Medication administration safety in medical and surgical units of the Gauteng Province

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"The greatest danger to our future is apathy"

Jane Goodall

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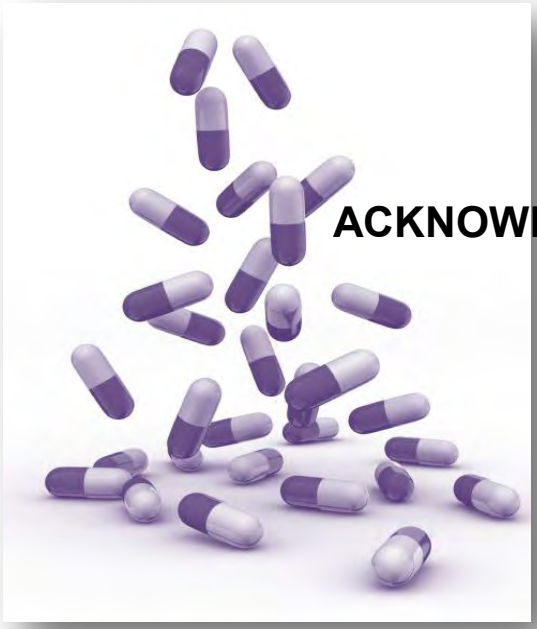

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ABSTRACT

Background: Several international studies have been published on the incidence of medication administration, as well as causes and solutions thereof. However, no similar research has been conducted in Africa, and nothing is known about the context-specific features of this patient-safety threat in South Africa.

Aim: To develop an intervention to improve medication administration safety in public hospitals of the Gauteng Province.

Design: A mixed method design, incorporating descriptive, explanatory, exploratory and contextual strategies was used.

Methods: Phase 1: A systematic review was conducted to determine the causes of medication administration errors. Phase 2: The incidence of medication administration errors was determined by direct observation. Phase 3: Calculation skills of medication administrators were tested. Phase 4: Perceptions of safety culture, medication administration error incidence, an overall grade on medication administration safety, causes of errors, incidence of error reporting and reasons of non-report were explored by means of surveys. Phase 5: Solutions to the problem were explored through semi-structured interviews with subject matter experts.

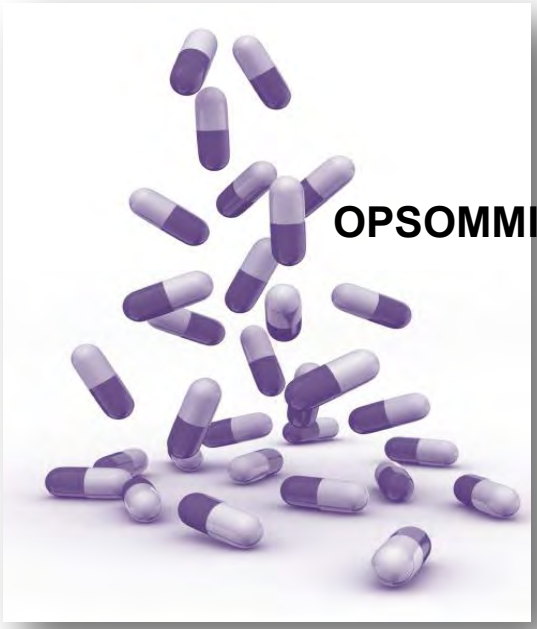
Setting and participants: Phase 1 (Systematic review): 70 international research studies were included. Phase 2 (Direct observation): Eight public hospitals within the Gauteng Province that met all the inclusion criteria were selected randomly. Ten

parenteral and ten enteral medication administrations were observed in one medical and one surgical unit of each of these hospitals (n = 315). Phase 3 (Knowledge testing): Medication administrators from units as sampled in phase 2 were included (n = 25). Phase 4 (Survey): An all-inclusive sample of medication administrators from all medical and surgical units of hospitals as was sampled in phase 2 was included to complete the survey (N = 683, n = 280). The response rate was 41%. Phase 5 (Semi-structured interviews): Fifteen unit managers from units sampled for phase 2 of the research were interviewed.

Results: Phase 1: Communication factors, human factors, environmental factors and medication-related factors were identified as causes of medication administration errors. Phase 2: 296 errors were identified, of which most were wrong-time errors (n = 127, 43%). Phase 3: 32% (n = 16) completed dosage calculations incorrectly. Phase 4: Medication administration safety was perceived as very good. Environmental factors impacted most on patient safety (M = 2.89). The three main causes of medication administration errors were workload (M = 3.39), stock distribution problems (M = 3.18) and illegible prescriptions (M = 3.05). Errors were only reported sometimes, with fear being the main cause of non-report. Phase 5: Adherence to existing protocols, auditing, education and training, collaboration, communication, the use of known products, resource- and time management could offer a way forward. The results of the five phases were converged to create an intervention aimed at improving medication administration safety in South Africa.

Conclusions: Medication administration errors pose a great threat to patient safety in public hospitals in the Gauteng Province. Both similarities with and differences to international literature were noted, which led to the need for an intervention that is developed for this specific setting.

Key words: Medication safety, medication administration error, public hospitals, developing countries, incidence, causes, interventions.



OPSOMMING

Agtergrond: Vele internasionale studies rakende die insidensie van medikasie toedieningsfoute, oorsake en oplossings daarvoor is gepubliseer. Daar is wel nie vergelykbare navorsing in Afrika uitgevoer nie, en die konteks-spesifieke aard van hierdie pasiënt-veiligheid bekommernis in Suid Afrika is onbekend.

Uitkoms: Om 'n intervensie ter verbetering van medikasie toedieningsveiligheids in publieke hospitale van die Gauteng Provinsie te ontwikkel.

Ontwerp: 'n Gemengde-metode ontwerp wat beskrywende, verduidelikende, verkennende en kontekstuele strategieë ingesluit het, was gebruik.

Metodes: Fase 1: 'n Sistematiese oorsig is gedoen om oorsake van medikasie toedieningsfoute te ontbloot. Fase 2: Die insidensie van medikasie toedieningsfoute is deur direkte observasie waargeneem. Fase 3: Rekeningsvaardighede van medikasie toedieners is getoets. Fase 4: Persepsies van veiligheidskultuur, insidensie, gradering van medikasie veiligheid, oorsake van foute, insidensie van foutrapportering en redes waarom medikasie toedieningsfoute nie aangemeld word nie was deur middel van vraelyste ondersoek. Fase 5: Oplossings vir die probleem is ondersoek deur middel van semi-gestruktureerde onderhoude met vakkundiges.

Milieu en deelnemers: Fase 1 (Sistematiese oorsig): 70 internasionale navorsingstudies was ingesluit. Fase 2 (Direkte observasie): Agt publieke hospitale in die Gauteng Provinsie wat aan al die insluitingskriteria voldoen het, is lukraak

gekies. Tien parenterale en tien enterale medikasie-toedienings is in een mediese en een chirurgiese eenheid van elk van hierdie hospitale geobserveer (n = 315). Fase 3 (kennis toetsing): Medikasietoedieners van eenhede soos in fase twee was ingesluit (n = 25). Fase 4 (Vraelyste): Alle medikasietoedieners van alle mediese en chirurgiese eenhede van hospitale soos in fase 2 gekies is ingesluit (N = 683, n = 280). Die terugvoerkoers was 41%. Fase 5 (Semi-gestruktureerde onderhoude): Onderhoude is gevoer met vyftien eenheidsbestuurders van fase 2 eenhede.

Resultate: Fase 1: Kommunikasiefaktore, menslike faktore, omgewingsfaktore en medikasie-verwante faktore is geïdentifiseer as oorsake van medikasie toedieningsfoute. Fase 2: 296 foute is geïdentifiseer, meestal verkeerde tyd foute (n = 127, 43%). Fase 3: 32% (n = 16) van deelnemers het dosisberekeninge inkorrek voltooi. Fase 4: Medikasie toedieningsveiligheid is as baie goed beleef. Omgewingsfaktore het die grootste impak op pasiëntveiligheid gehad (M = 2.89). Die drie hoof-oorsake van medikasie toedieningsfoute was werkslading (M = 3.39), voorraad-verspreidingsprobleme (M = 3.18), en onleesbare voorskrifte (M = 3.05). Foute word net soms aangemeld, met vrees as die hoofrede van non-aanmelding. Fase 5: Nakoming van bestaande protokolle, oudit, onderrig en opleiding, samewerking, kommunikasie, die gebruik van bekende produkte, hulpbron- en tydsbestuur kan 'n weg vorentoe bied. Die resultate van hierdie vyf fases is saamgesmelt om 'n intervensie te ontwikkel ter verbetering van medikasie administrasie veiligheid.

Gevolgtrekkings: Medikasie toediening in die Gauteng Provinsie hou 'n groot bedreiging vir pasiëntveiligheid in. Beide ooreenstemmings en verskille van internasionale literatuur is opgemerk, wat die behoefte aan 'n konteks-spesifieke intervensie onderskryf het.

Sleutelwoorde: Medikasie veiligheid, medikasie toedieningsfout, publieke hospitale, ontwikkelende lande, insidensie, oorsake, intervensies.

LIST OF ACRONYMS

A

AHRQ: Agency of Healthcare Research and Quality

AIDS: Acquired Immune Deficiency Syndrome

ANA: American Nurses‟ Association

AUKUH: Associations of the United Kingdom University Hospitals

C

CALNOC: Collaborative Alliance for Nursing Outcomes

CASP: Critical Appraisal Skills Programme

CFI: Comparative Fit Index

CMIN: Chi-squared test statistic

CQI: Continuous Quality Improvement

D

DF: Degrees of Freedom

DOH: Department of Health

E

ED: Emergency Department

G

GDP: Gross Domestic Product

H

HIV: Human Immunodeficiency Virus

HOD: Head of Department

HREC: Health Research Ethics Committee

I

ICU: Intensive care unit

ISMP: Institute for Safe Medication Practice

IV: Intravenous

J

JBI: Johanna Briggs Institute

M

MAE: Medication Administration Error

N

NFER: National Foundation for Educational Research

NICU: Neonatal Intensive Care Unit

NPO: Nil Per Os (nothing per mouth)

NPSA: National Patient Safety Agency

NWU: North-West University

P

PERC: Postgraduate Educational and Research Committee

PICO: Population Intervention Comparator Outcome

PO: Per Os (per mouth)

PRN: Pro Re Nata (as needed)

R

RMSEA: Root Mean Square Error of Approximation

RN4CAST: Registered Nurse Forecasting

Q

QID: Quarter die Sumendus (four times a day)

S

SA: South Africa

SANC: South African Nursing Council

SARS: South African Revenue Services

SONS: School of Nursing Science

SPSS: Statistical Package for the Social Sciences

STAT: Statim (immediately)

T

TDS: Ter Die Sumendum (three times a day)

U

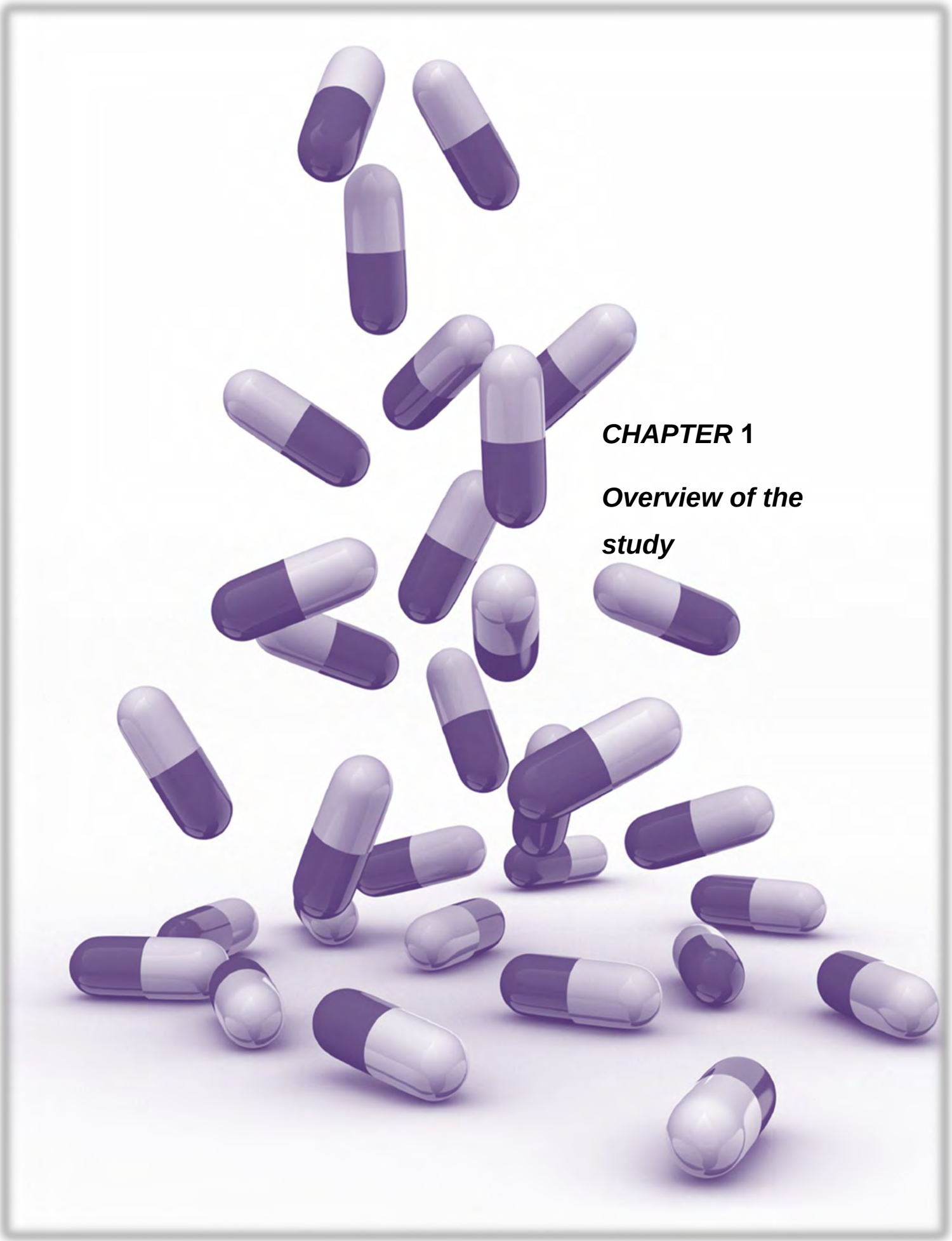
UK: United Kingdom

USP: United States Pharmacopeia

W

WHO: World Health Organization

WTE: Whole time Equivalent



CHAPTER 1

Overview of the study

1.1 INTRODUCTION AND BACKGROUND

Despite all the known power of modern medicine to cure and ameliorate illness, hospitals are not always safe places for healing, but often places fraught with risk of patient harm (Emanuel *et al.*, 2008:1). The WHO sees patient safety as a crucial element of quality of health care and is committed to enhancing this quality (WHO, 2013:1).

Adverse events and near-misses are threats to patient safety. The WHO (2015:9) defines an adverse event as an injury related to medical management (including all aspects of care, including diagnosis and treatment, failure to diagnose or treat, and the systems and equipment). Adverse events may be preventable or non-preventable. Geyer (2013:42) defined an adverse event as being a hurtful or injurious event that could lead to legal claims, while Speroni *et al.* (2013:19) defined a near-miss as a variation in a normal process that, if continued, could have a negative impact on patients. Speroni *et al.* (2013:19) identified medication administration and transcription errors as the most frequent types of near misses. Kim and Bates (2013:590) confirmed that medication administration errors represented one of the major concerns in patient safety.

McLeod *et al.* (2013:278) stated that medication administration errors were five times more likely to occur in intravenous medication administration than in non-intravenous medication administration. Watts and Parsons (2013:1) further mentioned that dosing errors (42% of medication administration errors) were the most predominant. However, Quélennec *et al.* (2013:1) argued that dosing errors were the second most common type of medication administration error at 8.1% and that the most common type of medication administration errors were omissions at 87.9%. Though differing in incidence, Härkänen *et al.* (2013:32) confirmed the most common types of medication administration errors to be wrong dose errors and omissions.

Alarming global statistics demonstrated the dire need of addressing medication administration errors. In the USA, the Institute of Medicine (2006:110) reported an incidence of 11% of medication administration errors occurring in hospitalised patients. Kliger (2010:290) estimated this incidence to relate to 450 000 medication errors annually, leading to costs between $3.5 billion and $29 billion each year for hospitals. In the UK, medication errors accounted for approximately 20% of all

deaths due to adverse events in hospitals (Leufer & Cleary-Holdforth, 2013:216). Furthermore, the National Patient Safety Agency (NPSA, 2010:1) in the UK reported 21383 patient safety incidents related to delay in administering medicines with 68 resulting in severe harm and 27 in death between 2006 and 2009. The Australian Council for Safety and Quality in Healthcare (2002:1) reported 22% of medication errors to have had moderate or significant consequences, whilst a further 37% had minor consequences for patients.

Research on medication administration error and safety has mostly been done in developed countries which revealed an average adverse event rate of about 10% (Bates, 2010:174). However, the Government of Ireland, Houses of the Oireachtas Joint Committee on Health and Children (2007:1) argued that 90% of medication administration errors went unreported, while Kim and Bates (2013:591) agreed that the design of many previous studies was flawed because it depended on individuals reporting on their own mistakes, which they were often unaware of. Furthermore, Bates (2010:174) raised the concern that less data were available from nations with developing economies such as South Africa, though the incidence of medication-administration-error-related harm in these settings tended to be higher.

However, professional nurses in South Africa perceived medication administration errors to be rare, as Blignaut *et al*. (2014:224) stated that professional nurses in South Africa reported medication administration errors to have only occurred a few times a year or less. Although South Africa has no current statistics available regarding the incidence of medication administration errors, 105 of 629 professional nurse misconduct cases between 2003 and 2008 were related to medication administration (South African Nursing Council [SANC], 2013:1).

Inadequate reporting of adverse advents may contribute to the perception of minimum medication administration error incidence. O"Connor *et al.* (2010:371) implied a gap between ideal disclosure practice and reality, thus referring to deliberate under-reporting of incidents. This contributed to the lack of insight into the actual extent of the problem of medication administration error in the South African context.

Freeman *et al.* (2013:176) stated that medication safety and the reduction of medication errors were high priorities not only for hospitals, but also for health-care providers and patients. This was due to the fact that medication errors not only impacted outcomes financially but may have also led to patient dissatisfaction, adverse patient outcomes, and death (Nguyen *et al.*, 2010:224). Glaister (2005:3) agreed that medication administration errors could lead to an increase in morbidity and mortality.

Leufer and Cleary-Holdforth (2013:213) explained that medication administration errors resulted from an interaction between extrinsic (organisation) factors and intrinsic (individual) factors. Extrinsic factors contributing to medication administration errors included interruptions, environmental distractions, prescription and patient-related factors, medication work organization, safety culture, workload issues, staffing levels, patient numbers and profiles, types and length of shifts, look-alike and sound-alike medications and packages, and communication (Aiken *et al.*, 2003:1617; Anderson & Townsend, 2010:23; Cohen, 2013:72; Leufer & Cleary-Holdforth, 2013:213; Metsälä & Vaherkoski, 2013:12; Nguyen *et al*., 2010:224; and Westbrook & Li, 2013:116). Interruptions were the leading extrinsic factor in medication administration errors. Trbovich *et al.* (2010:216) found that nurses were interrupted, on average, 22% of their time and were frequently interrupted while performing safety-critical tasks. Interruptions were caused by nursing colleagues, patients, alarms, family members, external conversations and other staff (Flanders & Clark, 2010:281; Pape *et al.*, 2005:109; and Trbovich *et al.*, 2010:217). Contributing to this problem at the intrinsic level was professional nurses who took pride in their ability to multitask and handle interruptions while administering medications (Jennings *et al*. 2011:1449).

Intrinsic factors contributing to medication administration errors included competence (knowledge or performance), skills mix and educational background (Aiken *et al.*, 2003:1617; Leufer & Cleary-Holdforth, 2013:213; and Metsälä & Vaherkoski, 2013:12). The leading intrinsic factor in medication administration errors was identified by Valdez *et al.* (2013:222) as poor adherence to the “five rights” in medication administration. Uys (2004:256) explained the “five rights” to be the right patient, the right medication, the right dose, the right route and the right time for administration. Failure to comply diligently with the five rights could result from either

a lack of knowledge or a lapse in performance due to many confounding factors (e.g. time constraints, over-confidence, etc.). Other important causes of the failure to comply with the five rights of medication administration were identified by Lingaratnam *et al.* (2013:48) who stated that lack of consumer knowledge about medicines could contribute to the incidence of medication administration errors. Lack of consumer knowledge about a certain medication could lead to confusion and subsequent wrong medication administration, incorrect dosage, wrong route or untimely administration.

Härkänen *et al*. (2013:33) also focused on the extrinsic factor of insufficient staffing needing adjustment if required as a solution for medication administration errors. According to the human resources for health strategy for the health sector from 2012 to 2016 as was compiled by the Department of Health ([DoH], 2011:35), there was no shortage of nurses in South Africa currently when compared to the nurse-patient ratios of countries such as Brazil, Chile, Costa Rica, Thailand and Argentina. The DoH (2011:35) did, however, reiterate that the actual shortage perceived depended on the competence and type of skills the nurses had, as well as the management of health needs in relation to outcomes.

As many causes for medication administration errors exist, many interventions were proposed to mediate the improvement of medication administration safety. These interventions could be either broad or focused on a certain extrinsic or intrinsic cause of medication administration error.

Wu *et al.* (2008:685) explained that recommendations for improvement in any patient safety endeavour should be aimed at the correct level of the health care system, implying a collaborative effort of all stakeholders. On a broader level, Zimlichman and Bates (2012:20) added that there were three key steps important in any national patient safety agenda, viz. using health information technology, dissemination and broad use of checklists and measuring patient safety over time at a national level. As medication administration errors pose a grave threat to patient safety, these key steps should not be neglected.

An added effort in decreasing medication administration errors was said to be the limitation of interruptions (Freeman *et al.,* 2013:178). In order to ensure fewer interruptions, several studies indicated the effectiveness of a vest, apron, sash,

button, or other clothing item to indicate that the nurse was administering medications and should not be interrupted (Anthony *et al.*, 2010:21; Flanders *et al.* 2010:184; Pape, 2003:77; and Relihan *et al.*, 2010:2).

Leufer and Cleary-Holdforth (2013:216) suggested that educational initiatives could address both extrinsic and intrinsic factors leading to medication administration errors. Härkänen *et al.* (2013:33) agreed that better training and proper induction of new personnel could pave the way of increased medication administration safety. Kim and Bates (2013:593) explained that educational strategies would be enhanced if tracking of performance was possible. Greater attention in the education of medication administration was warranted as Armitage and Knapman (2003:130) estimated that as much as 40% of clinical time of the professional nurse was dedicated to medication management. Keohane *et al.* (2008:19) agreed that medication administration was the most frequent activity performed by nurses.

The STAR technique was suggested to eliminate near-misses in medication administration: Stop, Think, Act, Review and Verify proper procedures or actions (Speroni *et al*., 2013:19). This was closely related to the crucial intervention of verifying the five rights in medication administration (Härkänen *et al*., 2013:35). Levine *et al.* (2001:426) not only saw adherence to the five rights of medication administration as a possible solution for the error problem, but as a key thereto.

Conrad *et al.* (2010:137) suggested “double checks” of high-risk medications such as insulin, warfarin, and heparin as measure to reduce medication administration errors. Härkänen *et al.* (2013:32) agreed that double checking medications could remediate medication administration errors, also adding an increase in verbal and written communication between health-care professionals as another important solution. Furthermore, the need of clear and unambiguous writing was emphasized (Härkänen *et al.*, 2013:35).

The economic benefits of improving patient safety were compelling (WHO, 2013:1). Studies as relayed by the WHO (2013:1) showed that additional hospitalization, litigation costs, infections acquired in hospitals, lost income, disability and medical expenses have cost some countries between US$ 6 billion and US$ 29 billion a year. Limiting assumed medication administration error inferred a cost to the 20% of all

adverse events as reported by Leufer and Cleary-Holdforth (2013:213), this translated to roughly between US$ 1.2 billion and US$ 5.8 billion.

Apart from the economic benefits of improving patient safety by limiting medication administration errors, it should be seen as a tremendous social responsibility (WHO, 2013:1). Taking up this responsibility, the researcher investigated medication administration errors in public hospitals of the Gauteng Province in South Africa. The incidence as well as the possible causes thereof was determined. The general medication safety climate, incidence of medication administration reporting and reasons for non-report were also explored. Solutions were identified and explored by means of subject-matter interviews. Thereafter interventions aimed at the improvement of medication administration safety were developed. This is all translated into interventions for future improvement of medication administration and on the whole improvement of patient safety. Van Beuzekom *et al.* (2013:107) stated that strategies for improving patient safety should be tailored specifically for a specific setting. This study therefore attempted to investigate medication administration errors within the South African public health setting.

1.2 PROBLEM STATEMENT

Medication administration errors account for a large portion of adverse events and near misses in hospitals and thus is seen as a major concern in patient safety (Kim & Bates, 2013:590). While no South African research on the incidence of medication administration errors were available, international research revealed statistics at around 11% for hospitalized patients (Kliger, 2010:290). However, this rate was proposed to be even higher in developing economies such as South Africa (Bates, 2010:174). Leufer and Cleary-Holdforth (2013:213) found that medication errors accounted for approximately 20% of all deaths due to adverse events in hospitals. Thus, this problem does not only lead to wastage of valuable and limited resources, but also in some cases the loss of life (Nguyen *et al.*, 2010:224). Many extrinsic and intrinsic causes related to medication administration errors were identified from international literature, including nursing competence, prescription factors and patient-related factors, medication work organization, nursing process and safety culture (Anderson & Townsend, 2010:23; Metsälä & Veherkoski, 2013:12; Nguen *et al.*, 2010:224; and Westbrook & Li, 2013:116). The international research on

interventions limiting medication errors was as vast as the research on the causative factors (Anthony *et al.*, 2010:21; Armitage & Knapman, 2003:130; Conrad *et al*., 2010:137; Flanders *et al.,* 2010:284; Freeman *et al*., 2013:178; Härkänen *et al*., 2013:32; Keohane *et al*., 2008:19; Kim & Bates, 2013:593; Leufer & Cleary-Holdforth, 2013:216; Levine *et al.*, 2001:426; Pape, 2003:77; Relihan *et al.,* 2010:2; Speroni *et al*., 2013:19; Wu *et al*., 2008:685 and Zimlichman & Bates, 2012:20). However, Emanual *et al.* (2008:16) emphasised the importance of any patient safety-improving intervention having been moulded to fit the specific setting. This reiterated the problem that the incidence of medication administration error, its causes and possible preventative interventions were not known within the South African context.

1.3 RESEARCH QUESTIONS

The above-mentioned problem statement led to the following main research questions:

- What are the common causes of medication administration errors according to literature?
- What is the incidence of medication administration errors within medical and surgical units of public hospitals in the Gauteng Province of South Africa?
- What are medication administrators‟ perceptions of the causes of medication administration errors, the incidence of medication administration errors and the incidence and reasons for non-report of medication administration errors?
- What solutions would unit managers propose to mitigate the problem of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa?
- What intervention can be developed in order to reduce medication administration errors within medical and surgical units of public hospitals in the Gauteng Province of South Africa?

1.4 AIM AND OBJECTIVES

The main aim of this study was to develop an intervention to improve medication administration safety practised by professional nurses, enrolled nurses and nursing

students in medical and surgical units of public hospitals in the Gauteng Province of South Africa. In order to reach this aim, the following objectives were identified:

- To develop a survey list to determine the causes of medication administration errors based on literature.
- To determine the incidence of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
- To determine the perceived causes and incidence of medication administration errors, as well as the perceived incidence and reasons for non-report of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
- To identify possible solutions for the problem of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
- To develop an intervention to reduce medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.

1.5 RESEARCH HYPOTHESES

Following is the set of research hypotheses relevant to this study:

H_0 1: Self-reported incidences of medication administration errors by medication administrators within medical and surgical units of public hospitals in the Gauteng Province of South Africa were comparable with observed incidences.

H_a 1: Self-reported incidences of medication administration errors by medication administrators within medical and surgical units of public hospitals in the Gauteng Province of South Africa were not comparable with observed incidences.

1.6 PARADIGMATIC FRAMEWORK

According to Burns and Grove (2013:41) assumptions are statements that are taken for granted or are considered true, even though they have not been scientifically tested. The following assumptions are thus seen as truth for the researcher.

1.6.1 Meta-theoretical assumptions

Meta-theoretical assumptions contain non-epistemic statements that are not meant to be tested (Mouton & Marais, 1994:192) and that share the views of the researcher. O"Loughlin (1999:49) explained that modernistic scientists depart from the assumption that knowledge should be generalizable and universally valid, though this study is built on the foundation of having to measure harm within a very specific context, determine causes within that context and create solutions specific to that setting.

Although the researcher strove towards positivism in some phases of the research, attempting to divorce facts from personal values, metaphysical assumptions and interests (Moore, 1982:70) by observing without interfering; interpretation of these results could not have been done without becoming involved in the process. In agreement with Willmot (1999:261) it was perceived that the positivist approach could lead to various forms of distortion, since research was not allowed to tell us anything about the interaction, the interconnection and the contradictions of a truly shared and lived reality. Another reason for rejecting the positivist approach on the meta-theoretical level is that the researcher believed in doctrine that could not be proven other than by the strength of the belief itself.

Following this, there were some post-modernistic assumptions mentioned by Van der Walt (2002:36) that were agreed upon:

- Rejection of the distinction between subject and object in research;
- No single approach to science can be appropriate for all forms of science;
- Acceptance that thoughts can influence individual scientists" operation;
- A relativistic view of scientific truth;
- Theoretical knowledge is not the highest form of knowledge to be aspired for in science; and
- The reluctance to generalize findings.

On this basis, the following assumptions of the world, man, health and nursing were shared:

1.6.1.1 The world

The world is a place for man to live in temporarily, in stewardship of everything thereon. This implies that man should strive to utilize all resources for the greater good and benefit of the world population. In this research the world and the environment and this stewardship were concentrated on the arena of public hospitals within the Gauteng Province of South Africa, in which nurses should take stewardship of their resources in order to better the lives of their patients. The environment encompasses the resource-limited setting of this developing country‟s government-funded portion of the health system. In this environment, many barriers to safe patient care exist, including high workloads, understaffing, gaps in communication between health-care workers representing more than the eleven official languages, and resource restraints to mention but a few. The world in this study is therefore an environment posing challenges to nursing care and encounters that might endanger the patients‟ safety, of which one big hazard involving a breach of patient safety is represented by medication administration errors. It is in this world that the nurse attempts to master stewardship of resources in such a way as to better the lives of his/her patients.

1.6.1.2 Man

Man is seen as a biological, psychological and social being, created with a body, soul and spirit. In the context of this research more focus was put on the physical body of man in the form of patients being harmed by medication administration errors, though the physical, social and psychological hurdles nurses experience in their daily lives were acknowledged as factors impacting on the safe practice of these nurses, while the psychological and social implications of a prolonged hospital stay for the patient caused by ineffective or harmful medication administration should also be considered in view of medication administration error repercussions. Being a composite of biological, psychological and social elements, it is expected that disharmony in one of these elements will cause flaws in human behaviour, leading to deviations from optimal performance. Thus, whenever a human being is involved, some degree of error is expected.

Man within the study context was mostly referred to as nurses, patients and other members of the health team, with the social element of communication between

these human beings acknowledged as an important impacting factor on medication administration safety.

1.6.1.3 Health

Health is seen as a continuum of functioning. Ill health would be non-functioning in some or all aspects of being while optimal health is considered as optimal functioning in some or all aspects of being. Though the focus was on the physical well-being of patients, safe medication administration is seen as a healthy ability of the nurse. Healthy professional nursing entails safe care of high quality.

1.6.1.4 Nursing

Nursing is seen both as a profession and a calling, being not only a vocation but a strong urge towards a particular way of life. Elements of nursing as provided by Kozier *et al.* (2004:7-8) were accepted by the researcher: Nursing is caring, it is an art, a science, it is client-centred, holistic, adaptive, concerned with health promotion, health maintenance and health restoration. In this profession, patient safety and quality of care encompass the principal concern and responsibility of the professional. Medication administration error poses a dire threat to the safety of the patient and the extent of quality of care that the patient perceives. Though medication administration absorbs a great portion of the nurse"s day, it is not the sole priority of a nurse. However, medication administration should be done including all the elements as mentioned.

1.6.2 Theoretical assumptions

Botma *et al*. (2010:187) explained that theoretical assumptions could include models, theories, concepts and definitions. Botma *et al.* (2010:96) further reiterated the importance of the theoretical basis, be it a theory, model or framework, by stating that it made research results meaningful and generalizable. While the *Oxford Dictionary* defined a model as a description of a system or process to assist calculations and predictions, a theory was defined as a set of related statements that describes or explains phenomena in a systematic way (Brink *et al.* 2013:218).

Emanuel *et al.* (2008:15) proposed a model with which to view patient safety aspects that will be used in this study as the theoretical framework (Figure 1.1).

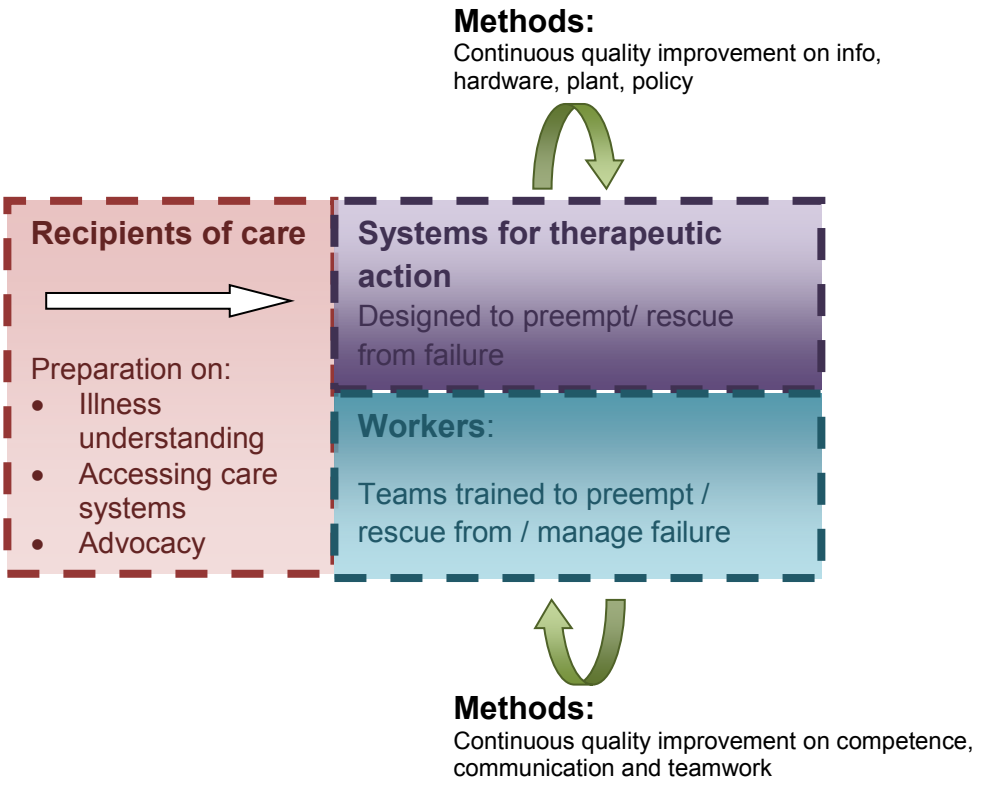


Figure 1.1. A patient safety model for health care (Emanuel *et al.* 2008:15).

This model divided the health care system into four main domains, namely those who work in health care, those who receive health care or have a stake in its availability, the infrastructure or systems for therapeutic interventions (health care delivery processes) and the methods for feedback and continuous improvement (Emanual *et al.*, 2008:15). All these domains were investigated in this study in understanding medication administration errors. Special attention was paid to this model in the Systematic Review (Phase 1) where causes of medication administration errors were reviewed related to the different domains of this model. Emanual *et al.* (2008:15) further explained that these four domains interacted with the other domains and with the environment, as depicted by the semi-permeable divisions between them and at their outer edges. Thus, interaction among these domains was also regarded in finding solutions to the problem of medication administration errors.

Emanual *et al.* (2008:16) emphasised that the fashion in which this model was to be applied must vary by setting; as settings may vary dramatically. Thus, this model was applied to the South African setting by creating an intervention and defining

recommendations and limitations within each domain as was relevant within this specific context to medication administration safety.

1.6.2.1 Central theoretical argument

The focus of this study is on medication administration errors as a threat to patient safety. Research revealed that many contributing causes of medication administration errors existed, as did a plethora of suggestions on how to minimise medication administration errors. Determining the incidence and contributing causes and identifying solutions with the assistance of subject matter experts, led to the development of intervention that could improve safe medication administration in the Gauteng province of South Africa.

1.6.3 Concept clarification

1.6.3.1 Medication administration

The definition for medication administration was derived from the study by Kim and Bates (2013:590) and included all medication administration routes, such as PO (per os), intramuscular injection and IV (intravenous), by registered and enrolled nurses, as well as nursing students from verbal or written orders by doctors in a hospital. Parenteral medication administration comprise medication administration with a needle, including subcutaneous, intramuscular, intradermal and intravenous routes of medication administration (Kozier, 2004:794) while enteral medication administration include drugs delivered via the digestive system, thus administered through the mouth or rectum (Endacott *et al.*, 2009:129).

1.6.3.2 Medication administration errors

Medication administration errors could be defined as mistakes associated with drugs and IV solutions that were made during the prescription, transcription, dispensing and administration phases of drug preparation and distribution (Wolf, 1989:9). In this study medication errors were related only to the administration phase.

1.6.3.3 Medication administrators

Medication administrators included any registered or enrolled nurse as well as nursing students who, during the course of their daily duties, administered medication to a patient.

1.6.3.4 Registered nurse

A registered nurse is a person registered by the South African Nursing Council as such, thus authorized in terms of the South African Nursing Act, 2005 (Act 33 of 2005) to practise as a nurse and to administer medication.

1.6.3.5 Enrolled nurse

An enrolled nurse is a person registered by the South African Nursing Council as such, thus authorized in terms of the South African Nursing Act, 2005 (Act 33 of 2005) to practise as an enrolled nurse and administer medication under direct supervision of a registered nurse.

1.6.3.6 Student nurse

A student nurse is a person registered by the South African Nursing Council as such, thus authorized in terms of the South African Nursing Act, 2005 (Act 33 of 2005) to practise as a student nurse and administer medication under direct supervision of a registered nurse.

1.6.3.7 Patient safety

According to Hassen (2010:51) patient safety is focused on the prevention of error in health-care settings. Medication administration safety is but one aspect of safe patient care.

1.6.4 Methodological assumptions

Cresswell and Planoclark (2007:20) explained that all studies include assumptions about the world and knowledge that informs the inquiries. For this reason, no research is value free (Klopper, 2008:67). Botma *et al.* (2012:188) stated that methodological assumptions explain what the researcher believes good scientific

practice is and how the researcher must investigate what he or she believes must be known.

The research cycle in patient safety as presented by Bates (2013:2) and depicted in Figure 1.2 was applied as basis for this study.

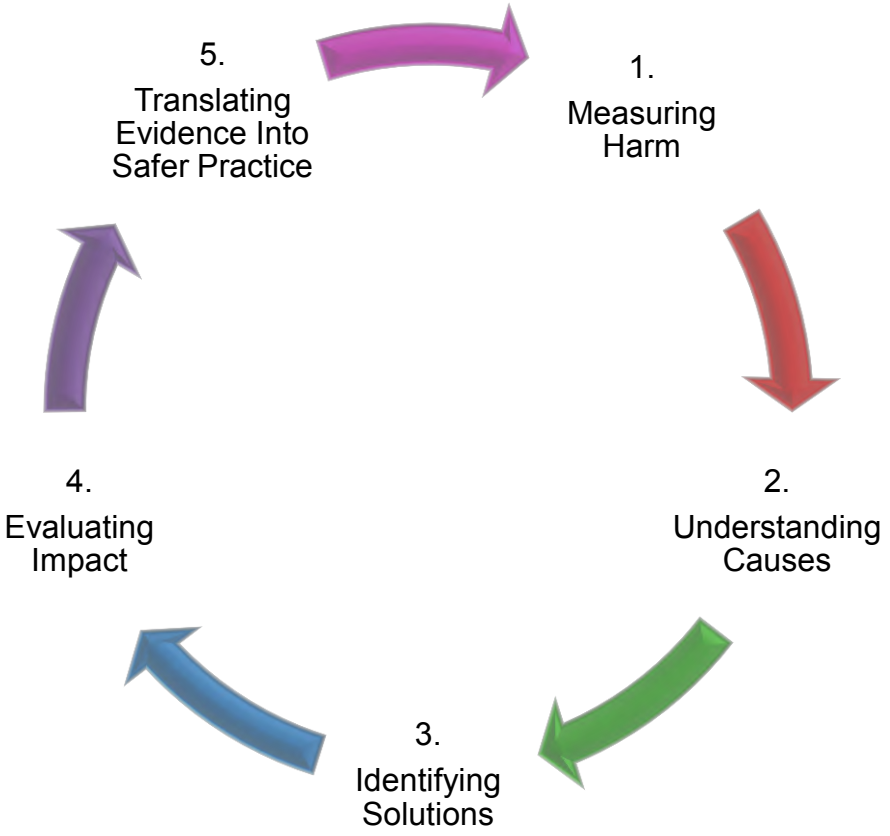


Figure 1.2. The research cycle in patient safety (Bates, 2013:2)

The first phase in this cycle included measuring harm. In the context of this study, harm was measured by determining the incidence of medication errors within the study context, firstly by direct observation (Chapter 3 – phase two of the study) and secondly through a survey (Chapter 4 – phase four of the study) determining the self-reported incidence of medication administration errors as well as the non-report thereof.

