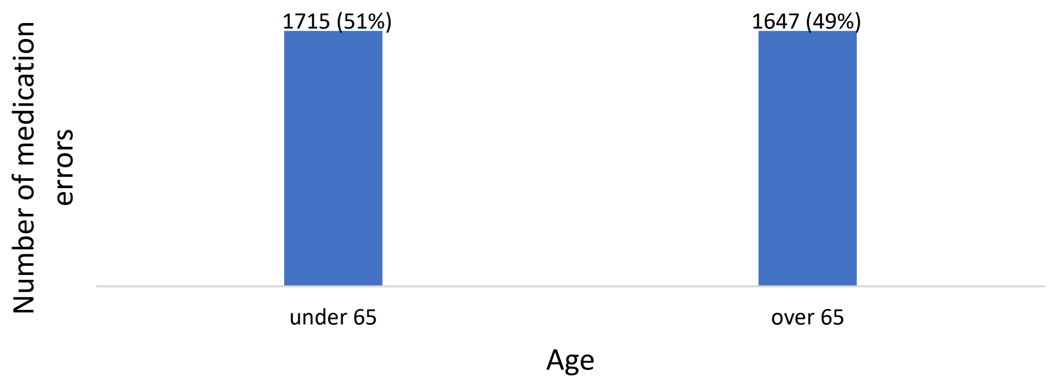
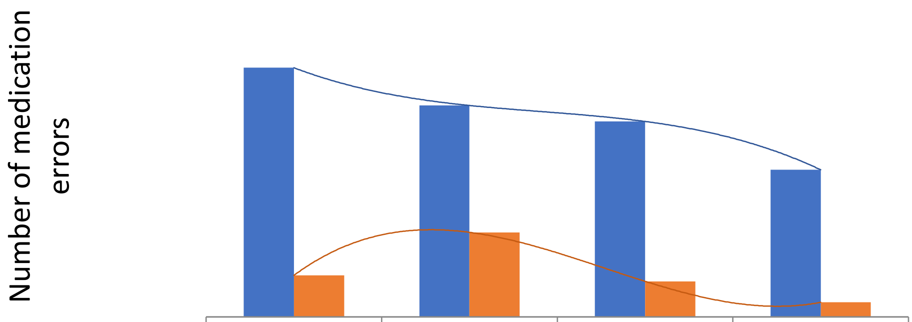


Figure 23: Medication errors among patients under or over 65 years' old

When medication errors are analysed by shift, a third of all medication errors (31.4%; n= 1,043) were reported in the morning shift. This is the highest incidence of medication errors and is likely to be due to a minimum of two medication rounds in the morning shift (8:00 am and 12:00 MD), with an additional 10:00 am round as well for selected patients. The night shift had both the lowest number of medication errors as well as the lowest rate per hour. However, it is noted that despite the highest number of errors occurring in the morning shift, the highest rate of medication errors was reported in the overlap period (354 per hour), doubling that of the morning shift (174 per hour) (see Figure 24).



	Morning (07:00 to 12:59)	Overlap (13:00 to 15:29)	Evening (15:30 to 20:59)	Night (21:00 to 06:59)
Medication Errors per Shift	1043	885	818	616
Medication Errors per Hour	174	354	149	61

Medication errors per shift and per hour

Figure 24: Medication errors per shift and per hour

There are many contributing factors that were reported with medication error incidents. In the AIMS report, there is a list of contributing factors and it was compulsory that at least one of them was noted by the reporting staff member for each medication error (see Table 11). Analysis of all medication incidents showed that approximately two-thirds of medication errors (63%) related to the failure of nursing staff to follow a hospital's policy or procedure. The second most contributing factor was misreading or not reading the documentation (14%). Together these total 77% of all contributing factors. The third factor was that either the nursing staff were inexperienced or they did not have enough knowledge when they administered the medications, contributing to 11% of total reported medication errors. Both communication problems and distraction or inattention were noted for 12% of all medication errors. It appears that medication errors fit into three broad domains of contributing factors: failure to follow policy and/or documentation, inadequate knowledge or experience, and lack of communication or inattention.

Table 11

Number and Percentage of Medication Error Incidents by Type of Staff Contributory Factor

Staff factor	Number	Percentage
Failure to follow policy or procedure	2,118	63%
Misread or did not read documentation	471	14%
Inadequate knowledge and/or inexperience	369	11%
Communication problem	268	8%
Distraction or inattention	136	4%
Total	3,362	100.0%

4.1.7. Descriptive characteristics of nurse staffing

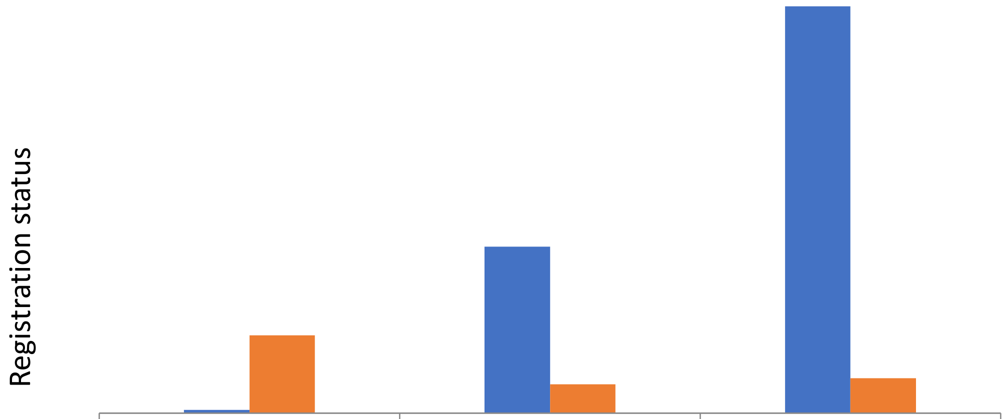
In this study, when a clinical incident was reported, the ward’s staffing level at the time of the incident was derived and recorded. Over the two-year study period (2011–2012), there were 101,929 nursing hours. The number of RNs and non-RNs (combination of ENs and AINs) were noted for each incident on every shift and ward, and their level of experience and registration status of the nurse attending the patient was recorded at the time of the incident. This also enabled the actual nursing hours of direct care per shift to be accurately calculated and used for modelling purposes. It is noted the majority of nursing staff were RNs (80.3%) compared to non-RNs (19.7%) (see Table 12).

Table 12

Nursing Staff Characteristics

Experience & Registration	Seniority			Total	Percentage
	Level (1) 0-2 years' experience	Level (2) 2-4 years' experience	Level (3) > 4 years' experience		
RN	35 (6%)	1,753 (28.9%)	4,280 (70.5%)	6,068	80.3%
Non-RN	818 (54.9%)	304 (20.4%)	368 (24.7%)	1,490	19.7%
Total	853 (11.3%)	2,057 (27.2%)	4,648 (61.5%)	7,558	100.0%

The level of experience was described by years of experience and registration status, where 61.5 % of total staff had more than 4 years of experience. It is noted that the majority of non-RNs were inexperienced (54.9%) whereas the majority of RNs were experienced (70.5%) (see Figure 25).



	0-2 years experience	2-4 years experience	>4 years experience
RN	35	1753	4,280
Non-RN	818	304	368

Experience levels

Figure 25: Nursing staff characteristics

4.2. Analysis of Research Questions

Multinomial logistic regression modelling was used to identify nurse staffing factors which are likely to impact on patients with selected outcomes (falls and medication errors).

A series of multinomial logistic regression models were computed yielding four final models. A final model was built for each of the four outcome variables including, (a) fall incidents, (b) medication error incidents, (c) severity of fall incidents, (d) severity of medication error incidents. These four models were able to address the research questions:

Q1: Is there a relationship between patient falls compared to medication errors and nurse staffing on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals?

4.2.1. Model 1: Covariates for Fall Incidents

The aim of this analysis was to identify possible factors which impact on patients having an in-hospital fall. Variables fitted to the model included: age groups, (being over or under 65 years or not), gender, shift, ward type, hospital, and nurse staffing (see Table 11 and Figure 26).

Multinomial logistic regression was performed to assess the impact of these factors on the likelihood of patients who had fall incidents compared to patients who had medications error incidents.

The model also contained three independent variables (RN or Non-RN, years of experience, and actual nursing hours). The full model containing all covariates was statistically significant, $\chi 2$ (12, N= 7558) = 845.40, $p < 0.005$, indicating that the model was able to find a relationship between nursing staff characteristics and patients having a fall. The model as a whole explained between 37% (Cox and Snell R-squared) and 49% (Nagelkerke R-squared) of the variance in falls and correctly classified 57.9% of cases. The two independent variables (level 1 years of experience, and actual hours) were not statistically significant covariates in the model (see Table 13 and Figure 26).

Table 13

Multinomial Logistic Regression Predicting Fall Incidents Compared to Medication Error Incidents by Patient, Shift, Ward, Hospital, and Nursing Staff Variables

Predictor	Significance (P)	Odds Ratio (OR)	95% C.I.	
			Lower	Upper
Patients' Gender				
*Male	.	.	.	.
Female	< 0.001	1.27	1.14	1.42
Patients' Age				
*Under 65 Years	.	.	.	.
Over 65 Years	<0.001	1.75	1.57	1.96
Shift				
*Morning	.	.	.	.
Overlap	0.02	1.53	1.20	5.37
Evening	0.06	1.07	0.98	4.40
Night	0.04	2.71	1.04	4.59
Ward type				
*Critical	.	.	.	.
Medical	<0.001	2.26	2.21	2.33
Surgical	<0.001	1.46	1.37	1.58
Hospital				
*Hospital C	.	.	.	.

Predictor	Significance (P)	Odds Ratio (OR)	95% C.I.	
			Lower	Upper
Hospital A	0.40	1.43	1.25	1.65
Hospital B	0.25	0.92	0.80	1.06
Nurse staffing				
*Non-RN	.	.	.	.
RN	0.02	0.79	0.65	0.96
Years of Experience				
*Level 3 (>4 years)	.	.	.	.
Level 1 (0-2 years)	0.01	1.22	0.96	1.57
Level 2 (2-4 years)	<0.001	1.21	1.07	1.38
Actual hours	0.03	0.36	0.07	2.20

*Note: * variable used as the reference variable.*

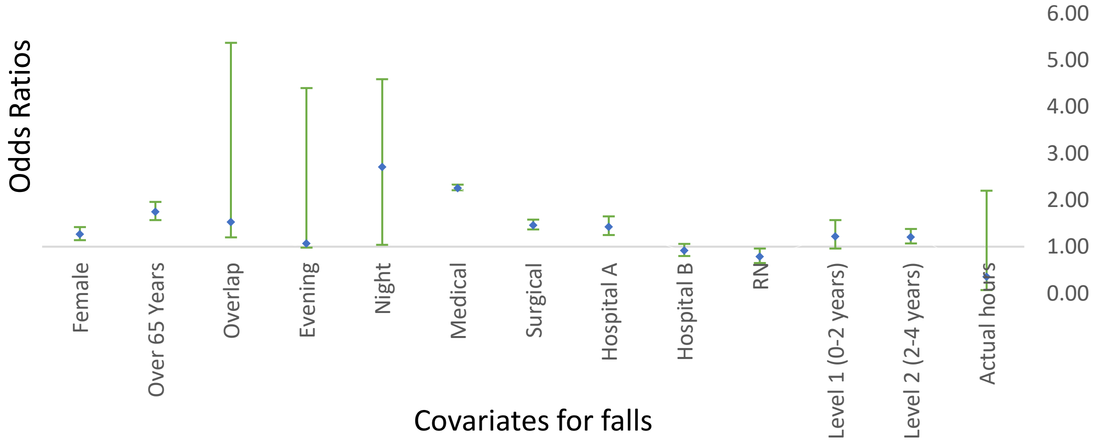


Figure 26: Likelihood of fall incidents compared to medication error incidents

Patient level analysis

Modelling found a relationship between patient's gender and patient falls. Females, compared to males, are more likely to fall. In the event of a fall, compared to a medication error the likelihood of the faller being female was 1.27 times more likely than a male (OR, 1.27 [95% CI, 1.14-1.42]). Older patients, compared to younger patients, are more likely to fall. The likelihood of a patient older than 65 years impacting on a fall was 1.75 times more than those under 65 years (OR, 1.75 [95% CI, 1.57 -1.96]).