The second phase in this cycle, namely understanding causes, was addressed by doing a systematic review of causes of medication administration errors (Chapter 2 – phase one of the study), secondly by means of a survey list structured from the systematic review results that determined the perceived causes of medication

administration errors and non-report thereof (Chapter 4 – phase four of the study) and thirdly by knowledge testing to determine the skill of dosage calculation of the medication administrators (Chapter 3 – phase three of the study).

Interviews with subject matter experts (unit managers) represented phase 3 in identifying solutions to decrease medication administration errors (Chapter 5 – phase five of the study). Solutions were focussed on the top three perceived causes as identified by the medication administrators. Solutions suggested by the unit managers were included in the development of an intervention-cluster aimed at reducing medication administration errors (Chapter 6).

Phase 4 (evaluating impact) was not included in the demarcations for this study, leaving a gap for future research related to the testing of effectiveness of the developed intervention.

Lastly, phase 5 (Translating evidence into safer practice) is to be addressed by disseminating the findings of the research with relevant recommendations for safer medication administration. The translation of evidence into safer practice will only occur after the planned intervention"s impact was evaluated.

1.7 RESEARCH DESIGN

Mouton (1996:107) described a research design as a set of guidelines and instructions to be followed in addressing the research problem.

Both quantitative and qualitative elements were included in this study, incorporating descriptive, explanatory, exploratory and contextual strategies. By implementing both quantitative and qualitative elements, the study represented a mixed method design. According to Botma *et al.* (2010:255) mixed methods denotes a class of research where the researcher mixes or combines quantitative and qualitative research approaches, techniques, methods, concepts or language into a single study.

The study was descriptive in that it was used to identify a phenomenon of interest, identify variables within the phenomenon, develop definitions of the variables and describe variables in a study situation (Burns & Grove, 2013:692). The phenomenon

of interest was medication administration errors, variables represented by causes of these errors, and description thereof encompassing the determination of incidence of these errors, as well as the perceptions of incidence and incidence of non-report of medication administration errors. Mouton (1996:102) explained that descriptive statements make claims about how things are, and what the actual fact of the matter is. Thus, the descriptive strategy involved in this study aimed to put forward what the actual incidence of medication administration errors are. Descriptive studies are also called observational, because subjects are observed without somebody otherwise intervening (Hopkins, 2008:2). Specific to this study, observations on medication administration error incidence were made.

Closely related to the descriptive element is how medication administration errors were influenced by different variables. This correlates with the definition or explanation as given by Burns and Grove (2013:13), saying that explanation clarifies the relationships among phenomena and clarifies why certain events occur.

Further embroidering on these designs, an exploratory design was included to explore possible solutions to the problem of medication administration errors. Mouton (1996:192) explained that explorative investigation allow the establishment of a list of possible answers and solutions, which describes the objective of phase three of the research cycle in patient safety, viz. identifying solutions (Chapter 5). Also compare Welman *et al.* (2011:201).

According to Welman *et al.* (2011:191) human behaviour cannot be understood without appreciating the context in which it takes place. Klopper (2008:68) explained that qualitative studies are always contextual, as the data is only valid in a specific context. In thus study, not only the qualitative elements are deemed contextual, as the qualitative findings are also closely bound to public hospitals in one province of South Africa. Thus the behaviour leading to medication administration errors should be seen in the light of setting-specific challenges and influences.

1.7.1 Context of the study

South Africa has nine provinces (see figure 1.3), each with its own legislature, premier and executive council, distinctive landscape, population, economy and climate (South Africa info, 2013a:1). They are:

- Eastern Cape
- Free State
- Gauteng
- KwaZulu-Natal
- Limpopo
- Mpumalanga
- Northern Cape
- North West
- Western Cape

Figure 1.3: The provinces of South Africa (Tumuga, 2010:1)

The Gauteng Province, though the smallest geographically, has the largest population of approximately 12.27 million inhabitants (South Africa info, 2013a:1). Population density correlates with the provinces' slices of South Africa's economy, with Gauteng having the biggest (South Africa info, 2013a:1). This Province contributed 33.7% to the national GDP in 2010 and 10% to the Gross Domestic Product of Africa as a whole (South Africa info, 2013a:1)

According to South Africa info (2013b:1) health care in South Africa varies from the most basic primary health care, offered free by the state, to highly specialised, hi-tech health services available in both the public and private sectors. However, the public sector is stretched and under-resourced in places. While the state contributes about 40% of all expenditure on health, the public health sector is under pressure to deliver services to about 80% of the population (South Africa info, 2013b:1). Van Rensburg (2004:354) adds that disparities in the distribution of human resources between the private and public sectors, accompanied by acute shortages of staff in the public sector, presents as a general rule and applies to most health professions.

According to South Africa Info (2013b:1), in 2011 the total spent on health was R248.6-billion, or around 8.3% of GDP. Despite this high expenditure, health outcomes remain poor when compared to similar middle-income countries. This can largely be attributed to the inequities between the public and private sector (South Africa Info, 2013b:1).

1.8 RESEARCH METHOD

According to the National Foundation for Educational Research (NFER, 2015:1), the research method should be selected with consideration of how the research questions could be answered or what method would best address the research objectives. For this reason, several methods were included to address all the study objectives. The research will be conducted in five phases. An overview of the methods is presented in figure 1.4 after which the research methods and the rigour of the study were explained in detail for each of the phases.

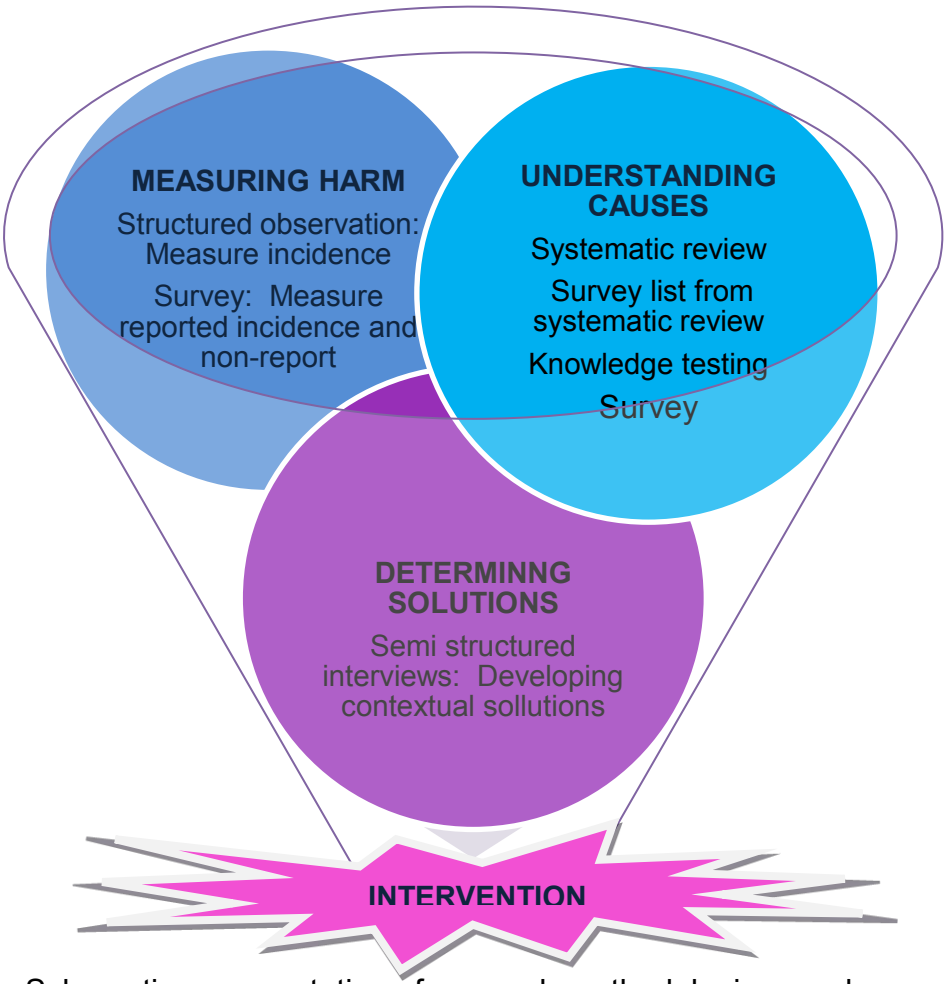


Figure 1.4. Schematic representation of research methodologies used

Methods included in this study were systematic review, direct observation, knowledge testing, survey, and semi-structured interviews. Each of these methods was applied to address a specific aspect of the research cycle in patient safety (Figure 1.2). These methods were implemented in five phases that will be discussed in further detail.

1.8.1 Phase 1: Systematic review

Population and sampling: All quantitative and qualitative studies that complied with the PICOT question were included: hospital setting (**p**opulation) medication administration (**i**ntervention) revealing different outcomes when taking into account causes (**c**omparator) of medication administration error (**o**utcome) from 2005 to 2015 (**t**ime) (JBI, 2013:24). The review question guiding this phase of the study was: "What are the nursing practice related causes of medication administration errors?" Studies had to achieve at least 70% in the quality assessment. Further inclusion criteria were that the studies should have been available in the English language and should have been peer reviewed, primary studies.

Data collection: A PICO (**P**opulation, **I**ntervention, **C**omparator and **O**utcome) question, key words and a search strategy was developed with the assistance of the subject librarian. A systematic approach was used in order to include all relevant studies. Evidence was searched and studies selected by using the eppi-software for literature reviews. The eppi-reviewer 4 software is a web-based programme for managing and analysing data and has been developed for all types of systematic reviews (eppi-Centre, 2008:1). Studies underwent quality assessment prior to inclusion. The Johns Hopkins Research Evidence Appraisal Tool was used to critically appraise quantitative, mixed-method and review articles while the Critical Appraisal Skills Programme (CASP) appraisal tool for qualitative studies was applied to critically appraise qualitative studies.

Data analysis: Data were extracted and synthesized by means of the eppi-reviewer 4 software programme and interpreted to determine all possible causes of medication administration errors related to nursing practice as presented in research.

Rigour: Borenstein *et al.* (2009:280) proposed the best approach to minimizing bias as to perform a truly comprehensive search of the literature. Therefore, a subject

librarian was involved in the development of the search strategy to ensure that all sources, including difficult to find studies was included, in order to reduce some of the effects of publication bias. Furthermore the reference lists of included articles were hand searched to ensure that all relevant studies were considered for inclusion.

1.8.2 Phase 2: Direct observation

Population and sampling: The guideline of a minimum of 300 cases of medication administration incidences as proposed by Kim and Bates (2013:590) was used.

Multiphase cluster sampling was incorporated in order to ensure a representative and sufficient sample. The Gauteng Province was purposively selected for this study due to the high concentration and variety of hospitals within its borders. As representing the largest portion of the South-African population, the Gauteng Province was chosen as it would best represent South Africa as a whole. Furthermore, the Gauteng Province represents the largest portion (26.2%) of the registered nursing population of South Africa, with 34847 registered nurses (SANC, 2015:5). The patient-to-nurse ratio within this Province is close to the average of the other provinces‟ ratios, with one registered nurse available for 371 people and one enrolled nurse for 781 people in Gauteng, and one registered nurse available for 406 people and one enrolled nurse for 807 people as average of the provinces (SANC, 2015:7).

The public hospital setting was purposively selected as there were no known interventions in this setting aimed at minimizing medication administration errors. Furthermore, this setting better represented health-care in a developing country, whereas the private hospital setting more closely represented developed countries‟ health-care. Lastly, the private healthcare setting was excluded from this study as interventions aimed at minimizing medication administration error already existed, though due to the vast difference between the South African public and private sectors, these were not necessarily applicable to the public sector.

The public hospital system consists of three levels of service, namely level 1, 2, and 3. These levels of hospitals are also referred to as District, Regional and Tertiary hospitals. Level one (district) hospitals are facilities at which a range of outpatient and inpatient services are offered (Cullinen, 2006:16). It is open 24 hours a day,

seven days a week. These hospitals have between 30 and 200 beds, a 24-hour emergency service and an operating theatre (Cullinen, 2006:17). This is also the first level of referral and generalist personnel are available for basic diagnostic and therapeutic services such as X-rays and basic laboratory tests. These hospitals play a supporting role to primary health care and serves as a gateway to more specialized services (DOH, 2002:8).

Level 2 (regional) hospitals are facilities that provide care requiring the intervention of specialists and general practitioners. Level two hospitals should provide at least five of the following eight basic specialities: surgery, medicine, orthopaedics, paediatrics, obstetrics and gynaecology, psychiatry, diagnostic radiology and anaesthetics (DOH 2003:28). Cullinen (2006:17) stated that regional hospitals are often the most over-burdened of all levels of hospitals, bearing the brunt of the many inadequacies in the district hospitals.

Level 3 (tertiary) hospitals receive patients from and provide sub-specialist support to a number of level two hospitals. According to Cullinen (2006:19) most of the care requires the expertise of clinicians working as sub-specialists or in rarer specialities (e.g. urology, neurosurgery, cardiothoracic surgery etc.) A general level 3 hospital will have sub-specialities representing at least 50% of the following range of specialities (Cullinan, 2006:18):

- Anaesthetics;
- Burns;
- Clinical pharmacology;
- Critical care and ICU;
- Dermatology;
- Diagnostic radiology;
- Ear, nose and throat;
- Gastroenterology;
- Infectious diseases;
- Mental health;
- Neonatology;
- Nephrology;
- Obstetrics and gynaecology;

- Ophthalmology;
- Orthopaedics;
- Paediatric medicine
- Paediatric surgery;
- Paediatric ICU;
- Plastic and reconstructive surgery;
- Rehabilitation centre;
- Respiratory medicine;
- Trauma;
- Urology; and
- Vascular surgery.

Proportionate sampling of these three levels of public hospitals was done. There are 27 public hospitals in the Gauteng Province of South Africa. Inclusion criteria were that the hospital had to have at least two medical and two surgical units and that the hospital granted ethical clearance for the research to be conducted. Nine hospitals were excluded as they did not have two medical and two surgical units. From the remaining eighteen hospitals, ten were sampled proportionate to hospital level representation for inclusion in the study. Four out of eight level one hospitals, three out of five level two hospitals and three out of five level three hospitals were selected.

Secondly, medical and surgical units complying with the inclusion criteria of having a bed-count of more than ten and being either medical or surgical were identified. Exclusion criteria included that the unit was anything other than medical or surgical, had too few beds or that the unit manager did not grant permission for the researcher to enter the unit. If the unit manager refrained from granting permission, the researcher would have replaced the unit with another unit in the same hospital, though managers from all units sampled agreed to the research being conducted. After compliant units were identified, two units (one medical and one surgical) were selected randomly. This was done by implementing the fishbowl method for random sampling – throwing in all numbers of compliant medical and surgical units respectively into an opaque bag and drawing one number from each selection.

Lastly, twenty observations were done in each of the chosen units. Ten of these observations were performed on enteral and ten on parenteral medication incidences. These observations were done on the medication administrator/s of the day of observation. Inclusion criteria comprised that the administrator should have been qualified to be a medication administrator as discussed in the concept clarification (section 1.6.3.3 – 1.6.3.6) and that he/she had to have given informed consent to be observed.

Measure: The checklist used by Kim and Bates (2013:590) was adjusted as provided in Addendum XI for data collection. Details of these adjustments were described in section 3.3.3.1.

Recruitment and data-collection procedure: One day before the planned observation in a specific ward, the unit manager of the ward was contacted in order to gain access to the ward. The direct observation plan and knowledge test were explained to him/her and his/her permission sought. After explaining this procedure to the unit manager, and permission being granted by him/her, the researcher requested to discuss the direct observation plan and knowledge test with the medication administrator of the following day and provided him/her with an information letter and informed consent form (Addendum IV). The researcher ensured that the medication administrator on the day of data-collection received the information. The unit manager served as the mediator, and was asked to follow-up with the possible medication administrator participant, and if he/she was willing, completed the informed consent form with the unit manager signing as a witness.

On the day of the observation, the researcher inspected the consent letters to ensure that the possible medication administrator/s participants gave voluntary informed consent. If this letter/s had been completed satisfactorily, the researcher verbally confirmed the prospective participant‟s understanding and consent to participate in the research study before starting with the observations, and again assured the participant of the confidentiality of the results.

Data analysis: Descriptive statistics were used to analyse the data obtained. This produced information on the incidence of medication administration error and the prevalent types of medication administration errors. Inferential statistics were used

to correlate certain demographic characteristics of the sample and the study environment to the results.

Storage of data: The confidential checklists were sealed in an envelope until the researcher could capture the data on a spread-sheet. All signed consent letters were kept safe in a locked filing cabinet in the office of the researcher. It will be kept for five years after the completion of the study and destroyed by shredding thereafter. After the data had been captured, the checklist was kept separately from the informed consent forms, in a locked filing cabinet in the office of the researcher. These forms will also be kept for five years after the completion of the study, and destroyed by shredding thereafter. The electronic data were stored on a password-protected computer of the researcher and the statistician.

Rigour: Only one observer, the primary researcher, was involved in data collection to ensure credibility and validity (Sim & Wright, 2002:101). In order to minimise the Hawthorne effect (Brink, 2006:100), recordings only ensued after the third medication administration, where after the ten study observations were completed.

Content validity of the tool that was used to collect data during the direct observation phase was checked in the initial study by Kim and Bates (2013:591) by three experts who were a head nurse, a charge nurse of the unit and a professor of a college of nursing, and used in several medication administration error studies with good validity and reliability reported (Kim & Bates, 2013:591). The altered checklist (see section 3.3.3.1 for details on alterations) was evaluated by the study promoters and a statistician for content validity.

1.8.3 Phase 3: Knowledge Testing

Population and sampling: The same medication administrators who were sampled for phase 2, were included in this phase. Thus, a minimum of 20 administrators and a maximum of 40 administrators were selected, depending on whether the same administrator administered enteral and parenteral medications. Inclusion criteria were the same as in phase 2.

Measure: Two questions on dose calculations were completed by the medication administrators as sampled in phase 2 (Addendum XII).

Recruitment and data-collection procedure: The recruitment for this phase flowed from phase 2. After the relevant amount of observations had been done, the knowledge test was administered. At this point, the participant had already completed the informed consent letter. However, the researcher still granted the prospective participant the choice of completing the knowledge test or not. Questions were completed in the same room as the researcher, so as to ensure truthfulness of the results. The participant was also given an envelope in which to put the completed questions so that the participant did not feel anxious about the outcome of the test. Confidentiality was again assured by the researcher. They were thanked for their time and they received a pen as a token of gratitude, irrespective of whether they chose to withdraw or not. The unit manager was thanked again and the researcher left the unit.

Data analysis: Descriptive statistics were used to report on dosage calculation mistakes.

Storage of data: The confidential knowledge tests were sealed in an envelope until data capturing could ensue. After the data had been captured, the knowledge tests were kept separate from the informed consent forms, in a locked filing cabinet in the office of the researcher. These tests will be kept for five years after the completion of the study, and will be destroyed by shredding thereafter.

Rigour: Questions were completed in the presence of the researcher to ensure validity and truthfulness. This ensured that the results of the knowledge test truly reflected the participant‟s knowledge of how to calculate certain dosages as the participant would be unable to seek assistance from other sources. As first-year nursing lecturer, the researcher extracted the two knowledge test questions from a test-paper previously used to test the calculation skills of first-year nursing students. This test was evaluated by a moderator and deemed fair and relevant to test these skills at first-year level. Furthermore, a colleague in the School of Nursing Science completed the questions as pilot and the questions were submitted to the promoters to ensure face and content validity. The questions were therefore accepted as clear and valid.

1.8.4 Phase 4: Survey

Population and sampling: The same ten hospitals as selected for Phase 2 was used for this phase, as it was seen as viable for this study and representative of the study population. Inclusion criteria were the same as for phase 2 and 3. Exclusion criteria included all prospective participants that were not proficient in the English language, although this was unlikely due to the fact that the business of nursing is conducted in English in public hospitals. An all-inclusive sample of medical and surgical units within these ten hospitals was assessed. An all-inclusive sample of medication administrators (all registered nurses, enrolled nurses and nursing students) of these units was included in the study.

Measure: Data were collected by using a survey synthesised from the Agency of Healthcare Research and Quality (AHRQ) Hospital Survey on Patient Safety (Sorra & Dyer, 2010:207), the Medication Administration Error Reporting Survey (Wakefield *et al*, 2005:475) and a survey list of causes of medication administration error as determined from the systematic review (Addendum XIII).

Recruitment and data collection procedure: One day prior to data collection for phases 2 and 3 in a specific hospital, the researcher personally contacted the unit managers of all medical and surgical units in the hospital and asked them whether they would be willing to distribute the surveys on behalf of the researcher. If they were willing, the researcher made an appointment with them for the following day to deliver enough surveys and informed consent forms for all prospective respondents in that unit. If they were not willing, the researcher asked the unit manager if he/she could contact the professional nurses in the unit in order to find a suitable alternative mediator. On the day that phases 2 and 3 were executed in a specific hospital, the researcher also distributed surveys to all medical and surgical units of that hospital. Enough surveys were left with the unit managers to include all day-shift and night-shift medication administrators. The unit manager or alternative mediator was asked to distribute the surveys.

Surveys were accompanied by informed consent forms (Addendum V), two unsealed envelopes and a pen as token of appreciation. A big black material sleeve with a post-split was placed in each unit, preferably in the tea-room, where the completed survey and completed letter of consent were posted in individual envelopes to

optimise confidentiality. The date for collection of the sleeve was indicated on it, so as to remind participants of how much time they had to complete the surveys. The sleeves were collected ten days to two weeks after distribution so as to give all rotating medication administrators a fair chance to participate in the study. Thus the role of the investigator was to ensure that enough surveys had been delivered to the mediators, to provide the sleeves for posting the surveys and informed consent forms in and lastly to collect the plastic sleeves after ten days to two weeks.

Data Analysis: Descriptive and inferential statistics were used to analyse these quantitative surveys.

Storage of data: The anonymous surveys were delivered by the researcher to the statistical consultation offices in a sealed box. After the data had been captured, the surveys were kept in a locked filing cabinet in the office of the researcher. It will be kept for five years after the completion of the study, and be destroyed by shredding thereafter. Informed consent forms will be kept separately from the surveys in a locked filing cabinet in the researcher‟s office and will be destroyed by shredding five years after the completion of the study.

Rigour: The portions of the Agency for Healthcare Research and Quality (AHRQ) Survey on Patient Safety Culture were previously examined for validity and reliability. Sorra and Dyer (2010:207) found all the subscales used to hold acceptable reliability. The Wakefield survey was previously assessed for face validity. Construct validity was determined by a factor analysis. Reliability was assessed using Cronbach's Alpha, revealing acceptable ranges (Wakefield *et al.*, 2005:482). Content validity of the developed survey was assessed by subject matter experts and a statistician before data collection. The final survey was submitted for ethical approval prior to administration.

After data collection, construct validity was determined by factor analysis to ensure validity in the South African context. Reliability of subscales was determined by exploring Cronbach‟s Alphas. Items that did not fit reliably within existing subscales within the study context were analysed as individual items.

1.8.5 Phase 5: Semi-structured interviews

Population and sampling: An all-inclusive sample of unit managers of units as selected in phase 2 was chosen.

Data collection: An interview schedule focussed on solutions for the top three causes as identified by participants in phase 4 of the study was used for data collection (Addendum XIV).

Recruitment and data-collection procedure: The researcher prepared for the interviews beforehand by revising the skills obtained during her training as nurse through a practice interview with a colleague who is an expert in research interviewing, so as to refine these skills if needed. Informed consent forms (Addendum VI) were distributed to all sampled unit managers two weeks prior to the planned day of data collection. Section matrons were asked to act as mediators. The research was explained to the unit manager and his/her voluntary participation as well as confidentiality was confirmed. The researcher inquired about their willingness to participate one week later. Appointments were scheduled to ensue two weeks after all surveys had been collected, so as to give time to determine the top three causes for medication administration errors as reported by the medication administrators of all hospitals collectively. Appointments were confirmed telephonically on the day prior to the proposed interview, the venue being the unit manager‟s office, the unit‟s tea room or any other venue which was comfortable for the unit manager and free of disturbances.

Verbal consent was confirmed by the researcher before continuing with the interview and the recording of the interview was explained to the participant, confirming that confidentiality would be ensured by the use of code names and that the recordings was to be destroyed as soon as the interviews had been transcribed. The researcher conducted the interviews. No emotional distress was noted during the interviews, though the interview would have been stopped immediately and counselling services offered if it did occur. The interviewee had the option to stop the interview at any time if he/she did not wish to continue. After the interview the interviewee was thanked and given a pen as token of appreciation.

Data analysis: Thematic content analysis as proposed by Holloway (2005:242) was used to analyse the data.

Storage of data: All signed consent letters were kept safely locked away in the researcher‟s office. These consent letters will be kept for five years and thereafter destroyed by shredding. Anonymous transcriptions with no identifying features were kept on a password protected computer. Transcripts will also be kept in a safe for five years, after which they will be deleted.

Rigour: Lincoln and Guba (1985:218) mentioned four criteria to ensure trustworthiness in qualitative research, namely credibility, transferability, dependability and conformability. Also compare Shenton (2004:63). Addressing these criteria will now be discussed.

According to Morrow (2005:252) *credibility* refers to the idea of internal consistency, were the core issue is how rigour is ensured in the research process and how this is communicated to others. Seven measures for ensuring credibility exist: Prolonged engagement, persistent observation, triangulation, peer debriefing, negative case analysis, referential adequacy, and member checks (Loh, 2013:5).

Prolonged engagement in the field or research site requires the researcher to immerse him or herself in the participants‟ world (Bitsch, 2005:76). By the time the qualitative phase of this research was conducted, the researcher had already spent several weeks in the participants‟ world, as she did direct observation within the units of which the unit managers were interviewed. Babbie *et al.* (2005:277) mentioned that prolonged engagement also implies that the researcher stays in the field until data saturation occurs. Brink *et al.* (2013:144) explained that data saturation occurs when additional sampling yields no new information, only redundancy of data already collected. Therefore, the researcher ensured data saturation by conducting a second set of interviews to ensure that no new information could be obtained. Furthermore the researcher‟s experience in the position of a registered nurse ensured prolonged engagement.

With regards to persistent observation, Miles and Huberman (1994:251) reported that data collected on entry to the field is weaker than that collected near the end of the study, which suggests that persistent observation gives an understanding of the

participants‟ world view and effects of the researcher‟s presence are minimized. It was thus beneficial that the qualitative phase of the study was done as the last phase of the study, when participants were used to the presence of the researcher and the researcher had already obtained insight into the worldviews of the participants. Babbie *et al.* (2005:277) further explain persistent observation as the consistent pursuing of interpretations in different ways, while Polit and Hungler (1997:305) mentioned that persistent observation is a process where the researcher focuses on characteristics or aspects of a situation or conversation that are relevant to the phenomena being studied, so as to provide more depth to the description. The study also took place under the supervisor of promoters and a co-coder who assisted in ensuring that data were viewed from all angles and that the depth of the data were thoroughly described.

Triangulation involves the use of multiple and different methods, investigators, sources and theories to obtain corroborating evidence (Onwuegbuzie & Leech, 2007:239). Different types of triangulation exist, viz. multiple data sources, multiple methods of data collection, multiple investigators, multiple perspectives to interpret a single set of data and multiple methods of data analysis (Polit & Hungler, 1997:305). Specific to this phase of the study, multiple data sources were included as the phase was informed by previous phases of the study and also embedded in current literature on the subject. Embedding findings in literature was also mentioned by Saks and Allsop (2013:97) and Botma *et al.* (2010:231) as a measure to ensure rigour. Multiple methods of data collection were incorporated to inform the study, while the participation of the promoters and co-coder complied with the multiple investigators guideline for triangulation. Their inputs also assisted in interpreting the data set from multiple perspectives.

Peer debriefing requires that a skilled external researcher should examine the transcripts, concepts and categories generated from the study (Pitney & Parker, 2001:187). This was done as a co-coder examined the transcripts and the categories generated from the study were discussed and agreed on between the researcher and the co-coder. Further peer debriefing was provided by the promoters. Peer debriefing will also be received from external and internal examiners.

Negative case analysis was not indicated, as the data emerging from the inquiry did not contradict the researcher"s expectations as Bitsch (2005:78) proposed that this was when negative case analysis were to be implemented.

Transferability is a form of external validity (Rolfe, 2004:305) and refers to the degree to which the results of qualitative research can be transferred to other contexts with other respondents (Tobin & Begley, 2004:390). According to Anney (2014:278) transferability of the inquiry is facilitated if the researcher provides a detailed description of the enquiry and participants were selected purposively. According to these two measures, transferability was ensured in this study.

Dependability is concerned with the stability of findings over time (Sinkovics *et al.*, 2008:696) and is established using an audit trail, a code-recode strategy, stepwise replication, triangulation and peer examination (Klopper & Knobloch, 2010:323 and Ary *et al.*, 2010:580).

An audit trail involves an examination of the inquiry process and product to validate the data, whereby a researcher accounts for all the research decisions and activities to show how the data were collected, recorded and analysed (Bowen, 2009:310). This process was followed as the inquiry process was described in detail and evaluated by her promoters and a co-coder.

The code-recode strategy was incorporated as the researcher recoded the data one week after initial coding to evaluate accuracy of the coding while stepwise replication is a qualitative research data evaluation procedure where two or more researchers analyse the same data and compare the results (Chilisa & Preece, 2005:124). Stepwise replication as well as peer examination was performed in that a co-coder was involved in the data-analysis process.

Lastly, conformability addresses the core issue that findings should represent, as far as is possible, the situation being researched rather than the beliefs, pet theories, or biases of the researcher (Morrow, 2005:252). This is the degree to which the results of an inquiry could be confirmed or corroborated by other researchers (Baxter & Eyles, 1997:510). The conformability of the findings were supported by evidence from literature and triangulation therewith.

To conclude, all means were complied with to ensure the trustworthiness of the qualitative phase of the study.

1.9 ETHICAL CONSIDERATIONS

Neale (2009:31) explained research ethics as a generic term for various ways of understanding and examining moral research. Peat *et al.* (2002:283) simplified the definition of research ethics by stating that the welfare and rights of the subject is always placed above the needs of the investigator. Ethics was considered a high priority in each phase of the research.

For this reason, the proposal was reviewed by the Postgraduate Education and Research Committee (PERC) of the School of Nursing Science (SONS), the proposal was defended in the presence of subject and methodological experts, and ethical approval was acquired from the Faculty of Health Sciences Human Research Ethics Committee of the North-West University, Potchefstroom Campus. (Approval certificate provided in Addendum I). Furthermore the Gauteng Provincial Department of Health was asked for ethical clearance (clearance certificate in Addendum II), as well as for all the levels 1, 2 and 3 hospitals (proof of approvals was rendered anonymous and provided in Addendum III).

Brink *et al.* (2013:34) provide three fundamental ethical principles that were applied to all phases of the research study, viz. respect for persons, beneficence and justice. These principles were based on the human rights of self-determination, privacy, anonymity and confidentiality, fair treatment and to be protected from harm (Brink *et al.,* 2013:34). All three ethical considerations, namely respect for persons, beneficence and justice received great consideration throughout the study and alterations were enforced if any of these principles appeared to be violated in the smallest way. These ethical principles as integrated into each phase of the research process are discussed below.

1.9.1 Phases 2 and 3: Direct observation and knowledge testing

Saks and Allsop (2013:111) mentioned that one of the threats to ethical observational research was that a thick description is often needed of the participants‟ attitudes, interactions and environment, which brings into question the

ethical issues of confidentiality and privacy. To minimise the risk of a specific participant being tracked down by thick description of observation, the researcher chose to make general field notes about the whole unit being observed and limited the field notes on personal characteristics of the medication administrator being observed to the rank of the medication administrator. Saks and Allsop (2013:111) also agreed that it might be prudent to negotiate access in relation to settings rather than specific individuals, thus to the medical and surgical unit and not the specific medication administrator working in that unit.

Furthermore, the direct observation participants were considered to be autonomous. They had the right to self-determination as proposed by Brink *et al.* (2013:35) by deciding whether or not to participate in the study, without any risk of penalty or prejudicial treatment. In addition, the units had the right to withdraw from the study at any time (Peat *et al.,* 2002:283), or refuse to divulge information to the researcher.

Saks and Allsop (2013:89) emphasised the need for informed consent, thus informed consent was obtained from these participants. Peat *et al.* (2002:283) explained that subjects had to be provided with information on the purpose, requirements and demands of the protocol prior to their giving consent. This guideline was adhered to.

During the direct observation, the researcher could have witnessed the occurrence of a potentially harmful medication error. The researcher would have been ethically bound to stop such a medication error from occurring as she should have also remained an advocate to the patient. Interference in such circumstances might, however, have influenced the outcome of the study. In the one instance that this occurred, the researcher waited to see whether the medication administrator would rectify his/her mistake until the administration was imminent. At that point the researcher asked the medication administrator if she could control the prescription with the researcher. In this manner the harmful medication error was prevented without the patient doubting the medication administrator‟s competence and without the medication administrator being implicated. The researcher, however, still recorded the incidence as a medication error occurring as in her absence it would have been made.

Risks involved for participants of this phase included anxiety if the participant felt that his/her mistakes were to be made public and that he/she would be held accountable for it. To limit this risk, the participant was assured repeatedly that results were not to be connectable to him/her. A further risk was that the participant lost approximately ten minutes of work-time to complete the informed consent and knowledge test. The participant was thanked for this sacrifice and he/she received a ruler to thank him/her for the time spent. With the exception of the incentive mentioned, benefits were indirect to the participants. It included knowledge acquisition, better safety culture in the hospitals, recommendations for a better practice environment and advocacy for better protocols and policy. Still, with the great risk medication error posed to patient safety, the social benefits of this phase of the research outweighed the risks.

1.9.2 Phase 4: Survey

Prior to administration of the survey, it was submitted for ethical approval, as the changes made with regards to the systematic review results needed to be scrutinised.

Saks and Allsop (2013:200) state that surveys studies are no different from other studies where human subjects are involved, in the sense that formal ethical approval is required. Saks and Allsop (2013:200) further explained that the following two rights of the participant were especially relevant to survey studies: Firstly, the right to autonomy and self-determination, which involved the right to agree or not agree to take part in the survey; and secondly, the right to be informed about the study, encompassing the right to informed consent. Both these rights were honoured during this data-collection phase by providing the potential participants with informed consent forms and the choice to complete the survey or not.

Risks of breach of confidentiality and anxiety due to reporting of medication administration error were mediated by strategies as mentioned in the data-collection procedure above. Apart from the pen given as token of appreciation, indirect benefits as discussed for the previous phase were relevant. Again, the benefits are seen to have outweighed the risks.

1.9.3 Phase 5: Semi-structured interviews

Prior to the interviews taking place, the researcher submitted the finalized interview schedule for ethical clearance.

Brink *et al.* (2013:36) explained that qualitative enquiry, by its very nature, risks exploring as yet unresolved issues, which can upset the participants and lead to emotional harm. For this reason, Botma *et al.* (2010:56) stated that the researcher should avoid asking insensitive and intrusive questions that may undermine the participant‟s autonomy. However, in this study, no question was aimed at uncovering personal or work-related issues, rather, supporting questions were asked to enquire about the participants‟ suggestions for improved medication administration safety and this should have left the participant uplifted and proud to be a transformation agent.

Also applicable to the semi-structured interview phase was informed consent, though here each participant, all of them being individual unit managers, was treated with respect for their autonomy and self-determination and asked to sign informed consent should they have agreed to participate in the study. They had more than 24 hours to complete the informed consent form before the scheduled interview. Again, the information on the purpose, requirements and demands of the research as proposed by Peat *et al.* (2002:283) was provided prior to the participants‟ signing of consent.

A small risk for emotional upset was present, but the biggest risk for the participants was the time set aside for the interview. Strict adherence to appointment schedules, sensitivity to participants‟ time constraints and conducting of the interview in a venue suitable and comfortable for the participant aimed to ameliorate this sacrifice. Apart from a pen as token of appreciation, all other benefits as discussed earlier, were indirect to the participant. Still, benefits in reducing medication error were seen to outweigh these risks.

1.10 CLASSIFICATION OF CHAPTERS

The classification of proposed chapters follows:

Chapter 1: Overview of the study

Chapter 2: Systematic review

Chapter 3: Direct observation and knowledge test

Chapter 4: Survey

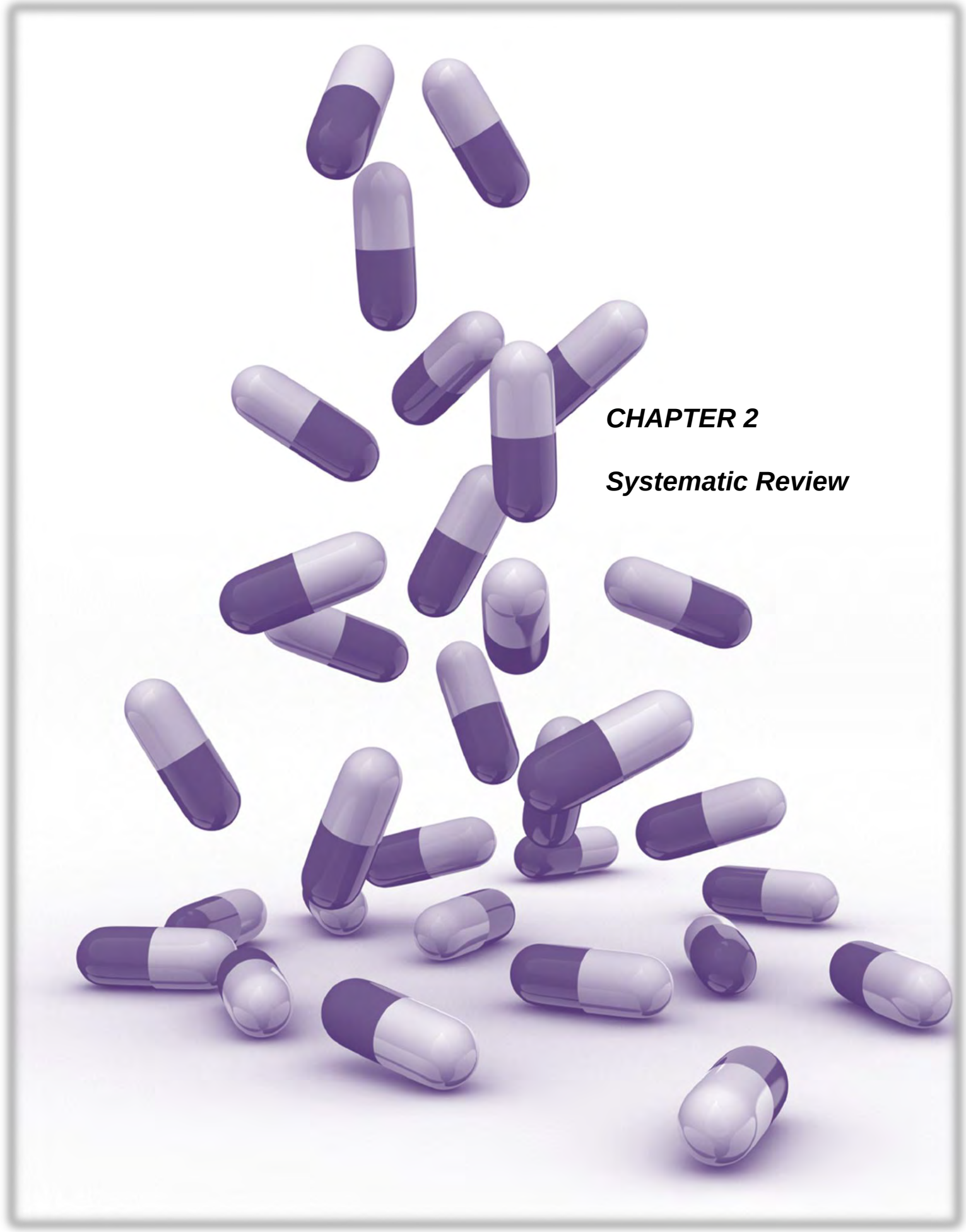
Chapter 5: Semi-structured interviews

Chapter 6: Intervention

Chapter 7: Evaluation of the study, limitations and recommendations for nursing practice, education, research and policy.

1.11 SUMMARY

Medication administration errors pose a great threat to patient safety. The extent of this problem was not well-defined within the South African context. An intervention was proposed to firstly determine the incidence of medication administration errors in medical and surgical units of public hospitals of the Gauteng Province of South Africa. Thereafter, the causes of medication administration errors were determined. Solutions to these problems were identified by means of consultation with unit managers, and developing an intervention focussed on attaining better medication administration safety. Lastly recommendations were drawn for dispersion of effective solutions. The research design and research methods proposed were discussed, as well as rigour, ethical considerations and classification of proposed chapters of the research. These chapters follow.



CHAPTER 2

Systematic Review

2.1 INTRODUCTION

Burns and Grove (2013:708) have defined a literature review as analysis and synthesis of what has been published on a topic by scholars and indicates what is known about a particular situation, phenomenon or problem, and to identify the knowledge gaps that exist. Literature reviews produce a much broader, comprehensive and accurate picture of a topic than a single study or piece of work (Neale, 2009:54). Furthermore, literature reviews provide a flexible method which can address complex policy and practice issues, process diverse types of information and be written in a style and format appropriate to the audience (Neale, 2009:54).

In this phase of the study, a systematic literature review was conducted to explore all the domains of patient safety as proposed by the patient safety model for nurse related causes of medication administration errors in the hospital setting, namely those who work in healthcare, those receiving healthcare, systems for therapeutic actions and continuous quality improvement (section 1.6.2). A systematic review attempts to bring the same level of rigour to reviewing research evidence as should be used in producing that research evidence in the first place (Hemingway & Brereton, 2009:1). According to Hemingway and Brereton (2009:1) high quality systematic reviews seek to:

- Identify all relevant published and unpublished evidence;
- Select studies or reports for inclusion;
- Assess the quality of each study or report;
- Synthesise the findings from individual studies or reports in an unbiased way; and
- Interpret the findings and present a balanced and impartial summary of the findings with due consideration of any flaws in the evidence.

Thus, this phase represents the second stage of the research cycle in patient safety, viz. understanding causes.

A plethora of research exists on the causes of medication errors in the hospital setting. However, only two critically appraised reviews could be found that attempted to combine the results of these studies systematically. Although Parry *et*

al. (2015) conducted a systematic review on factors contributing to registered nurse medication administration error they focussed on medication administration behaviour rather than an all-encompassing view of all nursing related factors that might cause medication errors in the hospital setting, such as environmental factors (workload, high patient acuity, problems with technology, etc.); human factors (lack of knowledge or skill, fatigue, etc.), communication related factors (illegible prescriptions, confusing orders, etc.) or medication related factors (look-alike, sound-alike medications, stock-distribution problems etc.). On the other hand, Keers *et al.* (2013) reviewed all causes relating to medication administration errors in the hospital setting, and thus focussed on a wider array of causes than what was demarcated within this phase of the study, as it did not only focus on nursing practice related causes alone.

The aim of this phase of the study flowed from this knowledge gap: To investigate the international and national in-hospital nursing practice related causes of medication administration errors and to develop a survey list to determine the causes of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa. The review question guiding this phase of the study was: "What are the nursing practice related causes of medication administration errors?"

2.2 METHOD

Data collection and data analysis methods will now be discussed. Data collection will be discussed with regard to databases used, keywords, inclusion and exclusion criteria and data analysis with regard to critical appraisal and categorization.

2.2.1 Data collection

Databases were searched during March 2015 for the keywords medication error, drug error and medication safety. A subject librarian assisted the researcher in the choice of keywords. No additional keywords were added so as keep the search wide enough to obtain all relevant studies. Though focus lay on in-hospital nursing related causes of medication errors, these causes could also be found in studies that were not necessarily demarcated in such detail. Databases included for the study were PubMed, EbscoHost (Academic Search Premier, E-Journals, Medline, International

Pharmaceutical Abstracts, Health Source Nursing/Academic Edition, CINAHL, MasterFILE Premier, CAB Abstracts and Health Source Consumer Edition) and SAe Publications.

English studies that reported data on in-hospital nursing related causes of medication errors published between 2005 and March 2015 were included. In 2004 the Institute for Safe Medication Practices (ISMP) started to review and analyse medication errors submitted to an electronic patient safety reporting system (ISMP, 2015:7), where-after more researchers chose to investigate medication error causes. For this reason, studies published from 2005 were included, this marks the shift regarding medication errors research. Prior to this, causes of medication administration errors were researched, but often limited to one causative factor per study.

No grey literature was included in the study. Grey literature has been defined as that which is produced on all levels of government, academics, business and industry in print and electronic formats, but not controlled by commercial publishers (Fourth International Conference on Grey Literature, 1999:4). It may include reports, theses, conference proceedings, technical specifications and standards, non-commercial translations, bibliographies, technical and commercial documentation, and official documents not published commercially (primarily government reports and documents) (Alberani *et al.*, 1990:358). Higgins and Green (2011:1) explained that the inclusion of data from unpublished studies could introduce publication bias as the studies that can be located may be an unrepresentative sample of all unpublished studies. Furthermore, unpublished studies may be of lower methodological quality than published studies (Higgins & Green 2011:1). The second exclusion criterion was publication language other than English.

To ensure that included studies were of good quality, all considered studies were critically appraised. A further exclusion criterion was a critical appraisal score of less than 70%. The score of 70% was decided upon as this ensured that most of the important aspects of a good quality study were addressed within the article. Critical appraisal is discussed in more detail under 2.2.2 Data analysis.

The initial search yielded 16525 results, 2917 from PubMed, 13442 from EbscoHost (3459 from Academic Search Premier, 2604 from E-Journals, 2236 from Medline, 1829 from International Pharmaceutical Abstracts, 1456 from Health Source Nursing/Academic Edition, 816 from CINAHL, 697 from MasterFILE Premier, 199 from CAB Abstracts, and 143 from Health Source Consumer Edition) and 166 from SAe Publications.

Figure 2.1 presents the exclusion process followed to obtain the final included articles.

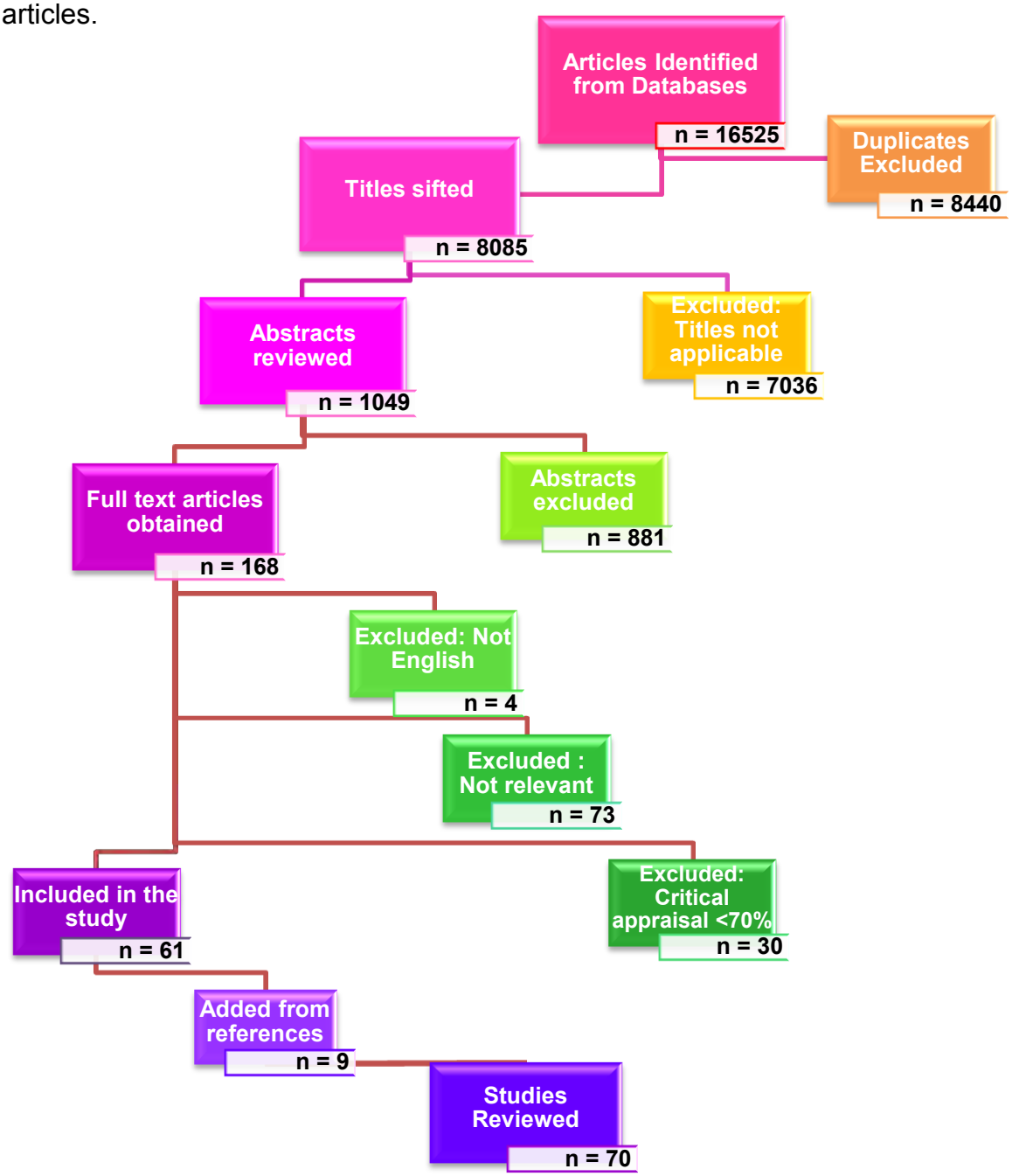


Figure 2.1: Study identification and exclusion process

From the 16 525 articles identified in the initial search, 8440 duplicate articles were excluded. This left 8085 titles to be sifted for relevance. From these, 7036 titles were excluded as not relevant to the study. Thereafter abstracts for the remaining 1049 articles were reviewed, of which 881 were excluded as not relevant. An attempt was made to obtain all 168 full text articles. Of these four were excluded due to being written in a language other than English. A further 73 were excluded due to not being relevant. At this stage, the remaining articles were critically appraised, after which 30 articles were excluded due to not complying sufficiently with the critical appraisal criteria.

The reference lists of included studies were hand-searched to identify additional eligible studies. Ten full-text publications could not be found by the researcher. With assistance of the subject librarian eight of these were tracked down and two were excluded due to unavailability. Fifty additional original studies were identified for possible inclusion after a manual search of the included studies" reference lists had been performed. After reviewing the abstracts of these articles, nine were excluded due to being published in a language other than English, nineteen were excluded due to non-relevance, and twenty-two full-text articles were retrieved for further review. Sixteen of these twenty-two articles were relevant to the study, though only eight were included after they had been found to satisfy at least 70% of the critical appraisal criteria. Of the articles included in the final review, seven were qualitative, fifty-two were quantitative, six presented both qualitative and quantitative methodologies and five were reviews.

All search results were imported into EPPI-Reviewer 4 software for research synthesis. EPPI-Reviewer 4 is a web-based software programme for managing and analysing data and has been developed for all types of systematic reviews (eppi-Centre, 2008:1). EPPI-Reviewer 4 has the functionality to manage systematic reviews through all stages of the process from bibliographic management, screening, coding and right through to synthesis (Thomas *et al.* 2010:1). By importing references into this software, duplicate studies can be removed automatically and near-identical abstracts are compared for further duplicate removal. Full-text studies can be uploaded onto the software, where coding and synthesizing of results are made possible. Full specifications of this software are available in Addendum XIX.

2.2.2 Data analysis

All publications that met the abovementioned inclusion criteria were critically appraised. This was done by means of the Critical Appraisal Skills Programme (CASP) appraisal tool for qualitative studies and the Johns Hopkins Research Evidence Appraisal Tool. The CASP Tool for Qualitative Studies was used for qualitative appraisals together with the Johns Hopkins tool, while all other study design publications were only measured to the Johns Hopkins standards. The CASP Tool was added for critical appraisal of qualitative studies as the Johns Hopkins tool alone was found to not address all important issues related to qualitative research. The CASP Tool for Qualitative Studies (Addendum VII) consisted of ten questions:

- Was there a clear statement of the aims of the research?
- Was a qualitative methodology appropriate?
- Was the research design appropriate to address the aims of the research?
- Was the recruitment strategy appropriate to the aims of the research?
- Was the data collected in a way that addressed the research issue?
- Has the relationship between the researcher and the participants been adequately considered?
- Have ethical issues been taken into consideration?
- Was the data analysis sufficiently rigorous?
- Was there a clear statement of findings? and
- How valuable is the research?

The Johns Hopkins Research Evidence Appraisal Tool aimed to evaluate the quality of evidence of a study (American Nurses Association [ANA], 2015:1). All research studies excluding systematic reviews were evaluated using the following thirteen questions as provided in the tool (Addendum VIII):

- Does the researcher identify what is known and not known about the problem and how the study will address any gaps in knowledge?
- Was the purpose of the study clearly presented?
- Was the literature review current (most sources within last five years or classic)?
- Was sample size sufficient based on study design and rationale?

- If there is a control group:
    - Were the characteristics and/or demographics similar in both the control and intervention groups?
    - If multiple settings were used, were the settings similar?
    - Were all groups equally treated except for the intervention group(s)?
- Are data collection methods described clearly?
- Were the instruments reliable (Cronbach's α [alpha] > 0.70)?
- Was instrument validity discussed?
- If surveys/questionnaires were used, was the response rate > 25%?
- Were the results presented clearly?
- If tables were presented, was the narrative consistent with the table content?
- Were study limitations identified and addressed?
- Were conclusions based on results?

Systematic reviews were evaluated by using the following seven questions as provided in the Johns Hopkins Tool (Addendum VIII):

- Was the purpose of the systematic review clearly stated?
- Were reports comprehensive, with a reproducible search strategy?
    - Were key search terms stated?
    - Were multiple databases searched and identified?
    - Were inclusion and exclusion criteria stated?
- Was there a flow diagram showing the number of studies eliminated at each level of review?
- Were details of included studies presented (design, sample, methods, results, outcomes, strengths and limitations)?
- Were methods for appraising the strength of evidence (level and quality) described?
- Were conclusions based on results?
    - Results were interpreted
    - Conclusions flowed logically from the interpretation and systematic review question
- Did the systematic review include a section addressing limitations and how they had been addressed?

A percentage was obtained by calculating a score out of relevant questions. Irrelevant questions were subtracted from the total used for calculating percentages. A question was labelled as irrelevant if it addressed an aspect that was not relevant to the specific type of study (for example no control group is relevant in a qualitative study). Any publication achieving a percentage above 70 was included for further review. For qualitative studies, a score was determined from the CASP tool as well as from the Johns Hopkins tool where after an average was calculated from these two scores.

The following details were extracted from all publications that met the inclusion criteria: Author, year published, title, purpose of the study, research design (sample, data collection and analysis) and in-hospital nursing-practice-related causes of medication error identified. Thereafter, causes were categorized as human factors, medication-related factors, environmental factors or communication factors.

2.3 RESULTS

Table 2.1 reveal a summary of quantitative, qualitative, mixed method and review studies respectively. Addendum IX presents a more detailed summary of these studies. For each of the first three categories of studies, the author, publication year, title, purpose of the study, sample, data collection and analysis method, in-hospital nursing-practice-related causes of medication error identified in the study and the critical appraisal score were reflected, while the search strategy (key words, databases used, sample size and sources overlapping with current study) replaced the methods section in the review category.

Table 2.1 Included studies

Authors	Date	Title	Setting
Quantitative studies			
Armutlu, M., Foley, M., Surette, J., Belzile, E. & McCusker, J.	2008.	Survey of nursing perceptions of medication administration practices, perceived sources of errors and reporting behaviours.	Quebec
Bae, S., Mark, B. & Fried, B.	2009.	Impact of nursing unit turnover on patient outcomes in hospitals.	United States of America
Beckett, R.D., Sheehan, A.H. & Reddan, J.G.	2012.	Factors associated with reported preventable adverse drug events: A retrospective, case-control study.	United States of America

Bohomol, E., Ramos, L.H. & D'Innocenzo, M.	2009.	Medication errors in an intensive care unit.	Brazil
Breckenridge-Sproat, S., Johantgen, M. & Patrician, P.	2012.	Influence of unit-level staffing on medication errors and falls in military hospitals.	United States of America
Brunetti, L., Santell, J.P. & Hicks, R.W.	2007.	The impact of abbreviations on patient safety.	United States of America
Chang, Y. & Mark, B.A.	2009.	Antecedents of severe and non-severe medication errors.	United States of America
Chang, Y. & Mark, B.	2011.	Effects of learning climate and registered nurse staffing on medication errors.	United States of America
Cheragi, M.A., manoocheri, H., Mohammadnejad, E. & Ehsani, S.R.	2013.	Types and causes of medication errors from nurse"s viewpoint.	Iran
Cottney, A. & Innes, J.	2014.	Medication-administration errors in an urban mental health hospital: A direct observation study.	United Kingdom
Deans, C.	2005.	Medication errors and professional practice of registered nurses.	Australia
Doherty, C. & McDonnell, C.	2012.	Tenfold medication errors: 5 years" experience at a university-affiliated pediatric hospital.	Canada
Donaldson, N., Aydin, C., Fridman, M. & Foley, M.	2014.	Improving medication administration safety: Using naïve observation to assess practice and guide improvements in process and outcomes.	United States of America
Ehsani, S.R., Cheraghi, M.A., Nejati, A., Salari, A., Exmaeilpoor, A.H. & Nejad, E.M.	2013.	Medication errors of nurses in the emergency department.	Iran
Freeman, R., Lee-Lebner, B. & Pesenecker, J.	2013.	Reducing interruptions to improve medication safety.	United States of America
Fry, M.M. & Dacey, C.	2007.	Factors contributing to incidents in medicine administration. Part 2.	United Kingdom
Günes, Ü.Y., Gürlek, Ö. & Sönmez, M.	2014.	Factors contributing to medication errors in Turkey: nurses" perspectives.	Turkey
Håkonsen, H., Hopen, H., Abelsen, L., Ek, B. & Toverud, E.	2010.	Generic substitution: A potential risk factor for medication errors in hospitals.	Norway

Härkänen, M., Ahonen, J., Kervinen, M., Turunen, H. & Vehviläinen-Julkunen, K.	2014.	The factors associated with medication errors in adult medical and surgical inpatients: a direct observation approach.	Finland
Kim, K.S., Kwon, S., Kim, J. & Cho, S.	2011.	Nurses‟ perceptions of medication errors and their contributing factors in South Korea.	South Korea
Latif, A., Rawat, N., Pustavoitau, A., Pronovost, P.J. & Pham, J.C.	2013.	National study on the distribution, causes and consequences of voluntarily reported medication errors between the ICU and non-ICU settings.	United States of America
Manias, E., Kinney, S., Cranswick, N. & Williams, A.	2014.	Medication errors in hospitalised children.	Australia
Mohamed, N. & Gabr, H.	2010.	Quality improvement techniques to control medication errors in surgical intensive care units at an emergency hospital.	Egypt
Mrayyan, M.T.	2012.	Reported incidence, causes, and reporting of medication errors in teaching hospitals in Jordan: A comparative study.	Jordan
Mrayyan, M.T. & Al-Atiyyat, N.	2011.	Medication errors in University-Affiliated Teaching Hospitals as compared to Non-University-Affiliated Teaching Hospitals in Jordan.	Jordan
Mrayyan, M.T., Shishani, K. & Al-Faouri, I.	2007.	Rate, causes and reporting of medication errors in Jordan: nurses‟ perspectives.	Jordan
Murphy, M. & While, A.	2012.	Medication administration practices among children‟s nurses: a survey.	London
Olds, D.M. & Clarke, S.P.	2010.	The effect of work hours on adverse events and errors in health care.	United States of America
Oshikoya, K.A., Oreagba, I.A., Ogunleye, O.O., Senbanjo, I.O., MacEbong, G.L. & Olayemi, S.O.	2013.	Medication administration errors among paediatric nurses in Laos public hospitals: An opinion survey.	Nigeria
Paquet, M., Courcy, F., Lavoie-Tremblay, M., Gagnon, S. & Maillet, S.	2013.	Psychosocial work environment and prediction of quality of care indicators in one Canadian health center.	Canada
Patrician, P.A. & Brosch, L.	2009.	Medication error reporting and the work environment in a military setting.	United States of America

Patrician, P.A., Loan, L., McCarthy, M. & Fridman, M., Donaldson, N., Bingham, M. & Brosch, L.R.	2011.	The association of shift-level nurse staffing with adverse patient events.	United States of America
Pham, J.C., Story, J.L., Hicks, R.W., Shore, A.D., Morlock, L.L., Cheung, D.S., Kelen, G.D. & Pronovost, P.J.	2008.	National study on the frequency, types, causes, and consequences of voluntary reported emergency department medication errors.	United States of America
Picone, D.M., Titler, M.G., Dochterman, J., Shever, L., Kim, T., Abramowitz, P., Kanak, M. & Qin, R.	2008.	Predictors of medication errors among elderly hospitalized patients.	United States of America
Rinke, M.L., Shore, A.D., Morlock, L., Hicks, R.W. & Miller, M.R.	2007.	Characteristics of pediatric chemotherapy medication errors in a national error reporting database.	United States of America
Roche, M., Diers, D., Duffield, C. & Catling-Paul, C.	2010.	Violence toward nurses, the work environment and patient outcomes.	Australia
Scott-Cawiezell, J.S., Pepper, G.A., Madsen, R.W., Petroski, G., Vogelsmeier, A. & Zellmer, D.	2007.	Nursing home error and level of staff credentials.	Columbia
Sears, K., O'Brien-Palla, L., Stevens, B. & Murphy, G.T.	2013.	The relationship between the nursing work environment and the occurrence of reported paediatric medication administration errors: a Pan Canadian study.	Canada
Shahrokhi, A., Ebrahimpour, F. & Ghodousi, A.	2013.	Factors effective on medication errors: A nursing view.	Iran
Shaw, K.N., Lillis, K.A., Ruddy, R.M., Mahajan, P.V., Lichenstein, R., Olsen, C.S. & Chamberlin, J.M.	2013.	Reported medication events in a paediatric emergency research network: sharing to improve patient safety.	United States of America
Stavroudis, T.A., Shore, A.D., Morlock, L., Hicks, R.W., Bundy, D. & Miller, M.R.	2010.	NICU medication errors: identifying a risk profile for medication errors in the neonatal intensive care unit.	United States of America
Tang, F., Sheu, S., Yu, S., Wei, I. & Chen, C.	2005.	Nurses relate the contributing factors involved in medication errors.	Taiwan

Ulanimo, V.M., O'Leary-Kelley, C. & Connolly, P.M.	2007.	Nurses‟ perceptions of causes of medication errors and barriers to reporting.	United States of America
Unver, V., Tastan, S. & Akbayrak, N.	2012.	Medication errors: Perspectives of newly graduated and experienced nurses.	Turkey
Valdez, L.P., De Guzman, A. & Escolar-Chua, R.	2013.	A structural equation modelling of the factors affecting student nurses‟ medication errors.	The Philippines
Valentin, A., Capuzzo, M., Guidet, B., Moreno, R., Metnitz, B., Bauer, P. & Metnitz, P.	2009.	Errors in administration of parenteral drugs in intensive care units: multinational prospective study.	27 Countries from 5 continents
Vazin, A. & Delfani, S.	2012.	Medication errors in an internal intensive care unit of a large teaching hospital: a direct observation study.	Iran
Vazin, A., Zamani, Z. & Hatam, N.	2014.	Frequency of medication errors in an emergency department of a large teaching hospital in southern Iran.	Iran
Volpe, C.R.G., Pinho, D.L.M., Stival, M.M. & De Olivera Karnikowski, M.G.	2014.	Medication errors in a public hospital in Brazil.	Brazil
West, N., Nilforushan, V., Stinson, J., Ansermino, J.M. & Lauder, G.	2014.	Critical incidents related to opioid infusions in children: a five year review and analysis.	Canada
Westbrook, J.I., Woods, A., Rob, M.I., Dunsmuir, W.T.M. & Day, R.O.	2010.	Association of interruptions with an increased risk and severity of medication administration errors.	Australia
Wolf, Z.R., Hicks, R. & Serembus, J.F.	2006.	Characteristics of medication errors made by students during the administration phase: a descriptive study.	United States of America
Qualitative studies			
Aljadhey, H., Mahmoud, M.A., Hassali, M.A., Alrasheedy, A., Alahmad, A., Saleem, F., Sheikh, A., Murray, M. & Bates, D.W.	2014	Challenges to and the future of medication safety in Saudi Arabia: A qualitative study.	Saudi Arabia
Nichols, P., Copeland, T., Craib, I.A., Hopkins, P. & Bruce, D.G.	2008.	Learning from error: identifying contributory causes of medication errors in an Australian hospital.	Australia
Pazokian, M., Tafreshi, Z. & Rassouli, M.	2014.	Iranian nurses‟ perspectives on factors influencing medication errors.	Iran

Sanghera, S., Franklin, B.D. & Dhillon, S.	2007.	The attitudes and beliefs of healthcare professionals on the causes and reporting of medication errors in a UK Intensive care unit.	United Kingdom
Smeulers, M., Onderwater, A.T., Van Zwieten, M.C.B. & Vermeulen, H.	2014.	Nurses‟ experiences and perspectives on medication safety practices: an explorative qualitative study.	The Netherlands
Treiber,.A. & Jones, J.H.	2010.	Devastatingly human: An analysis of registered nurses‟ medication error accounts.	United States of America
Vaismoradi, M., Jordan, S., Turunen, H. & Bondas, T.	2014.	Nursing students‟ perspectives of the cause of medication errors.	Iran
Mixed methods studies			
Hemingway, S., McCann, T., Baxter, H., Smith, G., Burgess-Dawson, R. & Dewhirst, K.	2014.	The perceptions of nurses towards barriers to the safe administration of medicines in mental health settings.	United Kingdom
Jylhä, V., Saranto, K. & Bates, D.W.	2011.	Preventable adverse drug events and their causes and contributing factors: the analysis of register data.	Finland
Maiden, J., Georges, J.M. & Connelly, C.D.	2011.	Moral distress, compassion fatigue and perceptions about medication errors in certified critical care nurses.	United States of America
Ozkan, S., Kocaman, G, Ozturk, C. & Seren, S.	2011.	Frequency of pediatric medication administration errors and contributing factors.	Turkey
Prakash, V., Koczmara, C., Savage, P., Trip, K., Stewart, J., McCurdie, T., Cafazzo, J. & Trbovich, P.	2014.	Mitigating errors caused by interruptions during medication verification and administration: interventions in a simulated ambulatory chemotherapy setting.	Canada
Treiber, L.A. & Jones, J.H.	2012.	Medication errors, routines, and differences between perioperative and non-perioperative nurses.	United States of America
Systematic reviews			
Biron, A.D., Loiselle, C.G. & Lavoie-Tremblay.	2009	Work interruptions and their contribution to medication administration errors: an evidence review.	
Keers, R., Williams, S.D., Cooke, J. & Ashcroft, D.M.	2013	Causes of medication administration errors in hospitals: a systematic review of quantitative and qualitative evidence.	
Metsälä, E. & Vaherkoski, U.	2013.	Medication errors in elderly acute care – a systematic review.	
Parry, A.M., Barriball,	2015.	Factors contributing to registered nurse medication	

K.L & While, A.E.		administration error: A narrative review.
Wilson, S., Bremner, A., Hauck, Y. & Finn, J.	2011.	The effect of nurse staffing on clinical outcomes of children in hospital: a systematic review.

The following nursing practice related causes of medication administration errors were identified in these articles:

- Look-alike medication labels or packaging;
- Look-alike or sound-alike medication names;
- Wrong medication provided by the pharmacy (including dosages different from that which is prescribed);
- Stock distribution problems – medications that are not available at the institution;
- A large variety of drugs are held in the medicine cabinet or medication trolleys are overstocked;
- Labels of medications are of poor quality, incorrect or damaged;
- Insufficient resources are available;
- Different therapeutic dosages are prescribed;
- Generic substitution of medications;
- The pharmacy does not pre-prepare medications or mark high alert medications;
- Communication lapses between the physician and the medication administrator;
- Communication lapses between the pharmacist and the medication administrator;
- Misunderstood orders;
- Confusing instructions (including “prn” prescriptions, omitted or misplaced decimal points or zeros, confusing units of measurement, wrong dosage prescribed or interactive drugs prescribed together);
- Frequent changes in prescriptions;
- Use of abbreviations in prescriptions;
- Illegible prescriptions;
- Incomplete prescriptions (including medication charts not rewritten, route, time or dosages that are not clear);
- Computerized prescribing;
- Cultural or language barriers between health care professionals;
- Having to administer a large number of medications at peak times;
- Interruptions or distractions (also multitasking);
- Work overload;

- High patient to nurse ratio;
- High acuity level of patients (very ill patients);
- Inadequate staffing;
- High staff turnover or the presence of new staff in the unit;
- Lack of supervision;
- Non-optimal learning climate (including absence of guidelines or supervision) or environment for medication preparation;
- Working more than 40 hours per week or working overtime;
- Lack of patient information (e.g. the patient‟s chart being unavailable, the patient being out of the unit or allergies that are not known prior to medication administration);
- Uncooperative or violent patients;
- Technology failures;
- Knowledge, educational or training deficits of the medication administrators;
- Procedures or policy not followed (e.g. not checking the five rights);
- Inexperience (including having to work in different units or on new shifts);
- Slips or memory lapses (also negligence);
- Psychological factors (e.g. being stressed, emotionally exhausted, discontent or experiencing personal, familial or financial problems);
- Physical factors (e.g. being tired or hungry);
- Miscalculations of dosages;
- Incorrect preparation of medications (including preparing medications too early or unauthorized drug administration);
- Incorrect labelling of medications;
- Not documenting promptly; and
- Failure in transcription of prescriptions.

These causes will now be further discussed.

2.4 DISCUSSION

The model with which to view patient safety aspects as proposed by Emanuel *et al.* (2008:15) divided the health care system into four main domains, namely those who work in health care, those who receive health care or have a stake in its availability, the infrastructure of systems for therapeutic interventions (health care delivery

processes) and the methods for feedback and continuous improvement. The causative factors with reference to medication error could also be divided into these domains, though the methods for feedback and continuous improvement fell outside of these demarcations. Furthermore those who receive health care were not perceived as posing nursing-practice-related threats for medication errors and were therefore not discussed as a separate domain, though their presence and actions added to the social environment and were discussed under environmental factors. Thus, causes as determined by means of the review were divided into those who work in health care (specifically medication administrating nurses) and the health care delivery processes or the infrastructure of systems for therapeutic interventions. Causes related to those who work in health care were referred to as human factors while the factors related to the health care delivery processes were divided into communication factors, medication-related factors and environmental factors.

2.4.1 Human factors

Though human factors in broad terms were considered to lead to medication errors (Jylhä *et al.*, 2011:189), several specific factors related to those working in healthcare were identified.

Knowledge deficit was stated by several studies (n = 22) as an error inducing human factor (Cheragi *et al*., 2013:230; Deans, 2005:31; Ehsani *et al.,* 2013:3; Hemingway *et al.*, 2014:4; Latif *et al.*, 2013:397; Manias *et al.*, 2014:74; Mohamed & Gabr, 2010:29; Murphy & While, 2012:930; Oshikoya *et al*., 2013:72; Patrician & Brosch, 2009:283; Pazokian *et al*., 2014:248; Pham *et al.*, 2011:487; Rinke *et al.*, 2007:192; Sanghera *et al*., 2007:58; Sears *et al*., 2013:354; Shaw *et al.*, 2013:816; Smeulers *et al*., 2014:279; Vaismoradi *et al*., 2014:436; Valdez *et al*., 2013:225; Valentin *et al.*, 2009:5; Vazin & Delfani, 2012:428; and Wolf *et al.*, 2006:42). A student interviewed by Vaismoradi *et al*. (2014:434) stated that students learned little about practical aspects of medication, and too long before their clinical placements.

Knowledge deficiency could emanate from educational deficits (Bae *et al.*, 2009:46; Chang & Mark, 2009:74; Chang & Mark, 2009:37; and Ehsani *et al.,* 2013:3) or training deficits (Cheragi *et al*., 2013:230; Deans, 2005:31; Kim *et al.*, 2011:350; Sears *et al*., 2013:354; Tang *et al*., 2007:451; Treiber & Jones, 2012:288; and West

et al., 2013:317). Aldadhey *et al.* (2013:328) related the confirming opinions of their participants in saying that insufficient basic medication safety training and a lack of continuous education in medication safety issues could lead to medication errors.

Though pharmaceutical knowledge could be adequate, slips or memory lapses such as listed by Bohomol *et al*. (2009:1263), Valdez *et al*. (2013:225), and Vazin and Delfani (2012:428) may represent more "innocent" mistakes. Slips might be the result of a skills deficit, another cause mentioned by Deans (2005:31), Ozkan *et al.* (2011:140) and Treiber and Jones (2012:288).

Contrary to innocent slips, Tang *et al*. (2007:451) mentioned personal neglect as the most common cause of medication errors (86.1%; n = 62). However, high work pressure could cause nurses to not follow established safety practices (Smeulers *et al*., 2014:280). Though not following protocol accounted for many negligent medication errors (Armutlu *et al.*, 2008:61; Bohomol *et al*., 2009:1263; Hemingway *et al.*, 2014:4; Jylhä *et al.*, 2011:189; Latif *et al.*, 2013:397; Ozkan *et al.*, 2011:140; Pham *et al.*, 2011:487; Sanghera *et al*., 2007:58, Treiber & Jones, 2010:1332; Valdez *et al*., 2013:225; Valentin *et al.*, 2009:5; Vazin & Delfani, 2012:428; West *et al.*, 2013:317; and Wolf *et al.*, 2006:42), inexperience with an unfamiliar protocol could lead to accidental medication errors (Sanghera *et al*., 2007:58).

Not following the five rights of medication administration was mentioned as a specific protocol not upheld (Mohamed & Gabr, 2010:29; Treiber & Jones, 2010:1332; Treiber & Jones, 2012:288; and Valdez *et al*., 2013:225) while Shaw *et al.* (2013:817) mentioned not confirming the patient‟s allergy status. In addition, Donaldson *et al.* (2014:63), Mrayyan (2012:223), Mrayyan and Al-Atiyyat (2011:210), Mrayyan *et al*. (2007:665), Murphy and While (2012:930), Ulanimo *et al.* (2007:31), Unver *et al.* (2012:322) and Valdez *et al*. (2013:225) mentioned not comparing the medication with medication administration records, identification not confirmed and procedure not explained to the patient. Günes *et al.* (2014:299) agreed that failing to confirm the patient identification from his/her armband was an error-conducive omission. In addition to this, preparing drugs too early (Günes *et al.*, 2014:299), failure to be alert while checking prescriptions (Kim *et al.*, 2011:350), not labelling medication prior to administration (Volpe *et al.*, 2014:556 and Wolf *et al.*, 2006:42)

and not double-checking (Kim *et al.*, 2011:350; Oshikoya *et al*., 2013:72; and Vazin & Delfani, 2012:428) could also pose medication safety risks.

Shaw *et al.* (2013:816) reported 13% (n = 78) of errors in a paediatric emergency department occurring due to miscalculation of dosages while Armutlu *et al.* (2008:61) report miscalculation as the second rated administration-related medication-error cause. Though allotting miscalculations a much smaller percentage of errors caused, Cheragi *et al*. (2013:230), Deans (2005:31), Ehsani *et al.* (2013:3), Günes *et al.* (2014:298), Hemingway *et al.*, 2014:4; Jylhä *et al.*, 2011:189; Latif *et al.* (2013:397), Manias *et al.* (2014:74), Mrayyan (2012:223), Mrayyan and Al-Atiyyat (2011:210), Mrayyan *et al*. (2007:665), Murphy and While (2012:930), Pham *et al.* (2011:487), Rinke *et al.* (2007:192), Ulanimo *et al.* (2007:31), Unver *et al.* (2012:322), Valdez *et al*. (2013:225) and Wolf *et al.* (2006:42) agreed with this finding. Miscalculations included decimal point errors, failure to divide daily doses, and calculations exceeding maximum doses (Shaw *et al.*, 2013:816). Ten-fold dosage errors were often the result of miscalculations (Doherty & McDonnel, 2012:5).

An error in writing, specifically when labelling medications, could cause medication errors (Doherty & McDonnell, 2012:5). Donaldson *et al.* (2014:63) added that the altogether absence of labelling also constitutes a safe practice deviation that might lead to error. Not documenting immediately after administration added to this risk of medication error (Donaldson *et al.*, 2014:63 and Günes *et al.*, 2014:298), especially the risk of duplicate doses (Shaw *et al.*, 2013:816).

Another documentation related factor, viz. transcribing errors, was listed by Armutlu *et al.* (2008:61) as the most frequently reported source of medication errors. Though not rated as the number one source of medication errors, Bohomol *et al*. (2009:1263), Latif *et al.* (2013:397), Maiden *et al.* (2011:342), Pham *et al.* (2011:487), Rinke *et al.* (2007:192), Shahrokhi *et al.* (2013:20), Stavroudis *et al.*, (2010:462), Vazin and Delfani (2012:428) and Wolf *et al.* (2006:42) also listed failure in transcription of the prescription to the pharmacy as a medication safety threat.

Though insufficient medication administration experience could cause medication error (Beckett *et al.*, 2012:637; Chang & Mark, 2009:74; Deans, 2005:31; Härkänen *et al.*, 2014:6; Mohamed & Gabr, 2010:29; Ozkan *et al.*, 2011:140;

Pham *et al.*, 2011:487; Sanghera *et al*., 2007:58; Sears *et al*., 2013:354; Shahrokhi *et al.*, 2013:20; Smeulers *et al*., 2014:279; Treiber & Jones, 2010:1332; Valentin *et al.*, 2009:5; and Vazin *et al.*, 2014:181), specific inexperience, such as having to administer unfamiliar medications (Kim *et al.*, 2011:350; Nichols *et al*., 2008:277; Sanghera *et al*., 2007:58; and Tang *et al*., 2007:451), using unfamiliar medication charts (Sanghera *et al*., 2007:58) or working in unfamiliar wards could also contribute to errors being made (Härkänen *et al.*, 2014:6 and Nichols *et al*., 2008:277).

Pazokian *et al*. (2014:248) conducted a qualitative inquiry that revealed psychological characteristics as an error-conducive factor. This was confirmed by a study conducted by Nichols *et al.* (2008:277) in which ten out of 26 interviewees mentioned stress as an error producing condition. Stress is mentioned by several other studies as a human cause of medication error (Deans, 2005:31; Manias *et al.*, 2014:74; Rinke *et al.*, 2007:192; Stavroudis *et al.*, 2010:462; and Valentin *et al.*, 2009:5). Other psychological factors impacting on medication safety is mentioned by Nichols *et al.* (2008:277) and Shahrokhi *et al.* (2013:20) as personal or family health issues and Mohamed and Gabr (2010:29) who mentioned a lack of job satisfaction.

Physical factors such as being hungry were not excluded from human factors impacting on medication safety (Sanghera *et al*., 2007:58) Sixteen articles added fatigue as an error-producing human condition (Cheragi *et al*., 2013:230; Deans, 2005:31; Ehsani *et al.,* 2013:3; Härkänen *et al.*, 2014:6; Mrayyan, 2012:223; Mrayyan & Al-Atiyyat, 2011:210; Mrayyan *et al*., 2007:665; Murphy & While, 2012:930; Nichols *et al.*, 2008:277; Sanghera *et al*., 2007:58; Sears *et al*., 2013:354; Ulanimo *et al.*, 2007:31; Unver *et al.*, 2012:322; Valdez *et al*., 2013:225; Valentin *et al.*, 2009:5; and West *et al.*, 2013:317).

2.4.2 Medication-related factors

The danger of look-alike or sound-alike medications was identified by Shaw *et al.* (2013:816) as the cause of over one third (n = 215) of medication errors committed in paediatric emergency departments. Armutlu *et al.* (2008:61) ranked look-alike labels and look-alike names of medications respectively as first and second in dispensing-related medication errors. Look-alike or sound-alike medications were often described as factors effecting the incidence of medication errors (Cheragi *et al*., 2013:230; Deans, 2005:31; Ehsani *et al.,* 2013:3; Fry & Dacey, 2007:677; Jylhä

et al., 2011:189; Kim *et al.*, 2011:350; Latif *et al.*, 2013:397; Manias *et al.*, 2014:74; Mohamed & Gabr, 2010:29; Mrayyan, 2012:223; Mrayyan & Al-Atiyyat, 2011:210; Mrayyan *et al*., 2007:665; Murphy & While, 2012:930; Oshikoya *et al*., 2013:72; Patrician & Brosch, 2009:283; Rinke *et al.*, 2007:192; Stavroudis *et al.*, 2010:462; Treiber & Jones, 2012:288; Ulanimo *et al.*, 2007:31; Unver *et al.*, 2012:322; Valdez *et al*., 2013:225; and Wolf *et al.*, 2006:42).

New packaging that resembled that of an already known medication could also contribute to look-alike medication confusion errors (Nichols *et al*., 2008:277). Similar packaging confusion was also mentioned by Deans (2005:31), Fry and Dacey (2007:677), Latif *et al.* (2013:397), Maiden *et al.* (2011:342), Mrayyan (2012:223), Rinke *et al.* (2007:192), Valdez *et al*. (2013:225) and Wolf *et al.* (2006:42). Pazokian *et al*. (2014:248) described an incident where a nurse administrated Aminophylline instead of Aminofusion as both the ampoule and dosage of these two medications were similar. Labels or packaging being of a poor quality or damaged also added to error risk (Mrayyan, 2012:223; Mrayyan & Al-Atiyyat, 2011:210; Mrayyan *et al*., 2007:665; Murphy & While, 2012:930; Stavroudis *et al.*, 2010:462; Ulanimo *et al.*, 2007:31; Unver *et al.*, 2012:322; and Wolf *et al.*, 2006:42).

Contributing to the name-confusion problem, generic substitution of medications was reported by respondents in a questionnaire study conducted by Håkonsen *et al*. (2009:123) as resulting in medication errors such as the administration of Cefalexin instead of Cefotaxim. Manias *et al.* (2014:74), Murphy and While (2012:930) and Wolf *et al.* (2006:42) confirmed the risk posed by generic and trade name confusion.

To add to this problem, the same medication could be prescribed in different therapeutic dosages (Cheragi *et al*., 2013:230; Ehsani *et al.,* 2013:3; and Wolf *et al.*, 2006:42). Doherty and McDonnel (2012:5) agreed that multiple strengths or formulations of the same medication could add to medication confusion. Medication sent from the pharmacy could also be of a different dose from what is prescribed (Günes *et al.*, 2014:298 and Patrician & Brosch, 2009:283) or completely wrong (Oshikoya *et al*., 2013:72). It is also possible that the wrong medication was kept at the patient‟s bedside medication drawer (Nichols *et al*., 2008:277). Günes *et al.*

(2014:298) added that medication errors could occur if the pharmacy did not pre-prepare medications for patients or did not mark high alert medications.