Shift level Analysis

Modelling found a relationship between shift time and falls. In the event of a fall, compared to a medication error the likelihood of the night shift impacting on patients having falls was more likely than other shifts. The likelihood of night shift impacting on patients having falls was 2.71 times more likely than the morning shift (OR, 2.71 [95% CI, 1.04 - 4.59]). The likelihood of the overlap period impacting on patients having falls was 1.53 times more likely than the morning shift (OR, 1.53 [95% CI, 1.20 - 5.37]). The likelihood of the evening shift impacting on patients having falls was not significantly different to that of the morning shift (OR, 1.07 [95% CI, 0.98 - 4.40]).

Ward level analysis

Modelling found a relationship between ward type and falls. Falls are more likely to happen in medical and surgical wards than critical care wards. In the event of a fall, compared to a medication error, the likelihood of medical wards impacting on patients having falls was 2.26 times more than falls among those admitted to critical care wards (OR, 2.26 [95% CI, 2.21 – 2.33]), and the likelihood of surgical wards was 1.46 times more than in critical care (OR, 1.46 [95% CI, 1.37 – 1.58]).

Hospital level analysis

Modelling found no relationship between the hospitals and patient falls.

Falls and nursing staff

Modelling found a relationship between attendance of RNs on the shift and patient falls (OR, 0.79 [95% CI, 0.65-0.96]). Falls are less likely to occur in attendance of RNs. In the event of a fall, compared to medication errors the likelihood of attendance with RNs impacting on patients having falls is reduced by 21% than when in attendance with Non-RNs.

Modelling found there was a likelihood that nursing staff experience impacted on the likelihood of patients having a fall. In the event of a fall, compared to a medication error the likelihood of level 1and 2 staff (less than four years in practice) in attendance impacting on patients having a fall was more likely than level 3 staff (four or more years in practice) in attendance. If junior staff with less than two years of experience are in attendance, the likelihood of impacting on a patient having a fall is 1.22 times more likely than if there were more senior staff with four or more years of experience in attendance (OR, 1.22 [95% CI, 0.96-1.57]). Also, if the staff working on the shift had two to four years of experience the likelihood of impacting on a patient having a fall was 1.21 times more than if staff with four or more years of experience are in attendance (OR, 1.21 [95% CI, 1.07-1.38]), about the same likelihood as level 1 staff.

A relationship was found between actual nursing hours and patient falls. However, the confidence interval included unity which indicated a non-significant result. It is noteworthy in that there may still be a clinical significance where more nursing hours may be associated with fewer falls.

Q2: Is there a relationship between nurse staffing and severity of fall incidents?

4.2.2. Model 2: Covariates for the Severity of Fall Incidents

The aim of this analysis was to identify possible factors which impact on the severity of falls. The variables gender, age group (being over or under 65 years), shift, ward, hospital, and nursing staffing variables were fitted to the model (Tables 15, 16, 17, 18, and 19). Modelling was performed against the most severe outcome (level 7: significant harm occurred).

Fall with Level 2 outcome (prior to causing harm)

Modelling found no relationship between any covariates and falls with level two outcome (prior to causing harm); with all variables having a p value greater than 0.05 except actual nursing hours, however the confidence interval included unity. These results are expected as level 2 severity was where the incident was intercepted prior to causing harm (see Table 14).

Table 14

Multinomial Logistic Regression Model Predicting Falls with Outcome Level 2 Compared to Medication Error incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Falls outcome level		Significance	Odds ratio	95% C.I. Lower	95% C.I. Upper
Level 2	*Male	.	.	.	.
(prior to causing harm)	Female	0.93	5.70	0.09	7.04
	*Under 65 Years	.	.	.	.
	Over 65 Years	0.30	5.33	0.22	12.52
	*Night	.	.	.	.
	Morning	0.51	0.24	.004	16.04
	Overlap	0.99	1.40	0.08	4.51
	Evening	0.98	1.58	0.12	2.14
	*Critical	.	.	.	.
	Medical	0.99	5.43	0.42	7.38
	Surgical	0.81	2.40	0.02	12.40
	*Hospital C	.	.	.	.
	Hospital A	0.99	1.70	1.30	2.24
	Hospital B	0.99	1.93	1.06	2.89
	*RN	.	.	.	.
	Non-RN	0.19	18.80	0.21	16.12

Falls outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.89	2.61	2.04	3.45
	Level 2 (2-4 years)	0.99	1.05	0.82	1.95
	Actual hours	<0.001	0.83	0.32	1.93

**Note: Level 7 used as the reference variable.*

Fall with Level 3 outcome (no harm)

Modelling found a relationship between age and falls with no harm. In the event of a fall, compared to a medication error, the likelihood of age over 65 years impacting on patients having no harm falls was 2.88 times more likely than patients under 65 years (OR, 2.88 [95% CI, 1.47 – 5.63]).

Also, a relationship was found between evening shift and falls with no harm. The likelihood of the evening shift impacting on patients having no harm falls was 2.76 times more likely than night shift (OR, 2.76 [95% CI, 1.12-6.82]) (see Table 15).

Table 15

Multinomial Logistic Regression Model Predicting Falls with Outcome Level 3 Compared to Medication Error incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Falls outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
Level 3	*Male	.	.	.	.
(no harm)	Female	0.11	1.57	0.89	2.78
	*Under 65 Years	.	.	.	.
	Over 65 Years	0.002	2.88	1.47	5.63
	*Night	.	.	.	.
	Morning	0.11	1.79	0.86	3.72
	Overlap	0.23	1.62	0.73	3.60
	Evening	0.02	2.76	1.12	6.82
	*Critical	.	.	.	.
	Medical	0.48	1.42	0.52	3.82
	Surgical	0.70	0.81	0.26	2.44
	*Hospital C	.	.	.	.
	Hospital A	0.58	0.82	0.40	1.66
	Hospital B	0.10	0.56	0.28	1.12
	*RN	.	.	.	.

Falls outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Non-RN	0.73	1.85	0.33	2.14
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.64	1.32	0.41	4.24
	Level 2 (2-4 years)	0.06	1.53	0.27	1.04
	Actual hours	0.02	0.71	0.57	1.59

**Note: Level 7 used as the reference variable.*

Fall with Level 4 outcome (minor harm)

Modelling found a relationship between age and falls with minor harm. In the event of a fall, compared to a medication error, the likelihood of age over 65 years impacting on patients having no harm falls was 2.30 times more likely than patients under 65 years (OR, 2.30 [95% CI, 1.27-4.16]).

Also, a relationship was found between falls with minor harm and medical wards. In the event of a fall, compared to a medication error, the likelihood of medical wards impacting on patients having no harm falls was 2.30 times more likely than falls in critical care (OR, 2.89 [95% CI, 1.24 - 6.74]). The likelihood of surgical wards impacting on patients having no harm falls was 2.75 times more likely than falls in critical care (OR, 2.75 [95% CI, 1.08 -6.98]).

For each increase in actual nursing hours, the odds of impacting on a patient with a fall (minor harm) was decreased by 51% (OR, 0.49 [95% CI, 0.11 – 0.83]) (see Table 16).

Table 16

Multinomial Logistic Regression Model Predicting Falls with Outcome Level 4 Compared to Medication Error incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Falls outcome level		Significance	Odds ratio	95% C.I. Lower	Upper
Level 4 (minor harm)	*Male	.	.	.	.
	Female	0.53	1.16	0.71	1.89
	*Under 65 Years	.	.	.	.
	Over 65 Years	<0.001	2.30	1.27	4.16
	*Night	.	.	.	.
	Morning	0.82	0.93	0.51	1.70
	Overlap	0.77	0.91	.46	1.76
	Evening	0.12	1.85	0.84	4.04
	*Critical	.	.	.	.
	Medical	0.01	2.89	1.24	6.74
	Surgical	0.03	2.75	1.08	6.98
	*Hospital C	.	.	.	.
	Hospital A	0.68	0.88	0.48	1.61

Falls outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Hospital B	0.59	1.17	0.65	2.10
	*RN	.	.	.	.
	Non-RN	0.67	1.85	0.40	1.80
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.99	1.00	0.37	2.70
	Level 2 (2-4 years)	0.15	1.66	0.38	1.16
	Actual hours	<0.001	0.49	0.11	0.83

**Note: Level 7 used as the reference variable.*

Fall with Level 5 outcome (moderate harm with minor treatment)

Modelling found a relationship between age and falls with moderate harm. In the event of a fall, compared to a medication error the likelihood of age over 65 years impacting on patients having moderate harm falls was 1.94 times more likely than patients under 65 years (OR, 1.94 [95% CI, 1.07–3.52]).

Also, a relationship was found between falls with moderate harm and medical wards. In the event of a fall, compared to a medication error the likelihood of medical wards impacting on patients having moderate harm falls was 4.31times more likely than falls in critical care (OR, 4.31 [95% CI, 1.80 - 10.30]). The likelihood of surgical wards impacting on patients having moderate harm falls was 3.55 times more likely than falls in critical care (OR, 3.55 [95% CI, 1.36 - 9.24]).

For each increase in actual nursing hours, the odds of impacting on a patient with a fall with minor treatment was decreased by 76% (OR, 0.24 [95% CI, 0.14 – 0.78]) (see Table 17).

Table 17

Multinomial Logistic Regression Model Predicting Falls with Outcome Level 5 Compared to Medication Error incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Falls outcome level		Significance	Odds ratio	95% C.I. Lower	95% C.I. Upper
Level 5	*Male	.	.	.	.
(moderate harm and minor treatment)	Female	0.61	1.88	0.54	1.43
	*Under 65 Years	.	.	.	.
	Over 65 Years	0.029	1.94	1.07	3.52
	*Night	.	.	.	.
	Morning	0.53	0.82	0.44	1.51
	Overlap	0.48	0.78	0.40	1.53
	Evening	0.24	1.60	0.72	3.51
	*Critical	.	.	.	.
	Medical	0.001	4.31	1.80	10.30

Falls outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Surgical	0.009	3.55	1.36	9.24
	*Hospital C	.	.	.	.
	Hospital A	0.57	1.19	0.64	2.19
	Hospital B	0.60	1.16	0.64	2.10
	*RN	.	.	.	.
	Non-RN	0.71	0.86	0.40	1.85
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.58	1.75	0.27	2.05
	Level 2 (2-4 years)	0.13	1.65	0.37	1.14
	Actual hours	0.01	0.24	0.14	0.78

**Note: Level 7 used as the reference variable.*

Fall with Level 6 outcome (moderate harm with major treatment)

Modelling found a relationship between age and falls with major harm. In the event of a fall, compared to a medication error, the likelihood of age over 65 years impacting on patients having major harm falls was 1.92 times more likely than patients under 65 years (OR, 1.92 [95% CI, 1.04 - 3.54]).

For each increase in actual nursing hours, the odds of impacting on a patient with a fall with major treatment was decreased by 87% (OR, 0.13 [95% CI, 0.10 – 0.45]) (see Table 18).

Table 18

Multinomial Logistic Regression Model Predicting Falls with Outcome Level 6 Compared to Medication Error incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Falls outcome level		Significance	Odds ratio	95% C.I. Lower	95% C.I. Upper
Level 6 (moderate harm with major treatment)	*Male	.	.	.	.
	Female	0.69	1.90	0.54	1.50
	*Under 65 Years	.	.	.	.
	Over 65 Years	0.037	1.92	1.04	3.54
	*Night	.	.	.	.
	Morning	0.25	0.69	0.36	1.30
	Overlap	0.39	0.73	0.36	1.48
	Evening	0.37	1.43	0.64	3.23
	*Critical	.	.	.	.
	Medical	0.18	1.83	0.74	4.49
	Surgical	0.10	2.22	0.83	5.92
	*Hospital C	.	.	.	.

Falls outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Hospital A	0.42	0.38	0.20	0.73
	Hospital B	0.28	0.71	0.39	1.31
	*RN	.	.	.	.
	Non-RN	0.04	0.71	0.31	1.59
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.04	1.28	0.44	3.67
	Level 2 (2-4 years)	0.02	1.72	0.40	1.29
	Actual hours	<0.001	0.13	0.10	0.45

**Note: Level 7 used as the reference variable.*

In summary, there was a statistically significant association found between the severity of falls and patients' age, ward, and actual nursing hours.

Q3: Is there a relationship between medication errors compared to patient falls and nurse staffing on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals?

4.2.3. Model 3: Covariates for Medication Error Incidents

A multinomial logistic regression model analysis was used to explore the relationship between nurse staffing and medication error incidents (see Table 14 and Figure 27).

Multinomial logistic regression was performed to assess the impact of these factors on the likelihood of patients who had medication error incidents compared to patients who had fall incidents.

The model contained three independent variables (RN or Non-RN, years of experience, and actual nursing hours). The full model containing all covariates was statistically significant, χ^2 (7, N= 7558) = 215 p < 0.005 indicating that the model was able to find a relationship between nursing staff characteristics and patients having a medication error. The model as a whole explained between 38% (Cox and Snell R square) and 50% (Nagelkerke R squared) of the variance in medication errors and correctly classified 58.7% of cases. Shift, ward, and hospital were entered as control variables in the statistical model. Table 19 shows the variables that made statistically significant contributions to the model.

Table 19

Multinomial Logistic Regression Predicting Medication Error Incidents Compared to Fall Incidents by Nursing Staff

Medication Errors outcome level	Significance	Odds ratio	95% C.I.	
			Lower	Upper
Patients' Gender				
*Male	.	.	.	.
Female	<0.001	1.27	1.15	1.40
Patients' Age				
*Under 65 Years	.	.	.	.
Over 65 Years	<0.001	1.75	1.59	1.94
Shift				
*Night	.	.	.	
Morning	0.02	2.18	1.12	4.26
Overlap	0.01	2.53	1.29	4.98
Evening	0.04	2.07	1.05	4.08

Medication Errors outcome level	Significance	Odds ratio	95% C.I.	
			Lower	Upper
Ward type				
*Critical	.	.	.	.
Medical	<0.001	3.26	3.22	3.32
Surgical	<0.001	2.46	2.38	2.57
Hospitals				
Hospital A	<0.001	1.43	1.27	1.62
Hospital B	0.20	0.92	0.81	1.04
*Hospital C	.	.	.	.
Nurse staffing				
*Non-RN	.	.	.	.
RN	0.01	0.79	0.66	0.94
Years of Experience				
*Level 3 (>4 years)	.	.	.	.
Level 1 (0-2 years)	0.08	1.29	0.98	1.53
Level 2 (2-4 years)	<0.001	1.18	1.08	1.36
Actual hours	0.02	0.22	0.12	0.33

**Variable used as reference variables*

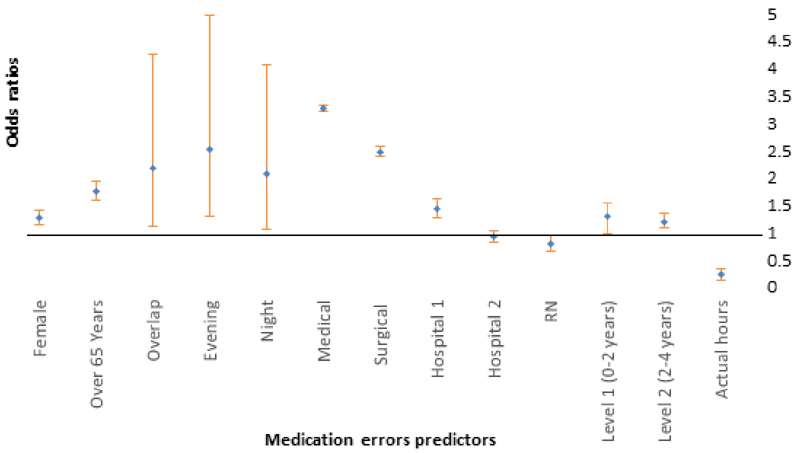


Figure 27: Likelihood of medication error incidents compared to fall incidents

Patient level analysis

Modelling found a relationship between patients' gender, age, and medication errors. In the event of a medication error, compared to a fall, females were more likely to experience medication errors than males. The likelihood of being female for patients having medication errors was 1.27 times more likely than being male (OR, 1.27 [95% CI, 1.15 - 1.40]). Older patients, compared to younger patients, are more likely to have medication errors. In the event of a medication error, compared to a fall, the likelihood of a patient older than 65 years impacting on a medication error was 1.75 times more likely than those under 65 years (OR, 1.75 [95% CI, 1.59-1.94]).

Shift level analysis

Modelling found a relationship between shift time and medication error. In the event of a medication error, compared to a fall, the likelihood of the night shift impacting on patients having medication errors was more likely than other shifts. The likelihood of the overlap period impacting on patients having medication errors was 2.53 times more likely compared to the night shift (OR, 2.53 [95% CI, 1.29 - 4.98]). The likelihood of the morning shift impacting on patients having medication errors was 2.18 times more likely than the night shift. (OR, 2.18 [95% CI, 1.12 -4.26]). The likelihood of the evening shift impacting on patients having medication errors was 2.07 times more than the night shift (OR, 2.07 [95% CI, 105 - 4.08]).

Ward level analysis

Modelling found a relationship between ward type and medication errors. Medication errors are more likely to happen in medical wards and surgical wards than critical care wards. In the event of a medication error, compared to a fall, the likelihood of medical wards impacting on patients having medication errors was 3.26 times more than in critical care (OR, 3.26 [95% CI, 3.22 – 3.23]), and the likelihood of surgical wards was 2.46 times more than in critical care (OR, 2.46 [95% CI, 2.38- 2.57]).

Hospital level analysis

Modelling found a relationship between the hospital and medication errors. Medication errors were more likely to happen in hospital A. In the event of a medication error, compared to a fall, the likelihood of medication errors in hospital A was 1.43 times more likely than medication errors in hospital C (OR, 1.43 [95% CI, 1.27- 1.62]).

Medication errors and nursing staff

Modelling found a relationship between RNs and medication errors. Medication errors are less likely to occur in attendance of RNs. In the event of a medication error, compared to falls, the likelihood of attendance with RNs impacting on patients having medication errors is reduced by 21% than when in attendance with non-RNs (OR, 0.79 [95% CI, 0.66- 0.94]).

Modelling found there was a likelihood that nursing staff experience impacted on patients having a medication error. In the event of a medication error, compared to a fall, the likelihood of level 1and 2 staff (less than four years in practice) in attendance impacting on patients having a medication error was more likely than level 3 staff (four or more years in practice) in attendance. If junior staff with less than two years of experience are in attendance, the likelihood of impacting on a patient having a medication error was 29% higher if there were more senior staff with four or more years of experience in attendance (OR, 1.29 [95% CI, 0.98 - 1.53]). Also, if the staff working on the shift had two to four years of experience the likelihood of impacting on a patient having a medication error was 18% higher if staff with four or more years of experience are in attendance (1.18 [95% CI, 1.08 - 1.36]) about the same likelihood as level 1 staff.

A relationship was found between actual nursing hours and medication errors. In the event of a medication error, compared to a fall the likelihood of each one-hour increase in actual nursing hours impacting on a patient having a medication error was 0.22 times less likely, (OR, 0.22 [95% CI, 0.12 - 0.33]), a decrease of 78%.

Q4: Is there a relationship between nurse staffing and severity of medication error incidents?

4.2.4. Model 4: Covariates for the Severity of Medication Error Incidents

The aim of this analysis was to identify possible factors which impact on the severity of medication errors. The variables gender, age group (being over or under 65 years), shift, ward, hospital, and nursing staffing variables were fitted to the multinomial logistic regression model (see Tables 20 to 24). Modelling was used to compare the most severe outcome level, significant harm occurred, (outcome level 7), with other outcome levels.

Medication errors with Level 2 outcome (prior to causing harm)

Modelling found a relationship between medication errors prior to causing harm (level 2) and shift, ward, and Non-RNs. Also, a relationship was found between shift time and medication errors prior to causing harm. In the event of a medication error, compared to a fall, the likelihood of the overlap period impacting on patients having medication errors prior to causing harm was 1.54 times more likely than night shift (OR, 1.54 [95% CI, 1.20 - 2.25]). The evening shift was 1.23 times more likely than the night shift (OR, 1.23[95% CI, 1.09 - 2.09]), and the morning shift was 3.10 times more likely than the night shift (OR, 3.10 [95% CI, 2.78 - 4.14]).

Also, a relationship was found between medication errors prior to harm and medical wards. In the event of a medication error, compared to a fall, the likelihood of medical wards impacting on medication errors prior to harm was 7.02 times more likely than medication errors in critical care (OR, 7.02 [95% CI, 4.30-9.37]), and the likelihood of surgical wards was 3.41 times more likely than medication errors prior to harm in critical care wards (OR, 3.41 [95% CI, 2.03 - 5.61]).

Modelling found a relationship between RN staff on the shift and medication errors prior to harm. Medication errors prior to harm are less likely to occur in attendance of RNs. In the event of a medication error, compared to falls the likelihood of attendance with non-RNs impacting on patients having medication errors prior to harm is increased by 33% than when in attendance with RNs (OR, 1.33 [95% CI, 1.05 – 2.25]).

A relationship was found between actual nursing hours and medication errors prior to harm. In the event of a medication error, compared to a fall the likelihood of each increase in actual nursing hour impacting on a patient having a medication error was 0.56 times less likely, (OR, 0.56 [95% CI, 0.23 – 0.89]), a decrease of 44% (see Table 20).

Table 20

Multinomial Logistic Regression Model Predicting Medication Errors with Outcome Level 2 Compared to Fall Incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
Level 2 (prior to causing harm)	*Male	.	.	.	.
	Female	0.74	1.18	0.46	3.03
	*Under 65 Years	.	.	.	.
	Over 65 Years	0.24	1.76	0.69	4.54
	*Night	.	.	.	.
	Morning	0.01	3.10	2.78	4.14
	Overlap	0.01	1.54	1.20	2.25
	Evening	<0.001	1.23	1.09	2.09
	*Critical	.	.	.	.
	Medical	<0.001	7.02	4.30	9.37
	Surgical	<0.001	3.41	2.03	5.61
	*Hospital C	.	.	.	.
	Hospital A	0.86	0.90	0.27	2.94
	Hospital B	0.44	1.75	0.43	7.19
	*RN	.	.	.	.

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Non-RN	.02	1.33	1.05	2.25
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.94	1.10	0.09	3.63
	Level 2 (2-4 years)	0.87	0.90	0.27	2.97
	Actual hours	0.03	0.56	0.23	0.89

*Note: *level 7 is considered as a reference variable.*

Medication errors with Level 3 outcome (no harm)

Modelling found a relationship between medication errors with no harm and shift, ward, RN attendance, and years of experience. In the event of a medication error, compared to a fall, the likelihood of the morning shift impacting on patients having medication errors with no harm was 4.01 times more likely than night shift (OR, 4.01 [95% CI, 3.67 -7.09]), evening shift was 2.29 times more likely than on night shift (OR, 2.29 [95% CI, 1.99-3.72]), and the overlap period was 1.20 times than the night shift (OR, 1.20 [95% CI, 0.78 - 2.02]).

Also, a relationship was found between medication errors with no harm and medical wards. In the event of a medication error, compared to a fall, the likelihood of medical wards impacting on medication errors with no harm was 6.13 times more likely than in critical care (OR, 6.13 [95% CI, 2.28 - 16.50]), and the likelihood of surgical wards was 4.70 times more likely than in critical care (OR, 4.70 [95% CI, 1.96 – 11.28]).