According to Bohomol *et al*. (2009:1263), Günes *et al.* (2014:298), Latif *et al.* (2013:397), Maiden *et al.* (2011:342), Manias *et al.* (2014:74), Ozkan *et al.* (2011:140), Vazin and Delfani (2012:428) and Wolf *et al.* (2006:42) problems in stock or distribution from the pharmacy could inhibit medication safety. Nurses interviewed by Smeulers *et al*. (2014:281) experienced difficulties in the delivery of medication from the pharmacy, which could produce medication errors. Results of studies conducted by Fry and Dacey (2007:677), Günes *et al.* (2014:298) and Kim *et al.* (2011:350) agreed with this finding. Bohomol *et al*. (2009:1263), Fry and Dacey (2007:677), Mohamed and Gabr (2010:29) and Stavroudis *et al.* (2010:462) added the unavailability of certain medications at the institution to stock distribution problems that could contribute to medication errors.

On the other hand, a large variety of medications held in the medicine cabinet (Cheragi *et al*., 2013:230; Ehsani *et al.,* 2013:3; and Fry & Dacey, 2007:677) or overstocked medication trolleys (Fry & Dacey, 2007:677) could also lead to confusion and resultant medication error.

2.4.3 Environmental factors

Nichols *et al.* (2008:277) explained that being distracted and having to multitask were error-producing conditions. Interruptions and disruptions appeared to be one of the most frequently reported error-producing factors (Armutlu *et al.*, 2008:61; Bohomol *et al*., 2009:1263; Cottney & Innes, 2014:68; Deans, 2005:31; Doherty & McDonnell, 2012:5; Donaldson *et al.*, 2014:63; Freeman *et al.*, 2013:185; Fry & Dacey, 2007:677; Günes *et al.*, 2014:298; Härkänen *et al.*, 2014:6; Hemingway *et al.*, 2014:4; Mohamed & Gabr, 2010:29; Mrayyan, 2012:223; Mrayyan & Al-Atiyyat, 2011:210; Mrayyan *et al*., 2007:665; Murphy & While, 2012:930; Oshikoya *et al*., 2013:72; Ozkan *et al.*, 2011:140; Patrician & Brosch, 2009:283; Pham *et al.*, 2011:487; Prakash, *et al.*, 2014:890; Sanghera *et al*., 2007:58; Scott-Cawiezell *et al.*, 2007:76; Sears *et al*., 2013:354; Shahrokhi *et al.*, 2013:20; Smeulers *et al*., 2014:279; Ulanimo *et al*., 2007:31; Unver *et al.*, 2012:322; Valdez *et al*., 2013:225; Volpe *et al.*, 2014:556; and Westbrook *et al.*, 2010:686).

Interruptions and distractions included a phone or patient call, distractions created by a patient or other personnel, and noise (Härkänen *et al.*, 2014:6; Deans, 2005:31; and Murphy & While, 2012:930). While Scott-Cawiezell *et al.* (2007:76) determined that a significant relationship between interruptions and medication errors existed ($p < .0099$) it was of interest to note that an inverse relationship between the rate of interruptions and medication errors was produced should wrong-time errors be omitted. Thus, interruptions did cause late medication administrations, but somehow seemed to be an alleviating determinant for all other categories of medication errors.

Having to administer a large number of medications at peak times impeded the safety of medication administration (Mohamed & Gabr, 2010:29; Oshikoya *et al*., 2013:72; Treiber & Jones, 2012:288; and Valdez *et al*., 2013:225). In a qualitative study conducted by Aldadhey *et al.* (2013:328) workload was seen as contributing to medication errors. Heavy workload was mentioned by several other studies as causing medication errors (Bohomol *et al*., 2009:1263; Hemingway *et al.*, 2014:4; Kim *et al.*, 2011:350; Murphy & While, 2012:930; Oshikoya *et al*., 2013:72; Ozkan *et al.*, 2011:140; Pham *et al.*, 2011:487; Rinke *et al.*, 2007:192; Sanghera *et al*., 2007:58; Sears *et al*., 2013:354; Smeulers *et al*., 2014:279; Stavroudis *et al.*, 2010:462; and Tang *et al*., 2007:451).

The workload could be directly associated with under-staffing, another error-producing condition mentioned by several studies (Deans, 2005:31; Maiden *et al.*, 2011:342; Mohamed & Gabr, 2010:29; Mohamed & Gabr, 2010:29; Murphy & While, 2012:930; Nichols *et al*., 2008:277; Sanghera *et al*., 2007:58; Sears *et al*., 2013:354; Shahrokhi *et al.*, 2013:20; Treiber & Jones, 2012:288; Vaismoradi *et al*., 2014:434; and Valentin *et al.*, 2009:5). Though the staffing quantity might be adequate, a less-than-optimal staffing skills-mix could also contribute to a greater medication error rate (Breckenrige-Sproat *et al*., 2012:463; Chang & Mark, 2009:37; Patrician & Brosch, 2009:283; and Patrician *et al.*, 2011:67).

Under-staffing leads to a high patient-to-nurse ratio. A high patient-to-nurse ratio is a management-controlled factor that can cause a medication error rate increase (Cheragi *et al*., 2013:230; Cottney & Innes, 2014:68; Ehsani *et al.,* 2013:3; Härkänen *et al.*, 2014:6; Mohamed & Gabr, 2010:29; Oshikoya *et al*., 2013:72; Paquet *et al*., 2013:90; Patrician *et al.*, 2011:67; Picone *et al.*, 2008:121; Treiber &

Jones, 2012:288; Valdez *et al*., 2013:225; Valentin *et al.*, 2009:5; Vazin *et al.*, 2014:181; and Volpe *et al.*, 2014:556).

If too few staff were employed at an institution, they might be required to work overtime. Treiber and Jones (2010:1331) stated that working double shifts can lead to medication error. Olds and Clarke (2010:156) confirmed that working overtime was correlated with more medication errors ($p < 0.001$) and explained that any work exceeding 40 hours a week was associated with medication error ($p < 0.01$). Paquet *et al*. (2013:90), Sears *et al*. (2013:354) and Shahrokhi *et al.* (2013:20) confirmed the correlation between overtime and medication errors. Oshikoya *et al*. (2013:72) contested the notion that normal long shift hours already posed a risk of medication error occurring.

High staff turnover with new staff (especially new graduates) added to staffing problems (Treiber & Jones, 2012:288). Sanghera *et al*. (2007:58) and Tang *et al*. (2007:451) confirmed that new staff may contribute to higher medication error rates.

More expertise is needed to nurse high-acuity patients. Breckenridge-Sproat *et al.* (2012:463) found a correlation ($p < 0.05$) between patient acuity and medication error rate. Härkänen *et al.* (2014:6), Mohamed and Gabr (2010:29), Ozkan *et al.* (2011:140), Patrician *et al.* (2011:67), Shahrokhi *et al.* (2012:20), Treiber and Jones (2012:288) and Valentin *et al.* (2009:5) established high acuity as an error-inducing condition.

New staff required higher levels of supervision, a lack of which could have added to medication error (Nichols *et al.*, 2008:277). Mohamed and Gabr (2010:29), Shaw *et al.* (2013:816) and Valentin *et al.* (2009:5) agreed that lack of supervision of trainees may be a contributing factor in medication errors.

Furthermore, medication-related support services were strongly associated ($p < 0.01$) with a decline in non-severe medication errors (Chang & Mark, 2008:74). This could be added to the positive correlation between a positive learning climate and the decrease in medication errors revealed by Chang and Mark (2011:37). According to Bae *et al.* (2009:46) positive work-group learning lead to a decrease in medication errors. On the other hand, the absence of guidelines for medication

administration impeded the learning climate of a unit (Mohamed & Gabr, 2010:29 and Ozkan *et al.*, 2011:140).

The absence of a suitable physical environment to prepare medication should also be considered with regards to medication safety (Shahrokhi *et al.*, 2013:20). This might include a lack of adequate lighting (Murphy & While, 2012:930).

Related to the physical environment, Beckett *et al.* (2012:637) related technology failures with an increase in medication errors. Sears *et al.* (2013:354), Stavroudis *et al.*, (2010:462), West *et al.*, 2013:317; Wolf *et al.* (2006:42) confirmed that equipment or supply problems could lead to medication errors. Intravenous pumps (Bohomol *et al*., 2009:1263; Doherty & McDonnell, 2012:5; Manias *et al.*, 2014:74; Mrayyan, 2012:223; Mrayyan & Al-Atiyyat, 2011:210; Mrayyan *et al*., 2007:665; Ozkan *et al.*, 2011:140; Pham *et al.*, 2011:487; Rinke *et al.*, 2007:192; Treiber & Jones, 2010:1333; Ulanimo *et al.*, 2007:31; Unver *et al.*, 2012:322; Vazin & Delfani, 2012:428 and Wolf *et al.*, 2006:42), bar-coding of patient identification (Treiber & Jones, 2010:1333), faulty computer interfaces (Kim *et al.*, 2011:350 and Wolf *et al.*, 2006:42), computerised provider order entry (Pham *et al.*, 2011:487 and Wolf *et al.*, 2006:42) and automatic dispensing technologies (Latif *et al.*, 2013:397; Oshikoya *et al*., 2013:72; Treiber & Jones, 2010:1333 and Wolf *et al.*, 2006:42) were mentioned as contributing to technology failures that lead to medication errors.

If the patient was unfamiliar with the medication administrator, or if it was difficult to access the patient information such as drug information, the chances of a medication administration error occurring increased (Nichols *et al.*, 2008:277; Oshikoya *et al*., 2013:72; Pham *et al.*, 2011:487; Sears *et al*., 2013:354; Tang *et al*., 2007:451; and Vazin & Delfani, 2012:428). Pazokian *et al*. (2014:248) confirmed that essential information about a patient was paramount in mitigating medication errors while a respondent in a survey study conducted by Treiber and Jones (2010:1331) stated that she would not have made a specific medication error if accurate information had been provided. Manias *et al.* (2014:74) also mentioned inadequate screening of a patient as a risk factor.

An example of essential information was mentioned by Shaw *et al.* (2013:816) in that the weight of a patient was not available to calculate the medication dosage. Deans (2005:31) explained that wrong information on the order, such as the incorrect

patient identification number on the medication order, might also contribute to medication error. In addition, should the patient be out of the ward at the time of medication administration, it could have led to missed dosages (Valdez *et al*., 2013:225) as could the unavailability of the patient‟s chart (Valdez *et al*., 2013:225).

Patients‟ choice of non-compliance with the prescription also posed a risk to medication safety (Kim *et al.*, 2011:350). Confronting or intimidating behaviour from patients may result in medication error (Deans, 2005:31; Manias *et al.*, 2014:74; and Valdez *et al*., 2013:225). Roche *et al.* (2009:17) determined that physical violence from patients was associated with medication errors and late administration of medications. Even the threat of violence was linked to medication errors (Roche *et al.,* 2009:17).

2.4.4 Communication factors

Aldadhey *et al.* (2013:328) explained that communication barriers between healthcare professionals represented one of the most important challenges to better medication safety. Although the authors of this study declared certain limitations of this study (specifically nurses being underrepresented in the study [Aldadhey *et al.*, 2013:328]), communication barriers were described by several other included studies and thus the severity of this problem was confirmed (Bae *et al.*, 2009:46; Bohomol *et al*., 2009:1263; Kim *et al.*, 2011:350; Murphy & While, 2012:930; Nichols *et al*, 2008:277; Hemingway *et al.*, 2014:4; Latif *et al.*, 2013:397; Pham *et al.*, 2011:487; Rinke *et al.*, 2007:192; Sanghera *et al*., 2007:58; Sears *et al*., 2013:354; Shaw *et al.*, 2013:816; Stavroudis *et al.*, 2010:462; Valdez *et al*., 2013:225; Valentin *et al.*, 2009:5; West *et al.*, 2013:317; and Wolf *et al.*, 2006:42).

Sanghera *et al*. (2007:58) and Wolf *et al.* (2006:42) elaborated by stating that communication failures could occur as a result of either verbal fallacies (such as difficulties in understanding another healthcare professional‟s accent) or written miscommunications. While Vaismoradi *et al*. (2014:434) found that the use of jargon, either verbally or in writing caused many miscommunications, nurses interviewed and surveyed by Smeulers *et al*. (2014:279) and Hemingway *et al.* (2014:4) experienced documentation and processing of prescriptions as being particularly error-prone. Jylhä *et al.* (2011:189) agreed that documentation of

medication data could contribute to medication errors. According to Aldadhey *et al.* (2013:328) multilingualism and healthcare professionals who came from different backgrounds could lead to the breakdown in communication.

Deans (2005:31), Mohamed and Gabr (2010:29) and Maiden *et al.* (2011:342) specifically mentioned communication lapses between the physician and the medication administrator while Mohamed and Gabr (2010:29) focused on poor communication between pharmacists and nurses as a threat to medication safety.

Elaborating on miscommunications between the physician and medication administrator, Armutlu *et al.* (2008:61) noted misunderstood orders as the fourth ranking prescribing-related cause of medication errors. Deans (2005:31) and Doherty and McDonnel (2012:5) agreed that misinterpreted orders were a frequent cause of medication errors.

Furthermore, prescribing errors may effect on nurses‟ medication errors (Bohomol *et al*., 2009:1263; Pazokian *et al*., 2014:248; and Rinke *et al.*, 2007:192). Confusing instructions were mentioned by Armutlu *et al.* (2008:61) as the second rated prescribing related cause of medication error as reported by 47.2% (n = 68) of the respondents. Tang *et al*. (2007:451) supported this finding by their report of 23.6% (n = 17) of sampled nurses reporting complicated doctor-initiated orders as cause of medication error. A few other studies also supported this finding (Oshikoya *et al*., 2013:72; Treiber & Jones, 2012:288; and Valdez *et al*., 2013:225).

The prescription of “pro re nata” (prn) doses was mentioned as example of confusing instructions (Cottney & Innes, 2014:69), while Doherty and McDonnel (2012:5) and Wolf *et al.* (2006:42) explained that an omitted or misplaced decimal point or multiple zeros in an order may also lead to confusion and resultant error. Further examples of confusing orders could include interactive medications prescribed at the same time (Günes *et al.*, 2014:298), contra-indicated medications prescribed (Latif *et al.*, 2013:397; Pham *et al.*, 2011:487; Stavroudis *et al.*, 2010:462; and Wolf *et al.*, 2006:42), wrong dose prescribed (Ulanimo *et al.*, 2007:31 and Unver *et al.*, 2012:322) and confusing units of measurement used (Manias *et al.*, 2014:74 and Wolf *et al.*, 2006:42).

The use of abbreviations in prescriptions contributed to 4.7% (n = 29,974) of medication errors reported to the MEDMARX program between 2004 and 2006 (Brunetti *et al.*, 2007:577). Cheragi *et al*. (2013:230) also reported the use of acronyms instead of full names of medications as a factor contributing to medication error. Some other studies mentioned misunderstood abbreviations as cause of medication errors (Deans, 2005:31; Ehsani *et al.,* 2013:3; Latif *et al.*, 2013:397; Pham *et al.*, 2011:487; Valdez *et al*., 2013:225; and Wolf *et al.*, 2006:42).

Contributing to prescription problems, illegible prescriptions were reported by Armutlu *et al.* (2008:61) as the second most frequently reported source of medication errors. Several other studies agreed that the illegibility of prescriptions contributed to the medication error problem (Cheragi *et al*., 2013:230; Deans, 2005:31; Ehsani *et al.,* 2013:3; Fry & Dacey, 2007:677; Günes *et al.*, 2014:298; Latif *et al.*, 2013:397; Manias *et al.*, 2014:74; Mrayyan, 2012:223; Mrayyan & Al-Atiyyat, 2011:210; Mrayyan *et al*., 2007:665; Pham *et al.*, 2011:487; Shahrokhi *et al.*, 2013:20; Treiber & Jones, 2012:288; Ulanimo *et al.*, 2007:31; Unver *et al.*, 2012:322; Valdez *et al*., 2013:225; and Wolf *et al.*, 2006:42). Additionally, frequent changes in prescriptions was found by Patrician and Brosch (2009:283) to be one of the five most frequently reported reasons for the occurrence of medication errors.

Incomplete prescriptions could add to the risk of medication errors (Fry & Dacey, 2007:677). Deans (2005:31) listed a misplaced or absent decimal as an example of an incomplete prescription while Günes *et al.* (2014:298) mentioned the route or time of administration not being indicated on the prescription. Prescriptions was often also not rewritten in time (Fry & Dacey, 2007:677 and Günes *et al.*, 2014:298).

Figure 2.2 provides an overview of in-hospital nursing-practice-related causes of medication error as identified by means of the systematic review.

Figure 2.2: Overview of in-hospital nursing-practice-related causes of medication error

Emanual *et al.* (2008:16) emphasised that the fashion in which the patient safety model applies must vary by setting as settings may vary dramatically. Thus, this model was applied to the South African setting and computerized prescribing, failure in transcription of prescriptions to the pharmacy and the pharmacy not preparing the medications for the patient was omitted as causes of medication error when the survey-lists were prepared, as these were not relevant to the South African public sector setting. The survey lists prepared from the results follow:

Please indicate how much of a risk the following communication factors pose in causing medication administration errors in your unit:	**No risk**	**Small risk**	**Moderate risk**	**Significant risk**
1. Communication lapses between the physician and the medication administrator	☐1	☐2	☐3	☐4
2. Communication lapses between the pharmacist and the medication administrator	☐1	☐2	☐3	☐4
3. Misunderstood orders	☐1	☐2	☐3	☐4
4. Confusing instructions	☐1	☐2	☐3	☐4
5 Frequent changes in prescriptions	☐1	☐2	☐3	☐4
6. Use of abbreviations in prescriptions	☐1	☐2	☐3	☐4
7. Illegible prescriptions	☐1	☐2	☐3	☐4
8. Incomplete prescriptions	☐1	☐2	☐3	☐4
9. Cultural or language barriers between health care professionals	☐1	☐2	☐3	☐4
10. Other (Please specify): _____	☐1	☐2	☐3	☐4

Please indicate how much of a risk the following human factors pose in causing medication administration errors in your unit:	**No risk**	**Small risk**	**Moderate risk**	**Significant risk**
1. Knowledge, educational or training deficit	☐1	☐2	☐3	☐4
2. Procedures or policy not followed (e.g. not checking the five rights of medication administration)	☐1	☐2	☐3	☐4
3. Inexperience	☐1	☐2	☐3	☐4
4. Slips or memory lapses	☐1	☐2	☐3	☐4
5. Psychological factors (e.g. being stressed or emotionally exhausted)	☐1	☐2	☐3	☐4
6. Physical factors (e.g. being too tired or hungry)	☐1	☐2	☐3	☐4
7. Miscalculations of dosages	☐1	☐2	☐3	☐4
8. Incorrect preparation of medications	☐1	☐2	☐3	☐4
9. Incorrect labelling of medications	☐1	☐2	☐3	☐4
10. Not documenting medication administration directly after administration	☐1	☐2	☐3	☐4
11. Other (Please specify): _____	☐1	☐2	☐3	☐4

Please indicate how much of a risk the following environmental factors pose in causing medication administration errors in your unit:	**No risk**	**Small risk**	**Moderate risk**	**Significant risk**
1. Having to administer a large number of medications at peak times	☐1	☐2	☐3	☐4
2. Interruptions or distractions	☐1	☐2	☐3	☐4
3. Work overload	☐1	☐2	☐3	☐4
4. High patient to nurse ratio	☐1	☐2	☐3	☐4
5. High acuity level of patients (very ill patients)	☐1	☐2	☐3	☐4
6. Inadequate staffing	☐1	☐2	☐3	☐4
7. High staff turnover (new staff)	☐1	☐2	☐3	☐4
8. Lack of supervision	☐1	☐2	☐3	☐4
9. Non-optimal learning climate	☐1	☐2	☐3	☐4
10. Working more than 40 hours per week	☐1	☐2	☐3	☐4
11. Lack of patient information	☐1	☐2	☐3	☐4
12. Uncooperative or violent patients	☐1	☐2	☐3	☐4
13. Technology failures (e.g. infusion pump problems)	☐1	☐2	☐3	☐4
14. Other (Please specify): _____	☐1	☐2	☐3	☐4

Please indicate how much of a risk the following medication-related factors pose in causing medication administration errors in your unit:	**No risk**	**Small risk**	**Moderate risk**	**Significant risk**
1. Look-alike medication labels or packaging	☐1	☐2	☐3	☐4
2. Look-alike or sound-alike medication names	☐1	☐2	☐3	☐4
3. Wrong medication provided by the pharmacy	☐1	☐2	☐3	☐4
4. Stock distribution problems – certain medications are not available at your institution	☐1	☐2	☐3	☐4
5. There is a large variety of drugs in the medicine cabinet or the medication trolleys are overstocked	☐1	☐2	☐3	☐4
6. Labels of medications are of poor quality or damaged	☐1	☐2	☐3	☐4
7. Insufficient resources such as medication glasses, etc.	☐1	☐2	☐3	☐4
8. The same medication is prescribed in different dosages	☐1	☐2	☐3	☐4
9. Generic substitution of medications (Different names for one medication)	☐1	☐2	☐3	☐4
10. Other (Please specify): _____	☐1	☐2	☐3	☐4

2.5 LIMITATIONS

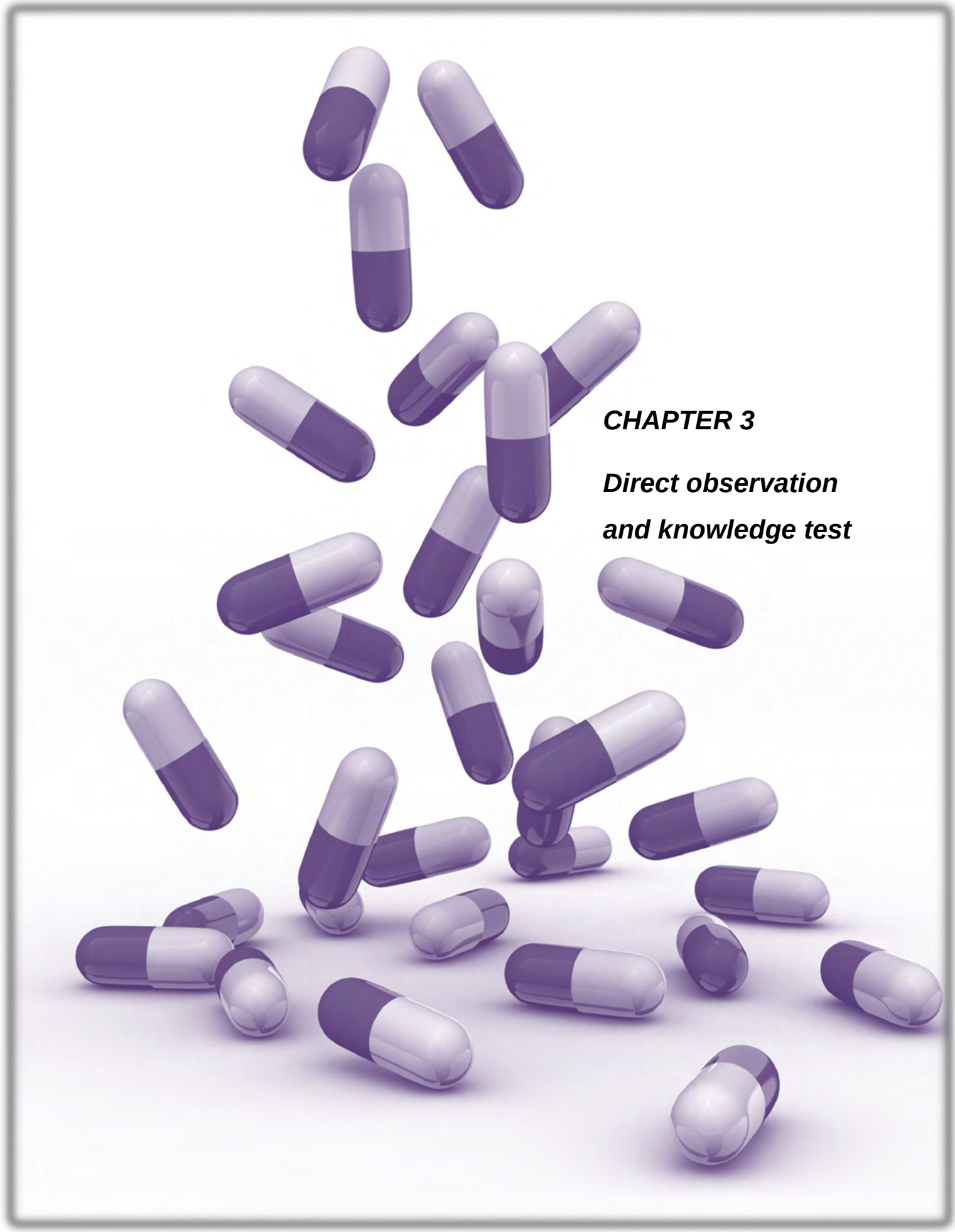
Though all articles that might have included information about the topic were thoroughly considered, the key-words used might have limited relevant studies. An attempt to mitigate this limitation was made by including studies identified from the reference lists of included studies and by making use of a subject librarian.

The exclusion of articles written in any other language than English could have led to the exclusion of relevant studies. Though the results of the study appeared to have reached data saturation, the inclusion of these studies would have added to the rigour of the study.

2.6 SUMMARY

As part of the second step in the research cycle for patient safety, a systematic review of the literature was performed to determine causes of medication errors. Several human, medication-related, environment-related and communication-related in-hospital nursing-practice-related causes of medication error were identified and discussed. A survey list emanating from these results was created that would be used in the fourth phase of this research to determine context-specific causes of these errors.

Next, the first step of this cycle, measuring harm, was done by means of direct observations and knowledge testing.



CHAPTER 3

Direct observation and knowledge test

3.1 INTRODUCTION

In the research cycle, the first step, measuring harm, is focused on the measurement of what goes wrong in health-care. The WHO (2015:1) explained that this entailed counting how many patients were harmed or killed, and from which types of adverse events. First on the WHO"s list of adverse events was medication errors (WHO, 2015:1). Andermann *et al.* (2013:553) and the WHO (2015:1) agreed that research built upon the aim of measuring harm was essential for raising awareness, increasing the knowledge base and setting research priorities for making health-care safer and reducing harm to patients.

The results of the systematic review done by Nabhan *et al.* (2012:129) revealed that medication adverse events were the most prevalent preventable harm affecting patients in health-care. Though the interpretation of harm done was very vague, any impairment of the physical, emotional, or psychological function or structure of the body and/or pain resulting there from could be seen as harm to the patient (Hartwig *et al.*, 1991:1).

Not all medication errors result in patient harm (Maaskant *et al.*, 2014:381) although many patients still experience deleterious effects from these errors. Shehata *et al.* (2015:1) found that 13% of reported medication errors led to patient harm, though Härkänen *et al.* (2015:297) reported that only 3.4% of medication errors caused patient harm. The incidence of harm resultant from medication errors was associated with the setting and type of medication administered, as shown by a study of opioid-related adverse events by Beaudoin *et al.* (2015:423) in which it was found that 43 out of 73 medication errors in an emergency department caused harm to the patients.

As harm is ultimately correlated with the amount of medication errors that occur in total, the exploration of the incidence of medication errors within a specific setting is the first step in measuring the harm caused by these errors. Internationally, the incidence of medication error was found to vary considerably from setting to setting, with an incidence as low as 1.2% of administered medications (Conroy *et al.*, 2007:18) and as high as 291 errors in 168 observed intravenous doses (O"Hare *et al.*, 1995:1536). The median medication error rate as derived from 91 international studies was found to be 19.6% of total opportunities for error (Keers *et al.,*

2013a:237). However, no studies could be found that addressed the question of incidence of medication administration errors in South Africa, let alone specific incidence of errors within medical and surgical units of public hospitals in the Gauteng Province. Thus, the aim of this phase of the study was to determine the incidence of medication administration errors by means of direct observation and knowledge testing in medical and surgical units of public hospitals in the Gauteng Province of South Africa.

3.2 CONCEPT CLARIFICATION

3.2.1 Medication error

Medication errors can be defined as mistakes associated with medications that were made during the prescription, transcription, dispensing and administration phases of medication preparation and distribution (Wolf, 1989:9). In this study only medication administration errors were observed. Medication errors could occur when a dose was not administered at all (omission), when administering a certain medication to one patient which was intended for another patient (wrong-patient error), when following the wrong route of administration for example administering an intravenous prescribed medication orally (wrong-route error), when administrating a medication different from what was prescribed (wrong-medication error), when administering a bigger or smaller dose from what was prescribed (wrong-dose error) or when medication was administered earlier or later than had been intended by the prescription (wrong-time error).

Most hospitals defined wrong-time errors as being administered more than 30 minutes before or after the scheduled administration time (Stokowski, 2012:1). However, the Institute for Safe Medication Practices (ISMP) stated that few medications (mostly medications with a dosing schedule more frequent than every four hours) may cause harm or sub-therapeutic effects if not administered within this time-window (ISMP, 2011:1). For this reason, a wrong-time error was defined as medication being administered more than one hour before or after the scheduled administration time for medications prescribed more frequently than daily and more than two hours before or after the scheduled administration time for medications prescribed daily, weekly or monthly, in accordance with the ISMP guidelines (ISMP, 2011:1).

3.2.2 Patient acuity

Patient acuity was defined as the level or severity of an illness. This parameter was considered in patient classification systems designed to serve as guidelines for allocation of nursing staff (Miller-Keane Encyclopaedia and Dictionary of Medicine, Nursing and Allied Health, 2003:1). In this study, the Associations of the United Kingdom University Hospitals (AUKUH) acuity/dependency tool (Addendum XVI) was used to observe patient acuity and staffing levels within. This tool is discussed under section 3.3.3.4.

3.2.3 Occupancy

Bed occupancy refers to the number of patients in a unit expressed as a percentage of bed numbers (Hurst, 2002:3).

3.2.4 Deviations from safe practice

Any practice that deviates from protocols intended to uphold patient safety during medication administration was labelled as a deviation from safe practice. These deviations included the medication label not being read; the prescription not read; a medication administrator other than the one preparing the dose, administered the dose; medications were not labelled directly after preparation thereof; the markings of a syringe were not read at eye-level; the wristband of the patient was not read; the patient‟s name was not asked; medication was not prepared directly before administration; hands were not disinfected or not disinfected thoroughly; intravenous bottles, bags and vials were not disinfected; sterility of needles and IV sets was not maintained; the injection site was not disinfected before administration; the medication administrator did not record the administration; the medication administrator recorded a time different from when the administration occurred, or recorded before the administration was completed; the administration was recorded by someone other than the medication administrator, or the medication administrator was interrupted during her task of medication administration to a specific patient.

3.3 METHOD

3.3.1.1 Data collection method for direct observation

Data collection for phase 3 was done through direct observation. Evans and Rooney (2011:217) explained that observational methods to collect data could be used in either experimental or non-experimental research. In this study, the observation was non-experimental, as the investigator did not control the independent variable namely medication administration errors.

Furthermore, observational studies could be divided into naturalistic, participant and contrived observation (Gravetter & Forzano, 2012:368). The observational method implemented in this study was naturalistic observation, as the researcher tried to be as inconspicuous and unobtrusive as possibly, passively recording what occurred while not modifying the behaviour occurring ordinarily in the natural setting (Gravetter & Forzano, 2012:369). The natural setting where the observations occurred was the medical and surgical units during medication administration rounds. Specific behaviour recorded was the method of administrating medications, with specific notes on the occurrence of medication administration errors and deviations from safe practice. Observations were done by following the medication administrator through the unit on the medication round and recording observations on the direct observation checklist (Addendum XI).

Jackson (2012:81) mentioned that naturalistic observation has greater validity than most other research methods as true and natural behaviours are observed. Jackson (2012:83) however cautioned that the influence of the researcher"s expectations on the outcome of the study is a primary concern in naturalistic studies as the researcher may pay more attention to behaviours that they expect or that support their hypotheses while possibly ignoring behaviours that might not support their expectations. In order to mediate this risk, the researcher chose to use a standardized checklist, thereby ensuring a measure of objectivity and forcing the researcher to record all positive and negative actions taken during the administration of medications.

Baily (1994:258) expanded on the use of checklists by stating that direct observation requires a standardized instrument. Jackson (2012:85) agreed that using checklists

leads to a more structured and objective method of data collection, allowing the researchers to focus on a limited number of specific behaviours. The researcher had prior experience in the completion of structured observation checklist completion as this method is also used to ascertain competency in procedures taught by the researcher at the university. A further advantage of the use of checklists is that the data are already quantified.

Gravetter and Forzano (2012:366) mentions the frequency method for quantifying observations, which entails the counting the instances of each specific behaviour that occur during a fixed time observation period. The frequency method was used in this study as that instances of medication administration errors as well as instances of deviations from safe practice were counted and commented on. Quantifying data is one of the last steps in the observational study. Baily (1994: 248) mentioned eight steps in observation:

- Deciding upon the goals of the study;
- Deciding upon the group for subjects to be observed;
- Gaining entry to the group;
- Gaining rapport with the subjects being studied;
- Conducting the study by observing and recording events;
- Dealing with crises that occur, such as confrontations with subjects who think you are some sort of spy;
- Exiting from the observational study;
- Analysing the data; and
- Writing a report presenting the findings.

All of these steps were followed in this study, the goals being to determine the incidence of medication administration errors, the group observed being the medication administrators of medical and surgical units of public hospitals within the Gauteng Province. Entry and rapport with the subjects were gained through the process of obtaining informed consent, which was followed by the actual observations. Observed medication administrators were regularly reminded that confidentiality would be maintained, thus dealing with step six of the observation process. In this chapter, the data analysis and writing up of results were concluded.

3.3.1.2 Data collection method for knowledge testing

After the direct observation was completed, two questions on dose calculations were completed by the medication administrators (Addendum XII).

3.3.2.1 Population and sampling for direct observation

The guideline of a minimum of 300 cases of medication administration incidences as proposed by Kim and Bates (2013:590) was used. Sampling was conducted as described in sections 1.8.2 and 1.8.3. From the ten sampled hospitals, two were excluded because ethical clearance had not been granted by the time the data-collection was done. By the time data-collection was completed, these two hospitals were allowed eight months of consideration for permission to conduct the research and still did not give any indication of granting or denying ethical clearance.

One medical and one surgical unit from each of the eight included hospitals were selected randomly. This was done by implementing the fishbowl method for random sampling – throwing in all numbers of compliant medical and surgical units respectively into an opaque bag and drawing one number from each selection. Of the originally selected units, no unit managers denied access to their units, and thus further unit sampling was not indicated.

3.3.2.2 Population and sampling for knowledge testing

The medication administrators who were administering medications in units sampled for the direct observation were included in this phase. 36 medication administrators were sampled (minimum two for each unit – one administering parenteral and one enteral medications).

3.3.3 Measures

3.3.3.1 Check-list for observing medication administration safety

The check-list was adapted from the check-list used by Kim and Bates (2013:591). The original tool was structured around the five rights of medication administration (right medication, right dose, right patient, right route and right time), adherence to basic infection control principles and recording. The checklist by Kim and Bates (2013:591) consisted of positive statements, such as “label the medication

immediately after preparation". However, the researcher chose to adapt this check-list to rather reflect the errors or deviations that did occur, thus the statements were changed to the negative, example: "Medications were not labelled immediately". This was done to prevent confusion during analysis, as the same headings could be reflected in the report. A space for indicating the rank of the medication administrator, the amount of different medications prescribed to the specific patient and the amount of interruptions occurring during the administration to the patient was added. Furthermore, omissions were added as possible error. Addendum X reveals the original check-list, while addendum XI includes the revised check-list.

Content validity of the original check-list was checked by three experts who were a head nurse, a charge nurse of a unit and a professor of a college of nursing, and it was used in several medication administration error studies with good validity and reliability reported (Kim & Bates, 2013:591). Content validity was again affirmed by the promoters and the statistician after the changes had been made.

3.3.3.2 Knowledge testing

Two basic dose-calculation sums were used to test these skills in the participants (Addendum XII). These two knowledge test questions were extracted from a test-paper previously used to test the calculation skills of first-year nursing students. This test was moderated externally and deemed fair and relevant to test these skills at first-year level. A pilot test was completed by a colleague in the School of Nursing Science after the questions had been submitted to the study promoters to ensure face and content validity. The sums were:

- Aterax 25mg / 25 kg is prescribed. One tablet = 25 mg. Your patient weighs 80kg, how many tablets will you administer? and
- The doctor prescribed 750 mg Rocephin IV to a patient. The vial contains 1 g. You dilute the substance with 4ml sterile water. How many millilitres will you administer?

3.3.3.3 Demographics sheet

The researcher compiled a demographics sheet in consultation with the promoters and statistician that was used to gather information about the hospital and the units

where observations were done. This sheet required information on the number of units and number of beds the hospital had, as well as the number of beds of the observed unit, occupancies on the day of observation, the average acuity of the patients in the unit that was observed, the number of patients representing each level of the AUKUH acuity/dependency tool and the number of staff (permanent, part-time and students) on the day of observation from the observed unit. The demographics sheet is added as Addendum XVII.

3.3.3.4 AUKUH acuity/dependency tool

The AUKUH Acuity/Dependency tool was based upon the classification of levels of care of critical care patients which have been adapted to support measurement across a range of units (AUKUH, 2015:5). This tool divides care into four levels, level 0 patients require hospitalisation, but their needs are met through normal unit care. Level 1 patients require more than baseline resources and are divided into level 1a patents who are acutely ill and requiring intervention or those who are unstable with a greater potential to deteriorate and level 1b patients who are in a stable condition but have an increased dependence on nursing support. Level 2 patients are unstable and at risk of deteriorating, while level three patients are in need of advanced respiratory support and therapeutic support of multiple organs (AUKUH, 2015:5). Further inclusion criteria and guidance on care required are provided in the tool for ease of use and quick reference (Addendum XVI).

Multipliers are provided to advise staffing levels appropriate for acuity levels. Multipliers are set out as Whole Time Equivalent (WTE) of which one WTE can be interpreted as one nurse working 37.5 hours a week (Hurst, 2002:3). The following multipliers are set out by AUKUH (2015:10):

Level 0: 0.79 WTE nurse per bed
Level 1a: 1.70 WTE nurse per bed
Level 1b: 1.86 WTE nurse per bed
Level 2: 2.44 WTE nurse per bed
Level three: 6.51 WTE nurse per bed.

Thus the AUKUH tool was used to both rate patient acuity and also to obtain an understanding of staffing levels that would be adequate to have nursed the patients

in the observed unit on the day of observations, thereby providing measures whereby the relationship between both acuity and staffing levels with medication error could be explored. The sum of the multipliers represents one week‟s staffing demand, therefore, the sum of the multipliers of the patients‟ acuity on the day of observation was divided by four, as one week is represented by four shifts‟ staff and only one shift‟s staff was counted on the day of observation.

The AUKUH tool was chosen because it is quick and easy to use (Ball, 2010:32) and thus did not cause extra workload to the unit staff as the researcher could directly apply the tool without encroaching on the time needed for medication administration observations. Furthermore, this tool was acknowledged to be used for benchmarking of staffing levels (Ball, 2010:32), the specific aim the researcher had in mind when choosing the tool. Though Ball (2010:32) mentioned that the AUKUH tool was not recommended for long-term forecasting, this limitation was not relevant to this study as only a brief overview on patient acuity and staffing levels on the day of observation was required. Sills (2013:2) confirmed that this tool provided a real-time picture of patient acuity and dependency. Another limitation of this tool was that it does not specify the needed skills mix among nurses. This implies that the tool will measure the staffing levels to be adequate even if no registered nurses were on duty but enough enrolled nurses were, which might skew the results to present a better image of the staffing levels than were in fact true as staff qualifications directly impact on the process of care and patient outcomes (Aiken *et al.*, 2002:2 and Paulson, 2004:307).

3.3.4.1 Data realisation for direct observation

The direct observational method was chosen for this phase of the study due to data collected through direct observation not being reliant on participants‟ honesty and the possibility thereof to uncover actions of which the participants themselves were unaware (Neale, 2009:228). During data collection, observations were structured by means of the check-list used by Kim and Bates (2013:590). Addendum XI reflects this check-list which was further discussed under 3.3.2.1.

Recruitment and the data-collection procedures realised as had been planned and discussed in section 1.8.2. All sampled medication administrators gave informed consent to be observed and tested. The researcher verbally confirmed the

participants‟ understanding and consent to participate in the research study before starting with the observations, and again ensured the participant of the confidentiality of the results and their right to withdraw from the study at any time. No medication administrators withdrew from the study at this point.

Only one observer (the researcher) performed the observations to ensure the credibility and validity of the observation. In order to minimise the Hawthorne effect, direct observation was only recorded after the third patient had received medication in an attempt to familiarise the participants with the observers‟ presence.

3.3.4.1 Data realisation for knowledge testing

After data collection from the planned amount of patients‟ medication-administrations (ten enteral and ten parenteral) were completed, the observer asked the relevant participant/s (depending on whether the same participant administered enteral and parenteral medications or whether two medication administrators were involved) to complete two calculations on medication dosages of medications often used in his/her hospital and unit, re-affirming his/her right to withdraw at this point as discussed in section 1.8.3. . Seven of the 36 medication administrators withdrew prior to the knowledge test. These participants agreed that observations done could be used in the study. They were treated in the same way as all other participants, thanked for their participation in the observation phase and given a pen.

Referring to the 25 medication administrators who agreed to complete this phase of the study, questions were completed in the same room as the researcher, so as to ensure truthfulness of the results. The participant was handed an envelope in which to seal the completed questions so that he/she did not feel anxious about the outcome of the test.

3.3.5.1 Data analysis for the direct observation

Statistical analysis in the form of frequencies of errors was performed. According to Bruce *et al.* (2008:49) a histogram can be used to present the frequency distribution of the data. Therefore, histograms were produced to indicate the aspects of medication administration that revealed the most errors, indicating both type of error and type of deviations from safe practice. Error incidence was extracted from the

data and analysed separately from deviations from safe practice. Frequencies of correct versus incorrect answers to the dose-calculation sums were also calculated.