Modelling found a relationship between non-RN staff on the shift and medication errors with no harm. Medication errors with no harm are less likely to occur in attendance of RNs. In the event of a medication error, compared to falls, the likelihood of non-RNs attendance impacting on patients having medication errors with no harm is increased by 56% than when in attendance of RNs (OR, 1.56 [95% CI, 1.16 – 2.95]).

Modelling found there was a likelihood that nursing staff experience impacted on patients having a medication error. In the event of a medication error, compared to a fall, the likelihood of level 1 staff (less than two years in practice) in attendance impacting on patients having medication errors with no harm was more likely than levels 2 and 3 staff (two or more years in practice) in attendance. If junior staff with less than two years of experience are in attendance, the likelihood of impacting on a patient having a medication errors with no harm was 4.58 times higher if there were more senior staff with two or more years of experience in attendance (OR, 4.58 [95% CI, 3.30 – 8.19]) (see Table 21).

Table 21

Multinomial Logistic Regression Model Predicting Medication Errors with Outcome Level 3 Compared to Fall Incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
Level 3	*Male	.	.	.	.

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
(no harm)	Female	0.27	0.67	0.32	1.37
	*Under 65 Years	.	.	.	.
	Over 65 Years	0.80	1.10	0.54	2.25
	*Night	.	.	.	.
	Morning	<0.001	4.01	3.67	7.09
	Overlap	<0.001	1.20	0.78	2.02
	Evening	<0.001	2.29	1.99	3.72
	*Critical	.	.	.	.
	Medical	<0.001	6.13	2.28	16.50
	Surgical	<0.001	4.70	1.96	11.28
	*Hospital C	.	.	.	.

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Hospital A	0.22	1.73	0.73	4.13
	Hospital B	0.31	3.75	1.18	11.87
	*RN	.	.	.	.
	Non-RN	<0.001	1.56	1.16	2.95
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.01	4.58	3.30	8.19
	Level 2 (2-4 years)	0.35	1.50	0.64	3.52
	Actual hours	<0.001	0.88	0.11	1.03

*Note: *level 7 is considered as a reference variable.*

Medication errors with Level 4 outcome (minor harm)

Modelling found a relationship between medication errors with minor harm (level4) and patients' age, shift, ward, RN attendance, and years of experience.

In the event of a medication error, compared to a fall, the likelihood of age over 65 years impacting on patients having medication errors with minor harm was 3.07 times more likely than patients under 65 years (OR, 3.07 [95% CI, 2.52 -4.19]). The likelihood of being female impacting on patients with medication errors with minor harm was 29% less likely than being male (OR, 0.71[95% CI, 0.34 -1.45]), however, it was not statistically significant because the CI included "1".

The likelihood of the morning shift impacting on patients having medication errors minor harm was 4.89 times more likely than on the night shift (OR, 4.89 [95% CI, 3.11 -7.23]), the likelihood on the overlap period was 4.24 times more likely than on night shift (OR, 4.24 [95% CI, 4.01 - 6.03]), and the likelihood of evening shift was 1.10 times more likely than night shift (OR, 1.10 [95% CI, 0.87-2.18]).

Also, a relationship was found between medication errors with minor harm and medical wards. In the event of a medication error, compared to a fall the likelihood of medical wards impacting on patients having medication errors with minor harm was 4.12 times more likely than medication errors in critical care (OR, 4.12 [95% CI, 1.71 – 9.93]). The likelihood of surgical wards impacting on patients having medication errors with minor harm was 5.91 times more likely than medication errors in critical care (OR, 5.91 [95% CI, 2.19– 15.96])

Modelling found there was a likelihood that nursing staff experience impacted on patients having medication errors with minor harm. In the event of a medication error, compared to a fall, the likelihood of level 1and 2 staff (less than four years in practice) in attendance impacting on patients having medication errors with minor harm was more likely than level 3 staff (four or more years in practice) in attendance.

If junior staff with less than two years of experience are in attendance, the likelihood of impacting on a patient having a medication error with minor harm was 22% higher if there were more senior staff with four or more years of experience in attendance (OR, 1.22 [95% CI, 0.23 - 6.31]). Also, if the staff working on the shift had two to four years of experience the likelihood of impacting on a patient having a medication error with minor harm was 33% higher if staff with four or more years of experience are in attendance (OR, 1.33 [95% CI, 0.57 – 3.14]), about the same likelihood as level 1 staff (see Table 22).

Table 22

Multinomial Logistic Regression Model Predicting Medication Errors with Outcome Level 4 Compared to Fall Incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
Level 4 (minor harm)	*Male	.	.	.	.
	Female	0.03	0.71	0.34	1.45
	*Under 65 Years	.	.	.	.
	Over 65 Years	0.01	3.07	2.52	4.19
	*Night	.	.	.	.

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Morning	<0.001	4.89	3.11	7.23
	Overlap	<0.001	4.24	4.01	6.03
	Evening	<0.001	1.10	0.87	2.18
	*Critical	.	.	.	.
	Medical	<0.001	4.12	1.71	9.93
	Surgical	<0.001	5.91	2.19	15.96
	*Hospital C	.	.	.	.
	Hospital A	0.51	1.34	0.56	3.21
	Hospital B	0.11	4.50	1.42	14.28
	*RN	.	.	.	.
	Non-RN	<0.001	1.91	0.26	3.19

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.02	1.22	0.23	6.31
	Level 2 (2-4 years)	0.01	1.33	0.57	3.14
	Actual hours	<0.001	0.94	0.63	2.08

*Note: *level 7 is considered as a reference variable.*

Medication errors with Level 5 outcome (moderate harm with minor treatment)

Modelling found a relationship between medication errors with moderate harm requiring minor treatment (level 5) and RN attendance.

Modelling found a relationship between non-RN staff on the shift and medication errors with moderate harm. Medication errors with moderate harm are less likely to occur in attendance of RNs. In the event of a medication error, compared to falls, the likelihood of non-RNs attendance impacting on patients having medication errors with moderate harm is 1.64 times that than when in attendance of RNs (OR, 1.64 [95% CI, 1.18 – 3.29]) (see Table 23).

Table 23

Multinomial Logistic Regression Model Predicting Medication Errors with Outcome Level 5 Compared to Fall Incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
Level 5 (moderate harm and minor treatment)	*Male	.	.	.	.
	Female	0.22	0.63	0.31	1.31
	Under 65 Years	.	.	.	.
	*Over 65 Years	0.04	1.32	0.64	2.73
	*Night	.	.	.	.
	Morning	0.21	2.66	1.99	4.02
	Overlap	0.78	1.55	1.27	3.99
	Evening	0.29	1.13	0.78	1.89
	*Critical	.	.	.	.
	Medical	0.08	4.26	1.74	10.43
	Surgical	0.09	5.21	1.90	14.30
	*Hospital C	.	.	.	.

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Hospital A	0.91	1.05	0.44	2.54
	Hospital B	0.43	3.34	1.05	10.66
	*RN	.	.	.	.
	Non-RN	0.01	1.64	1.18	3.29
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.63	1.52	0.29	8.06
	Level 2 (2-4 years)	0.63	1.24	0.52	2.94
	Actual hours	<0.001	0.81	0.55	1.36

*Note: *level 7 is considered as a reference variable.*

Medication errors with Level 6 outcome (moderate harm with major treatment)

Modelling found no relationship between any covariates and medication errors with moderate harm with major treatment (level 6) (see Table 24).

Table 24

Multinomial Logistic Regression Model Predicting Medication Errors with Outcome Level 6 Compared to Fall Incidents by Patient, Shift, Ward, Hospital, and Nursing Staff

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
Level 6	Male	.	.	.	.
(moderate harm with major treatment)	*Female	0.43	0.74	0.34	1.58
	*Under 65 Years	.	.	.	.
	Over 65 Years	0.23	1.42	0.66	3.03
	*Night	.	.	.	.
	Morning	0.09	0.01	0.00	0.16
	Overlap	0.11	0.01	0.00	0.24
	Evening	0.06	0.00	0.00	0.11
	*Critical	.	.	.	.
	Medical	0.53	1.35	0.53	3.44
	Surgical	0.07	2.59	0.92	7.32
	*Hospital C	.	.	.	.

Medication errors outcome level		Significance	Odds ratio	95% C.I.	
				Lower	Upper
	Hospital A	0.08	2.28	0.91	5.74
	Hospital B	0.09	3.74	1.12	12.50
	RN	.	.	.	.
	*Non-RN	0.91	1.08	0.28	4.11
	*Level 3 (>4 years)	.	.	.	.
	Level 1 (0-2 years)	0.13	1.92	0.16	5.32
	Level 2 (2-4 years)	0.76	1.15	0.46	2.87
	Actual hours	0.04	0.58	0.12	1.69

*Note: *level 7 is considered as a reference variable.*

In summary, there is a statically significant association found between a number of factors (patients' age, nursing staff seniority, if the medications were administered by registered nurses or not, shift and ward), and the impact these had on patients and the severity of their medication error incidents.

4.3. Hypotheses Analysis

According to the modelling results the following hypotheses were accepted or rejected:

- *Fall incidents hypothesis:*
  - ***Null Hypothesis***: there is no relationship between nurse staffing and the likelihood or the severity of patients who had fall incidents compared to patients who had medication error incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals(rejected).
  - ***Alternative Hypothesis****:* there is a relationship between nurse staffing and the likelihood or the severity of patients who had fall incidents compared to patients who had medications error incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals (accepted).

The alternative hypothesis has been accepted according to the following results:

Hypothesis H01: *at the patient level*: there is no statistically significant difference in the occurrence and severity of falls based on the patients' gender (rejected).

Hypothesis HA1: *at the patient level*: there is a statistically significant difference in the occurrence of falls based on the patients' gender (accepted).

Hypothesis H02: *at the patient level*: there is no statistically significant difference in the severity of falls based on the patients' gender (accepted).

Hypothesis HA2: *at the patient level*: there is a statistically significant difference in the severity of falls based on the patients' gender (rejected).

Hypothesis H03: *at the patient level,* there is no statistically significant difference in the occurrence of falls based on patients' age (rejected).

Hypothesis HA3: *at the patient level,* there is a statistically significant difference in the occurrence of falls based on patients' age (accepted).

Hypothesis H04: *at the patient level,* there is no statistically significant difference in the severity of falls based on patients' age (rejected).

Hypothesis HA4: *at the patient level,* there is a statistically significant difference in the severity of falls based on patients' age (accepted).

Hypothesis H05: *at the shift level,* there is no statistically significant difference in the occurrence of falls based on shift time (rejected).

Hypothesis HA5: *at the shift level,* there is a statistically significant difference in the occurrence of falls based on shift time (accepted).

Hypothesis H06: *at the shift level,* there is no statistically significant difference in the severity of falls based on shift time (accepted).

Hypothesis HA6: *at the shift level,* there is a statistically significant difference in the severity of falls based on shift time (rejected).

Hypothesis H07: *at the ward level,* there is no statistically significant difference in the occurrence of falls between medical, surgical, and critical care wards (rejected).

Hypothesis HA7: *at the ward level,* there is a statistically significant difference in the occurrence of falls between medical, surgical, and critical care wards (accepted).

Hypothesis H08: *at the ward level,* there is no statistically significant difference in the severity of falls between medical, surgical, and critical care wards (rejected).

Hypothesis HA8: *at the ward level*, there is a statistically significant difference in the severity of falls between medical, surgical, and critical care wards (accepted).

Hypothesis HA9: *at the hospital level*, there is a statistically significant difference in the occurrence and severity of falls based on the hospital (rejected).

Hypothesis H09: *at the hospital level,* there is no statistically significant difference in the occurrence and severity of falls based on the hospital (accepted).

Hypothesis H010: *at the hospital level,* there is no statistically significant difference in the severity of falls based on the hospital (accepted).

Hypothesis HA10: *at the hospital level*, there is a statistically significant difference in the severity of falls based on the hospital (rejected).

Hypothesis H011: there is no statistically significant difference in the occurrence and severity of patient falls based on nursing staff registration status (rejected).

Hypothesis HA11: there is a statistically significant difference in the occurrence of patient falls based on nursing staff registration status (accepted).

Hypothesis H012: there is no statistically significant difference in the severity of patient falls based on nursing staff registration status (accepted).

Hypothesis HA12: there is a statistically significant difference in the severity of patient falls based on nursing staff registration status (rejected).

Hypothesis H013: there is no statistically significant difference in the occurrence of patient falls based on the nursing staff years of experience (accepted).

Hypothesis HA13: there is a statistically significant difference in the occurrence of patient falls based on the nursing staff years of experience (rejected).

Hypothesis H014: there is no statistically significant difference in the severity of patient falls based on the nursing staff years of experience (accepted).

Hypothesis HA14: there is a statistically significant difference in the severity of patient falls based on the nursing staff years of experience (rejected).

Hypothesis H015: there is no statistically significant difference in the occurrence of patient falls based on the actual nursing hours (accepted).

Hypothesis HA15: there is a statistically significant difference in the occurrence of patient falls based on the actual nursing hours (rejected).

Hypothesis H016: there is no statistically significant difference in the severity of patient falls based on the actual nursing hours (rejected).

Hypothesis HA16: there is a statistically significant difference in the severity of patient falls based on the actual nursing hours (accepted).

- *Medication error incidents hypothesis:*

  - ***Null Hypothesis***: there is no relationship between nurse staffing and the likelihood or the severity of patients who had medication error incidents compared to patients who had fall incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals (rejected).

- ***Alternative Hypothesis****:* there is a relationship between nurse staffing and the likelihood or the severity of patients who had medication error incidents compared to patients who had fall incidents on a shift-by-shift and ward-by-ward level in Western Australian tertiary hospitals(accepted).

The alternative hypothesis has been accepted according to the following results:

Hypothesis H017: *at the patient level*: there is no statistically significant difference in the occurrence of medication errors based on the patients' gender (rejected).

Hypothesis HA17: *at the patient level*: there is a statistically significant difference in the occurrence of medication errors based on the patients' gender (accepted).

Hypothesis H018: *at the patient level*: there is no statistically significant difference in the severity of medication errors based on the patients' gender (accepted).

Hypothesis HA18: *at the patient level*: there is a statistically significant difference in the severity of medication errors based on the patients' gender (rejected).

Hypothesis H019: *at the patient level,* there is no statistically significant difference in the occurrence of medication errors based on patients' age (rejected).

Hypothesis HA19: *at the patient level*, there is a statistically significant difference in the occurrence of medication errors based on patients' age (accepted).

Hypothesis H020: *at the patient level,* there is no statistically significant difference in the severity of medication errors based on patients' age (accepted).

Hypothesis HA20: *at the patient level,* there is a statistically significant difference in the severity of medication errors based on patients' age (rejected).

Hypothesis H021: *at the shift level,* there is no statistically significant difference in the occurrence of medication errors based on shift time (rejected).

Hypothesis HA21: *at the shift level,* there is a statistically significant difference in the occurrence of medication errors based on shift time (accepted).

Hypothesis H022: *at the shift level,* there is no statistically significant difference in the severity of medication errors based on shift time (rejected).

Hypothesis HA22: *at the shift level,* there is a statistically significant difference in the severity of medication errors based on shift time (accepted).

Hypothesis H022: *at the ward level,* there is no statistically significant difference in the occurrence and severity of medication errors between medical, surgical, and critical care wards (rejected).

Hypothesis HA22: *at the ward level,* there is a statistically significant difference in the occurrence medication errors between medical, surgical, and critical care wards (accepted).

Hypothesis H024: *at the ward level,* there is no statistically significant difference in the severity of medication errors between medical, surgical, and critical care wards (rejected).

Hypothesis HA24: *at the ward level*, there is a statistically significant difference in the severity of medication errors between medical, surgical, and critical care wards (accepted).

Hypothesis H025: *at the hospital level*, there is no statistically significant difference in the occurrence and severity of medication errors based on the hospital (rejected).

Hypothesis HA25: *at the hospital level*, there is a statistically significant difference in the occurrence of medication errors based on the hospital (accepted).

Hypothesis H026: *at the hospital level*, there is no statistically significant difference in the severity of medication errors based on the hospital (accepted).

Hypothesis HA26: *at the hospital level*, there is a statistically significant difference in the severity of medication errors based on the hospital (rejected).

Hypothesis H027: there is no statistically significant difference in the occurrence and severity of patient medication errors based on nursing staff registration status (rejected).

Hypothesis HA27: there is a statistically significant difference in the occurrence of patient medication errors based on nursing staff registration status (accepted).

Hypothesis H028: there is no statistically significant difference in the severity of patient medication errors based on nursing staff registration status (rejected).

Hypothesis HA28: there is a statistically significant difference in the severity of patient medication errors based on nursing staff registration status (accepted).

Hypothesis H029: there is no statistically significant difference in the occurrence and severity of patient medication errors based on the nursing years of experience (rejected).

Hypothesis HA29: there is a statistically significant difference in the occurrence of patient medication errors based on the nursing staff years of experience (accepted).

Hypothesis H030: there is no statistically significant difference in the severity of patient medication errors based on the nursing years of experience (accepted).

Hypothesis HA30: there is a statistically significant difference in the severity of patient medication errors based on the nursing staff years of experience (rejected).

Hypothesis HA31: there is a statistically significant difference in the occurrence of patient medication errors based on the actual nursing hours (accepted).

Hypothesis H031: there is no statistically significant difference in the occurrence and severity of patient medication errors based on the actual nursing hours (rejected).

Hypothesis HA32: there is a statistically significant difference in the severity of patient medication errors based on the actual nursing hours (accepted).

Hypothesis H032: there is no statistically significant difference in the severity of patient medication errors based on the actual nursing hours (rejected).

4.4. Summary of Results

This chapter has explored the relationship between the impact nurse staffing factors have on patients with specific outcomes (falls and medication errors) at the shift, ward, and hospital levels. Multinomial logistic regression modelling techniques have been used to identify these factors. The following summarises the results that have been reported in this chapter.

- There were 7,558 incidents reported in three hospitals in the metropolitan area of Perth, Western Australia, during the study period (2011–2012), comprising 55% falls and 45% medication errors. The number of reported falls increased over the study period, whilst the number of medication error incidents decreased over the same period.
- Most incidents were reported on *Mondays*, however, there was no significant difference between the weekday and the incidents over the study period.
- There was a significant annual pattern to of incidents reports, with cases peaking in *July* (winter), and at their lowest point in *December* (summer).
- A significant difference existed between the occurrence of reported incidents and the hour of the day, with the occurrence of incidents peaking during the late morning and overlap period (13:00 pm to 15:30 pm).
- There was a significant difference in representation of gender, where males fell less than females.
- There is a higher likelihood of a patient over 65 years having a fall or medication error.

- The most frequent contributing factor impacting on patients with falls was *communication problems*, whilst *failure to follow policy or procedure* was the most common contributing factor impacting on patients with medication errors. However, *inadequate knowledge and/or inexperienced staff* were among the top leading factors in both incidents.
- *Omission to give medication* was the most common medication error and *fall on the same level* was the most common type of fall.
- *The night shift* was more likely to impact on patients with falls, whereas *morning shift* was more likely to impact on patients with medication errors.
- *Medical wards* were more likely to impact on patients with medication errors and falls than surgical and critical care wards. Ward type was significantly associated with both patient medication errors and falls. In the event of a fall or medication error, it is less likely that a patient will have one of these incidents if the patient was attended by RNs or experienced nursing staff.
- In the event of a fall, it is more likely that there is a greater *severity of falls* if there are *elderly patients*
- Statistically significant associations were found between *medical wards* and the impact this had on the patient regarding both *severity of falls and severity of medication errors*.
- In the event of a medication error, an increase in the actual nursing hours is likely to be associated with a patient who has a less number of medication errors but in the event of a fall, not likely to be associated with patients who have a less number of fall incidents. However, an increase in the actual nursing hours is likely to be

associated with patients who have less severe falls but not less severe medication errors.

The data clearly indicate that the null hypothesis, that there is no relationship between the incidence of patient medication errors and falls and nurse staffing on a shift by shift and ward by ward level in Western Australian tertiary hospitals, should be rejected. The alternative hypothesis should be accepted as valid, that there is a relationship between the incidence of patient medication errors and falls and nurse staffing on a shift by shift and ward by ward level in Western Australian tertiary hospitals.

CHAPTER V: DISCUSSION AND CONCLUSION

The overall aim of this study was to determine whether a relationship existed between reported incidence and severity of patient falls, medication errors and nursing staff on a shift-by-shift and ward-by-ward basis in Western Australian tertiary hospitals. This study was undertaken using data linkage methods for data extracted from three hospitals in Perth, Western Australia, over the two-year period from January 2011 to December 2012.

The Nurse Staffing and Patient Outcomes Model (Kane et al., 2007) was used as the conceptual framework for the current study to explain the relationship between nurse staffing and outcomes of care. This model states that several factors leading to better or worse patients' outcomes included nurses' characteristics, patient factors, hospital factors, and organisation factors.

Overall, this study has addressed shortfalls noted in the current literature regarding the relationship between patient falls, medication errors, and staffing at a shift by shift and ward by ward level. The research questions addressed in this research have immediate clinical relevance to nearly all stakeholders in the healthcare enterprise: nurses, doctors, patients, hospital administrators, government agencies, and medical insurance providers.

The two adverse outcomes addressed in this study, falls and medication errors, not only have significant clinical importance but are also of importance in economic terms as incidents afford a financial burden, given their potential to result in lengthening hospital stays or subsequent deleterious effects. These subsequent untoward effects add to an already increasing strain on financial resources of health care systems around the world and create an obstruction to the delivery of effective and efficient health care.

As the data was geared for analysis at multiple levels, results from this research can be utilised to explore patient outcomes; not only at the hospital level but also at the ward and shift level. This chapter is organised as following; first, the results are summarised and discussed. Second, the strengths and limitations of the study are identified. Finally, the implications for clinical practice and recommendations for future research are presented.

5.1. The relationship between patient characteristics and falls

Relationships were identified between patients' age and gender and the reported occurrence of falls. Patient gender was significantly different, with 56% of reported fall cases being male, however, according to the model results, in the event of a fall there was more likelihood of the faller being female. Male patients were dominant across all age groups except the very old (85+ years) patients because women have longer life expectancy than men on average. This trend can be explained simply by the greater longevity of females in Australia as reflected in the literature (Centres for Disease Control, 2013). Life expectancy for Australasian women in 2013 was 84.3 years compared to men was 80.1 years according to Australian Bureau of Statistics (ABS) 2014 and AIHW 2013, so more female incidents are expected after the age of 85 years.

According to the WHO Global Report on Falls Prevention in Older Age (2016), both males and females are at risk of falls. It has also been noted that males are more likely to have more severe falls and die from a fall, while females suffer more non-fatal falls (WHO, 2016). The current study also showed there was more likelihood of fallers being female, although there was not any significant difference in severity of falls based on gender.

Studies have also shown that most falls were sustained in patients aged 65 years or more, which is consistent with research confirming a greater incidence of falls as patient age increases (Clyburn & Heydemann, 2011; Rubenstein & Josephson, 2002). In this study, the highest rate of falls incidents occurred in the 80+ year age group. Specifically, the results of the current study were consistent with previous research which found that worldwide falls incidents occurred mostly in the 80+ year age group. However, a statistically significant association was also found where in the event of a fall, there was an increased likelihood that patients over 65 years would have more severe injuries after falling. These injuries varied from moderate harm to severe injuries or death. This study found no gender influence on the patients' severity of falls and modelling did not show a gender bias.