P values (statistical significance derived from t-tests) and effect sizes (practical significance derived from Cramer"s V and correlations) of relationships between medication errors and acuity; staffing levels; occupancy; interruptions; unit type; administration route; hospital level; and the rank of medication administrator were used to obtain insight into these relationships. According to Whitley and Ball (2002:223) the p value measures how likely it is that any observed difference between groups is due to chance. Values close to 0 (zero) indicate that the observed difference is unlikely to be due to chance, whereas a p value close to 1 suggests there is no difference between groups other than that due to random variation (Whitley & Ball, 2002:223). P-values smaller or equal to 0.05 were considered statistically significant (Ellis & Steyn, 2003:1).

Cramer"s V was calculated to determine the effect size (practical significance) between incidence of medication errors or deviations from safe practice and type of unit, level of hospital or administration route. Correlations were calculated by means of the SAS software between incidence of medication administration errors or deviations from safe practice and patient acuity, staffing levels, percentage occupancy, interruptions and rank of medication administrator, taking into account the dependency of data on individual hospitals. According to Durlak (2009:918) the effect size gives an indication of the magnitude and direction of the difference between two groups or the relationship between two variables. Ellis (2003:52) explained that the effect size was conventionally interpreted as small if it is 0.10, medium if it is 0.30, or large if it is 0.50. An association with the effect size higher or equal to 0.5 was considered as practically significant.

Due to the unique nature of each hospital, associations between variables were tested firstly within singular hospitals. If differences between hospitals were not practically significant, variables were grouped together, and associations with hospital level (three groups), unit type (two groups), administration route (two groups) or rank of the administrator (three groups) were examined. If a practical significant difference between hospitals however was presented, more detailed analyses of associations were required to ensure that the hospital-dependence of

these associations were taken into account. Practical significance was reported even in the absence of statistical significance, as p-values are not relevant in the case of a non-random sample and are only reported for completeness.

Odds ratios were calculated for correlations with either practical or statistical significance, taking into account the dependency of variables within hospitals. Dancy *et al.* (2012:173) explain that if the odds of two groups are equal, the odds-ratio would be one. Altman (1991:268) further elaborated that the chance of a difference in outcomes between groups is measured by the size of the odds-ratio. For this reason, odds ratios close to one were not interpreted as significant, though ratios above two were deemed significant.

3.3.5.2 Data analysis for the knowledge testing

Descriptive statistics were used to report on dosage calculation mistakes.

3.4 RESULTS

Hospital demographics and unit demographics will be discussed, followed by descriptive results for medication administration errors. Medication administration errors will then discussed by error type (omissions, wrong medication-, wrong dosage-, wrong route-, wrong patient- and wrong time errors); hospital level (level one, level two and level three hospitals); unit type (medical or surgical) and administration route (enteral or parenteral). Following these descriptive results, the associations between medication administration errors and hospital level, unit type, administration route and medication administrator rank as determined by Cramer"s V will be discussed. Correlations between medication administration errors, occupancy, patient acuity, staffing levels and interruptions then followed.

Results of deviations from safe practice will follow. Deviation type (wrong medication related deviations, wrong dose related deviations, wrong patient related deviations, wrong-time related deviations, asepsis related deviations, documentation related deviations and interruptions) are presented per hospital level, unit type and administration route. Associations between these deviations and hospital level, unit type, administration route and medication administrator rank are then provided as

determined by Cramer‟s V, after which correlations between deviations from safe practice and occupancy, patient acuity, staffing and interruptions follow.

Medications most often involved in medication administration errors will be presented, where-after the results section will be concluded with the results from the knowledge test.

3.4.1 Hospital demographics

Level three hospitals had bed capacities between 850 and 857, while level two hospitals had bed capacities between 408 and 730 and level one hospitals between 126 and 178. The number of units varied from 26 and 28 in level three hospitals, ten and 22 in level two hospitals and seven and ten in level one hospitals.

3.4.2 Unit demographics

Observed unit demographics related to bed-count, beds occupied, percentage occupancy, average patient acuity as determined by the AUKUH tool, staff required for the observed shift as determined by the AUKUH tool, the number of staff and the percentage of the needed staff available were presented in Table 3.1.

Table 3.1: Unit demographics on day of observation in respective hospitals

Medical units

HOSPITALS	1a	1b	1c	2a	2b	2c	3a	3b	AVERAGE
Beds	27	41	30	42	42	31	40	40	37
Beds occupied	27	40	21	42	42	31	40	35	35
% Occupancy	100	98	70	100	100	100	100	88	94
Average acuity (AUKUH)	0.70	1.00	0.76	0.95	0.93	0.87	0.88	0.91	0.88
Staff required on shift (AUKUH)	10	17	7	18	18	12	16	15	14
Permanent staff	7	11	7	6	7	7	4	5	7
Part-time staff	0	0	0	0	0	0	0	0	0
Students	0	0	0	0	1	0	4	4	1
Total staff	7	11	7	6	8	7	8	9	8
Percentage of required staff available	71	64	100	33	45	57	50	61	60

Surgical units

HOSPITALS	1a	1b	1c	2a	2b	2c	3a	3b	AVERAGE
Beds	33	37	30	42	32	26	40	42	35
Beds occupied	30	23	14	38	32	26	40	40	30
% Occupancy	91	62	47	90	100	100	100	95	86
Average acuity (AUKUH)	0.43	0.22	0.43	0.16	0.59	0.38	0.83	0.40	0.43
Staff required on shift (AUKUH)	9	6	4	10	11	8	16	12	9
Permanent staff	8	6	7	7	4	7	3	4	6
Part-time staff	0	0	0	0	0	0	0	0	0
Students	0	4	0	0	2	2	2	4	2
Total staff	8	10	7	7	6	9	5	8	8
Percentage of required staff available	88	174	166	72	54	119	32	69	97

Most medical units were filled to capacity and on average harboured patients with higher acuity and lower staffing levels than those of surgical units. Only one medical unit had the optimal staffing level when compared to patient acuity levels, while three surgical units had more staff than was needed. However, two of these units‟ staffing levels exceeded what was needed because of students, who were not placed there permanently and who might have in turn added to the workload due to their need for constant supervision. On average, units were severely understaffed, with three units having had to function with fewer than 50% of the recommended staff.

3.4.3 Medication administration errors descriptive statistics

Medication administrations to a total of 315 patients were observed. Medication administration to twenty patients per unit could not always be observed as planned, due to there not being enough patients in the unit, time scheduled for observations not being honoured and/or time-restraints. However, administrations of 1847 prescribed doses were observed. 158 medical unit patients and 157 surgical unit patients were observed. 159 of these patients were observed while receiving enteral medications, while 156 were observed while receiving parenteral medications.

A total of 296 errors were identified. Though more than one error often occurred at one patient, on average one error was delivered to nine out of ten patients (94%). The most common types of errors were wrong-time errors at 43% (n = 127) and errors of omission at 41% (n = 122). Wrong-patient errors represented less than 1% of errors made (n = 1) while wrong-medication and wrong-route errors both represented 2% of the errors (n = 7 and n = 6 respectively). Wrong-dose errors represented 12% of the error-incidence (n = 33).

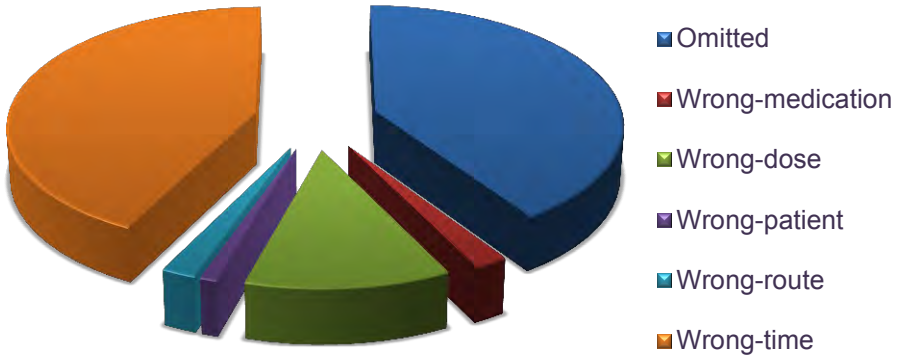


Figure 3.1: Error incidence by type of error

3.4.4 Type of medication administration error by hospital level, unit type and administration route

The most errors were observed in level two hospitals (n = 139, 117%) while the least errors were observed in level one hospitals (n = 74, 64%). Level three hospitals revealed a middling incidence of 83 errors (104%)

Overall, 3% more medication errors occurred while parenteral medications were administered than when enteral medications were administered (n = 149; 96% versus n = 147; 93%). However, when considering medical units only, enteral medication administration errors occurred more than parenteral medication administration errors (n = 82; 104% versus n = 74; 94%), which showed that an average of more than one medication administration error occurred during administration of enteral medication to medical unit patients. Overall medical units revealed more medication administration errors than surgical units (n = 156; 99% versus n = 140; 89%).

An overview of error incidence by type of error, hospital and unit type as well as route is reported in table 3.2 after which each error type was discussed individually with reference to hospital level, unit type and administration route.

Table 3.2: Error incidence by error type, hospital level, unit type and administration route

			Amount of observations done		Omitted f (%)		Wrong-medication f (%)		Wrong-dose f (%)		Wrong-patient f (%)		Wrong-route f (%)		Wrong-time f (%)		Total enteral f (%)	Total parenteral f (%)
			E‡	P‡	E	P	E	P	E	P	E	P	E	P	E	P		
Level 1 hospitals	a	Medical	9	10	3 (30)*	0 (0)	0 (0)*	0 (0)	1 (11)*	1 (10)	0 (0)*	0 (0)	0 (0)*	0 (0)	7 (78*)	0 (0)	11 (122)	1 (10)
	b	Medical	10	10	7 (70)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (20)	2 (20)	8 (80)	9 (90)	13 (130)
	c	Medical	10	10	5 (50)	4 (40)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (50)	4 (40)
		Total Medical	29	30	15 (52)	7 (23)	0 (0)	0 (0)	1 (4)	1 (3)	0 (0)	0 (0)	0 (0)	2 (7)	9 (31)	8 (27)	25 (86)	180 (60)
	a	Surgical	10	10	3 (30)	3 (30)	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	5 (50)	4 (40)	9 (90)
	b	Surgical	10	10	3 (30)	4 (40)	1 (10)	0 (0)	0 (0)	3 (30)	0 (0)	0 (0)	0 (0)	1 (10)	3 (30)	3 (30)	7 (70)	11 (110)
	c	Surgical	10	7	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)
		Total Surgical	30	27	6 (20)	7 (26)	1 (3)	0 (0)	0 (0)	4 (15)	0 (0)	0 (0)	0 (0)	1 (4)	4 (13)	8 (30)	11 (37)	20 (74)
	Total level one		59	57	21 (36)	14 (25)	1 (2)	0 (0)	1 (2)	5 (9)	0 (0)	0 (0)	0 (0)	3 (5)	13 (22)	16 (28)	36 (61)	38 (67)
Level 2 hospitals	a	Medical	10	10	0 (0)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	10 (100)	10 (100)	12 (120)
	b	Medical	10	9	4 (40)	6 (67)*	1 (10)	0 (0)*	1 (10)	2 (22)*	0 (0)	0 (0)*	0 (0)	0 (8)*	2 (20)	2 (22)*	8 (80)	10 (111)*
	c	Medical	10	10	2 (20)	7 (70)	0 (0)	1 (10)	2 (20)	2 (20)	0 (0)	0 (0)	0 (0)	1 (10)	10 (100)	5 (50)	14 (140)	16 (160)
		Total Medical	30	29	6 (20)	15 (52)	1 (3)	1 (3)	3 (10)	2 (14)	0 (0)	0 (0)	0 (0)	1 (3)	22 (73)	17 (57)	32 (107)	38 (131)
	a	Surgical	10	10	4 (40)	0 (0)	0 (0)	0 (0)	0 (0)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	8 (80)	10 (100)	12 (120)	13 (130)
	b	Surgical	10	10	11 (110)	3 (30)	0 (0)	0 (0)	0 (0)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	7 (70)	12 (120)	12 (120)
	c	Surgical	10	10	4 (40)	5 (50)	2 (20)	0 (0)	3 (30)	1 (10)	1 (10)	0 (0)	0 (0)	0 (0)	1 (10)	3 (30)	11 (110)	9 (90)
		Total Surgical	30	30	19 (63)	8 (27)	2 (7)	0 (0)	3 (30)	6 (20)	1 (3)	0 (0)	0 (0)	0 (0)	10 (33)	20 (67)	35 (117)	34 (140)
	Total level two		60	59	25 (42)	23 (39)	3 (5)	1 (2)	6 (10)	10 (17)	1 (2)	0 (0)	0 (0)	1 (2)	32 (53)	37 (63)	67 (112)	72 (122)
Level 3 hospitals	a	Medical	10	10	10 (100)	5 (50)	0 (0)	1 (10)	2 (20)	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	12 (120)	8 (80)
	b	Medical	10	10	2 (20)	4 (40)	0 (0)	0 (0)	1 (10)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	4 (40)	13 (130)	10 (100)
		Total Medical	20	20	12 (60)	9 (45)	0 (0)	1 (5)	3 (15)	3 (15)	0 (0)	0 (0)	0 (0)	0 (0)	10 (50)	5 (25)	25 (125)	18 (90)
	a	Surgical	10	10	6 (60)	5 (50)	0 (0)	0 (0)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	2 (20)	2 (20)	3 (30)	10 (100)	10 (100)
	b	Surgical	10	10	6 (60)	1 (10)	0 (0)	1 (10)	1 (10)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	2 (20)	7 (70)	9 (90)	11 (110)
		Total Surgical	20	20	12 (60)	6 (30)	0 (0)	1 (5)	3 (15)	2 (10)	0 (0)	0 (0)	0 (0)	2 (10)	4 (20)	10 (50)	19 (95)	21 (105)
	Total level three		40	40	24 (60)	15 (38)	0 (0)	2 (5)	6 (15)	5 (13)	0 (0)	0 (0)	0 (0)	2 (5)	14 (35)	15 (38)	44 (110)	39 (98)
Total Medical			79	79	33 (42)	31 (39)	1 (1)	2 (3)	7 (9)	8 (10)	0 (0)	0 (0)	0 (0)	3 (4)	41 (52)	30 (38)	82 (104)	74 (94)
Total Surgical			80	77	37 (46)	21 (27)	3 (4)	1 (1)	6 (8)	12 (16)	1 (1)	0 (0)	0 (0)	3 (4)	18 (23)	38 (49)	65 (85)	75 (97)
Total			159	156	70 (44)	52 (33)	4 (3)	3 (2)	13 (8)	20 (13)	1 (1)	0 (0)	0 (0)	6 (4)	59 (37)	68 (44)	147 (93)	149 (96)
																	296 (94)	

‡ E = Enteral, P = Parenteral

* Less than 10 patients' medication administration observed

3.4.4.1 Errors of omission

122 of 1847 prescribed doses were omitted (6%). On average an omission was bound to reach two in five patients (39%, n = 122). More doses were omitted in medical than in surgical units (n = 64 and n = 58), though these incidences were comparable. However, enteral medications were more involved in errors of omission than parenteral medications (n = 70 and n = 52) with three medical units and one surgical unit revealing contrary results (n = 2, 4, 2 and 3 enteral omissions versus 4, 6, 7 and 4 parenteral omissions).

Though omission incidence varied considerably between different hospitals, on average level three hospitals had more omissions than level two hospitals with 49% (n = 39) of patients in level three hospitals and 41% (n = 49) of patients in level two hospitals not receiving prescribed medications. In level one hospitals 31% (n = 35) of patients were subjected to omissions.

Though reasons for omissions could not be derived in all instances, nine recurring reasons were observed: 18% of total omissions (n = 21) were committed when *ter die sumendum* (tds [three times a day]) or *quater die sumendus* (qid [four times a day]) prescriptions were treated as *pro re nata* (prn [as needed]) prescriptions; 15% of all omissions (n = 18) were committed due to stock distribution problems; 4% of omissions (n = 5) occurred when patients were uncooperative; 3% of omissions (n = 3) occurred for each of the following reasons: the patient was not in the unit when medication rounds took place, the prescription was illegible and the patient was kept *nil per os* (npo [nothing per mouth]); 2% of omissions (n = 2) occurred due to charts that had not been reviewed and 2% more (n = 2) due to patients who vomited.

3.4.4.2 Wrong medication errors

Seven out of 315 patients (2%) received the wrong medications. These errors were equally distributed between medical and surgical units and between enteral and parenteral medications prescribed (n = 3 medical, n= 4 surgical, n = 4 enteral and n = 3 parenteral). Four out of seven wrong-medication errors (57%) occurred in level two hospitals.

3.4.4.3 Wrong dose errors

33 patients (11%) received a bigger or smaller dose than had been prescribed. More wrong-dose errors occurred in surgical units than in medical units (n = 18; 11% versus n = 15; 10%) while parenteral medications were more often involved in wrong-dose errors than enteral medications (n = 20; 13% versus n = 13; 8%). However, in one level three hospital"s medical and surgical units and one surgical unit of a level two hospital, enteral medication administrations revealed a greater incidence of this type of error. Both level three and level two hospitals revealed an average wrong-dose incidence of 14% (n = 11 and n = 16 respectively) while level one hospitals showed a lower wrong-dose incidence of 5% (n = 6).

3.4.4.4 Wrong-patient errors

Only one wrong-patient error was observed in a surgical unit of a level two hospital. This error occurred while enteral medication was being administered.

3.4.4.5 Wrong route errors

Six patients received wrong-route errors. These errors were evenly distributed between medical and surgical units with an incidence of three for both types of units. All of these errors were committed while administering parenteral medications. Parenteral prescribed medications were administered orally in all of these instances.

Two wrong-route errors occurred in level three hospitals (5%), while one wrong-route was observed in a level two hospital (2%) and three in level one hospitals (5%).

3.4.4.6 Wrong time errors

As the most prevalent medication error type observed, wrong-time errors affected a total of 127 of the 315 observed patients (40%) in a total of 173 doses administered (9% of doses prescribed). Though wrong time errors were more prevalent in medical enteral medication administrations (n = 41; 52%), it proved to be the second highest prevalence in surgical parenteral medication administrations (n = 38; 49%). Surgical enteral medication administrations revealed the lowest incidence of wrong type errors at 23% (n = 18).

Level two hospitals had the highest prevalence of these type of errors at 58% (n = 69), which showed that more than half of medications were administered either too late or too early in these hospitals. Level three hospitals with the second highest wrong-time-error prevalence revealed that more than a third of medications administered in these hospitals were administered too late or too early (n = 29; 36%). Though wrong-time errors were least prevalent in level one hospitals, one quarter of these hospitals‟ medications were still administered at the wrong time (n = 29; 25%).

Figure 3.2 provides an overview of observed medication errors by error type incidence in relation to unit type and administration route.

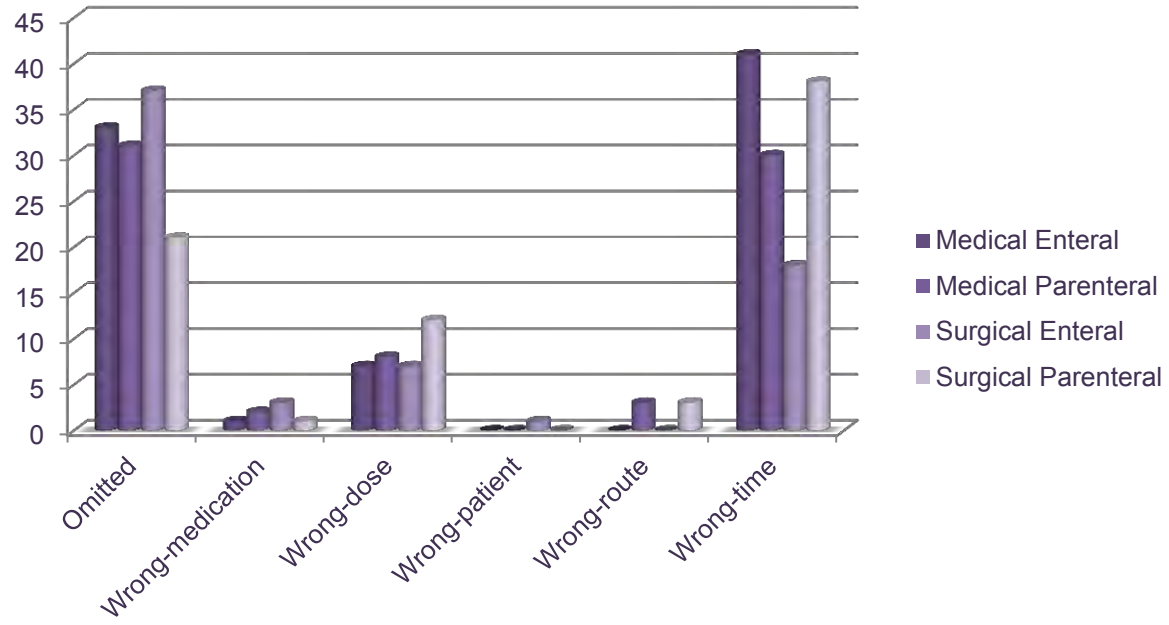


Figure 3.2: Error type by incidence indicating differences in unit and route outcomes

3.4.5 Associations between medication administration errors and hospital level, unit type, administration route and rank of the administrator

A consideration of the association between the different types of medication administration errors and hospital level, unit type, administration route and rank of the medication administrator now follows. Wrong patient errors were left out of this discussion as only one of these errors had been observed and no association with any of these variables could thus be determined. However, before general associations between these variables could be determined, the association between all eight hospitals and the incidence of medication administration errors had to be determined due to the possible dependency of data on the hospital.

3.4.5.1 Association of medication administration error incidence with individual hospitals

Table 3.3 presents the association between individual hospitals and the incidence of different types of medication administration errors.

Table 3.3 Associations of hospitals with medication administration error incidence

Error type	n	%	Cramer's V	p-value
Omission	100	32.0%	0.17	0.069
Wrong medication	7	2.2%	0.16	0.354
Wrong dose	32	10.2%	0.17	0.216
Wrong route	6	1.9%	0.20	0.077
Wrong time	127	40.6%	0.54	0.000

A practically and statistically significant association (Cramer"s V = 0.54; p = 0.000) between wrong time errors and specific hospitals was identified.

The highest percentage of wrong time errors were observed in a level two hospital (n = 38). 95.0% of patients observed in this hospital were affected by these errors. In one level one hospital, no wrong time errors were observed, while all other hospitals displayed a range of wrong time errors between 15.0% and 57.5% (n = 6 to 23). Due to the strong dependency on specific hospitals, wrong time errors as medication administration error type was considered both within different groupings and separately during the exploration of all other associations.

3.4.5.2 Associations pertaining to hospital level

Table 3.4 presents the association between hospital level and the incidence of errors of omission, wrong medication errors, wrong dose errors, wrong route errors and wrong time errors.

Table 3.4 Association between hospital level and error incidence

Error type	n	%	Cramer's V	p-value
Omission	100	32.0%	0.17	0.069
Wrong medication	7	2.2%	0.07	0.432
Wrong dose	32	10.2%	0.11	0.110
Wrong route	6	1.9%	0.06	0.552
Wrong time	127	40.6%	0.29	0.000

Only one statistically significant association between medication administration error type and hospital levels was identified. Hospital level revealed to be associated with wrong time errors (Cramer"s V = 0.29; p = 0.000). Although overall more wrong time errors were observed in level two hospitals it is important to remember that different hospitals were significantly associated with wrong time errors (section 3.5.5.1), thus making it dangerous to assume a generalized increased wrong time error rate within a specific hospital level.

3.4.5.3 Associations pertaining to unit type

Table 3.5 presents the association between unit type and medication administration error by error type.

Table 3.5 Association between unit type and error incidence

Error type	n	%	Cramer's V	p-value
Omission	100	32.0%	0.09	0.782
Wrong medication	7	2.2%	0.02	0.709
Wrong dose	32	10.2%	0.08	0.399
Wrong route	6	1.9%	0.00	0.994
Wrong time	127	40.6%	0.10	0.076

The unit type did not associate significantly with any medication administration error type incidence. Taking into account that hospitals were associated with wrong time errors, Table 3.6 provides an overview of all significant associations between unit type and wrong time error incidence as considered dependent on the hospital in which data were collected.

Table 3.6 Hospital dependent association between wrong time error incidence and unit type

Hospital	Unit type	n	%	Cramer's V	p-value
2c	Medical	15	75.0%	0.55	0.000
	Surgical	4	20.0%		

A practical as well as statistical significance to the association between wrong time errors and unit type was revealed in one level two hospital (Cramer's V = 0.55 and p = 0.000). In this hospital, more wrong time errors were committed in medical units.

3.4.5.4 Associations pertaining to administration route

Table 3.7 presents the associations between administration route and medication administration error by error type.

Table 3.7 Associations between administration route and error incidence

Error type	n	%	Cramer's V	p-value
Omission	100	32.0%	0.12	0.464
Wrong medication	7	2.2%	0.02	0.709
Wrong dose	32	10.2%	0.11	0.142
Wrong route	6	1.9%	0.14	0.013
Wrong time	127	40.6%	0.06	0.279

No practically significant association between the administration route and medication administration error incidence could be identified, though a statistically significant association was identified between the administration route and wrong route errors, indicating that parenteral medications were more often administered via the wrong route.

Again it is important to remember the dependence of wrong time errors on specific hospitals, thus the association between wrong time errors and unit type should be considered within individual hospitals. However, no significant association between unit type and this type of errors could be identified in any hospital.

3.4.5.5 Associations pertaining to medication administrator rank

Table 3.8 presents the associations between medication administrator rank and medication administration error by error type.

Table 3.8 Associations between medication administrator rank and error incidence

Error type	n	%	Cramer's V	p-value
Omission	100	32.0%	0.17	0.056
Wrong medication	7	2.2%	0.21	0.001
Wrong dose	32	10.2%	0.13	0.032
Wrong route	6	1.9%	0.15	0.030
Wrong time	127	40.6%	0.12	0.122

As only effect sizes greater than 0.5 were considered practically significant, no practically significant association was identified between errors and the rank of the medication administrator could be identified, though statistical significance was assigned to the associations between wrong medication errors, wrong dose errors and wrong route errors when taking into account the rank of the medication administrator.

When considering that wrong time errors are dependent on specific hospitals, one significant association between the rank of the administrator and these type of errors were identified in one hospital. Table 3.9 presents this association.

Table 3.9 Hospital dependent association between wrong time error incidence and medication administrator rank

Hospital	Administrator rank	n	%	Cramer's V	p-value
2c	Registered nurse	8	40.0%	0.72	0.000
	Enrolled nurse	11	100.0%		
	Student nurse	0	0.0%		

In one level two hospital, the incidence of wrong time errors was practically and significantly associated with the rank of the administrator (Cramer's V = 0.72; p = 0.000). In this hospital, all eleven patients that were observed as receiving

medications from enrolled nurses received their medications at the wrong time. 40% (n = 8) of the twenty medications administered by registered nurses were administered late, while student nurses managed to administer their nine observed medications on time.

3.4.6 Correlations between medication administration errors, unit occupancy, patient acuity, percentage of required staff available and interruptions

Table 3.10 indicates the correlation coefficients between certain unit demographical data (such as bed occupancy, average patient acuity and percentage of required staff available on the observation day), interruptions as deviation from safe practice, and the incidence of medication errors by error type. In these correlations the dependency of measurements from the same hospital has been taken into account.

Table 3.10 Correlation between unit demographics, interruptions and medication error, taking into account the dependency of measurements in a hospital

	% Occupancy	Average patient acuity	% of required staff available	Interruptions
Error of omission	0.181*	0.104	0.141	-0.000
Wrong medication error	0.034	-0.040	0.048	-0.016
Wrong dose error	0.071	-0.061	-0.004	-0.115*
Wrong route error	0.023	0.072*	-0.025	-0.045
Wrong time error	0.222	0.054	-0.251	-0.029

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

Errors of omission were correlated with percentage occupancy (r = 0.181, p = 0.036). Though of no statistical significance, the average patient acuity and percentage of staff available had a small effect on errors of omission (r = 0.104 and 0.141 respectively, p = 0.149 and 0.201).

No correlation could be identified between any of the unit demographical variables and wrong medication errors.

Interruptions correlated negatively with wrong dose errors (r = 0.115, p = 0.029). It was observed that medication administrators often rechecked the prescription after

an interruption took place, which might have led to the decrease in wrong-dose errors with an increase of interruptions.

Though of statistical significance the correlation between the average patient acuity and wrong route errors was not practically significant (r = 0.072, p = 0.046).

Wrong time errors were correlated with percentage occupancy (r = 0.222, p = 0.089) and with the percentage of the required staff being available (r = 0.251, p = 0.146) though these correlations were not of statistical significance.

3.4.7 Odds ratio calculation for correlations

Table 3.11 reports the odds ratios calculated for the correlations identified in table 3.9 that were practically or statistically significant or that had a medium practical correlation. Dependency of variables within hospitals was taken into account. For these odds ratios errors were either reported as present or not, thus being counted as either zero or one.

Table 3.11 Odds ratios

	% Occupancy		Average patient acuity		% of required staff available		Interruptions	
	Unadjusted odds ratios							
	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]
Error of omission	1.03*	1.00-1.06						
Wrong medication error								
Wrong dose error							2.56*	0.16-0.91
Wrong route error			10.55*	1.32-84.25				
Wrong time error	1.04	0.99-1.08			0.99	0.97-1.00		

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

Two significant correlations were determined by means of odds ratios. Firstly, a statistical significant inversed correlation with medium effect was identified between wrong dose errors and interruptions (OR = 2.56, p <0.05). Thus, for every interruption, the medication administrator was 2.56 times less likely to commit a

wrong dose error, possibly due to double-checking the prescription after the interruption has passed.

The only other correlation confirmed by odds ratio was the statistical and practical significant relationship between the average patient acuity and wrong route errors (*OR* = 10.55; $p < 0.05$). One could deduct that wrong route errors increase tenfold with every point the average patient acuity of the unit climbed on the AUKUH scale. The interval of this odds ratio result is very wide, indicating that the average patient acuity of the unit could hold as little as 1.32 times the threat of wrong route errors and up to 84.25 times the threat. This could be due to the fact that very ill patients often receive numerous parenteral medications, which is easily substituted by medication administrators for oral medications that is less time-consuming and easier to administer.

3.4.8 Type of deviations from safe practice hospital level, unit type and administration route

For each of the medication errors described, associated deviations from safe practices were identified. A discussion of these deviations follows.

3.4.8.1 Wrong medication related deviations from safe practice

Table 3.12 provides an overview of deviations from safe practices related to the wrong medication error. These include the medication name not read on the label; the medication name not read on the prescription; medication was prepared and administered by different medication administrations; and medication was not labelled immediately after the preparation thereof.

Table 3.12 Incidence of wrong-medication error related deviations from safe practice by deviation type, hospital level, unit type and administration route

			Amount of observations done		Medication name not read on label f (%)		Medication name not read on prescription f (%)		Medication prepared and administered by different administrators f (%)		Medication not labelled immediately f (%)		Total enteral f (%)	Total parenteral f (%)
			E‡	P‡	E	P	E	P	E	P	E	P		
Level 1 hospitals	1	Medical	9	10	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	1 (10)	0 (0)	1 (10)
	2	Medical	10	10	1 (10)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	6 (60)	2 (20)	6 (60)
	3	Medical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	3 (33)	0 (0)	0 (0)	0 (0)	3 (33)	0 (0)
		Total Medical	29	30	1 (4)	0 (0)	1 (4)	0 (0)	3 (10)	0 (0)	0 (0)	7 (23)	5 (17)	7 (23)
	1	Surgical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (30)	0 (0)	3 (30)
	2	Surgical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	1 (10)	1 (10)	1 (10)
	3	Surgical	10	7	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	2 (29)*	0 (0)	2 (29)
		Total Surgical	30	27	0 (0)	0 (0)	0 (0)	0 (0)	1 (33)	0 (0)	0 (0)	6 (22)	1 (3)	6 (22)
	Total level one		59	57	1 (2)	0 (0)	1 (2)	0 (0)	4 (7)	0 (0)	0 (0)	13 (23)	6 (10)	13 (23)
Level 2 hospitals	1	Medical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	0 (0)	10 (100)
	2	Medical	10	9	0 (0)	0 (0)*	1 (10)	0 (0)*	3 (30)	2 (20)*	0 (0)	1 (13)*	4 (40)	3 (33)
	3	Medical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)	2 (29)	0 (0)	3 (30)
		Total Medical	30	29	0 (0)	0 (0)	1 (3)	0 (0)	3 (10)	3 (10)	0 (0)	13 (43)	4 (13)	16 (53)
	1	Surgical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (60)	0 (0)	6 (60)
	2	Surgical	10	10	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	1 (13)	0 (0)	2 (20)
	3	Surgical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
		Total Surgical	30	30	0 (0)	0 (0)	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)	7 (23)	0 (0)	8 (27)
	Total level two		60	59	0 (0)	0 (0)	0 (0)	1 (2)	3 (5)	3 (5)	0 (0)	20 (34)	4 (7)	24 (41)
Level 3 hospitals	1	Medical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (20)	0 (0)	1 (10)	0 (0)	3 (30
	2	Medical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7 (70)	0 (0)	7 (70
		Total Medical	20	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (10)	0 (0)	8 (40)	0 (0)	10 (50)
	1	Surgical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	2	Surgical	10	10	0 (0)	1 (10)	0 (0)	1 (10)	0 (0)	1 (10)	0 (0)	9 (90)	0 (0)	12 (120)
		Total Surgical	20	20	0 (0)	1 (5)	0 (0)	1 (5)	0 (0)	1 (10)	0 (0)	9 (45)	0 (0)	12 (60)
	Total level three		40	40	0 (0)	1 (3)	0 (0)	1 (3)	0 (0)	3 (8)	0 (0)	17 (43)	0 (0)	22 (55)
Total Medical			79	79	1 (1)	0 (0)	2 (3)	0 (0)	6 (8)	5 (6)	0 (0)	28 (35)	9 (11)	33 (42)
Total Surgical			80	77	0 (0)	1 (1)	0 (0)	2 (3)	1 (1)	1 (1)	0 (0)	22 (29)	1 (1)	26 (34)
Total			159	156	1 (1)	1 (1)	2 (1)	2 (1)	7 (4)	6 (4)	0 (0)	50 (32)	10 (6)	59 (38)
													69 (22)	

‡ E = Enteral, P = Parenteral

* Less than 10 patients' medication administration observed

Both the medication-name-not-read-on-label and the medication-name-not-read-on-prescription deviations from safe practice occurred very seldom (n = 2; 1% and n = 4; 3% respectively). Both of these incidences only occurred during the administration of enteral medications in medical units and during the administration of parenteral medications in surgical units. These deviations seemed to be isolated, not specific to any hospital level.

When medication administrators worked together during a medication round, it sometimes happened that one administrator took a place at the patient‟s file and prepared the medication (usually a registered nurse) while the other administrator would do the actual administration thereof (usually an enrolled nurse). This custom

led to the omission of the last double check when the medication was to be correlated a last time with the prescription before administration and was therefore seen as a deviation from safe practice.

This deviation mostly occurred in medical units (n = 11; 7%), while it was only observed twice in surgical units (1%). Even distribution of this deviation between enteral and parenteral medication administration instances occurred (n = 6; 8% and n = 5; 6% in medical units and n = 1; 1% and n = 1; 1% in surgical units). Incidence of this deviation was found to be highest in level two hospitals, effecting one in ten patients‟ medication administration (n = 6; 10%), while the incidence thereof was the lowest in level one hospitals, affecting only four of the observed patients (3%). Level three hospitals had a one per cent higher incidence at 4% (n = 3) than that of level one hospitals.

Though not-labelling-medication-immediately was not seen to be relevant to enteral medication administration, it still revealed to be the most common wrong-medication associated deviation from safe practice. 50 prepared doses (32%) of all administered parenteral medications were not labelled after preparation. This tendency was a bit higher in medical than in surgical units with an incidence of 35% (n = 28) in medical units and 29% (n = 22) in surgical units.

The incidence of medication not being labelled immediately decreased as the hospital level decreased (n = 17, 34% in level three hospitals, n = 20, 34% in level two hospitals and n = 13, 23% in level one hospitals). Figure 3.3 provides an overview of observed wrong-medication related deviations from safe practice by deviation type incidence in relation to unit type and administration route.

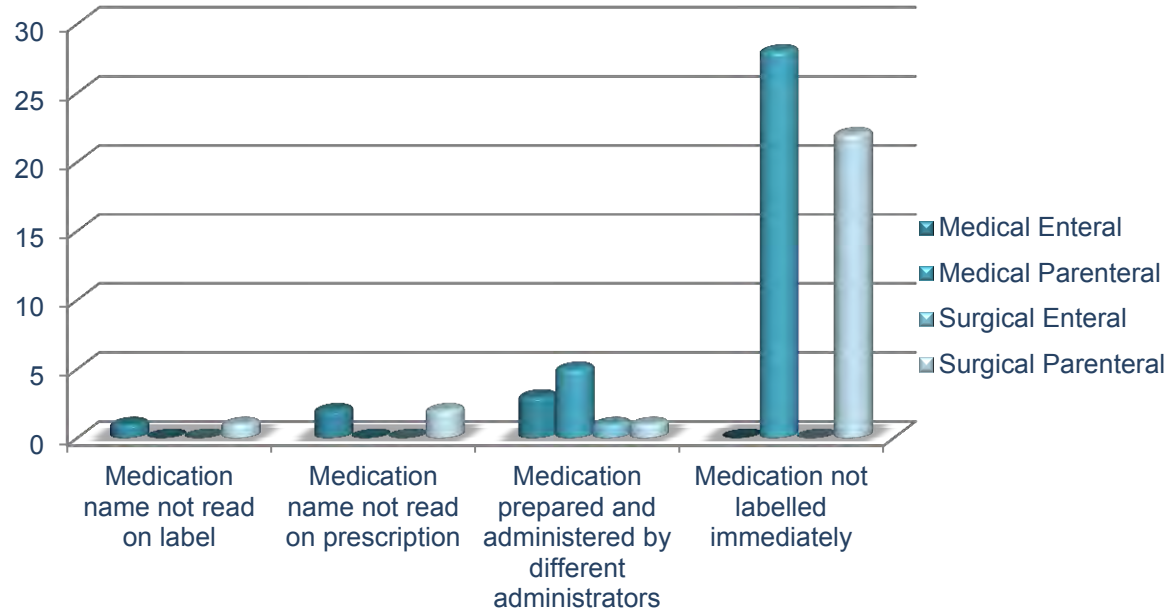


Figure 3.3 Wrong-medication related deviations from safe practice incidence indicating differences in unit and route practices

3.4.8.2 Wrong dose related deviations from safe practice

Table 3.13 provides a summary of the observed incidence and tendencies of wrong-dose related deviations from safe practice. Wrong-dose-error deviations include the dosage not read on the label, the dosage not read on the prescription and syringe markings not read at eye level.

Table 3.13 Incidence of wrong-dose-error related deviations from safe practice by deviation type, hospital level, unit type and administration route

			Amount of observations done		Dosage not read on label f (%)		Dosage not read on prescription f (%)		Syringe markings not read at eye level f (%)		Total enteral f (%)	Total parenteral f (%)
			E‡	P‡	E	P	E	P	E	P		
Level 1 hospitals	a	Medical	9	10	0 (0)*	1 (10)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)	1 (10)
	b	Medical	10	10	1 (10)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	2 (20)	0 (0)
	c	Medical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
		Total Medical	29	30	1 (5)	1 (5)	1 (5)	0 (0)	0 (0)	0 (0)	2 (7)	1 (3)
	a	Surgical	10	10	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)
	b	Surgical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (20)	0 (0)	2 (20)
	c	Surgical	10	7	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)
		Total Surgical	30	27	0 (0)	1 (5)	0 (0)	0 (0)	0 (0)	2 (7)	0 (0)	3 (11)
	Total level one		59	57	1 (2)	2 (3)	1 (2)	0 (0)	0 (0)	2 (3)	2 (3)	4 (18)
Level 2 hospitals	a	Medical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	b	Medical	10	9	0 (0)	1 (10)*	0 (0)	2 : 20*	0 (0)	0 (0)*	0 (0)	3 (30)
	c	Medical	10	10	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	1 (10)
		Total Medical	30	29	0 (0)	1 (5)	0 (0)	3 (10)	0 (0)	0 (0)	0 (0)	4 (13)
	a	Surgical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (30)	0 (0)	3 (30)
	b	Surgical	10	10	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)	2 (20)
	c	Surgical	10	10	0 (0)	0 (0)	2 (20)	0 (0)	0 (0)	0 (0)	2 (20)	0 (0)
		Total Surgical	30	30	0 (0)	1 (5)	2 (7)	0 (0)	0 (0)	4 (13)	2 (7)	5 (17)
	Total level two		60	59	0 (0)	2 (3)	2 (3)	3 (5)	0 (0)	4 (7)	2 (3)	9 (15)
Level 3 hospitals	a	Medical	10	10	0 (0)	1 (10)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	2 (20)
	b	Medical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
		Total Medical	20	20	0 (0)	1 (5)	0 (0)	1 (5)	0 (0)	0 (0)	0 (0)	2 (10)
	a	Surgical	10	10	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)
	b	Surgical	10	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)	1 (10)
		Total Surgical	20	20	1 (5)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	1 (5)	1 (5)
	Total level three		40	40	1 (3)	1 (3)	0 (0)	1 (3)	0 (0)	1 (3)	1 (3)	3 (8)
Total Medical			79	79	1 (1)	3 (4)	1 (1)	4 (5)	0 (0)	0 (0)	2 (3)	7 (9)
Total Surgical			80	77	1 (1)	2 (3)	2 (3)	0 (0)	0 (0)	7 (9)	3 (4)	9 (12)
Total			159	156	2 (1)	5 (3)	3 (2)	4 (3)	0 (0)	7 (5)	5 (3)	16 (10)
											21 (7)	

‡ E = Enteral, P = Parenteral
* Less than 10 patients' medication administration observed

21 deviations from safe practice related to wrong dose errors were observed (7%). In seven cases (2%) the dose was not controlled on the medication label. This deviation occurred more often when parenteral medications were administered (n = 5; 3%) than when enteral medications were administered (n = 2; 1%). Medical units showed a slightly higher incidence of this deviation from safe practice than surgical units did (n = 4; 3% in medical units versus n = 3; 2% in surgical units). Two of these

deviations took place in both level two and level three hospitals (effecting 3% of patients in both of these levels of hospitals) while three took place in level one hospitals (effecting 5% of patients in these hospitals).