5.2. Fall incidents by time of day

Most falls were reported during the night shift although a considerable number of events were also reported during the morning shift. More than a third (34.3%) of fall incidents were reported between the hours of 21:00 pm and 06:59 am which represent the 10 hours' night shift in Australian hospitals. These results are not surprising and there are several possible explanations for these findings, such as a lesser number of nursing staff working on night duty as well as the fact that the night period leads many patients to confusion and agitation (Abreu, Mendes, Monteiro, & Santos, 2012). Decreased cognition and limited mobility are other known risk factors, which can be exacerbated at night time, increasing the risk of falling in the elderly population (Muir, Gopaul, & Montero Odasso, 2012). Also decreased visual acuity is a known risk factor for falls in the elderly (Lord, 2006). This is exacerbated at night time due to a low level of lighting used in hospitals to assist patients in sleeping. Poor lighting at night time in a patients' room can easily be seen to result in a fall.

This study also found that 26.3% of falls occur during the six hours morning shift (07:00 am- 12: 59). There are studies that have found that falls are more reported on morning shift because more activities happen during the morning shifts, such as getting up, showering, examinations, and treatments. Also, patients tend to take charge of their normal daily routines, when possible (Evans *et al.*, 1998), and all these have potential to lead to more falls.

The overlap shift is mainly unique for the Australian context, being the last hours of morning staff shifts. A considerable number of fall incidents were also reported during the overlap period, in fact, one fifth of all fall incidents occurred in this two and half hour period. Falls at this time of day can be explained by the clinical situation that exists on the ward at this time. Despite there being more staff rostered on, there is actually less staff available for patient care due to staff meal breaks, professional development and training, and other non-clinical administrative duties such as notewriting and handover to evening staff. At the same time lunchtime toileting occurs and with less staff available within this time, falls are more likely. Many other possible explanations exist where the risk of falls was associated with the afternoon nap including patients feeling sleepy, fatigue, tired (Stone, 2006).

When the morning shift and overlap period were merged as one shift, this meant 44.6% of total fall incidents (26.3% in the morning shift and 18.3% in the overlap period) occurred in this period. These results align with other studies such as Abreu, (2012) which found that more fall incidents are reported during the eight and a half-hours morning shift from 07:00 am to 15:30 pm, the applicable standard morning shift for most international hospitals.

5.3. Where are the falls taking place?

This study found that there was a significant difference in the occurrence of falls and ward type. Medical wards tend to have the highest records of falls within hospitals while surgical and critical care wards tend to have lower records of falls than medical wards. These findings are consistent with other research studies findings (Dunton *et al.*, 2004, Dunton *et al.*, 2007, Lake *et al.*, 2010) who also found that most falls occurred in the medical ward, then surgical and critical care wards respectively. This finding is not surprising as critically ill patients in critical care wards tend to be less ambulatory, bedridden and/or sedated. They may have medical conditions and invasive lines which would limit the incidence of an untoward fall in a hospital setting.

The lower occurrence of falls in surgical compared with medical wards is likely due to the surgical patients' length of stay being shorter on average, and usually, the acute cases admissions are likely to be admitted to surgical wards. In addition, medical ward patients are older than any other wards, with patients 65 years old or older in medical wards almost double those admitted in surgical wards. A higher incidence of falls in the elderly people is known as "geriatric syndrome" (Moreira, 2007).

Another factor that may reflect the incidence of falls in the various hospital wards may be the degree of nursing education and who looks after the patient, RN or not. More educated staffing means better understanding of fall prevention, meaning less falls. The main proportion of staffing in critical care wards are RNs to meet the needs of the patient and any activities that involve direct contact with the patient must always be performed in the immediate presence of a RN based on the College of Intensive Care Medicine of Australia and New Zealand (2013) minimum standards for intensive care units. In addition, the nurse to patient ratio in a critical care ward is likely to be higher than the ratio in a medical ward (Dunton et al., 2004). ICU patients require a standard nurse/patient ratio of at least 1:1 according to the Australian College of Critical Care Nurses Ltd. (ACCCN, 2013).

As discussed in Kane's model, hospital factors can lead to better patient outcomes including mortality, adverse drug events, patient satisfaction, better quality of care, and shorter LOS. Hospital size was also one of these factors but it is assumed that in addition to size, hospitals will have variations in their reporting systems and the corporate environment in which staff are encouraged to report incidents. Also, staffing structures, training, and resources may vary from hospital to hospital. Given these variations may exist, and despite this study being unable to measure these factors due to data limitations, it still found that there was no significant trend in fall incidents by the hospital. Modelling also found that there was no statistically significant difference between hospital factors and either patient incidence or severity of patient falls.

5.4. Impact of RN attendance on patient having falls

In this study, both attendance of RNs on a shift and the level of nursing experience impacted on patients having fall incidents, compared to medication errors.

This study found that nursing staff level of education has a significant effect on the patients who fell and the severity of their falls. The results were consistent with previous research (Dunton et al., 2007; Patrician et al., 2011; Staggs et al., 2012). In addition, the results demonstrated a significant association between nursing staff years of experience and patients who had falls. More fall incidents were reported in the wards that had staff with the least number of years of experience. The findings from the current study are consistent with the study by Struksnes (2011) that examined nursing staff's opinion of falls and found that RNs used interventions to a significantly higher degree to prevent falls than ENs. It was also found staff with more than 5 years of experience used the fall prevention strategies significantly more often than colleagues with less experience (Struksnes, 2011).

5.5. The relationship between patient characteristics and medication errors

This study showed a significant association with age, but not gender with patients who had medication errors. The data analysis demonstrated that in the event of a medication error, it was more likely that the patient was 65 years or older.

Assessment of this suggests that older patients are likely to have additional comorbidities and advanced disease states than younger patients for example; osteoporosis, poor vision, hypo or hypertension, diabetes mellitus, osteoarthritis, mobility impairment, and other underlying risks (Boyd et al., 2005). Thus, the patients are likely to have been prescribed multiple medications leading to more medication errors. The increase in medication number and types would most likely lead to potential sources of medication error regarding both type and dosage, and omission. This study found that the most common medication group reported as an error was the anticoagulants family, for example, warfarin and heparin. These are usually prescribed by doctors as treatment or preventative intervention for elderly patients suffering from strokes or heart diseases, especially atrial fibrillation (AF). Sellers and Newby (2011) found a direct relationship between the anticoagulant medication usage among elderly patients older than 65 years and the consequences of fall, mainly post fall bleeding complications. These patients should be observed closely because they are high fall risk patients.

The second most common medication involved in the incidents was oxycodone which is used to treat moderate to severe pain among hospitalised patients. This medication has documented side effects such as dizziness or severe drowsiness which can cause falls or other accidents and the fact that it is the second most common drug in medication errors causes concern. Further study is needed to investigate the correlation between the type of medications and fall risk, for example, painkillers, antihypertensive, and the antipsychotic drugs.

5.6. Medication errors by time of day

There were three major peaks in the number of medication errors throughout the day that appeared to coincide with the times of the medication rounds. Nearly a third of reported medication errors (31%) occurred between 07:00 am and 12: 59. This research found that there was a significant association with shift time and patients who had medication errors. As noted in section 4.4.2, the likelihood of the night shift impacting on patients with medication errors was greater than the morning shift.

Of interest, the likelihood of the overlap period impacting on patients with medication errors was also greater compared to the night shift. Significantly, 26.3% of medication errors were reported during the overlap period (13:00 pm and 15:29 pm) and that period had the highest number of reported medication errors per hour (see Figure 24). There are several possible explanations for these findings; first, it is the morning staff lunch break time, meaning less staff on the floor. Second, a lot of hospital training and education seminars are scheduled at this time of the day to target as many morning and afternoon staff as possible. Often these trainings are mandatory because all hospitals are under pressure to meet the health agencies accreditation standards. Furthermore, it is after the lunch medication round, so further medication errors would also be expected. Add to this many surgeries are being finalised and the patients are ready to be admitted to the wards, whilst at the same time, hospitals are discharging patients before midday to accommodate these admissions. Finally, when the afternoon staff begin work they usually have handover and ward rounds where more errors may be discovered at this time. More attention may need to be taken by hospital management to assess and improve the delivery of care during this peak time to reduce the rate of adverse events.

Possible explanations for this result that may be that the overlap period is when the incidents were detected during the clinical handover checks. Handover is where a nursing staff transfer the responsibility and accountability for patient care from one provider or team of providers to another (Australian Medical Association, 2006). Hence, there is a period present where there is more staff rostered but less staff on the floor. Also, during the overlap period, a transition period between staff members at the hospital ward, there may be a lack of appropriate handover as one of the causes of the medication error and could include missing or erroneous information such as allergies, patient weight, and/or incorrect medication information. In addition, one may surmise that there may not be appropriate procedures in place during the morning shift or the overlap period to prevent medication errors during these time periods.

In response to these problems, the Australian Commission on Safety and Quality in Health Care in 2010 addressed the impact of nursing handover on patients' safety, and created a tool, the "OSSIE Guide to Clinical Handover Improvement". This was created and recommended to be used in Australian hospitals as it is a smart and quick tool which addresses elements that contribute to a better handover. The acronym OSSIE stands for: O = Organisational leadership, S = Simple solution development, S

= Stakeholder engagement, I = Implementation, E = Evaluation and maintenance (ACSQHC2010). Roll up and uptake of this tool across all hospital wards may contribute to a better handover environment that would have potential to reduce errors.

Similarly, another Australasian study of 707 health professional staff also found poor clinical handover was a significant cause of adverse events. The authors argued that the barriers of effective clinical handovers were insufficient training, lack of role modelling, and lack of confidence and misunderstanding of handover processes. Finally, they recommended that senior staff should act as role models, and recommended training and education (Manias, Geddes, Watson, Jones, & Della, 2016).

This research results clearly indicated that more medication errors occur when nurse staffing did not follow the hospital policies and procedures. One of the most important policies to address include how staff are handing over between shifts, and how often the staff are checking the documentation such as medication orders which are likely to be the possible source of medication error to occur.

5.7. Where are the medication errors taking place?

This research also found that there was a significant association between ward type and patients who had medications errors. Most medication errors occurred in the medical and surgical wards with the least number reported in the critical care wards. Several interpretations can be made here, for in their role, critical care nurses must be proficient in a wide variety of high-level nursing skills and specialised nursing knowledge, especially drug calculation and problem-solving skills. Add to that a higher nurse to patient ratio, the likelihood of medication errors was lower for patients than those whose nurses had more patients to look after in medical-surgical wards. In critical care wards, often one nurse is responsible for all aspects of patient care versus team nursing care found in most medical-surgical wards. Additionally, in critical care wards, the nurse-patient ratio is much higher, in some hospitals 1:1. Additionally, the medical and surgical wards tend to be where junior staff members are placed. These considerations may influence the medication administration processes.

Unlike fall incidents, there was a statistically significant difference in the number of medication errors based on the size of the hospital ($\chi 2=7.7$, df (2), $p=0.02$). However, the data demonstrated that the smallest hospital in size (hospital A) had almost the same percentage of medication error incidents as the largest one (hospital C). Several interpretations can be made: hospitals are varied in teaching and training processes, one of the hospitals was recognised as a Magnet hospital for the quality of nursing care provided, which means a different and accredited system for better patient outcomes. Finally, it may simply be because some hospitals were reporting more than others.

5.8. Impact of RN attendance on patient having medication errors

This study showed that there is a significant association between nursing staff registration status and severity of medication errors. When medications are administered by RNs, there is less likelihood that patients will have a medication error.

RNs are reporting medication errors more than any other healthcare professionals (Aronson, 2009; Zakharov et al., 2012) because they mainly administer the medications in the hospitals. A lot of research has been conducted exploring the effect of RNs and level of education on the occurrence of medication error incidents. The general conclusion from recent studies is that medications administered by RNs lead to fewer numbers of medication errors and less harm after administration (Cleary-Holdforth, 2013; Sears, 2016).