The prescription was not consulted for the dosage prescribed in seven instances (2%). Medical units revealed a higher incidence of dosage not read on the prescriptions than surgical units (n = 5; 3% in medical units compared to n = 2; 1% in surgical units). Parenteral medication administration was more often involved in this deviation (n = 4; 3%) when compared to the administration of enteral medications (n = 3; 2%). While this deviation was observed once in both level one and level three hospitals (affecting 2% and 3% respectively of patients observed in these hospitals), level two hospitals revealed a higher incidence of these deviations at 9% of patients observed in these hospitals being affected (n = 5).

Markings on syringes not read at eye-level were seen to be a deviation from safe practice when administering parenteral medications. All of these type of deviations were observed in surgical units (n = 7, 9% of patients in surgical units effected). Again, level two hospitals were found to have the highest incidence of this deviation at 7% of observed patients in these hospitals effected (n = 4). 3% of observed patients in level three hospitals (n = 1) and another 3% of patients observed in level one hospitals (n = 2) were affected by this deviation.

Figure 3.4 provides an overview of observed wrong-dose-related deviations from safe practice by deviation-type-incidence in relation to unit-type and administration-route.

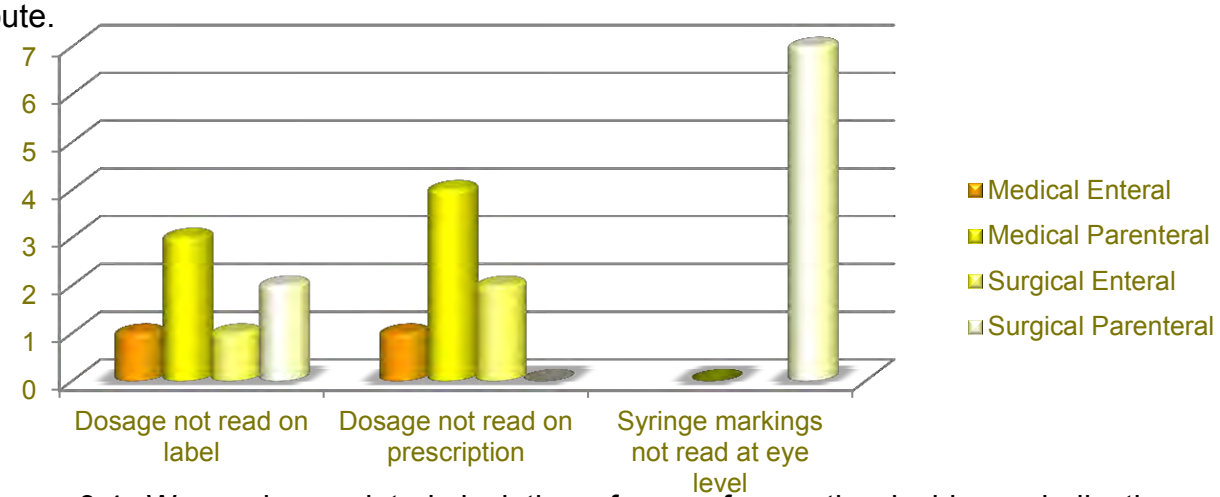


Figure 3.4: Wrong-dose related deviations from safe practice incidence indicating differences in unit and route practices

3.4.8.3 Wrong patient related deviations from safe practice

Table 3.14 provides a summary of the observed incidence of wrong-patient-error related deviations from safe practice in relation to unit type and administration route. This type of deviation includes the wristband not read, the patient‟s name not asked and the patient name not read on the prescription.

Table 3.14 Incidence of wrong-patient-error related deviations from safe practice by deviation type, hospital level, unit type and administration route

					Wristband not read f (%)		Patient's name not asked f (%)		Patient name not read on prescription f (%)		Total enteral f (%)	Total parenteral f (%)
			Amount of observations done		E‡	P‡	E‡	P‡	E‡	P‡		
Level 1 hospitals	a	Medical	9	10	6 (67)*	9 (90)	6 (67)*	10 (100)	0 (0)*	0 (0)	12 (133)	19 (190)
	b	Medical	10	10	9 (90)	10 (100)	9 (90)	5 (50)	1 (10)	0 (0)	19 (190)	15 (150)
	c	Medical	10	10	9 (90)	10 (100)	8 (80)	8 (80)	0 (0)	2 (20)	17 (170)	20 (200)
		Total Medical	**29**	**30**	24 (83)	29 (97)	23 (79)	23 (77)	1 (4)	2 (7)	48 (166)	54 (90)
	a	Surgical	10	10	10 (100)	7 (70)	10 (100)	7 (70)	0 (0)	0 (0)	20 (200)	14 (140)
	b	Surgical	10	10	10 (100)	10 (100)	10 (100)	5 (50)	0 (0)	0 (0)	20 (200)	15 (150)
	c	Surgical	10	7	6 (60)	7 (100)*	6 (60)	7 (100)*	0 (0)	0 (0)*	12 (120)	14 (200)
		Total Surgical	**30**	**27**	26 (87)	24 (89)	26 (87)	19 (70)	0 (0)	0 (0)	52 (173)	43 (159)
	Total level one		**59**	**57**	50 (85)	53 (93)	49 (83)	42 (74)	1 (2)	2 (4)	100 (170)	97 (170)
Level 2 hospitals	a	Medical	10	10	10 (100)	8 (80)	10 (100)	9 (90)	0 (0)	0 (0)	20 (200)	17 (170)
	b	Medical	10	9	10 (100)	9 (100)*	10 (100)	9 (100)*	3 (30)	2 (22)*	23 (230)	20 (222)
	c	Medical	10	10	10 (100)	5 (50)	9 (90)	5 (50)	1 (10)	0 (0)	20 (200)	10 (100)
		Total Medical	**30**	**29**	30 (100)	22 (76)	29 (97)	23 (79)	4 (13)	2 (7)	63 (210)	47 (160)
	a	Surgical	10	10	2 (20)	10 (100)	0 (0)	10 (100)	0 (0)	1 (10)	2 (20)	21 (210)
	b	Surgical	10	10	10 (100)	10 (100)	10 (100)	10 (100)	0 (0)	0 (0)	20 (200)	20 (200)
	c	Surgical	10	10	9 (90)	10 (100)	8 (80)	10 (100)	3 (30)	0 (0)	20 (200)	20 (200)
		Total Surgical	**30**	**30**	21 (70)	30 (100)	18 (60)	30 (100)	3 (10)	1 (3)	42 (140)	61 (203)
	Total level two		**60**	**59**	51 (85)	52 (88)	47 (78)	53 (90)	7 (12)	3 (5)	105 (175)	108 (183)
Level 3 hospitals	a	Medical	10	10	7 (70)	8 (80)	4 (40)	7 (70)	0 (0)	4 (40)	11 (110)	19 (190)
	b	Medical	10	10	0 (0)	2 (20)	0 (0)	6 (60)	0 (0)	0 (0)	0 (0)	8 (80)
		Total Medical	**20**	**20**	7 (35)	10 (50)	4 (20)	13 (65)	0 (0)	4 (20)	11 (55)	27 (135)
	a	Surgical	10	10	5 (50)	9 (90)	4 (40)	6 (60)	1 (10)	5 (50)	10 (100)	20 (200)
	b	Surgical	10	10	0 (0)	4 (40)	2 (20)	2 (20)	0 (0)	0 (0)	2 (20)	6 (60)
		Total Surgical	**20**	**20**	5 (25)	13 (65)	6 (30)	8 (40)	1 (5)	5 (25)	12 (60)	26 (130)
	Total level three		**40**	**40**	12 (30)	23 (58)	10 (25)	21 (53)	1 (3)	9 (23)	23 (58)	53 (132)
Total Medical			**79**	**79**	61 (77)	61 (80)	56 (71)	59 (79)	5 (6)	8 (11)	122 (154)	128 (162)
Total Surgical			**80**	**77**	52 (66)	67 (87)	50 (63)	57 (74)	4 (5)	6 (8)	106 (133)	130 (169)
Total			**159**	**156**	113 (71)	128 (82)	106 (67)	116 (74)	9 (6)	14 (9)	228 (143)	258 (165)
												486 (154)

‡ E = Enteral, P = Parenteral

* Less than 10 patients' medication administration observed

Not reading the patients‟ wristbands was found to be the most prevalent wrong patient-related deviation from safe practice at an incidence of 77% of patients involved (n = 241). In total, medical units were affected more than surgical units (n =

122; 77% and 119; 75% respectively) though during parenteral medication administrations in surgical units a higher incidence of this type of deviation was revealed (n = 67; 87% of patients in these units effected). In medical units, incidences of wristbands not read were similar during the administration of parenteral and enteral medications (n = 61 in both instances; 77% in enteral cases and 80% in parenteral cases). Level three hospitals revealed the lowest incidence of this deviation from safe practice, with 35 observed patients‟ wristbands not read (44%) while both level one and level two hospitals had an incidence of 103 patients‟ wristbands not read (89% and 87% respectively).

Most patients were also not asked to confirm their name (n = 222; 71%). Medical units revealed the greatest incidence of this deviation from safe practice at 115 (73%) compared to the lower incidence of 107 patients‟ names not asked in surgical units (68%). In both medical and surgical units the parenteral medication administrations had a higher incidence of patients whose names were not asked than enteral medication administrations (n = 59; 78% versus n = 56; 71% in medical units and n = 57; 74% versus n = 50; 63% in surgical units). Level three hospitals again shared a lower incidence of this wrong-patient-error related deviation from safe practice at 31 (39%) with level one hospitals (n = 91; 79%) while level two hospitals showed the highest incidence of this deviation at 100 (84%).

In total, 23 patients‟ names were not read on the prescription (7%). The difference between medical and surgical and parenteral and enteral medication administrations reflected the same relationship as that determined for patients whose names were not asked. The names of eight patients receiving parenteral medication in medical units were not controlled with the prescription (11%) while this happened five times when enteral medications were administered (6%). Six patients‟ names were not read on the prescription when parenteral medications were administered in surgical units (8%) while four patients were subjected to this deviation when enteral medication was administered in these units (5%). Almost half of these observed deviations (n = 10) occurred in one level three hospital, subjecting 13% of their patients to this type of deviation. A further ten patients‟ names were not read on the prescription in two level two hospitals (8%), while only three of these wrong-patient-error related deviations from safe practice occurred in level one hospitals (3%).

Figure 3.5 provides an overview of observed wrong-patient related deviations from safe practice by deviation type incidence in relation to unit type and administration route.

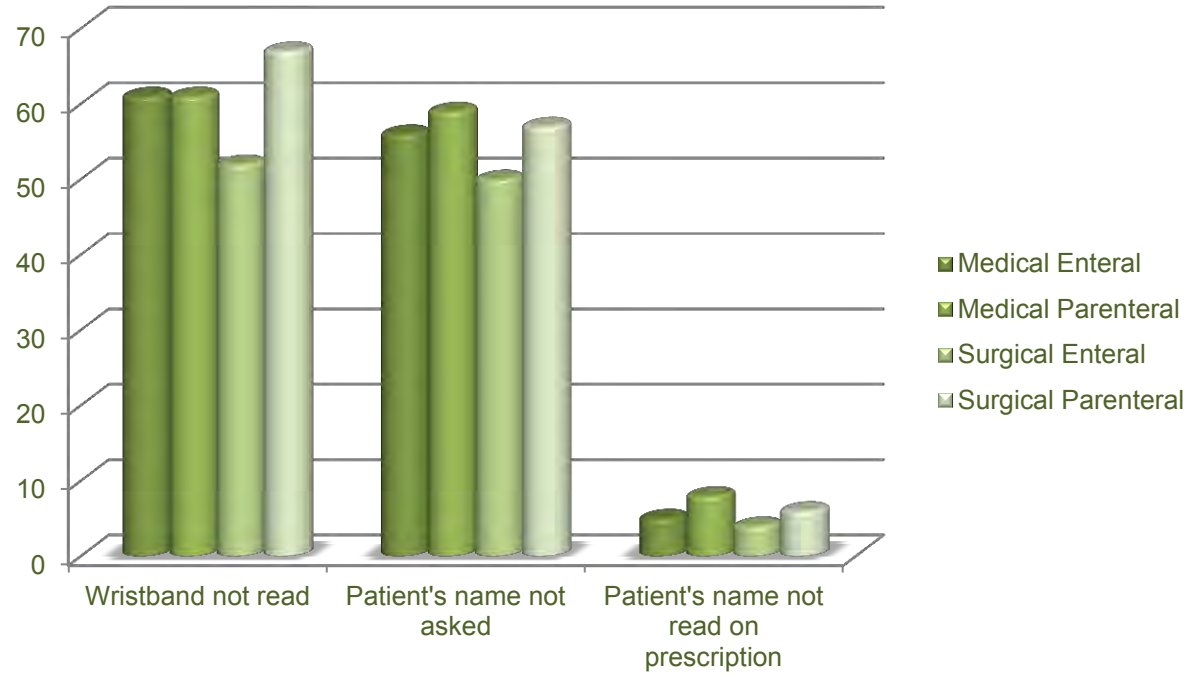


Figure 3.5: Wrong-patient related deviations from safe practice incidence indicating differences in unit and route practices

3.4.8.4 Wrong route related deviations from safe practice

Only six deviations from safe practice related to administration route were observed from all 1847 doses. Though three of these deviations occurred in both medical and surgical units, these units were from five different hospitals. None of the doses observed were administered via routes not applicable to the medications. The six deviations where the prescription was not read to determine the relevant route occurred mostly when parenteral medications were prescribed (n = 5), while only one occurred when enteral medication was prescribed in a medical unit of a level one hospital. Three of these deviations originated in level three hospitals, while the other two occurred in level two hospitals.

Figure 3.6 provides an overview of observed wrong-route related deviations from safe practice by deviation type incidence in relation to unit type and administration route. Wrong-route related deviations included the route not read on the prescription and the administration route not being applicable to the specific medication.

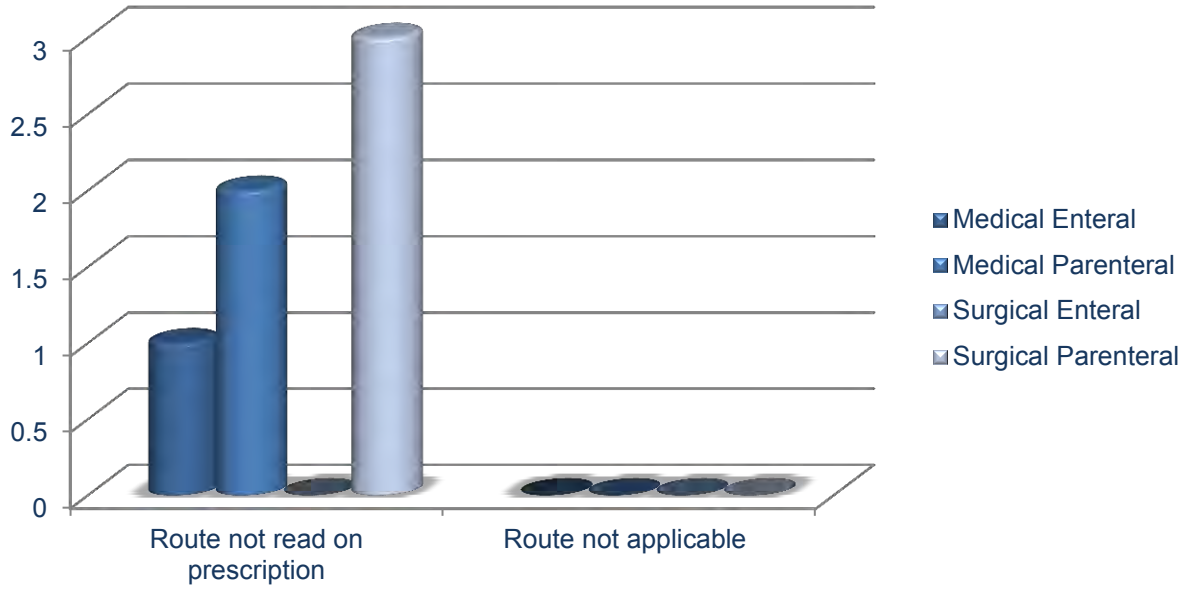


Figure 3.6: Wrong-route related deviations from safe practice incidence indicating differences in unit and route practices

3.4.8.5 Wrong time related deviations from safe practice

Of the 315 patients‟ medications observed, only 14 doses were not prepared directly before administration. 79% (n = 11) of these wrong-time-error related deviations occurred in medical units, and ten of these were observed within one medical unit of a level one hospital. Of the observed doses not prepared directly prior to administration, one enteral dose was prepared long before administration and thirteen were parenteral doses that were not prepared directly prior to administration. One of these deviations occurred in a level three hospital, one in a level two hospital, and the rest in level one hospitals.

Figure 3.7 provides an overview of observed wrong-time related deviations from safe practice by deviation type incidence in relation to unit type and administration route. This type of deviation occurred when medications were not prepared directly before administration.

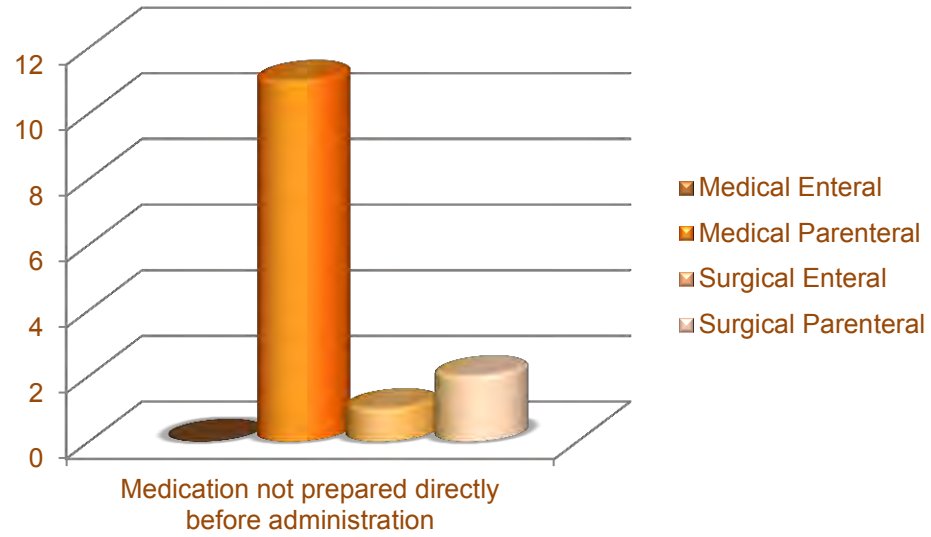


Figure 3.7 Wrong-time related deviations from safe practice incidence indicating differences in unit and route practices

3.4.8.6 Asepsis-related deviations from safe practice

Asepsis-related deviations include hands not disinfected, hands disinfected for less than fifteen seconds, all the areas of the hands not disinfected, intravenous bottles, vials and bags were not disinfected, the sterility of needles and intravenous lines compromised and the injection site not disinfected.

Table 3.15 provides a summary of the observed incidence of asepsis-related deviations from safe practice in relation to unit type and administration route.

Table 3.15 Incidence of asepsis related deviations from safe practice by deviation type, hospital level, unit type and administration route

			Amount of observations done		Hands were not disinfected f (%)		Hands were cleaned for less than 15 seconds f (%)		All areas of the hands were not disinfected f (%)		IV bottles, vials and bags were not disinfected f (%)		Sterility of needles and IV-sets were not maintained f (%)		The injection site was not disinfected f (%)		Total enteral f (%)	Total parenteral f (%)
			E‡	P‡	E	P	E	P	E	P	E	P	E	P	E	P		
Level 1 hospitals	a	Medical	9	10	3 (33)*	3 (30)	9 (100)*	9 (90)	9 (100)*	10 (100)	0 (0)*	4 (40)	0 (0)*	0 (0)	0 (0)*	0 (0)	21 (230)	26 (260)
	b	Medical	10	10	7 (70)	1 (10)	10 (100)	9 (90)	10 (100)	10 (100)	0 (0)	5 (50)	0 (0)	5 (50)	0 (0)	0 (0)	27 (270)	30 (300)
	c	Medical	10	10	4 (40)	0 (0)	10 (100)	10 (100)	10 (100)	10 (100)	0 (0)	10 (100)	0 (0)	8 (80)	0 (0)	0 (0)	24 (240)	38 (380)
		Total Medical	29	30	14 (48)	4 (13)	29 (100)	28 (93)	29 (100)	30 (100)	0 (0)	19 (63)	0 (0)	13 (43)	0 (0)	0 (0)	72 (248)	94 (313)
	a	Surgical	10	10	9 (90)	3 (30)	10 (100)	5 (50)	10 (100)	10 (100)	0 (0)	5 (50)	0 (0)	0 (0)	0 (0)	0 (0)	29 (290)	23 (230)
	b	Surgical	10	10	10 (100)	4 (40)	10 (100)	8 (80)	10 (100)	8 (80)	0 (0)	2 (20)	0 (0)	1 (10)	0 (0)	0 (0)	30 (300)	23 (230)
	c	Surgical	10	7	7 (70)	0 (0)*	10 (100)	7 (100)*	10 (100)	7 (100)*	0 (0)	7 (100)*	0 (0)	1 (14)*	0 (0)	0 (0)*	27 (270)	22 (314)
		Total Surgical	30	27	26 (87)	7 (26)	30 (100)	20 (74)	30 (100)	25 (86)	0 (0)	14 (52)	0 (0)	2 (7)	0 (0)	0 (0)	86 (287)	68 (252)
	Total level one		59	57	40 (68)	11 (19)	59 (100)	48 (84)	59 (100)	55 (97)	0 (0)	33 (58)	0 (0)	15 (26)	0 (0)	0 (0)	158 (268)	162 (284)
Level 2 hospitals	a	Medical	10	10	8 (80)	1 (10)	10 (100)	10 (100)	10 (100)	10 (100)	0 (0)	9 (90)	0 (0)	2 (20)	0 (0)	0 (0)	28 (280)	32 (320)
	b	Medical	10	9	10 (100)	0 (0)*	10 (100)	8 (89)*	10 (100)	8 (89)*	0 (0)	5 (56)*	0 (0)	2 (22)*	0 (0)	2 (22)*	30 (300)	25 (275)
	c	Medical	10	10	9 (90)	1 (10)	10 (100)	10 (100)	10 (100)	10 (100)	0 (0)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	29 (290)	24 (240)
		Total Medical	30	29	27 (90)	2 (7)	30 (100)	28 (97)	30 (100)	28 (97)	0 (0)	17 (59)	0 (0)	4 (14)	0 (0)	2 (7)	87 (290)	81 (279)
	a	Surgical	10	10	10 (100)	0 (0)	10 (100)	5 (50)	10 (100)	5 (50)	0 (0)	8 (80)	0 (0)	1 (10)	0 (0)	0 (0)	30 (300)	19 (190)
	b	Surgical	10	10	10 (100)	0 (0)	10 (100)	8 (80)	10 (100)	9 (90)	0 (0)	9 (90)	0 (0)	0 (0)	0 (0)	5 (50)	30 (300)	31 (310)
	c	Surgical	10	10	10 (100)	6 (60)	10 (100)	9 (90)	10 (100)	10 (100)	0 (0)	7 (70)	0 (0)	5 (50)	0 (0)	0 (0)	30 (300)	37 (370)
		Total Surgical	30	30	30 (100)	6 (20)	30 (100)	22 (73)	30 (100)	24 (80)	0 (0)	24 (80)	0 (0)	6 (20)	0 (0)	5 (17)	90 (300)	87 (290)
	Total level two		60	59	57 (95)	8 (14)	60 (100)	50 (85)	60 (100)	52 (88)	0 (0)	41 (70)	0 (0)	10 (17)	0 (0)	7 (12)	177 (295)	168 (285)
Level 3 hospitals	a	Medical	10	10	10 (100)	0 (0)	10 (100)	10 (100)	10 (100)	10 (100)	0 (0)	10 (100)	0 (0)	3 (30)	0 (0)	2 (20)	30 (300)	35 (350)
	b	Medical	10	10	3 (30)	3 (30)	10 (100)	10 (100)	10 (100)	10 (100)	0 (0)	3 (30)	0 (0)	0 (0)	0 (0)	1 (10)	23 (230)	27 (270)
		Total Medical	20	20	13 (65)	3 (15)	20 (100)	20 (100)	20 (100)	20 (100)	0 (0)	13 (65)	0 (0)	3 (15)	0 (0)	3 (15)	53 (265)	62 (310)
	a	Surgical	10	10	9 (90)	6 (60)	10 (100)	10 (100)	10 (100)	10 (100)	0 (0)	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	29 (290)	36 (360)
	b	Surgical	10	10	3 (30)	5 (50)	9 (90)	9 (90)	10 (100)	10 (100)	0 (0)	4 (40)	0 (0)	5 (50)	0 (0)	1 (10)	22 (220)	34 (340)
		Total Surgical	20	20	12 (60)	11 (55)	19 (95)	19 (95)	20 (100)	20 (100)	0 (0)	14 (70)	0 (0)	5 (25)	0 (0)	1 (5)	51 (255)	70 (350)
	Total level three		40	40	25 (63)	14 (35)	39 (98)	39 (98)	40 (100)	40 (100)	0 (0)	27 (68)	0 (0)	8 (20)	0 (0)	4 (10)	104 (260)	132 (330)
Total Medical			79	79	54 (68)	9 (11)	79 (100)	76 (96)	79 (100)	78 (99)	0 (0)	49 (62)	0 (0)	20 (25)	0 (0)	5 (6)	212 (268)	237 (308)
Total Surgical			80	77	68 (85)	24 (31)	79 (99)	61 (79)	80 (100)	69 (90)	0 (0)	52 (68)	0 (0)	13 (17)	0 (0)	6 (8)	227 (284)	225 (292)
Total			159	156	122 (77)	33 (21)	158 (99)	137 (88)	159 (100)	147 (94)	0 (0)	101 (65)	0 (0)	33 (21)	0 (0)	11 (7)	439 (276)	462 (296)
																	901 (286)	

‡ E = Enteral, P = Parenteral

* Less than 10 patients' medication administration observed

Almost half of medication administrations were performed without the medication administrators disinfecting their hands prior to administration (n = 155; 49%). Surgical units had a much higher incidence of this deviation from safe practice than medical units (n = 92; 59% versus n = 63; 40%). Parenteral medication administrations were effected less than enteral medication administrations in this regard, with the absence of hand-disinfection present in 33 parenteral medication administrations (21%) and in 122 enteral medication administrations (77%). The incidence of hand-disinfection differed from medication administrator to medication administrator and though level one hospitals revealed to have the lowest overall average of this deviation from safe practice (n = 51; 44%), two units within this hospital level still revealed a lack of hand-disinfection above 90% (n = 10; 100 and n = 90; 90%).

When hands were disinfected, they were only disinfected for an adequate amount of time in 20 instances (6%). In medical units, hands were cleaned for less than the optimal time in 155 instances (98%) while in surgical units this happened in 140 instances (88%). Of the 20 instances where hands were disinfected for the appropriate amount of time, only one represented enteral medication administration (1%) while the other nineteen represented parenteral medication administration (12%). In level one and two and three hospitals, hands were cleaned for less than 15 seconds in 107 and 110 instances respectively (92% in both hospital levels). Level three hospitals showed an even higher incidence of this deviation at 78 instances (98%).

Also, when hands were disinfected, all areas of the hands were not disinfected in most incidences (n = 306; 97%). 157 of these incidences occurred in medical units (99%) while 149 occurred in surgical units (95%). All areas of the hands were not cleaned even once out of all enteral medication administrations observations. All areas of the hands were only cleaned before nine cases of parenteral medication administration (6%). Washing of all areas of the hands was demonstrated in level two and three hospitals only (n = 7; 6% in level two hospitals and n = 2; 1% in level one hospitals).

Of the three asepsis-related deviations from safe practices impacting only on parenteral medications, not cleaning intravenous bottles, bags and vials prior to

administration was the most common (n = 101; 65%). This deviation took place more in surgical units (n = 52; 68%) than in medical units (n = 49; 62%). Not disinfecting parenteral supplies prior to administration occurred less in level one hospitals (n = 33; 58%) while the incidences of this deviation were comparable in level three and level two hospitals (n = 27; 68% in level three hospitals and n = 41; 70% in level two hospitals).

Sterility of needles and intravenous sets were not maintained during the administration of parenteral medications to 33 patients (21%). These deviations occurred more in medical than in surgical units (n = 20; 25% in medical units and n = 13; 17% in surgical units). One quarter of patients in level one hospitals were exposed to this deviation (n = 15; 26%) while level two hospitals were found to show the lowest incidence of sterility of needles and intravenous sets not maintained, with ten (17%) of patients having been exposed to non-sterile needles or intravenous sets. In level three hospitals, this deviation reached eight patients (20% of patients observed while receiving parenteral medications). The following examples of sterility of needles and intravenous sets not maintained were observed: The administrator touched the open end of the intravenous line with her bare hands; the end of the open intravenous line had contact with the floor or was hanging open in the unit between medication rounds; the mixing needle were left open on the trolley or in a non-sterile kidney-dish; an open intravenous infusion solution was closed with an unsterile needle cap for later use; and more than one patients‟ intravenous infusion was attended to with a single pair of gloves.

The injection sites of eleven patients overall were not disinfected before administration of a parenteral medication (7% of all observed patients receiving parenteral medications). Five of these deviations from safe practice occurred in medical units (6%) while six occurred in surgical units (8%). Level one hospitals were completely free from these type of deviations during observations, while the incidence in level three and two hospitals were similar (n = 4; 10% in level three hospitals, and n = 7; 12% in level two hospitals).

Figure 3.8 provides an overview of observed asepsis-related deviations from safe practice by deviation type incidence in relation to unit type and administration route.

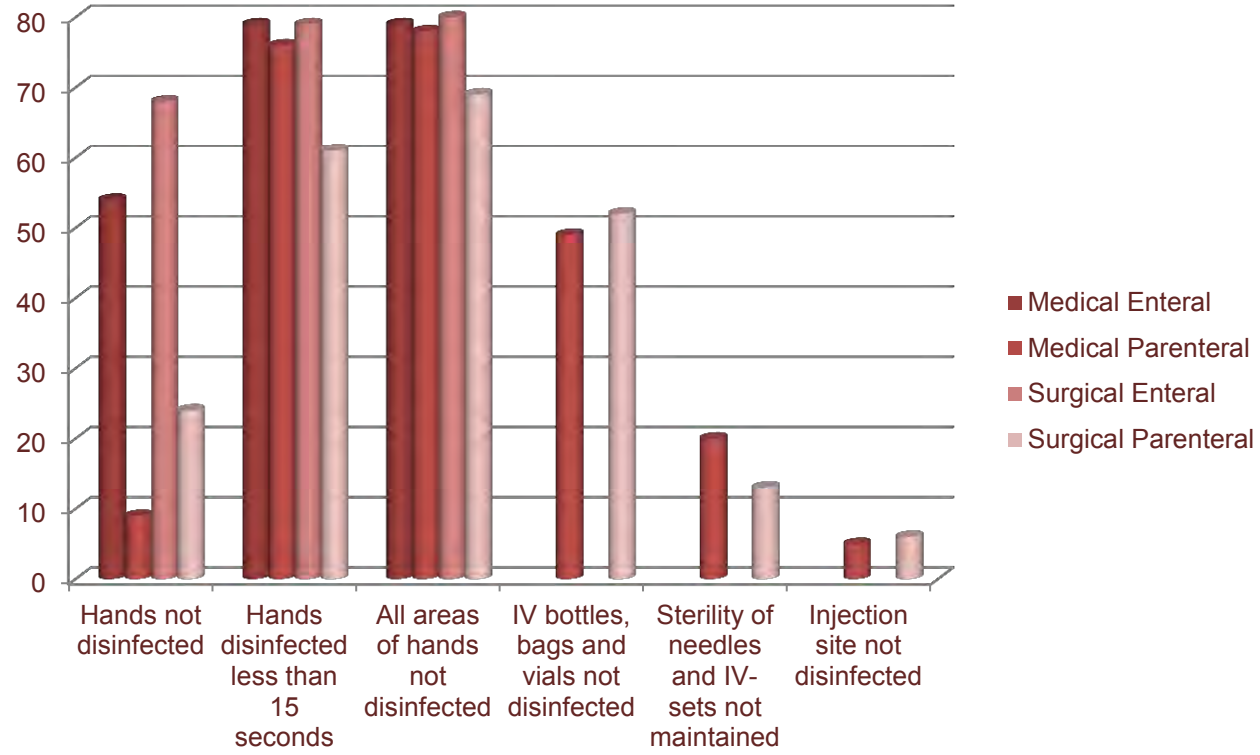


Figure 3.8: Asepsis-related deviations from safe practice incidence indicating differences in unit and route practices

3.4.8.7 Documentation related deviations from safe practice

Documentation related deviations occurred when the administering nurse did not do the recording, when the actual time of administration was not recorded and when the administration was recorded before it was completed.

Table 3.16 provides a summary of the observed incidence of documentation related deviations from safe practice in relation to unit type and administration route.

Table 3.16 Incidence of documentation-related deviations from safe practice by deviation type, hospital level, unit type and administration route

			Amount of observations done		Administering nurse did not record f (%)		Actual time were not recorded f (%)		Recorded before administration were		Total enteral f (%)	Total parenteral f (%)
			E‡	P‡	E‡	P‡	E‡	P‡	E‡	P‡		
Level 1 hospitals	a	Medical	9	10	0 (0)*	0 (0)	3 (33)*	1 (10)	4 (44)*	6 (60)	7 (78)	7 (70)
	b	Medical	10	10	1 (10)	0 (0)	1 (10)	3 (30)	1 (10)	1 (10)	3 (30)	4 (40)
	c	Medical	10	10	2 (20)	0 (0)	1 (10)	1 (10)	8 (80)	2 (20)	11 (110)	3 (30)
		Total Medical	29	30	3 (10)	0 (0)	5 (17)	5 (17)	13 (45)	9 (30)	21 (72)	14 (47)
	a	Surgical	10	10	0 (0)	2 (20)	4 (40)	2 (20)	3 (30)	3 (30)	7 (70)	7 (70)
	b	Surgical	10	10	1 (10)	0 (0)	1 (10)	5 (50)	0 (0)	4 (40)	2 (20)	9 (90)
	c	Surgical	10	7	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)*	0 (0)	0 (0)
		Total Surgical	30	27	1 (3)	2 (7)	5 (17)	7 (26)	3 (10)	7 (26)	9 (30)	16 (59)
	Total level one		59	57	4 (7)	2 (4)	10 (17)	12 (21)	16 (27)	16 (28)	30 (51)	30 (53)
Level 2 hospitals	a	Medical	10	10	0 (0)	0 (0)	9 (90)	10 (100)	0 (0)	3 (30)	9 (90)	13 (130)
	b	Medical	10	9	5 (50)	7 (78)*	2 (20)	9 (100)*	7 (70)	6 (67)*	14 (140)	22 (244)
	c	Medical	10	10	0 (0)	0 (0)	10 (100)	2 (20)	3 (30)	3 (30)	13 (130)	5 (50)
		Total Medical	30	29	5 (17)	7 (24)	21 (70)	21 (72)	10 (33)	12 (40)	36 (120)	40 (138)
	a	Surgical	10	10	0 (0)	0 (0)	5 (50)	10 (100)	0 (0)	0 (0)	5 (50)	10 (100)
	b	Surgical	10	10	1 (10)	0 (0)	6 (60)	6 (60)	7 (70)	4 (40)	13 (130)	10 (100)
	c	Surgical	10	10	0 (0)	0 (0)	1 (10)	2 (20)	1 (10)	7 (70)	2 (20)	9 (90)
		Total Surgical	30	30	1 (3)	0 (0)	12 (40)	18 (60)	8 (27)	11 (37)	21 (70)	29 (97)
	Total level two		60	59	6 (10)	7 (12)	33 (55)	39 (66)	18 (30)	23 (39)	57 (95)	69 (117)
Level 3 hospitals	a	Medical	10	10	0 (0)	2 (20)	0 (0)	3 (30)	2 (20)	6 (60)	2 (20)	11 (110)
	b	Medical	10	10	0 (0)	0 (0)	0 (0)	2 (20)	0 (0)	0 (0)	0 (0)	2 (20)
		Total Medical	20	20	0 (0)	2 (10)	0 (0)	5 (25)	2 (10)	6 (30)	2 (10)	13 (65)
	a	Surgical	10	10	0 (0)	0 (0)	2 (20)	3 (30)	2 (20)	3 (30)	4 (40)	6 (60)
	b	Surgical	10	10	0 (0)	1 (10)	1 (10)	1 (10)	1 (10)	2 (20)	2 (20)	4 (40)
		Total Surgical	20	20	0 (0)	1 (5)	3 (15)	4 (20)	3 (15)	5 (25)	6 (30)	10 (50)
	Total level three		40	40	0 (0)	3 (8)	3 (8)	9 (23)	5 (13)	11 (28)	8 (20)	23 (58)
Total Medical			79	79	8 (10)	9 (11)	26 (33)	31 (53)	25 (32)	27 (34)	59 (75)	67 (85)
Total Surgical			80	77	2 (3)	3 (4)	20 (25)	29 (38)	14 (18)	23 (30)	36 (46)	55 (71)
Total			159	156	10 (6)	12 (8)	46 (29)	60 (39)	39 (25)	50 (32)	95 (60)	122 (78)
												217 (69)

‡ E = Enteral, P = Parenteral

* Less than 10 patients' medication administration observed

During medication administration to 22 patients, the administering nurse did not record the administration (affecting 7% of observed patients). This deviation occurred more in medical units than in surgical units (n = 17; 11% in medical units and n = 5; 3% in surgical units). The administration of parenteral medication revealed an increased incidence of this documentation related deviation from safe practice (n = 12; 8% versus n = 10; 6%). In level one hospitals, the incidence of this deviation was 6 (6%) and level three hospitals revealed an incidence of the administering nurse not completing the documentation of three (4%). In level two hospitals, thirteen patient files were not completed by the medication administrator

who administered medication to the specific patient (effecting 11% of patients in these hospitals). However, this deviation was found to be hospital specific as these thirteen incidences were all observed in one hospital (effecting 33% of patients observed in this hospitals).

The most common documentation related deviation from safe practice was found to be the actual time of the administration not being recorded, which occurred in one-third of medication administration documentation (n = 106; 34%). This deviation was observed more in medical units (n = 57; 36%) than in surgical units (n = 49; 31%). 39% of parenteral medication administrations were recorded to have been administered 30 minutes or more before or after the actual administration took place (n = 60) while this deviation took place during the documentation of 29% of observed enteral medications (n = 46). In level two hospitals, more than half of medication administration times were recorded incorrectly (n = 72; 61%) while level one and level three hospitals showed a much lower incidence of this type of deviation during observation (n = 22; 39% and n = 12; 15% respectively).

28% of medications were documented as administered before the administration was completed (n = 89). Medication administrators observed in medical units documented administration prior to administration more than those in surgical units (n = 52; 33% versus n = 37; 24%). This deviation occurred more during the observed administration of parenteral medications (n = 50; 32%) than during the administration of enteral medications (n = 39; 25%). Again, medication administrators observed in level two hospitals deviated more in this regard, effecting more than one third of their patients‟ safety (n = 41; 35%). Level three hospitals showed a lower incidence of this documentation related deviation from safe practice at 16 patients effected (20%) while level one hospitals represented the middle of the two extremes at an incidence of 32 (28%).

Figure 3.9 provides an overview of observed documentation-related deviations from safe practice by deviation type incidence in relation to unit type and administration route.

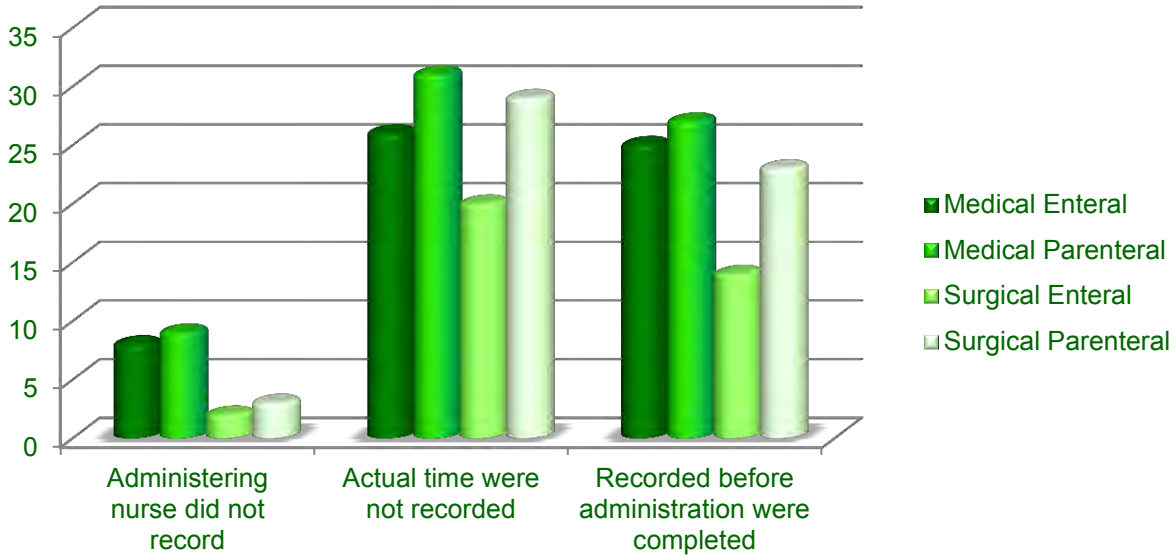


Figure 3.9: Documentation-related deviations from safe practice incidence indicating differences in unit and route practices

3.4.8.8 Interruptions as deviations from safe practice

Four types of interruptions were observed, viz. interruptions by other hospital staff, interruptions by the medication administrator him/herself, interruptions by patients and interruptions of other origin.

Table 3.17 provides a summary of the observed incidence of interruptions as deviations from safe practice in relation to unit type and administration route.

Table 3.17 Incidence of interruptions as deviations from safe practice by interruption origin, hospital level, unit type and administration route

			Amount of observations done		Interruptions by staff f (%)		Interruptions by self f (%)		Interruptions by patients f (%)		Other interruptions f (%)		Total enteral f (%)	Total parenteral f (%)
			E‡	P‡	E	P	E	P	E	P	E	P		
Level 1 hospitals	a	Medical	9	10	1 (11)*	4 (40)	2 (22)*	0 (0)	1 (11)*	1 (10)	0 (0)	0 (0)	4 (44)	5 (50)
	b	Medical	10	10	1 (10)	0 (0)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (30)	0 (0)
	c	Medical	10	10	4 (40)	1 (10)	6 (60)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	3 (30)
		Total Medical	29	30	6 (21)	5 (17)	10 (35)	2 (7)	1 (4)	1 (3)	0 (0)	0 (0)	17 (59)	8 (27)
	a	Surgical	10	10	0 (0)	4 (40)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	3 (30)	5 (50)
	b	Surgical	10	10	0 (0)	0 (0)	5 (50)	6 (60)	0 (0)	0 (0)	0 (0)	0 (0)	5 (50)	6 (60)
	c	Surgical	10	7	2 (20)	2 (29)*	1 (10)	1 (14)*	1 (10)	1 (14)*	0 (0)	0 (0)*	4 (40)	4 (57)
		Total Surgical	30	27	2 (7)	6 (22)	9 (30)	7 (26)	1 (3)	1 (4)	0 (0)	1 (4)	12 (40)	15 (56)
	Total level one		59	57	8 (14)	11 (19)	19 (32)	9 (16)	2 (3)	2 (4)	0 (0)	1 (2)	29 (49)	23 (40)
Level 2 hospitals	a	Medical	10	10	3 (30)	3 (30)	1 (10)	0 (0)	1 (10)	1 (10)	0 (0)	0 (0)	5 (50)	4 (40)
	b	Medical	10	9	0 (0)	1 (11)*	1 (10)	1 (11)*	2 (20)	0 (0)*	0 (0)	0 (0)*	3 (30)	2 (22)
	c	Medical	10	10	1 (10)	0 (0)	1 (10)	1 (10)	3 (30)	1 (10)	0 (0)	0 (0)	5 (50)	2 (20)
		Total Medical	30	29	4 (13)	4 (14)	3 (10)	2 (7)	6 (20)	2 (7)	0 (0)	0 (0)	13 (43)	8 (28)
	a	Surgical	10	10	1 (10)	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	2 (20)	0 (0)
	b	Surgical	10	10	0 (0)	1 (10)	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	1 (10)
	c	Surgical	10	10	2 (20)	9 (90)	0 (0)	2 (20)	1 (10)	0 (0)	0 (0)	0 (0)	3 (30)	11 (110)
		Total Surgical	30	30	3 (10)	10 (33)	1 (3)	2 (7)	2 (7)	0 (0)	0 (0)	0 (0)	6 (20)	12 (40)
	Total level two		60	59	7 (12)	14 (24)	4 (7)	4 (7)	8 (13)	2 (3)	0 (0)	0 (0)	19 (32)	20 (34)
Level 3 hospitals	a	Medical	10	10	1 (10)	1 (10)	3 (30)	3 (30)	1 (10)	2 (20)	0 (0)	0 (0)	3 (30)	6 (60)
	b	Medical	10	10	0 (0)	1 (10)	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	1 (10)	1 (10)
		Total Medical	20	20	1 (5)	2 (10)	3 (15)	3 (15)	2 (10)	2 (10)	0 (0)	0 (0)	6 (30)	7 (35)
	a	Surgical	10	10	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10)	0 (0)
	b	Surgical	10	10	1 (10)	2 (20)	0 (0)	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)	2 (20)	2 (20)
		Total Surgical	20	20	1 (5)	2 (10)	1 (5)	0 (0)	1 (5)	0 (0)	0 (0)	0 (0)	3 (15)	2 (10)
	Total level three		40	40	2 (3)	4 (10)	4 (10)	3 (8)	3 (8)	2 (3)	0 (0)	0 (0)	9 (23)	9 (23)
Total Medical			79	79	11 (14)	11 (14)	16 (20)	7 (9)	9 (11)	5 (6)	0 (0)	0 (0)	36 (46)	23 (29)
Total Surgical			80	77	6 (8)	18 (23)	11 (14)	9 (12)	4 (5)	1 (1)	0 (0)	1 (1)	21 (26)	29 (38)
Total			159	156	17 (11)	29 (19)	27 (17)	16 (10)	13 (8)	6 (4)	0 (0)	1 (1)	57 (36)	52 (33)
														109 (35)

‡ E = Enteral, P = Parenteral

* Less than 10 patients' medication administration observed

A total of 109 interruptions were observed during medication administration to 315 patients (35%). Most interruptions were either caused by other hospital staff (n = 46) or the medication administrators themselves (n = 43), influencing medication administrations to 15% and 14% of patients observed respectively. Interruptions by patients took place nineteen times during medication administrations, effecting medication administration to 6% of observed patients, while only one patient's medication administration was affected by an interruption of another origin (1%).

59 interruptions took place during medication administration to medical patients (37%) while 50 interruptions took place during medication administration to surgical patients (32%). A similar incidence of interruptions was observed during enteral and parenteral medication administrations (n = 57; 36% in enteral medication administrations and n = 52; 33% in parenteral medication administrations). More interruptions took place in level one hospitals, effecting more than half of medication administrations observed in these hospitals (n = 52; 45%). Medication administration

to one third of patients in level two hospitals were interrupted (n = 39; 33%) while medication administration to almost one quarter of patients in level three hospitals were interrupted (n = 18; 23%).

Figure 3.10 provides an overview of observed interruptions as deviations from safe practice by interruption origin in relation to unit type and administration route.

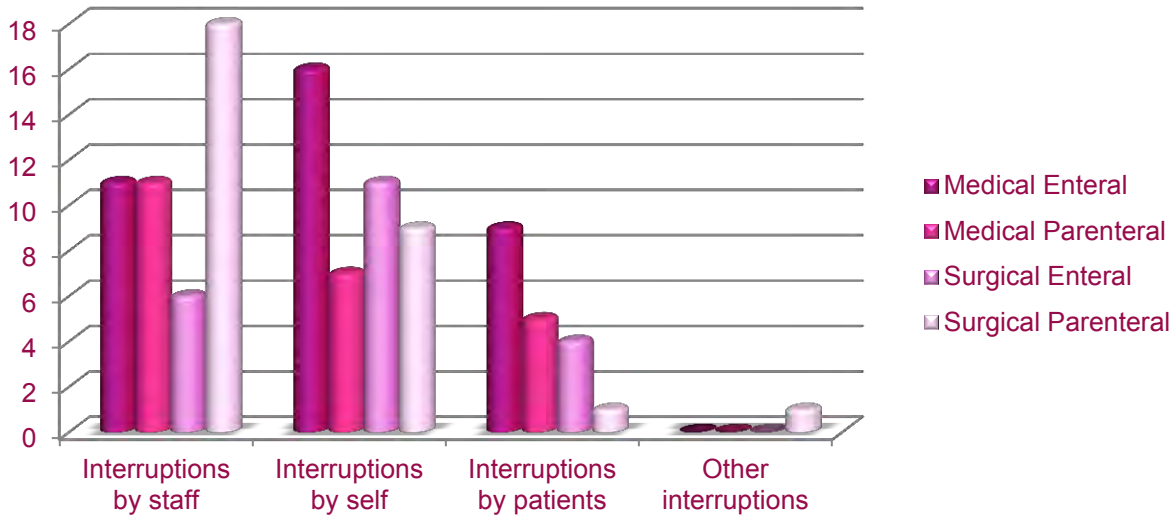


Figure 3.10: Interruption type incidence by unit and administration route

3.4.9 Association between deviations from safe practice and hospital level, unit type, administration route and interruptions

3.4.9.1 Association of deviations and individual hospitals

Table 3.18 shows the association between different deviations from safe practice and individual hospitals. These associations were investigated to determine whether they were dependent on hospitals before grouping influential variables such as hospital levels, unit types, administration routes and administrator ranks together.

Table 3.18 Association of deviations from safe practice with individual hospitals

Deviation type	n	%	Cramer's V	p-value
Label not read: name of medication	2	0.6%	0.14	0.513
Prescription not read: name of medication	4	1.3%	0.16	0.326
Medication not labelled immediately	13	4.2%	0.67	0.000
Medications administered by another nurse	50	36.0%	0.21	0.067
Label not read: dose	7	2.2%	0.16	0.334
Prescription not read: dose	7	2.2%	0.18	0.180
Syringe markings not read at eye-level	7	58.3%	0.58	0.264
Wristband not read	241	76.8%	0.60	0.000
Patient's name not asked	222	70.7%	0.47	0.000
Prescription not read: name of patient	23	7.3%	0.31	0.000
Prescription not read: route	6	1.9%	0.12	0.710
Medication prepared ahead of time	14	4.5%	0.42	0.000
Hands were not disinfected	155	49.2%	0.23	0.021
Hands disinfected for less than 15 seconds	146	89.0%	0.20	0.476
All areas of the hands were not washed	147	89.6%	0.30	0.044
Parenteral supplies were not disinfected	101	68.7%	0.50	0.000
Sterility of needles and IV sets were not maintained	33	22.1%	0.37	0.006
Injection site was not disinfected	11	23.9%	0.71	0.001
Administrating nurse did not record	22	7.0%	0.40	0.000
Actual administration time was not recorded	106	33.9%	0.53	0.000
Administration recorded prior to administration	89	28.4%	0.39	0.000
Interruptions: Other staff	4	1.3%	0.21	0.013
Interruptions: Administrator self	39	12.4%	0.23	0.000
Interruptions: Patients	19	6.0%	0.14	0.535
Interruptions: Other	1	0.3%	0.15	0.419

Six practically and statistically significant associations were identified between specific hospitals and certain deviations from safe practice. Firstly, the medication not being labelled immediately after preparation thereof was significantly associated with individual hospitals (Cramer's V = 0.67, p = 0.000). One level two and one level three hospital each showed an incidence of medications not labelled immediately of

80% and above (80.0%, n = 16 and 94.1%, n = 16 respectively). All the other hospitals revealed an incidence of this deviation from safe practice lower than 42%.

The second hospital-dependent deviation from safe practice was identified to be syringe markings not being read at eye-level (Cramer‟s V = 0.58, p = 0.264). Medication administrations by syringe were observed in only four hospitals, contributing to this association. Only twelve medication administrations by syringe were observed in total, of which seven were administered without reading the syringe markings at eye-level. This deviation was observed during three out of five syringe administrations in a level two hospital, and once in a hospital representing each of the hospital levels respectively.

The wristband of the patient not being read was also associated with specific hospitals (Cramer‟s V = 0.60, p = 0.000). The incidence of this deviation from safe practice was between 75% and 100% for all level one and two hospitals. In one level three hospital, only six patients received medication without their wristband being read (15.0%), though in the other level three hospital 29 (72.5%) patients‟ wristbands were not read prior to medication administration.

Parenteral supplies not being disinfected was practically and statistically associated with individual hospitals (Cramer‟s V = 0.50, p = 0.000). In one level one and one level three hospital, IV bottles or vials were not cleaned during a single observed parenteral medication administration from the 37 parenteral doses observed between these two hospitals. The incidence of this deviation from safe practice ranged between 41.2% (n = 7) and 85.0% (n = 17) in the other six sampled hospitals.

The injection site not being disinfected prior to medication administration was significantly associated with specific hospitals (Cramer‟s V = 0.71, p = 0.001). Seven of these deviations were observed in a level two hospital, while two of these deviations were observed in each of the two level three hospitals.

Lastly, the actual time of administration not being recorded was the sixth deviation from safe practice associated with individual hospitals (Cramer‟s V = 0.53, p = 0.000). The three highest incidences of these deviations from safe practice were observed in the three level two hospitals (n = 15, 23 and 34; 37.5%, 60.5% and

85.0% respectively) while the observed incidence from the other hospitals varied between 2 (5.6%) and 10 (25.6%).

Due to the strong dependency on hospitals, these six deviations from safe practice were considered both within different variable groupings and separately during the exploration of all other associations.

3.4.9.2 Association related to hospital level and deviations from safe practice

Table 3.19 provides an overview of the association between hospital level and deviations from safe practice.

Table 3.19 Association between hospital level and deviations from safe practice

Deviation type	n	%	Cramer's V	p-value
Label not read: name of medication	2	0.6%	0.07	0.513
Prescription not read: name of medication	4	1.3%	0.03	0.858
Medication not labelled immediately	13	4.2%	0.04	0.824
Medications prepared and administered by different nurses	50	36.0%	0.21	0.048
Label not read: dose	7	2.2%	0.03	0.875
Prescription not read: dose	7	2.2%	0.11	0.178
Syringe markings not read at eye-level	7	58.3%	0.49	0.240
Wristband not read	241	76.8%	0.46	0.000
Patient's name not asked	222	70.7%	0.41	0.000
Prescription not read: name of patient	23	7.3%	0.15	0.028
Prescription not read: route	6	1.9%	0.08	0.343
Medication not prepared directly prior to administration	14	4.5%	0.22	0.001
Hands were not disinfected	155	49.2%	0.09	0.262
Hands were disinfected for less than 15 seconds	146	89.0%	0.17	0.096
All areas of the hands were not washed	147	89.6%	0.13	0.279
Parenteral supplies were not disinfected	101	68.7%	0.11	0.447
Sterility of needles and IV sets were not maintained	33	22.1%	0.10	0.462
Injection site was not disinfected	11	23.9%	0.35	0.062
Administrating nurse did not record	22	7.0%	0.12	0.097
Actual administration time was not recorded	106	33.9%	0.45	0.000
Administration recorded prior to administration	89	28.4%	0.13	0.077
Interruptions: Other staff	4	1.3%	0.08	0.443
Interruptions: Administrator self	39	12.4%	0.19	0.001
Interruptions: Patients	19	6.0%	0.09	0.279
Interruptions: Other	1	0.3%	0.074	0.423

No practical significance could be linked to associations between different deviations from safe practice and hospital levels. However, the dependency on individual hospitals had to be taken into account for the medication not being labelled immediately, syringe markings not read at eye-level, the patients‟ wristbands not read, parenteral supplies not disinfected, injection sites not disinfected and the actual

time of the medication administration not being documented. Only three of these deviations were close to practical significance when associated with hospital level.

Firstly, the association between hospital level and syringe-markings not read at eye level was found to be close to practical significance (Cramer"s V = 0.49; p = 0.240). However, due to the small sample of these deviations observed, it is dangerous to conclude that one hospital level was more prone to these deviations than other levels.

Secondly, the association between hospital level and wristbands not read was found to be of large effect and statistically significant (Cramer"s V = 0.46 and p = 0.000). More of these deviations were observed in level one and level two hospitals.

Lastly, a large effect size and statistical significance was identified between hospital level and the actual time of administration not being recorded (Cramer"s V = 0.45 and p = 0.000). The practice of recording a time other than the actual time of administration was observed more in level two hospitals.

3.4.9.3 Relationship between unit type and deviations from safe practice

Table 3.20 provides an overview of the associations between unit type and deviations from safe practice.

Table 3.20 Association between unit type and deviations from safe practice

Deviation type	N	%	Cramer's V	p-value
Label not read: name of medication	2	0.6%	0.00	1.000
Prescription not read: name of medication	4	1.3%	0.00	1.000
Medication not labelled immediately	13	4.2%	0.15	0.010
Medications prepared and administered by different nurses	50	36.0%	0.07	0.384
Label not read: dose	7	2.2%	0.02	0.702
Prescription not read: dose	7	2.2%	0.07	0.251
Syringe markings not read at eye-level	7	58.3%	0.53	0.067
Wristband not read	241	76.8%	0.02	0.689
Patient's name not asked	222	70.7%	0.06	0.321
Prescription not read: name of patient	23	7.3%	0.04	0.516
Prescription not read: route	6	1.9%	0.00	1.00
Medication not prepared directly prior to administration	14	4.5%	0.13	0.025
Hands were not disinfected	155	49.2%	0.19	0.001
Hands were disinfected for less than 15 seconds	146	89.0%	0.26	0.001
All areas of the hands were not washed	147	89.6%	0.33	0.000
Parenteral supplies were not disinfected	101	68.7%	0.07	0.368
Sterility of needles and IV sets were not maintained	33	22.1%	0.11	0.181
Injection site was not disinfected	11	23.9%	0.18	0.215
Administration not recorded by administering nurse	22	7.0%	0.15	0.008
Actual administration time was not recorded	106	33.9%	0.05	0.360
Administration was recorded prior to administration	89	28.4%	0.10	0.065
Interruptions: Other staff	4	1.3%	0.06	0.575
Interruptions: Administrator self	39	12.4%	0.08	0.561
Interruptions: Patients	19	6.0%	0.12	0.034
Interruptions: Other	1	0.3%	0.06	0.315

Only one practically significant association between unit type and deviations from safe practice could be established, viz. the association between syringe markings

not read at eye-level and unit type. All seven of these observed deviations were observed in surgical units. Again, the hospital dependency of the six deviations identified in 3.5.9.1 merited exploration of possible hospital-specific associations.

Regarding the medication not labelled immediately after preparation thereof, table 3.21 presents the significant association between this deviation and the unit type in one hospital.

Table 3.21 Hospital dependent association between medication not labelled immediately and unit type

Hospital	Unit type	n	%	Cramer's V	p-value
2a	Medical	10	100.0%	0.50	0.025
	Surgical	6	60.0%		

The association between unit type and not labelling medication immediately after preparation was found to be practically significant in one hospital (Cramer"s V = 0.50) wherein a statistical significance was also determined with the p-value of 0.025 as stated. More medications were not labelled in the medical unit of this hospital.

Table 3.22 presents the hospital-specific significant associations between unit type and syringe markings not read at eye level.

Table 3.22 Hospital dependent association between syringe markings not read at eye-level and unit type

Hospital	Unit type	n	%	Cramer's V	p-value
2b	Medical	0	0.0%	0.58	0.248
	Surgical	7	70.0%		

A practically significant association between abovementioned variables was seen in one level two hospital, with more syringe markings not being read at eye-level in the surgical unit than in the medical unit.

Considering the patient"s wristbands not read prior to medication administration, no practically significant association between the unit type and this deviation from safe practice was noted in any individual hospital.

Furthermore, no practical significance could be connected to any association between unit type and parenteral supplies not disinfected in specific hospitals.

However, practical significance was detected during consideration of hospital dependence of the injection site not being disinfected as associated with unit type. Table 3.23 presents the significant associations between these variables.

Table 3.23 Hospital dependent association between injection sites not disinfected and unit type

Hospital	Unit type	n	%	Cramer's V	p-value
2b	Medical	2	40.0%	1.00	0.083
	Surgical	5	100.0%		
3a	Medical	2	100.0%	0.65	0.088
	Surgical	0	0.0%		
3b	Medical	1	100.0%	0.66	0.038
	Surgical	1	16.7%		

The association between the injection sites not disinfected and unit type is non-linier. In two hospitals, more of these deviations occurred in the medical unit, while the surgical unit was implicated in the other hospital. Again it is important to note the small sample of these deviations from safe practice which could impact the significance of this finding.

Lastly, the unit type was not significantly associated with the incidence of the actual administration time not recorded in any of the individual hospitals.

3.4.9.4 Association between administration route and deviations from safe practice

Table 3.24 provides an overview of the associations between administration route and deviations from safe practice.

Table 3.24 Association between administration route and deviations from safe practice

Deviation type	n	%	Cramer's V	p-value
Label not read: name of medication	2	0.6%	0.00	0.993
Prescription not read: name of medication	4	1.3%	0.00	0.990
Medication not labelled immediately	13	4.2%	0.02	0.786
Medications prepared and administered by different nurses	50	36.0%	0.06	0.452
Label not read: dose	7	2.2%	0.07	0.244
Prescription not read: dose	7	2.2%	0.02	0.690
Wristband not read	241	76.8%	0.13	0.027
Patient's name not asked	222	70.7%	0.08	0.157
Prescription not read: name of patient	23	7.3%	0.06	0.265
Prescription not read: route	6	1.9%	0.09	0.096
Medication not prepared directly prior to administration	14	4.5%	0.19	0.001
Hands were not disinfected	155	49.2%	0.56	0.000
Hands were disinfected for less than 15 seconds	146	89.0%	0.14	0.067
All areas of the hands were not washed	147	89.6%	0.18	0.019
Administration not recorded by administering nurse	22	7.0%	0.03	0.636
Actual administration time was not recorded	106	33.9%	0.10	0.087
Administration was recorded prior to administration	89	28.4%	0.08	0.157
Interruptions: Other staff	4	1.3%	0.10	0.194
Interruptions: Administrator self	39	12.4%	0.10	0.411
Interruptions: Patients	19	6.0%	0.09	0.107
Interruptions: Other	1	0.3%	0.06	0.312

A statistical as well as practical significance was designated to the association between the administration route and medication administrators‟ not disinfecting their hands. Oral medications were administered more often without disinfecting hands, with 76.6% (n = 122) of observed oral medication administrations being administered

without hand-sanitizing and 21.2% (n = 33) of observed parenteral medication administrations being affected.

Medication not labelled directly after preparation, not cleaning parenteral supplies prior to medication administration sterility of needles and intravenous sets not maintained and injection sites not cleaned prior to medication were only applicable to parenteral medication administration, thus no associations between administration route and these deviations were investigated. Further hospital-dependent associations were therefore also not investigated.

Regarding the other two hospital-dependent deviations from safe practice not included in parenteral-specific deviations, both the wristband not being read and the actual administration time not being recorded revealed no significant association between the administration route and incidence of these deviations in individual hospitals.

3.4.9.5 Association between medication administrator rank and deviations from safe practice

Table 3.25 provides an overview of the associations between administrator rank and deviations from safe practice.

Table 3.25 Association between rank of the administrator and deviations from safe practice

Deviation type	n	%	Cramer's V	p-value
Label not read: name of medication	2	0.6%	0.02	0.961
Prescription not read: name of medication	4	1.3%	0.02	0.923
Medication not labelled immediately	13	4.2%	0.13	0.063
Medications prepared and administered by different nurses	50	36.0%	0.26	0.005
Label not read: dose	7	2.2%	0.08	0.366
Prescription not read: dose	7	2.2%	0.22	0.001
Syringe markings not read at eye-level	7	58.3%	0.56	0.152
Wristband not read	241	76.8%	0.15	0.026
Patient's name not asked	222	70.7%	0.11	0.128
Prescription not read: name of patient	23	7.3%	0.16	0.019
Prescription not read: route	6	1.9%	0.05	0.701
Medication not prepared directly prior to administration	14	4.5%	0.14	0.050
Hands were not disinfected	155	49.2%	0.27	0.000
Hands were disinfected for less than 15 seconds	146	89.0%	0.14	0.207
All areas of the hands were not washed	147	89.6%	0.21	0.029
Parenteral supplies were not disinfected	101	68.7%	0.10	0.489
Sterility of needles and IV sets were not maintained	33	22.1%	0.08	0.607
Injection site was not disinfected	11	23.9%	0.34	0.075
Administering nurse did not record	22	7.0%	0.18	0.008
Actual administration time was not recorded	106	33.9%	0.10	0.200
Administration recorded prior to administration	89	28.4%	0.08	0.351
Interruptions: Other staff	4	1.3%	0.05	0.857
Interruptions: Administrator self	39	12.4%	0.06	0.857
Interruptions: Patients	19	6.0%	0.15	0.028
Interruptions: Other	1	0.3%	0.06	0.615

No practical significance in the association between the rank of the administrator and deviations from safe practice could be derived. With regards to hospital dependent deviations from safe practice, three deviations were associated with the rank of the administrator in specific hospitals, namely the syringe markings not read at eye level, the injection site not disinfected and the actual time of medication administration not

being recorded. Table 3.26 provides an overview of the association between the rank of the administrator and the syringe markings not read at eye level as dependent on individual hospitals.

Table 3.26 Hospital dependent association between the rank of the medication administrator and the incidence of syringe markings not read at eye level

Hospital	Administrator rank	n	%	Cramer's V	p-value
2b	Registered nurse	1	50.0%	0.58	0.248
	Enrolled nurse	0	0.0%		

When considering syringe markings not read at eye level as deviation from safe practice, it is important to note that only four opportunities for medication administration via syringe were observed in this hospital. Therefore, though the registered nurse only once did not read the syringe markings at eye level, this represented 50% of the two syringe medication administrations that she was responsible for. As the enrolled nurse read the syringe markings at eye level for both the syringe administrations that she was responsible for, the difference between the two administrators‟ ranks as related to this deviation shown to be practically significant (Cramer‟s V = 0.58) though of no statistical significance (p = 0.248). No syringe administrations were completed by student nurses and therefore they were not included in the exploration of this association.

Considering the injection site not being disinfected, a significant association between the rank of the administrator and this deviation from safe practice was noted in two hospitals. Table 3.27 provides the relevant data for this association.

Table 3.27 Hospital dependent association between medication administrator rank and the injection site not being disinfected

Hospital	Administrator rank	n	%	Cramer's V	p-value
2b	Registered nurse	5	100.0%	0.66	0.038
	Enrolled nurse	2	40.0%		
3a	Registered nurse	0	0.0%	1.00	0.083
	Enrolled nurse	2	100.0%		

Medication administrator rank was practically and significantly association with the injection site not being disinfected in one level two hospital (Cramer"s V = 0.66; p = 0.038) while it was practically but not statistically significant in one level three hospital (Cramer"s V = 1.00, p = 0.083). In the level two hospital, the registered nurse more often committed this deviation from safe practice, while the enrolled nurse from the level three hospital was implicated more. Again, it is of importance to note the small sample of medications administered via syringe, which could influence the truth value of these associations.

The last hospital dependent deviation from safe practice, viz. the actual time of the medication administration not being recorded, was significantly associated with the medication administrator rank in one hospital. Table 3.28 provides the details of this association.

Table 3.28 Hospital dependent association between rank of the medication administrator and the actual time of the medication administration not being recorded

Hospital	Administrator rank	n	%	Cramer's V	p-value
2c	Registered nurse	4	20.0%	0.81	0.000
	Enrolled nurse	11	100.0%		
	Student nurse	0	0.0%		

Enrolled nurses most often did not record the actual time of the medication administration in one level two hospital. Registered nurses recorded the actual time of four out of twenty administered doses (20.0%), while student nurses recorded the actual time of administration of all nine doses administered by them in this hospital.

This led to a practical and statistical association between the rank of the medication administrator and the actual time of medication administration not being recorded.

This concludes the associations between hospital level, unit type, administration route and medication administrator rank and the incidence of deviations from safe practice.

3.4.10 Medications involved in medication errors

Certain medications were found to be more prone to be erroneously administered. Table 3.29 provides an analysis of medications observed to be involved in medication administration error.

Table 3.29 Medications involved in medication errors

Medication category	Medication name	Omitted	Wrong medication	Wrong dose	Wrong patient	Wrong route	Wrong time	Total error per medication	Total error per category
Anti-infective agents	Ampicillin	1					1	2	100
	Amoxicillin	4	2	9		2	25	42	
	Azithromycin						1	1	
	Cefazolin			1			3	4	
	Ceftriaxone	3					9	12	
	Cloxacillin	1		3			2	6	
	Ciprofloxacin	5		2			1	8	
	FDC 1	1						1	
	Fluconozole	1						1	
	Lamivudine						1	1	
	Metronidazole	2	1	1		1	5	10	
	Niastatin	1						1	
	Penicillin			1			2	3	
	Pyridoxine						1	1	
	Rifampicin						3	3	
	Sulfamethozole and Trimethoprim				1		2	3	
	Zidovudine						1	1	

Pain relief medications	Diclofenac	6					1	7	**74**
	Dihydrocodeine Tartrate	1						1	
	Ibuprofen	1		1			5	7	
	Meperidine	2						2	
	Naproxine						1	1	
	Paracetamol	15		2			4	21	
	Tramadol	21	2	1			11	35	
Heart and circulatory medications	Amlodipine			1			2	3	**38**
	Enalapril	2					8	10	
	Furosemide	3				1	3	7	
	Hydrochlorothiazide	2	1				9	12	
	Nifedipine						2	2	
	Perindopril	1						1	
	Potassium Chloride	1						1	
	Simvastatin	1					1	2	
Hormones, diabetes and related medications	Azathioprine	1						1	**23**
	Diabetic phosphate	1						1	
	Estradiol	2					1	3	
	Hydrocortisone sodium succinate	2						2	
	Insulin			1				1	
	Metformin						4	4	
	Prednisone			5			5	10	
	Ranitidine						1	1	
Blood modifying medications	Asprin	3						3	**23**
	Enoxaparin	11		4		2	1	18	
	Tranexamic acid						1	1	
	Warfarin	1						1	
Supplements	MgSO4	1						1	**13**
	Potassium Chloride	1					1	2	
	Pregamal	1						1	
	Sodium Polystyrene	1						1	
	Thiamine	1		1			2	4	
	Vitamin B.Co	2						2	
	Vitamin C	2						2	

Gastrointestinal medications	Aluminium hydroxide	1						1	**9**
	Loperamide	1					1	2	
	Metochlopramide	1						1	
	Pantoprazole	1						1	
	Polyethylene glycol	1						1	
	Saline Enema	1						1	
	Senna	1	1					2	
Central nervous system medications	Citalopram						1	1	**8**
	Clonazepam	1						1	
	Diazepam						1	1	
	Fluoxetine	1					2	3	
	Haloperidol	1					1	2	
Neuro-muscular medications	Orphenadrine	1						1	**5**
	Phenetoin	2						2	
	Sodium valproate	1					1	2	
Unknown		3						3	**3**
Error type total		**122**	**7**	**33**	**1**	**6**	**127**	**296**	**296**

One hundred out of 296 erroneously administered medications represented anti-infective agents (34%). Among these is Amoxicillin, the medication administered wrongly most often. 74 doses of pain-relief medications were administered incorrectly (25%). Tramadol was administered incorrectly 35 times. Heart and circulatory medications represented another big portion of the incorrectly administered medications (n = 38; 13%) while hormones, diabetes and related medications, blood-modifying medications, supplements, gastro-intestinal medications, central nervous system medications and neuromuscular medications each represented less than 10% of the wrongly-administered medications. Three medications were omitted due to the prescription-chart being illegible, thus the names and categories of these medications remain unknown.

3.4.11 Knowledge testing

25 medication administrators agreed to complete the knowledge test (N = 36). Table 3.30 reveals the results of the knowledge test.

Table 3.30 Results of the knowledge test by question type, administrator rank, unit type and hospital level

			Enteral question	Parenteral question	Enteral question	Parenteral question	Total correct	Total incorrect
			Correct answer		Incorrect answer			
Level three hospitals		Enrolled nurses	1		1	2	1	3
		Registered nurses	3	3			6	0
	Total medical		4	3	1	2	7	3
		Enrolled nurses	1			1	1	1
		Registered nurses	1	1			2	0
	Total surgical		2	1	0	1	3	1
Total level three			6	4	1	3	10	4
Level two hospitals		Enrolled nurses	1	1	2	2	2	4
		Registered nurses	1	1			2	0
	Total medical		2	2	2	2	4	4
		Enrolled nurses	3	1		2	4	2
		Registered nurses	2	2			4	0
	Total surgical		5	3	0	2	8	2
Total level two			7	5	2	4	12	6
Level one hospitals		Enrolled nurses	1	1			2	0
		Registered nurses	2	2			4	0
	Total medical		3	3	0	0	6	0
		Enrolled nurses	1	1	2	2	2	4
		Registered nurses	3	1		2	4	2
	Total surgical		4	2	2	4	6	6
Total level one			7	5	2	4	12	6
Total medical			9	8	3	4	17	7
Total surgical			11	6	2	7	17	9
Total enrolled nurses			8	4	5	9	12	14
Total registered nurses			12	10	0	2	22	2
Total			20	14	5	11	34	16

Thirteen participants were enrolled nurses (52%) and Twelve participants were registered nurses (48%). It took an average of 11 minutes (ranging between two and eighteen minutes) for medication administrators to complete the two calculations. Sixteen calculations were answered incorrectly (32%). Most of the incorrect answers were provided by enrolled nurses (n = 14, 88%) while only two wrong answers were given by registered nurses (n = 2, 13%). Two more calculation mistakes were made

in surgical than in medical units (n = 9, 56% and n = 7, 44% respectively). Medication administrators struggled more to calculate parenteral dosages, which led to more calculation mistakes (n = 11, 69% of calculation mistakes were made in the parenteral calculation). Four out of fourteen calculations completed in level three hospitals were erroneous (29%) while level two and three hospitals shared the same incidence of six calculation errors in eighteen calculations (33%). Figure 3.11 shows the different trends of calculation errors by medication-administrator rank, administration-route, unit-type and hospital-level.

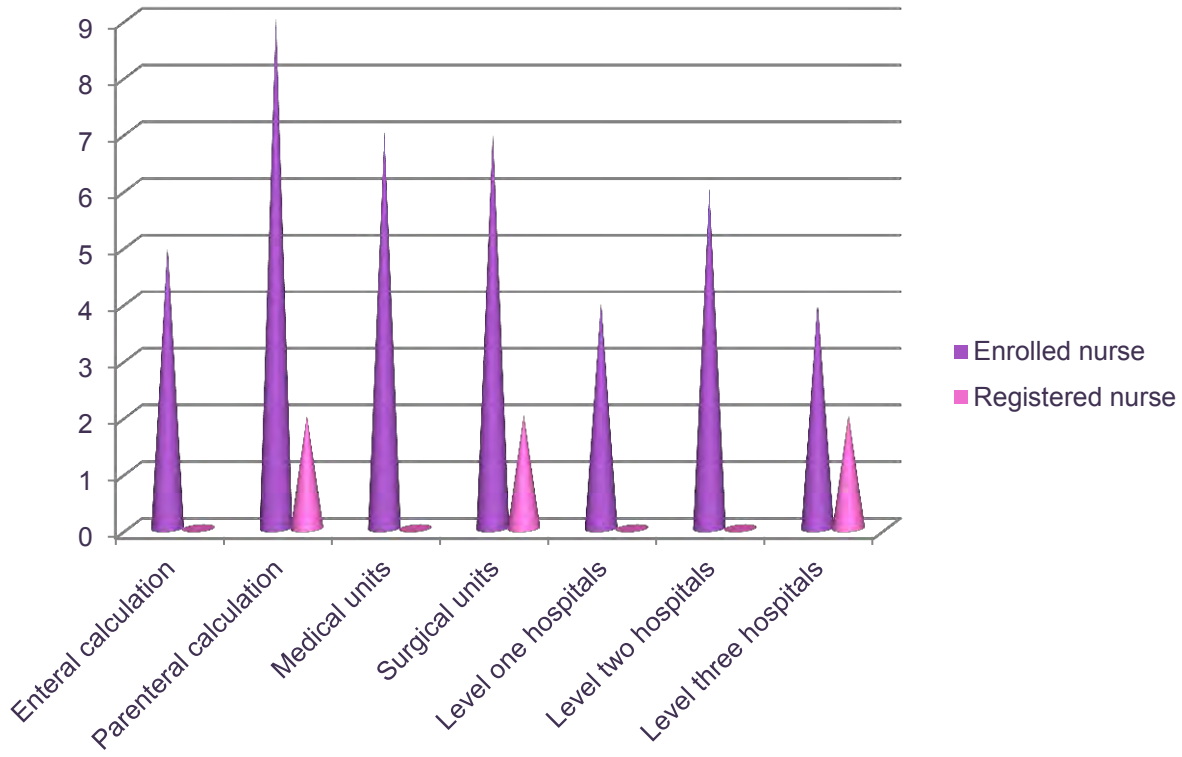


Figure 3.11: Trends in calculation errors by medication-administrator rank, administration-route, unit-type and hospital-level

3.5 DISCUSSION

In a non-recent article by Hamel and Janssen (1988:139), the average occupancy of public hospitals in sub-Saharan Africa was stated to be 86%. Though old, this information correlated with the average occupancy observed in surgical units of public hospitals in the Gauteng province. The increased occupancy observed in medical units could be due to the burden of HIV/AIDS, as the Ministry of Health of another African developing country explained that an increased occupancy could be

a result of the continued increase in numbers of AIDS patients hospitalized (Mpundu, 2000:6). These patients not only require longer hospital stays compared with other diseases, but are often also admitted for AIDS-related opportunistic infections (Mpundu, 2000:6). This threat was emphasised by the mid-year report of Statistics South Africa (2015:5) in which it was stated that an estimated 10.2% of South-Africa‟s total population was HIV-positive in 2014. These patients are often admitted in medical units of South-Africa‟s public hospitals.

The under-staffing problem was also not unique to South Africa as an African country. Under-staffing of hospitals was seen to be one of the major problems in limited-resource countries (Alp *et al.*, 2011:36). It is important to note that two of the hospitals that showed a higher-than-required staffing level had students as part of the work-force on the days of observation. Though students can help with menial nursing tasks, they need more supervision and might in certain instances add to the work-load instead of lightening it. Skills mix should therefore also be considered when determining staffing levels of units. Aiken *et al.* (2002:2) and Paulson (2004:307) confirmed that staff qualifications directly impact on the process of care and patient outcomes. This was further established by the direct observation outcomes that showed that student nurses were more often involved in medication administration errors while enrolled nurses were less likely to be able to do accurate dosage-calculations.

Demographic variables are sure to impact patient safety. Though the data-synthesis of 91 studies revealed that the median medication administration error rate determined by observational techniques was 19.6% (Keers, Williams, Cooke & Ashcroft, 2013b:237), some studies showed results of medication administration errors similar to what was observed in this study. O‟Hare *et al.* (1995:1536) found that the medication error rate was 93.9% while Hartley (1998:38) found a medication error rate of 78.6%. Both these studies were conducted in the United Kingdom, a developed country of which is expected to have a lower incidence of medication administration errors than a developing country such as South Africa.

Demographic unit data were not the sole contributing factor to medication administration errors. Parenteral medications were found to be involved in medication errors more often than enteral medications (Bertsche *et al.*, 2015:1 and

Härkänen *et al.*, 2015:297). Valentin *et al.* (2009:b814) agreed that parenteral medication errors at the administration stage are common and a serious safety problem. The presence of students in medical units and their administration of enteral medications greatly impacted the incidence of medication administration error, skewing the results to show enteral medication administration in medical units to be subjected to more errors.

Another predictor of medication errors was unit type. Though medical units in the Gauteng Province revealed a greater incidence of medication administration error than surgical units by 10%, both Rentero *et al*. (2014:398) and Van Wagtendonk *et al.* (2010:1733) stated that the rate of medication error was higher in surgical than in non-surgical care. The discrepancy as determined by Rentero *et al.* (2014:398) was found to be almost 20%.

Omissions were one of the top two medication errors observed. A few studies supported this finding (Teixeira *et al.*, 2014:100; Buckley *et al.*, 2013:1599; and Quélennec *et al.*, 2013:530). The 41% of errors represented by errors of omission were found to be comparable to the 36% as was mentioned by Bowns and Gill (2012:20), though the 39% of observed patients affected by omissions were much lower than the 73% as identified by chart-review done by Shandiva *et al.* (2015:12). This discrepancy could be explained as Shandiva *et al.* (2015:12) studied charts that were completed for more than one medication administration round, magnifying the risk of omission for every round completed.

Two reasons for medication administration omissions mentioned by Dalton *et al.* (2015:1) overlapped with those of this study, viz. drugs not being available (stock distribution problems) and patient condition (patients uncooperative, patients vomiting or patients taking nothing per mouth) while Shandiva *et al.* (2015:12) also mentioned patients‟ refusal, patients‟ condition and medication unavailability. A further reason for medication omissions was found to be illegible handwriting. Sound nurse-physician communication is a cornerstone of safe, efficient, and effective patient care (Arford, 2005:72). The three omitted doses related to illegible physician handwriting attested to this statement, proving that a breakdown in communication may lead to less safe and less effective patient care.

Though not a reason for omission, bed-occupancy was found to be a contributing factor thereof. The association identified between bed occupancy and omission incidence was confirmed by Duffield *et al.* (2015:1288) who concluded that instability in patient factors (such as occupancy) could contribute to potentially negative patient outcomes (such as medication errors). Scott *et al.* (2014:157) and Maitoko *et al.* (1993:29) concurred that increased occupancy was related to higher medication error incidence while Valentin *et al.* (2009:928) clarified that occupancy rate per 10% increase raised the odds ratio for the occurrence of medication errors. However, Watts *et al.* (2013:264) disagreed with their findings revealed that no significant change in medication error incidence was seen with a change in the occupancy rate.