Results were similar to the study by McGillis Hall, Doran and Pink (2004) in that the researchers found a higher RN staffing mix was significantly associated with lower rates of medication administration errors. The results are consistent with prior research in identifying significant relationships between RNs attendance and less medication error incidents.

In Blegan's (1998) landmark study "the optimal RNs rate" was 85% of total staffing, however, the percentage of RNs in this current study was 80.3%. So, it is surmised that if the percentage of RNs were increased, this is likely to lead to a decrease in medication errors.

5.9. Impact of actual nursing hours on both patients' outcomes

This study indicates that actual nursing hours is an important factor in reducing patient fall and medication error incidents in hospitals.

Fall Incidents

Historically researchers have used more general variables such as total nursing hours per patient day to explore fall incidents. Those studies demonstrated a significant association between reductions of inpatient falls and total nursing hours per patient day (Sovie & Jawad, 2001; Whitman *et al.,* 2002; Dunton *et al.*, 2004; Dunton et al., 2007; Patrician *et al.*, 2011), RN skill mix (Blegen & Vaughn,1998; Dunton et al., 2004; Dunton *et al.*, 2007; Patrician et al., 2011), and RN hours per patient day (Sovie & Jawad, 2001; Lake et al., 2010). However, none of them also studied the effect of nurse staffing on the severity of fall incidents. An Australian study by Johnson (2011) found e-learning falls education program can change nurses' knowledge, behaviour and hence falls incidents and severity. This implies fall prevention programs should be provided to all levels of clinical staff, in particular to RNs, which will raise nurses' awareness of falls and the expensive consequences of the incidents. One of the most common training programmes in Western Australian tertiary hospitals is the "Stay On Your Feet" fall prevention program. As there are fewer fall incidents reported every year, that means more education and training is a worthy strategy and it should be compulsory.

This study also found that in the event of a fall, an increase in in the actual nursing hours led to patients having less severe post-fall injuries (levels 5 and 6). This formula appears simple, where more time provided for nurses to care for patients means less feelings of being under time pressure. This may result in raised concentration levels during procedures and more importantly, more time for communication between nursing staff and their patients. As the nurses will have a better understanding of their patients' needs, this will likely lead to fewer incidents and better quality of care and patient outcomes.

Medication Error Incidents

This study also found that in the event of a medication error, an increase in the actual nursing hours can lead to the patient having fewer medication errors. This may be related to the staff having more time for checking and not feeling under pressure to finish their medication round. However, it is noted that although modelling found actual nursing hours were not a significant predictor of medication errors severity in this study, due to non-significant confidence intervals, it is still considered worthy of discussion here in view of the fact that this may still be clinically significant.

5.10. Length of Experience

Who are making the errors, experienced or novice nurses? A current review of the literature found little research addressing length of experience as an independent variable for falls and medication error incidents, although staff age was frequently represented in descriptive data.

An earlier landmark study by Walter (1992) on the occurrence and reporting of medication errors, found that RNs over the age of 35 years reported making fewer errors than those under age 35, though this result was not statistically significant. In addition, the researcher found fewer medication errors were reported by nurses who had either been in nursing over one year or employed in the same hospital for more than one year. To fill this gap in the body of nursing knowledge, the length of experience was one of the key variables for falls and medication errors used in this current study.

The results of the current study found nurses' years of experience had a significant relationship with patients' outcomes, where more experienced nursing staff meant better patient outcomes. A statistically significant association was found between the number of years of experience impacting on patients who had either falls or medication errors, so more experienced staff led to patients who had fewer falls and medication errors. Furthermore, an association was detected between the severity of the incidents and number of years of experience where in the event of an incident, if there were more novice nursing staff on the shift there was more likelihood the patient would have a more severe incident. This is consistent with previous research by Chang and Mark (2009) who investigated differences in staff experiences and severe or nonsevere medication errors. Their study found that 12 % of fall and 11% of medication errors also occurred due to inadequate knowledge or inexperienced staff.

5.11. Actual Incidents Time Vs. Reporting Time

The WA clinical incident management policy encourage a 'no blame' reporting culture (DOH, 2015), however, the majority of incidents are still underreported (Varallo, Guimaraes Sde, Abjaude, & Mastroianni Pde, 2014) so what we see is the tip of the iceberg. The decision regarding whether or not an incident has occurred and whether or not to complete an incident report is made based on nursing judgment. This varies among nurses because of differences in the area of nursing practice and experience. Reasons for underreporting included that many nurses are hesitant to complete an incident report especially if little or no patient harm resulted from the incident (Waters, Hall, Brown, Espezel, & Palmer, 2012), or if the reporting process is difficult, too time-consuming, or if they fear reprisal in an organisation that is not supportive of error. The likelihood of reporting a serious error was higher in nurses who had reported a serious error in the past (Wagner, Harkness, Hebert, & Gallagher, 2012).

As reported earlier, extensive analyses of free text fields were undertaken to ascertain whether the event was witnessed or not. It is accepted that this approach was blunt and not capable of accurately identifying every witnessed event due to the diversity of language and text used in the description text fields of the dataset, but results did show that 27.2 % of total incidents were witnessed. Manual checking of sample reports suggests that the percentage of witnessed events may have been underreported by this technique. However, this still means the majority of falls and medication error incidents were unwitnessed by nursing staff, and that the majority of the incident reports reflected the report time, rather than the actual incident time.

It is not entirely clear what effect this has on the interpretation of these results and may have differing implications for both incidents and severity.

Fall Incidents

It is expected that the time difference between the actual fall and the reporting of the fall would not be too long. This is because according to standard hospital policy, patient checks should be regularly conducted and for many areas of the hospital, this should be every 15 minutes, although this may vary according to patient acuity. Therefore, we can assume with a high degree of confidence that unwitnessed falls did still occur within a reasonably close time frame to the time of reporting. Given that some falls will have occurred right at the change of shift time and may have actually occurred in the previous shift, it can be assumed that the majority of falls were likely to have occurred in the same shift as reported. This implies a higher degree of reliability of the data for the analysis of shift by shift outcomes.

This has a clinical importance as the earlier detection of a fall leads to better outcomes, for it is known that the longer a patient is down, the greater the likelihood of more severe harm, complications and consequences.

Medication Error Incidents

Medication errors are harder to detect unless self-reported and are likely to be detected and reported at the next medication administration round. This on average is likely to be between two to four hours but could be longer depending on the frequency of medication administration times. In view of this, harm may occur before the error has been detected and also may be harder to detect if there are no obvious and immediate adverse reactions noticed.

This implies that prevention becomes paramount in any strategy to reduce medication errors. Like falls, various procedures, policies and technologies may help prevent incidents, but for medication errors prevention may require a more challenging approach than to falls. This is likely to require a holistic approach to changing practice that encourages increased patient safety. This may involve increased awareness of, firstly, the potential for error before the time of administration and, secondly, increased education, better technologies to support safe administration, double-checking of drugs by staff, more rigorous medication competencies and superior vigilance by staff for adverse effects should they occur.

This is an area where tangible improvements of outcomes are likely to be effected simply by small and incremental changes in policy, procedures and practice. This area is very worthy of further research.

5.12. Research Implications

This study was undertaken to better understand the impact of nursing staff as they relate to the patient outcomes of falls and medication errors. Results of this study have important implications for individual staff nurses, nurse administrators, as well as hospital administration and hospital systems in terms of medication error reduction and patient safety. The findings of this study may translate into evidence to implement changes and policies at the organisational level to measure and improve nursing performance, delivery, and/or practice. This unique longitudinal, shift-level analysis contributes to the growing understanding of the dynamic nature of nurse staffing and workload at the micro level. It supports the growing literature on the variation in nursing staffing and the influence on patient outcomes. As the policy-makers struggle to identify optimum staffing levels, understanding day-to-day, shift-to-shift, and ward-to-ward variation is an important piece of the puzzle.

5.12.1. Implications for Practice

The implications for practice are substantial. While the study is not conclusive in describing and identifying the practical impact on patients' outcomes based on the level of education and years of experience of nursing staff, it has shown that an increase in the level of education has a decreasing effect on the occurrence of both falls and medication errors. Based on this, hospitals should consider experienced and higher educated nurses in the recruitment process.

Fall Incidents

The occurrence of fall incidents was not associated with actual nursing hours; however, the severity of falls was significant. In the event of a fall, the likelihood of each increase in actual nursing hour impacted on patients who fell with minor harm (level 4, decreased by 51%), falls with moderate harm (level5, decreased by 76%) and falls with major treatment (level 6, decreased by 87%). Less actual nursing hours could have potentially serious consequences for patient outcomes, where more serious injuries after falls are expected to occur.

Worthy of immediate consideration is the number of incidents that occurred during the overlap period. It is necessary to address this quickly and take measures to improve communication and teamwork during the overlap period to minimise the number of fall incidents during this transition period in the hospital setting. This could be as simple as more frequent checking of patients or the implementation of tools such as sighting charts. The hospital physical environment should be reviewed to reduce the risk of fall injury especially during the night shift.

The main contributing factors to falls were communication problems and poor teamwork. Improving teamwork can transform care and impact the occurrence of preventable adverse outcomes such as falls (Rahn, 2016). This area needs further scrutiny to find better ways of team collaboration such as defining the roles and responsibilities; respect, trust, education and liability (McInnes, 2015). In the light of the large proportion of falls that occurred in the overlap period, strategies will be required to make most efficient use of staff and resources to reduce the risk of falls. Rescheduling of professional development and other training activities away from this period may be required. Also, improving nursing teamwork, collaboration and communication with both staff and patients may be useful. There are many techniques, tools and technologies that can assist with this transition, including computer-based training such as virtual simulation (Kalisch, 2015).

Medication Error Incidents

In the event of a medication error, it was less likely for each increase in actual nursing hour that patients would have medication error incidents, a decrease by 78%. However, for severity, only potential medication errors (level 2) were significant with the likelihood decreased by 44% for each increase in actual nursing hour. Less actual hours could have potentially serious consequences where more medication errors would be expected to occur. As most medication errors occur in the morning shift, it is important to improve processes that decrease the number of medication errors reported during this period. Findings from the current study suggest that any extra hour added to the actual nursing care hours decreased incidents dramatically.

Measures such as improved communication channels among the nursing staff, pharmacy, and physicians need to be implemented to decrease the medication errors noted in the overlap period. Other items to consider implementing are process improvements to ensure appropriate medication and doses are delivered in a safe manner, seeing as the majority of reported errors were either missed doses (omission) or overdoses. More practical interventions are recommended to address these two errors and to improve medication safety, for example, increasing nurse staffing levels, RN independent double-checks and introducing new technological systems including bar-coded medication administration and other medication safety technologies. Special attention is needed if the patients' medication profile contains either anticoagulants or oxycodone as this study highlighted these medications were the top two groups involved in clinical incidents.

As the main contributing factor to medication errors was failure to follow correct procedures and policies, this area needs further scrutiny to find opportunities to enable nursing staff to access, understand these policies and change practice accordingly. If evaluation of these policies show them to be inappropriate or irrelevant, then measures should be taken for review, implementation and evaluation of better best practice policies and procedures.

5.12.2. Implications for Nurse Managers, Leaders, and Nurse Executives

The implications of these results for management and leadership are quite important. Management and leadership roles need to assess the risk of untoward outcomes between nursing staff and falls and medication errors on a ward by ward and shift by shift basis.

Fall Incidents

To decrease the risks, nursing management teams need to be aware of the impact of nursing staff on untoward events like patient falls. Findings from this study suggest that the leaders should consider more attention to the communication between staff as this is the major contributing factor leading to more incidents, especially between the team during the shift. As reported, a quarter of all falls occurred due to poor communication.

More attention is also needed for older patients especially 65 years or older, and it should start from the admission of these patients who have a higher risk of adverse events than younger patients. This age group needs more close monitoring and simple implementation of tools like patient sighting charts may help.

Management needs to review the procedures and policies in place regarding falls happening on the night time shift. This may involve reviewing the environmental factors leading to those fall during the night such as lighting and other factors such as less staffing on the night shift, and the length of night shift causing nurse fatigue.

Strategies such as structured communication techniques can create a better teamwork environment (O'Daniel, 2008). Failure to follow the hospital policy or the procedure was one of the leading causes of incidents, but why? According to the Australian Commission on Safety and Quality in Health Care 2013, nurses fail to follow policy because they get caught up in other things that happen behind the scenes. These may include complex situations on the ward with competing priorities, and skill mix issues because of sick leave and other factors. It is suggested that as soon as there is an overreaction or pre-judgement, the staff will tend to hide facts and not be honest about what happened (ACSQHC, 2013).

The nursing management teams should be encouraged to find new ways to make their staff more aware of the hospital policies, for example, managers should ensure staff read the fall prevention policy as a part of each incident follow up.

Medication Error Incidents

Nursing leaders can use the information revealed from this study to address the significant frequency of medication errors noted in this study in the overlap period. Procedures that currently are in place clearly need a review to help decrease the number of events occurring over this time. Medication administration policy may be driven by evidenced-based practice, allowing for policy improvement within an acute care facility to decrease the frequency of medication errors noted in the morning shift.

In this study, no data were available for some nurse characteristics based on Kane's model such as nurse age, use of contract nurses and internationally educated nurses, also nurse outcomes included nurse job satisfaction, retention rate, and burnout rate. As this was outside the scope of this study, the effect of these characteristics on medication errors was not explored, however, it is noted that these factors remain worthy of further research.

Management needs to review the staffing numbers, levels of experience, and education in the medical wards as the majority of both incidents occurred in medical wards. This implies that more RNs and more professional development and training for nursing staff who work in medical wards are required, especially on the night shift.

An increase in actual nursing hours was associated with patients having less severe medication error incidents. Nurse managers should consider these results when assigning nurses to patients' care. Nurse managers should aim to maintain an optimal balance between attendance of RNs and attendance non-RNs. Replacing RNs with other nursing staff such as unregistered staff may be an ineffective strategy and although it may be cost-effective in the short term it could in the end prove not cost effective if it ends up compromising patient safety.

However, it is accepted that modern hospital systems work with tight budgetary pressures and it is suggested that a more flexible, streamlined and needs-based approach to allocations of existing nurse resources may be a solution. This is likely to challenge existing rostering and management frameworks, but it behoves managers to seek alternate models to achieve best patient outcomes.

5.12.3. Implications for Education

Several important implications for education have emerged. Despite the diversity of educational programs preparing nurses and a logical connection between education and clinical judgment, it is known that nurses' education level had an obvious impact on patient outcomes (Cleary, 2013; Hickam, 2003; Kutney & Aikin 2008; Sears, 2016).

Fall Incidents

Falls are less likely to occur in the attendance of RNs. In the event of a fall, there is a reduced likelihood of 21% when a patient is in the attendance of higher educated staff (RNs). This study suggests education regarding falls prevention needs to be included in the early stages of any nursing studies and need to be a crucial part of any orientation program. Knowledge of the risks on a shift by shift and ward by ward basis needs to be acknowledged by nursing leaders to improve procedures and policies and to minimise untoward events.

Attention should be paid to the initial education, initial orientation, and fall prevention programs that are currently in place. Improvement in safety awareness, transfer and ambulation techniques, and education for the staff members regarding other currently identified risk factors for falling, may help to reduce the number of falls that occur in the wards. Also, teaching nursing staff how to use fall prevention devices such as sensor mats and laser detectors will lead to closer monitoring and earlier fall detection.

Medication Error Incidents

Patients are less likely to have a medication error incident if the medications are administered by RNs. An orientation program for newly employed registered nurses at any teaching hospital should aim to examine the ability of nurses to identify medication errors as well as applying strategies to prevent medication incidents. Simulated medication administration scenarios are recommended (Sears, Goldsworthy, & Goodman, 2010).

For other staff, medication administration competency is recommended to be renewed yearly across the hospitals, to make sure that nurses are competent and their medication administration knowledge is up-to-date, and to decrease the number medication errors. It is also recommended that if the staff have made multiple medication errors, they are compelled to redo the competency again regardless of when it had been done.

5.13. Recommendations for Future Research

While this study addressed some weaknesses and gaps in the current published literature, several areas of further fruitful research remain. Based on the finding of the current study, the following recommendations are suggested for further research.

Although the nursing demographical data provided by Department of Health WA elicited the registration status and years of experience of nursing staff only, further research is required to determine the impact of other nursing demographics such as contract type (full time, part time, casual, agency), and education degree (Diploma, BSc, Masters, PhD.), on the patients' outcomes. Characteristics such as pre-registration qualification should also be considered, and further research could look at the impact of other nurses' characteristics such as age, first language, immigration status, and salary on the patients' outcomes.

Although this study only showed an association with falls and medication errors, but not at a significant level, the impact of actual nursing hours on other nurses' sensitive outcomes still needs further investigation, for example, length of stay and mortality rate. In future research, it will be important to use more patient characteristics such as patients' medical diagnosis, background and race as this information wasn't available for this study. This information may help determine with more precision which patients are at risk, which will lead to less severe outcomes.

This study was conducted in one metropolitan centre of WA so the relationships between nurse staffing and patient outcomes in different states or countries remain unknown, although it is expected these results could be generalizable. This study suggests replication with a larger national and international sample would be worthy to investigate the relationships between nurse staffing and patient outcomes across differing and diverse health care system.

Although only three hospitals were investigated in this study, hospital ID was able to be used as a control variable, but other hospital characteristics such as hospital Magnet and teaching status were not examined. Exploring additional hospital characteristics could be fruitful in informing the evidence of the effect nursing staff has on patient outcomes. Future observational studies should be directed toward the relationship between staff communication, team working and patient outcomes. Future study will include other factors that have not been covered in this study from Kane's model due to data availability, such as job satisfaction, retention rate, and burnout rate.

5.14. Strengths and Limitations

This study is unique and important as it contributes to the body of knowledge on shift and ward-level research. This study's strengths include retrospective data collection allowing longitudinal evaluation of the relationship between staffing, and patients' outcomes. To date, most empirical studies have been at the hospital level. This study is important as its data was captured and analysed at the shift level whilst being controlled for at ward and hospital level.

The following limitations have been identified in this study. Firstly, it is acknowledged that there is the probability of inaccurate or missing data because not all medication errors and falls are either recognised or reported. It is likely there has been under-reporting of these issues among nursing staff (Allan & Barker, 1990; Blegen et al. 2001; Gladstone 1995; Kapborg & Svennson 1999; Osborne et al. 1999; Wakefield et al. 1996, 2001). As noted earlier, it was more likely that falls or medication errors were reported by RN staff rather than non-RN staff members. Because the attendance of RNs was higher than non-RNs in this study, there will be less reporting by non-RNs and as such, there may have been a bias in the reporting of falls or medication errors in this study, but the extent of this bias remains unknown.

Additionally, the whole study took place in one Australian state (Western Australia). Therefore, the results of this study may not generalise to the other states and territories in Australia or internationally with a different structure of staffing.

Also as this study relied on secondary data; the researcher was limited to the type and number of variables available, measurements, type of data collection and other aspects which influenced the design. Due to the nature of this study, the data collection occurred at more than one institution, so that variation in data collection is not only likely but also inherent. Considering that the data are longitudinal in nature, it is possible that some data may be missing or incorrectly reported and that there were different reporting structures and coding interpretation used by the data entry personnel. However, a great many procedures were established in ensuring that the final data was clean, reliable and valid.

Finally, neither hospitals bed occupancy, admissions nor midnight census data were available during the data collection period. As a result, the researcher was unable to calculate ratios or proportions of patients who had incidences compared to total number of patients. Further, as there were no contrast data such as non-falls or non-medication errors, all modelling was performed comparing falls against medication errors and vice versa. Therefore, the comments in this thesis refer to the likelihood of an independent variable contributing to an event and not the likelihood of that event. In the event of that the odds ratios reported are significant, it is inferred that that these assertions are meaningful within the context of the analysis.

The major strength of studying existing administration data is the ability to obtain a large sample which improves the study power. This is particularly helpful in staffing and outcomes research, which requires a large number of variables and large sample sizes for proper analysis, and using existing data is a widely-used approach for nurse staffing studies (Blegen et al., 1998; Blegen & Vaughn, 1998; Dunton et al., 2004; Kovner & Gergen, 1998; Kovner et al., 2002; Lichtig et al., 1999; Needleman et al., 2002; Twigg et al., 2011; Twigg et al., 2009; Unruh, 2003; Whitman et al., 2002).

There may have been local different environmental factors in each of the three hospitals that led to a difference in the incidence of falls or medication errors. For example, one of the hospitals may have had improved lighting or non-slip floors or bathroom showers which might have led a decreased incidence of night-time falls compared to the other two hospitals. However, for the purposes of this study, it was assumed that the local environment at a hospital was homogenous to the other hospitals in the data collection and assessment. This assumption may not be completely true and may have led to some bias in the assessment of the data.

Finally, this study was limited to showing association or relationships only among the available and recorded variables in the dataset. Although Kane and other authors also outlined other factors that may affect patient outcomes, this study was unable to control for the influence of unrecorded variables such as job satisfaction, staffing turnover, and supervision (Leggat et al., 2010; Maas et al., 1996). It is believed this that may be a focal point for fruitful further research.

5.15. Conclusion and Summary

In this study, a retrospective, longitudinal, non-experimental design was used employing a secondary analysis of existing databases of three hospitals. Hospital databases were examined to explore the relationship of nurse staffing on selected patient outcomes.

The study included hospital, ward, and nurse staffing variables and used modelling to predict patient outcomes. Nurse staffing variables included number of staff, years of experience, registration status and actual nursing hours. Patient outcomes included patient falls and medication errors and the severity of each.

Higher experienced nursing staff, more attendance of RNs on the shift, and an increase in actual nursing hours was associated with patients with a decrease in number and severity of adverse events.

As the majority of incidents are preventable, this work provides insights to identify gaps in the health care system which can lead to continuous improvement and development in the care and safety of patients in hospital.

In conclusion, this study did find a relationship between the occurrence and the severity of patient fall medication error incidents and nurse staffing on a shift by shift and ward by ward level in WA tertiary hospitals. Nationally and internationally adverse patient outcomes at the shift-level have not been widely researched, and specifically for Australia, research in the overlap period research is almost non-existent.

Nursing management can use the results of this study to develop effective staffing models which optimise the use of staff working on or off peak times, to meet the needs of the patient with the best outcome. This study supports the importance of RN staffing levels in improving patient outcomes. However, it also shows that the relationship between nurse staffing and patient outcomes can be affected by different factors such as patient characteristics, nurse characteristics, and ward type.

Nurse staffing is a key component in any hospital, and understanding the most efficient use of staff to minimize harm and improve the patient safety in hospitals is paramount. Both desirable and adverse patient outcomes are linked to nursing staff characteristics, however, it is a complex area and so it is essential to advance the field of study to replicate, extend, and refine the current body of knowledge. The need for a safe staffing nursing model is critical to ensuring the best outcomes for patients in hospital.

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Appendix A: Advanced Incident Management System (AIMS)

Appendix available on request

Appendix B: Study approval by Edith Cowan University Human Research Ethics Committee

Appendix available on request

Appendix C: Study approval by Sir Charles Gairdner Hospital Human Research Ethics Committee (SCGH-HREC)

Appendix available on request

Appendix D: Study approval by Royal Perth Hospital Human Research Ethics Committee (RP-HREC)

Appendix available on request

Appendix E: Study approval by Fremantle Hospital Human Research Ethics Committee (FH-HREC)

Appendix available on request

Appendix F: Confidentiality declarations

Appendix available on request

Appendix G: Study waiver

Appendix available on request

Appendix H: SPSS Syntax

Appendix available on request