Another contributing factor to omission was identified as understaffing. West *et al.* (2012:22) explained that inadequately staffed shifts could increase the likelihood of adverse events such as medication error. Valentin *et al.* (2009:928) agreed that the increase of number of patients per nurse increased the odds ratio for the occurrence of medication errors. Workload in general poses a challenge to medication safety practices (Aljadhey *et al.*, 2014:326 and Duffield *et al.*, 2011:244).

In contrast with omissions, wrong-medication errors were rare, representing but 2% of all medication errors observed. This finding was confirmed by that of Härkänen *et al.* (2014:5) who determined wrong-medication errors to represent 1.3% of all medication administration errors observed. Most of these errors were committed by student nurses. Registered nurses‟ knowledge of medication was found to be superior to that of student nurses (Simonsen *et al.*, 2014:1). Despite this fact, student nurses often find themselves in situations where they have to act despite feeling unsure or nervous (Dolansky *et al.*, 2013:105), which might lead them to commit wrong-medication errors due to not double-checking or seeking supervisory input prior to medication administration.

Presenting a higher incidence, Quélennec *et al.* (2013:530) found that 8.1% of errors represented wrong dose errors while Deans (2005:31) found this error-type‟s incidence to be 7.6%. Though wrong-dosage errors occurred more than this in Gauteng (11%), it was less than the incidence of this type of error observed by Cottney and Innes (2014:68) and Kim *et al.* (2011:349) who respectively determined 18% and 26.8% of medication administration errors to be wrong-dosage errors.

Interruptions had an alleviating effect on wrong-dosage errors. Though interruptions as cause of medication errors are much sited, Elfering *et al.* (2015:139) found that compliance with safety regulations was not related to interruptions. Pape (2003:79) found that wrong-dosage error was the only error type that had a non-significant association with interruptions while Berdot *et al.* (2012:63) could not determine any significant effect between interruptions and medication administration errors. Scott-Cawiezell *et al.* (2007:76) agreed to this study‟s finding of an inverse association between the rate of interruptions and medication errors (excluding wrong-time errors).

An element that did contribute to an increased incidence of wrong-dosage errors was medication administrator rank. Student nurses were found to be less knowledgeable with regards to medications‟ doses and strengths (Simonsen *et al.*, 2014:585). Simonsen *et al.* (2014:580) also found a large difference between the dose-calculation-accuracy of registered nurses and that of student nurses. Though student nurses made more wrong-dosage errors than registered nurses in the Gauteng Province, registered nurses‟ confidence in their own abilities might in turn cause medication errors according to Dickinson *et al.* (2010:733) as senior nurses may display misplaced confidence and administer incorrectly calculated medicinal dosages.

This confidence was seen in the lack of following safe protocol for patient identification, though only one wrong-patient error was observed. In contrast, wrong-patient errors were the error-type most reported by nurses (Günes *et al.*, 2014:298) Günes *et al.* (2014:298) determined that 24.7% of errors reported by nurses were wrong-patient errors while 8.6% of medication administration errors reported by means of survey represented wrong-patient errors (Kim *et al.*, 2011:349). However, results of observational studies showed a different incidence of wrong-patient errors, with some studies not observing even one wrong-patient error (Vazin & Delfani, 2012:427) or only one (Cottney & Innes, 2014:66). This confirms the actual incidence of wrong-patient error as observed in medical and surgical units of public hospitals in the Gauteng Province.

Registered nurses over-confidence did, however, add to wrong-route errors, as they often chose to administer the enteral equivalent of parenteral prescribed medications

as these were more easily accessible and faster to administrate. This led to registered nurses implicated for all cases of wrong-route errors. As enrolled nurses rarely administered parenteral medications and thus rarely had the option of an alternative administration route, the statistically significant association between medication administrator rank and wrong-route errors developed.

Peaking at error-type incidence, 127 wrong-time errors were observed. Several other studies found wrong-time errors to be the most prevalent of all medication administration error types (Berdot *et al.*, 2012:59; Choi *et al.*, 2015:1; Deans, 2005:31; and Oguz *et al.*, 2015:395) Deans (2005:31) found a wrong-time-error incidence of 31.6%, 12% less than what was determined in this study. However, Berdot *et al.* (2012:61) discovered a much higher rate of wrong-time errors, at 72.6%. The incidence of wrong-time errors is greatly dependent on the definition thereof, which could either lead to a lower incidence due to too much time allowed before a wrong-time error was identified, or a higher incidence due to too little time allowed before a wrong-time error was identified. The high incidence of wrong-time errors reported by Berdot *et al.* (2012:61) could have been intensified by their definition of wrong-time errors, allowing one hour before or after the specified time, regardless of the prescribed interval.

Contributing to wrong-time error incidence were high patient-to-nurse ratios. Berdot *et al.* (2012:59) confirmed that the number of patients under one nurse‟s care was associated with medication errors. The more patients to be attended to by one nurse, the more nursing time was required and the bigger the risk of medications being administered late became.

The rank of the administrator played a role in wrong-time error incidence as well. Student nurses were found to be less knowledgeable in medication management (Simonsen *et al.*, 2014:580). The time needed to research medications or ask for supervisory input from senior nurses might cause a delay in medication administration and therefore lead to wrong-time errors. Inexperience is another predictor of medication error (Fasolino & Snyder, 2012:E11) as the student might take longer to identify the indicated medication or to gather needed supplies than the nurse who administers medication every day.

Still considering factors adding to medication error, the number of doses prescribed per patient was found to be a determinant of medication administration error. Ben-Yehuda, *et al.* (2011:491) also found an increased amount of doses prescribed per patient as a statistically significant predictor of medication error ($p = 0.049$). This association was agreed on by Härkanen *et al.* (2015:297).

Deviations from safe practice with regard to medication administration could also impact on the safety of medication administration. In the study conducted by Kim and Bates (2013:593) only 1.4% of medication administrators did not read the name of the medication indicated on the label, while another 1.4% did not read the name of the medication on the prescription chart. This correlated with the findings of this study where 1% of medication administrators did not read the label and 3% did not read the prescription with regards to medication name. Another study showed that compliance with the procedure of reading the medication label was 97.2% (Westbrook *et al.*, 2011:1030), further validating the range of findings

When considering more wrong-medication related deviations from safe practice, the 4% of medications administered by a medication administrator other than the one who prepared it, was much lower than the incidence of this deviation from safe practice observed in Korea (28%) as determined by Kim and Bates (2013:593). However, medication that was not labelled directly after preparation had a much higher incidence in the Gauteng Province (32% of all parenteral medication administered) than that observed by Kim and Bates (2013:593) in Korea (2.5%). Not labelling or inadequate labelling of medications was mentioned by Agyemang and While (2010:381) as a frequent cause of medication administration errors, therefore this deviation was identified as a large threat to medication safety in South Africa.

The incidence of two wrong-dose related deviations from safe practice was found to be similar to those identified by Kim and Bates (2013:593) who found that 1.4% of medication administrators did not verify the amount of medication indicated on the label of the medication and another 1.4% did not verify the amount of medication prescribed. Only 5% of medications‟ dosages that were administered via syringes were criticised due to the markings of the syringes not being read at eye level. This was much lower than the incidence of this deviation as observed by Kim and Bates (2013:593) who found that 54.4% of markings were not read at eye level. This

discrepancy could be due to the observer not including doses where whole vial volumes were extracted for administration and also due to the scarcity of medications administered via syringe observed in the Gauteng Province.

Moving on to wrong-patient related deviations from safe practice, another study indicating high incidence of wrong-patient related deviations concluded that patients‟ identifications were only checked in 47.9% of cases prior to medication administration (Westbrook *et al.*, 2011:1027). Though the results found in the Gauteng province showed significantly higher incidences of patients‟ wristbands not read (77%) and patients not asked to verify their names (71%), it was still found to be lower than that observed in Korea (93.5% and 96.6% respectively [Kim & Bates, 2013:593]). Nurses interviewed by Dougherty *et al*. (2011:1302) explained that they failed to check patients‟ identities because they felt that they knew the patients well enough. Nevertheless, if procedures were not always followed by habit, the failure to follow proper protocol might become common practice, leaving the not-well-known patients at increased risk of wrong-patient medication administration errors.

Checking of medication routes on prescriptions was better complied with. The 2% of medication routes not checked on the prescription chart was found to be similar to the 1.4% incidence of this deviation indicated by Kim and Bates (2013:593). However, incidence of wrong-time related deviations from safe practice was found to be much lower in the Gauteng Province (medications not prepared directly before administration in 4% of medication administrations observed) than in Korea (30% of medications not prepared directly before administration) according to Kim and Bates (2013:593). Conversely, the preparation of medications before the indicated time of administrations was done to limit the time needed for medication administration later in order to be able to complete a medication round within acceptable time-limits, thus to prevent wrong-time errors.

Continuing to asepsis-related deviations from safe practice, hands were not disinfected prior to the administration of enteral medication in 77% of cases. Though findings by Kim and Bates (2013:594) revealed that 71.1% of nurses disinfected their hands prior to parenteral medication administration, 3.4% of them did not wash their hands for the adequate amount of time while 6.9% did not wash all the areas of their hands. The incidence of this deviation from safe practice increased drastically

during the administration of enteral medications, with only 4.5% of nurses disinfecting their hands prior to administration (Kim & Bates, 2013:594).

International literature revealed a better compliance with aseptic technique, especially aseptic technique applied during the administration of parenteral medications. The compliance with aseptic technique during the administration of parenteral medications was found to be 90% in a study done in Australia (Westbrook *et al.*, 2011:1030). In the Gauteng Province, only 42% of parenteral supplies were disinfected prior to medication administration, sterility of parenteral supplies was not maintained in 21% of patients nursed and another 7% of patients‟ injection sites were not cleaned prior to injection. Thus, these findings were in accordance with those of Bertsche *et al.* (2015:1) who stated that flaws in hygiene were identified to be one of the most important deviations from safe practice related to parenteral medication administration.

Documentation deviations from safe practice, though not as prevalent as asepsis-related deviations, could potentially cause more severe errors. Confirming the incidence of 7%, another study showed an incidence of 6.7% of medication administrators not recording the medication administration (Westbrook *et al.*, 2011:1030). According to Elfering *et al.* (2006:457) incomplete or incorrect documentation was the most frequently observed safety-related incident related to workplace stress. The failure to document or to document the correct time might flow from the stress caused by a high workload in an ill-staffed unit.

Contributing to the medication administrator‟s workload, interruptions were often observed. Based on fourteen observational studies, Biron *et al.* (2009b:70) reported that nurses cite interruptions as a significant contributing factor to medication error incidence. Interruptions were also one of the most cited causes of medication administration errors determined in the systematic review done in phase one of the study and was found to be one of the most prevalent deviations from safe practice deviations mentioned by Donaldson *et al.* (2014:63). However, no practical or statistically significant correlation could be drawn in this phase of the study to support the association between interruptions and medication error incidence.

The work of Biron *et al.* (2009a:330) supported the findings of this study in that most interruptions during preparation of medications were found to be caused by other

hospital staff and that the interruptions during medication administration were mostly self-initiated.

Anti-infective agents were found to be most often associated with medication errors in an Australian study as well (Westbrook, 2011:1031), though other medications involved did not show the same ranking in medication-error-involvement as this study. Quélennec *et al.* (2013:530) found that nervous system medications, gastrointestinal medications and cardiovascular medications were the medications most often associated with medication errors, though the incidence of gastrointestinal and central nervous system medications were found to be among the three medication categories least associated with medication errors in the Gauteng Province, representing 3% of medication errors each. 13% of medication errors involving cardiovascular medications, compared better to the 18% as determined by Quélennec *et al*. (2013:530). Warne *et al.* (2010:112) found that analgesia and anti-inflammatory drugs were the most common missed medications (28%). This is close to the error rate in administration of pain-relief medication in public hospitals of the Gauteng Province (25%).

Though medication category could predispose medication administrations to all kinds of errors, calculation competence could lead to wrong-dose errors specifically. Between 71% and 79.9% of respondents in a different calculation-knowledge-test conducted by Simonsen *et al*. (2014:585) were able to correctly calculate dosages to be administered. The calculation skills of medication administrators of the Gauteng Province‟s public hospitals proved to be slightly less, with 68% of medication administrators reaching the accurate answer.

According to Van Wagtendonk *et al.* (2010:1733) the incorrect fit between an individual‟s training or education and a particular task could cause unintended events such as medication errors. The discrepancy between knowledge tests outcomes of enrolled nurses versus registered nurses could be explained by the observation made by Fleming *et al.* (2014:55) that there exist inconsistencies in the amount of pharmacology content and drug calculation skills delivered within nursing curricula. Following this, the curricula for enrolled nurses appear to be lacking in this training.

3.6 LIMITATIONS

Medication administrations were observed by only one observer. Though medication administration errors could have been missed due to this limitation, the observer double-checked all medication administration errors with the prescription and medications to ensure that medication administration error incidence was not inflated. The Hawthorne effect, another limitation of direct observational studies, was also mitigated by the single observer, as one observer is more likely to be absorbed in unit-business and environment than two. The observer further moderated the Hawthorne effect by allowing the medication administrator to become familiar with the observation prior to starting the recorded observations.

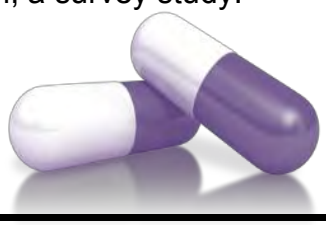
The small sample of the knowledge testing phase was seen as another limitation. However, the outcomes of this phase still confirmed that the lack of competency in dosage calculations could contribute to medication administration errors.

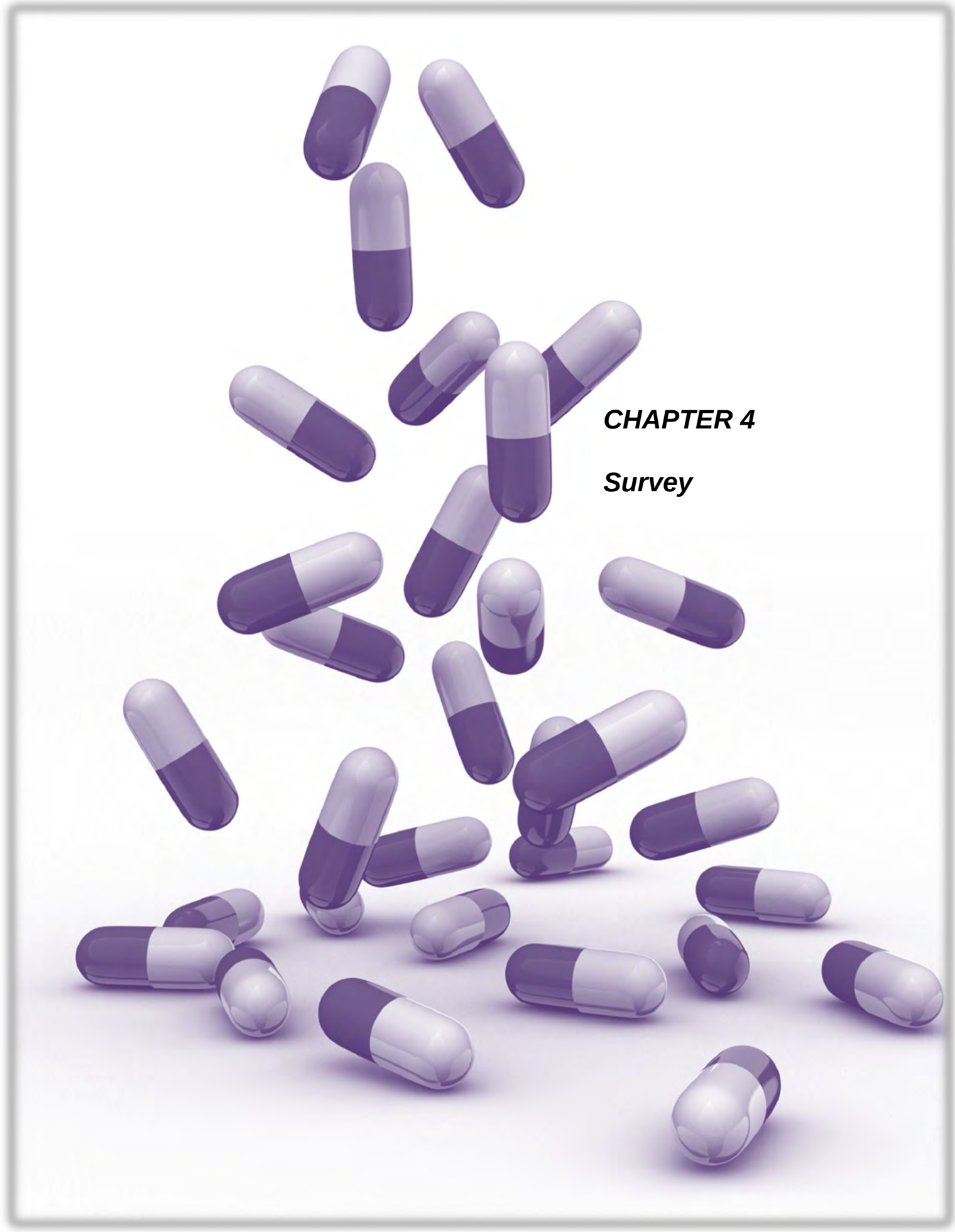
3.7 SUMMARY

This section completed the first step in the research cycle, viz. measuring harm. The incidence of medication administration errors within medical and surgical units of public hospitals of the Gauteng Province was determined. Nine out of ten patients in these units were subjected to one or more medication errors. Wrong-time errors and errors of omission were found to be most prevalent. Only one wrong-patient error was observed, while wrong-dose errors were third most prevalent. Six wrong-route errors were observed. Factors that exacerbated the medication administration error incidence were bed occupancy, percentage of required staff available, and rank.

A knowledge test was directed at determining medication administrator"s dose calculation skills. Two-thirds of calculations were completed correctly, with a definite dominance by registered nurses over enrolled nurses.

The following step of the research cycle, namely determining causes, will follow in the next phase of the research, a survey study.





CHAPTER 4

Survey

4.1 INTRODUCTION

After measuring the harm by determining the incidence of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province, the causes of medication error specific to this context as perceived by medication administrators were explored. Determining causes represents the second step in the research cycle in patient safety as presented by Bates (2013:2).

Ultimately, the safety culture of a hospital or unit determines the safety outcomes of the patients treated in that hospital or unit, which include the degree of medication safety maintained. Thus safety culture was identified as the foundation of quality care and patient safety (Pham *et al.*, 2012:451). Rich (2005:11) explained that the culture needed for the reduction of medication errors is one in which nurses are empowered to speak out, to report errors committed and nearly made, to want to find out why errors occur, and to change systems so that mistakes do not recur. Though nurses could easily pin-point specific causes of medication error, the existence of the safety climate of a unit or hospital is more complex to determine. However, the gaps in safety climate in a hospital or unit should be determined in order to more fully grasp the underlying factors associated with medication errors in that hospital or unit.

Further contributory factors not easily identifiable by the nurses themselves are knowledge or insight deficits. Knowledge and insight in the occurrence of error and safety issues could allay other causes of medication errors. Saintsing *et al.* (2011:358) explained that knowledge about error potential and awareness of this potential may help reduce the medication error rates and improve overall patient safety. Miracle (2009:52) agreed that once awareness of the potential for medication errors was created, steps of prevention could be developed. Following this statement, one could derive that the absence of knowledge and awareness of errors might in turn lead to more errors. For this reason it was important to determine the level of knowledge and awareness that medication administrators in the Gauteng Province had with regards to the incidence of medication error and level of medication administration safety in their units.

A plethora of research elaborated on the multiple causes of medication administration error (Armutlu *et al.*, 2008:61; Bohomol *et al.*, 2009:1263; Cottney & Innes, 2014:68; Deans, 2005:31; Doherty & McDonnell, 2012:5; Donaldson *et al.*,

2014:63; Fry & Dacey, 2007:677; Günes *et al.*, 2014:298; Härkänen *et al.*, 2014:6; Hemingway *et al.*, 2014:4; Mohamed & Gabr, 2010:29; Mrayyan, 2012:223; Mrayyan & Al-Atiyyat, 2011:210; Mrayyan *et al.*, 2007:665; Murphy & While, 2012:930; Oshikoya *et al.*, 2013:72; Ozkan *et al.*, 2011:140; Parshuram *et al.*, 2008:47; Patrician & Brosch, 2009:283; Pham *et al.*, 2011:487; Sanghera *et al.*, 2007:58; Sears *et al.*, 2013:354; Shahrokhi *et al.*, 2013:20; Smeulers *et al.*, 2014:279; Ulanimo *et al.*, 2007:31; Unver *et al.*, 2012:322; Valdez *et al.*, 2013:225; and Volpe *et al.*, 2014:556). However, Emanual *et al.* (2008:16) emphasized the importance of context, thus it was important to determine the perceived causes of medication error specific to the sample context.

A factor contributing to medication error incidence after-the-fact is a medication error reporting system. A well-developed medication error reporting system could allow hospitals to collect vital information for root cause analysis and risk assessment (Wong *et al.*, 2009:163). The presence of a reporting system within a hospital could moderate causes of medication administration errors, as risk factors related to medication administration errors could be identified and addressed. This reporting system should, however, be non-punitive and accessible. McGrath (2010:6) agreed that safe routes for nurses to report all errors, including near misses and patient safety issues were imperative for changes to occur.

For this reason, the aim of this phase of the study was to determine by means of a survey the perceived unit-safety-culture, incidence of medication error, level of overall medication safety, causes of medication administration errors, as well as the incidence and reasons for non-report of medication administration errors in medical and surgical units of private and public hospitals in the Gauteng Province of South Africa.

4.2 CONCEPT CLARIFICATION

4.2.1 Patient safety

Patient safety is focused on the prevention of error in health-care settings (Hassen, 2010:51).

4.2.2 Medication administration safety

Building upon the definition of patient safety, medication safety is focused on the prevention of error during medication administration. Medication administration safety is seen as a branch of safe patient care.

4.2.3 Safety culture

A hospital or unit"s safety culture can be defined as management and staff values, beliefs, and norms about what is important in a health care organization, how organizational members are expected to behave, what attitudes and actions are appropriate and inappropriate, and what processes and procedures are rewarded and punished with regard to patient safety (Sorra & Dyer, 2010:199).

4.3 METHOD

Gravetter and Forzano (2012:373) explain that the survey provides a snapshot of the group at a particular time in order to obtain an accurate picture of the individuals being studied. The survey method holds the advantage that a large group of individuals could be studied more easily (Jackson, 2012:17). Gravetter and Forzano (2012:385) agree that one of the main advantages of surveys is that information on a wide variety of different variables could be obtained in a relatively easy and efficient manner.

More advantages of surveys included that it is convenient and anonymous, nonthreatening to participants, easy to administer, participants can stay at their place of work, and it grants access to a large number of participants with common characteristics (Gravetter & Forzano, 2012:385). Evans and Rooney (2011:240) agree that especially self-administered surveys promoters the feeling of anonymity of the respondents. A self-administered survey, such as was used in this phase of the research, includes survey questions that are read and answered by the respondent with little or no direct contact with the researcher. Though Gravetter and Forzano mentions a possible low response rate and the difficulty to analyse or summarize data as possible limitations, these limitations were mitigated in this study as the personal contact with the mediator firstly promoted better response rates and secondly factor analysis was conducted to investigate subscales wherein data could be more easily grouped and presented.

4.3.1 Population and sampling

As with the previous research phase, multiphase cluster sampling was incorporated in order to ensure a representative and sufficient sample. The hospitals selected for this phase of the study were the same as those selected for the previous phases of the research (direct observation and knowledge testing). However, when units were sampled, all medical and surgical units in the whole hospital were included. Within these units, an all-inclusive sample of medication administrators working on all shifts within a two-week period, were selected (N = 683), although an exclusion criterion for the units were those of which the unit-manager did not grant permission to enter the unit, none of the units sampled needed to be excluded due to this criterion. 280 surveys were returned, thus the response rate was 41%.

4.3.2 Instruments

Portions of two validated and reliable surveys were merged with the survey list as prepared in phase one of this research study to create the survey on medication administration safety that was used in this phase of the research. This newly-developed survey consisted of seven portions (Addendum XIII).

The first portion of the survey was taken from the Agency of Healthcare Research and Quality (AHRQ) hospital survey on patient safety culture. 17 five-point Likert-scale items ranging from strongly disagree (1) to strongly agree (5) and representing five patient safety culture composites were used. These questions represented the non-punitive response to error subscale (three items); the organizational learning and continuous improvement subscale (two items); the overall perceptions of patient safety subscale (four items); the staffing subscale (four items); and the teamwork within units subscale (four items). The reliability of the patient safety composites was determined by Sorra and Dyer (2010:207) to be 0.78, 0.71, 0.74, 0.62 and 0.79 respectively. A further patient safety culture composite drawn from the AHRQ hospital survey on patient safety culture was used in the fifth portion of the developed survey: frequency of events reported. This composite consisted of three five-point Likert-scale items ranging from never (1) to always (5). The initial Cronbach‟s alpha determined for this subscale was 0.85 (Sorra & Dyer, 2010:207). A fourth item was added to this subscale by the researcher to determine the perception of incidence of reporting errors that caused harm to a patient.

One other portion of the survey used was derived from an existing survey, the Medication Administration Error Reporting Survey (Wakefield *et al*, 2005:475). 16 six-point Likert-scale items ranging from strongly disagree (1) to strongly agree (6) representing four different subscales of why medication errors were not reported were included. These subscales were "disagree with definition of medication error" (four items); "reporting error" (two items); "fear" (five items); and "administrative response" (four items). Cronbach‟s alphas determined for the subscales by four different confirmatory factor analyses revealed results between 0.76 and 0.77 for the "disagreement over error" subscale, between 0.79 and 0.86 for the "reporting effort" subscale, between 0.85 and 0.87 for the "fear" subscale, and between 0.69 and 0.78 for the "administrative response" subscale (Wakefield *et al.* (2005:483). One item, "The expectation that medications be given exactly as ordered is unrealistic," was not divided into a specific subscale by Wakefield *et al.* (2005:484).

Two individual questions were derived from the Registered Nurse Forecasting (RN4CAST) survey. One seven-point Likert-scale item ranging from never (1) to every day (7) was added to determine the perceptions of how often medication errors occurred in the respondent‟s unit: In your unit, how often would you say medication errors occur? Another general five-point Likert-scale item ranging from excellent (1) to failing (5), determined the perceptions of an overall medication administration safety grade: Please give your unit in this hospital an overall grade on medication administration safety.

Perceptions of causes of medication errors were determined in four subscales ranging on a four point Likert scale from no risk (1) to significant risk (4). These subscales were derived from Phase 1 on of the study, the systematic review (section 2.4). The first subscale included ten items on perceived risk-significance of communication factors, the second subscale included eleven items on perceived risk-significance of human-factors, the third subscale addressed fourteen items of environmental factors impacting on medication errors, while the last subscale included ten items measuring the perceived risk-significance of medication-related factors. A small demographic section was also included to determine the respondent‟s gender, age, full-time or part-time employment status, years of experience of medication administration (both in general and in the specific hospital), rank and highest level of qualification.

4.3.2 Data realisation

On the day that phases 2 and 3 were executed in a specific hospital, the researcher distributed surveys to all medical and surgical units of that hospital. Enough surveys were left with the unit managers to include all day-shift and night-shift medication administrators. The unit managers were informed about the research, the informed consent letter and the data-collection process were described to the unit managers and they were asked whether they would act as mediators in the recruitment process. All unit managers agreed and distributed the surveys among their staff.

Surveys (Addendum XIII) were accompanied by informed consent forms (Addendum V), two sealable envelopes and a pen as a token of appreciation. A black sealed fabric sleeve with a post-split (Figure 4.1) was placed in each unit, most often in the units‟ tea-rooms, where the completed surveys were posted, so as to optimise confidentiality. The date for collection of the sleeve was indicated on it so as to remind participants of how much time they had to complete the surveys. The sleeves were collected ten days to two weeks after distribution so that all rotating medication administrators had a fair chance to participate in the study.

Figure 4.1: Sleeve for data collection

The right to autonomy and self-determination, which involves the right to agree or not agree to take part in the survey and the right to be informed about the study as emphasized by Saks and Allsop (2013:200) were emphasised to the unit managers as mediators.

4.3.4 Data analysis

Validity and reliability of the instrument were determined prior to further data analysis. Exploratory factor analyses were performed on the different sections of the survey in order to simplify interrelated measures into subscales, where-after confirmatory factor analyses and the determination of Cronbach alpha scores followed. Exploratory factor analysis could be described as ordering interrelated measures while confirmatory factor analysis is used to verify the theoretical factor structure of a set of observed variables (Suhr, 2006:1). Construct validity was determined by means of exploratory and confirmatory factor analyses.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was used to determine the factorability of the data. The following measures of interpretation as proposed by Friel (2015:19) were applied:

- 0.90 to 1.00 – Marvellous;
- 0.80 to 0.89 – Meritorious;
- 0.70 to 0.79 – Middling;
- 0.60 to 0.69 – Mediocre;
- 0.50 to 0.59 – Miserable; and
- 0.00 to 0.49 – Don"t factor.

Lorenzo-Seva (2013:12) mentions explained variance as an intuitive index of goodness of fit. The higher the percentage of variance a proposed model manages to explain, the more valid the model seems to be (Lorenzo-Seva, 2013:12). Beavers *et al.* (2013:8) explained that 75% to 90% of the variance should be accounted for, though the variance explained as low as 50% could be seen as acceptable.

Thereafter, confirmatory factor analyses were done to confirm the validity of subscales of the different sections of the developed survey. A well-fitting model is one that is reasonably consistent with the data and so does not necessarily require re-specification (Kenny, 2014:2). During confirmatory factor analysis, several goodness-of-fit measures were considered as multiple fit indices are typically needed to evaluate overall model fit (Bergh & Ketchen, 2006:404). According to Williams and Vogt (2011:577), the chi-square statistic can be used to test the relative fit of models while Hardy and Bryman (2004:445) mentioned the Comparative Fit index

(CFI) as one of the most popular fit indices and Yang (2010:172) added the Root Mean Square Error of Approximation (RMSEA) as one of the most widely acceptable fit indices. The following measures for these indices were used in this study:

- If the Chi-squared test statistic is smaller than 0.05, the model is accepted as bad fitting (Barret, 2007:815). However, adjustment of the Chi-squared test statistic for the degrees of freedom was done in an attempt to specify the graduated approximate fit.
- In general, a model with a Minimum Sample Discrepancy (Chi-squared test statistic divided by degrees of freedom [CMIN/DF]) value above five tends to be rejected and good models show values below three (Mazzocchi, 2008:329).
- CFI values of above 0.9 indicate an overall good fit. According to Kenny (2014:5, a value between 0.90 and 0.95 was considered marginal, above 0.95 is good and below 0.90 was considered poor.
- Regarding the RMSEA value with a 90% confidence interval, values of 0.10 and larger should not be accepted. MacCallum *et al.* (1996:130) have used 0.01, 0.05, and 0.08 to indicate excellent, good, and mediocre fit, respectively.

Cronbach alpha tests were done to assure internal consistency of items in a scale - indicating to what measure a certain construct is tested consistently (Gliem & Gliem, 2008:85). Though the aim for the Cronbach alpha for a survey should be 0.8, 0.7 was seen as acceptable (Gliem & Gliem, 2008:85).

After validity and reliability of the instrument were determined, the results obtained therewith were analysed. Neale (2009:131) proposed the use of descriptive and inferential statistics to analyse quantitative surveys. The first level of analysis followed this by focusing on basic descriptive statistics (frequencies, means and standard deviations) where-after inferential statistics were used to identify relationships between hospital level, unit type, rank of the administrator and subscales. Individual item relationships were determined by means of Cramer‟s V‟s, wherein the effect size was interpreted as small if it was 0.10, medium if it was 0.30, or large if it was 0.50. A relationship with the effect size higher or equal to 0.5 was considered as practically significant. T-tests were conducted to identify relationships between hospital levels; unit type; and administrator rank and subscale responses, rendering p-values and Cohen‟s d values, interpreted as a small effect at 0.2,

medium at 0.5 and large at 0.8. Spearman's rank correlations were incorporated to represent correlations between subscales, non-factorable items and certain demographical data of the respondents such as gender, full-time or part-time employment, age, experience as a medication administrator, experience within the specific unit, rank and qualifications.

4.4 RESULTS

4.4.1 Demographics of respondents

280 completed surveys were returned (41% response rate). Most respondents were female and employed permanently. Though the age groups of 25 to 29, 30 to 34, 40 to 44 and 50 to 54 were evenly represented, more respondents represented the 45 to 49 and the 35 to 39 age group while less respondents represented the 55 to 59 and the below 25 age group and least the 60 and above age group. The highest age recorded was 70 years. Figure 4.2 indicates the age-representation of the respondents.

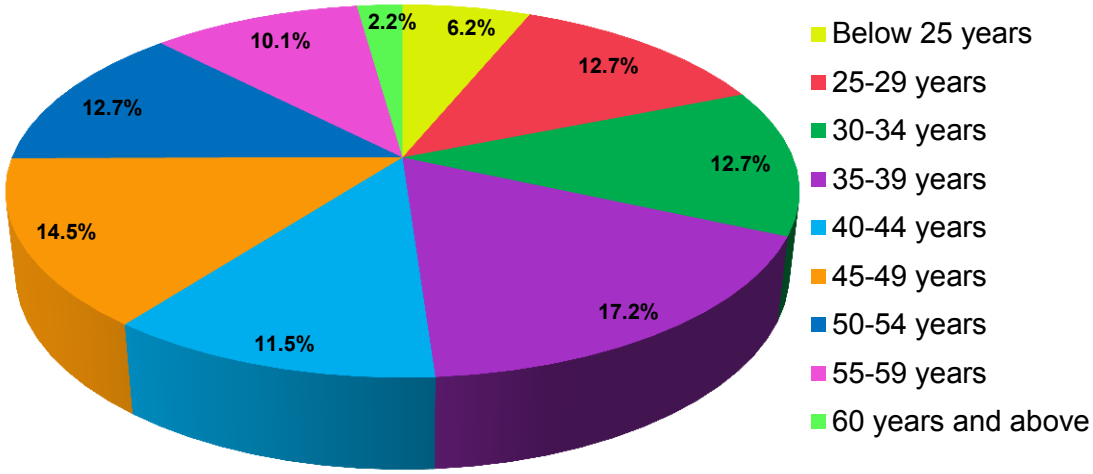


Figure 4.2: Age of respondents

Table 4.1 indicates an overview of demographic data from the respondents, including gender, full-time or part-time employment, age, years of experience (overall and in the specific unit), rank and highest qualification.

Table 4.1 Respondents demographic data

Demographic element	Amount [n (%)]
Gender:	
Male	25 (10.2)
Female	220 (89.8)
Employment:	
Full-time	236 (94.4)
Part-time	14 (5.6)
Age:	
<25 years	14 (6.2)
25-29 years	29 (12.7)
30-34 years	29 (12.7)
35-39 years	39 (17.2)
40-44 years	26 (11.5)
45-49 years	33 (14.5)
50-54 years	29 (12.7)
55-59 years	23 (10.1)
60 years and above	5 (2.2)
Years of experience in administering medication:	
<5 years	51 (23.2)
5-9 years	52 (23.6)
10-14 years	37 (16.8)
15-19 years	19 (8.6)
20-24 years	20 (9.1)
25-29 years	16 (7.3
30-34 years	15 (6.8)
35 years or more	10 (4.6)
Years of experience in current hospital:	
<5 years	79 (38.0)
5-9 years	45 (21.6
10-14 years	30 (14.4)
15-19 years	14 (6.7)
20-24 years	14 (6.7)
25-29 years	11 (5.3)
30-34 years	12 (5.8)
35 years or more	3 (1.4)
Rank:	
Registered nurses	120 (51.3)
Enrolled nurses	104 (44.5)
Student nurses	10 (4.3)
Highest qualification:	
Degree	22 (9.4)
Diploma	113 (48.3)
Certificate	81 (34.6)
Grade 12	18 (7.7)

The mean years of experience of being a medication administrator was thirteen years, while the mean years of being a medication administrator in the current place

of work was ten years. Almost one-quarter of staff had fewer than five years‟ experience. Most of the respondents had between five and nine years‟ experience and a downwards trend was noted from ten years‟ experience onwards.

4.4.2 Descriptive statistics

Responses for individual survey items will now be presented The Cramer‟s V was calculated to determine if there was any association between individual hospitals and responses to survey items, as this would have influenced whether results could be grouped together or not. For this reason the Cramer‟s V and p-values were also reported.

4.4.2.1 Descriptive statistics for the AHRQ hospital survey on medication safety (safety climate items)

Table 4.2 presents the responses for the seventeen items from the AHRQ survey on general medication administration safety. Percentages for each of the possible responses, means and standard deviations as well as the association between responses and individual hospitals including Cramer‟s V and p-values are provided. The cut off score of 3.5 for negative items and 2.5 for positive items will be used to determine the existence of safety climate concerns and will be discussed as such.

Table 4.2 Responses to individual AHRQ Hospital Survey on Patient Safety Culture items

Items	Percentage of responses					Mean	Standard Deviation	Association	
AHRQ Hospital Survey on Patient Safety Culture	1. Strongly disagree	2. Disagree	3. Neither	4. Agree	5. Strongly agree			Cramer's V	p-value
A1. People support one another in this unit	5.2%	6.3%	8.5%	45.6%	34.4%	3.98	1.073	0.18	0.139
A2. We have enough staff to handle the workload	53.4%	29.6%	5.4%	10.5%	1.1%	1.76	1.026	0.19	0.046
A3. When a lot of work needs to be done quickly, we work together as a team to get the work done	6.2%	6.9%	6.9%	46.0%	33.9%	3.95	1.116	0.15	0.597
A4. In this unit, people treat each other with respect	5.8%	13.9%	13.5%	36.1%	30.7%	3.72	1.203	0.23	0.000
A5. Staff work longer hours than is best for patient care	4.5%	14.8%	10.2%	43.2%	27.3%	3.74	1.145	0.15	0.709
A6. We are actively doing things to improve medication administration safety	1.9%	2.7%	4.9%	54.5%	36.0%	4.20	0.805	0.18	0.185
A7. We use more temporary staff than best for patient care	53.8%	25.2%	7.9%	10.2%	3.0%	1.83	1.127	0.25	0.000
A8. Staff feel like their errors are held against them	13.7%	27.8%	14.9%	29.8%	13.7%	3.02	1.296	0.21	0.025
A9. Mistakes have led to positive changes here	6.2%	10.4%	15.4%	51.5%	16.5%	3.62	1.071	0.22	0.004
A10. It is just by chance that more serious medication administration mistakes don't happen around here	8.1%	20.4%	8.5%	44.2%	18.8%	3.45	1.234	0.26	0.000
A11. When one area in this unit gets really busy, others help out	8.8%	17.6%	8.8%	37.9%	26.8%	3.56	1.293	0.21	0.008
A12. When a medication administration error is reported, it feels like the person is being written up, not the problem	16.1%	28.9%	14.9%	25.3%	14.9%	2.94	1.335	0.21	0.020
A13. We work in "crisis mode" doing too much, too quickly	6.8%	9.5%	11.4%	43.0%	29.3%	3.78	1.167	0.23	0.002
A14. Medication administration safety is never sacrificed to get more work done	11.2%	16.3%	14.3%	40.6%	17.5%	3.37	1.259	0.20	0.048
A15. Staff worry that mistakes are kept in personnel files	6.8%	22.7%	10.2%	36.0%	24.2%	3.48	1.267	0.25	0.000
A16. We have medication administration safety problems	29.1%	31.8%	10.9%	22.5%	5.8%	2.44	1.278	0.24	0.001
A17. Our procedures and systems are good at preventing medication errors from happening	4.2%	6.9%	8.8%	49.2%	30.9%	3.96	1.026	0.22	0.004

Three items revealed areas of concern, viz. the perception of having enough staff to handle the workload (A2), trying to do too much in too little time (A13), and having to work longer hours than what is best for patient care (A5). All three of these items could be related to staffing shortages.

83% (n = 230) of respondents did not feel that their unit had enough staff to handle the workload, with more than half (53.4%, n = 148) of respondents who strongly disagreed with the statement that there were enough staff for the workload. Three-quarters of respondents reported to work in "crisis mode", trying to do too much, too quickly (72.3%, n = 190). Furthermore, most respondents (70.5%, n = 186) agreed that staff in their units worked longer hours than what was best for the patient.

No significant association between responses to these items and individual hospitals could be determined, indicating that further analyses of these items could be done on the sum of responses across all hospitals.

4.4.2.2 Descriptive statistics – incidence of medication administration errors

Table 4.3 reveals the percentages, means and standard deviations and Cramer"s V and p-values for associations between individual hospitals and responses on respondents" perceptions of how often medication errors occurred in their units. These perceptions were measured on a seven-point Likert-scale ranging from never, through a few times a year or less, once a month or less, a few times a month, once a week, a few times a week, to every day.

Table 4.3 Responses indicating incidence of medication administration errors

Percentage of responses							Mean	Standard Deviation	Association	
1. Never	2. A few times a year or less	3. Once a month or less	4. A few times a month	5. Once a week	6. A few times a week	7. Every day			Cramer's V	p-value
23.2%	47.9%	11.6%	10.8%	0.8%	4.2%	1.5%	2.37	1.336	0.19	0.108

One quarter (23.2%, n = 60) of respondents were of opinion that medication errors never happened in their units. Most respondents thought medication errors occurred

a few times a year or less in their units (47.9%, n = 124). Only four respondents (1.5%) admitted that medication errors could occur in their units every day. No association between perceptions of medication administration error incidence and specific hospitals could be determined.

4.4.2.3 Descriptive statistics – Overall grade on medication administration safety

Table 4.4 presents respondents‟ overall grade on medication administration safety of their units. These perceptions were rated on a five-point Likert-scale ranging from excellent to failing, including options for very good, acceptable or poor.

Table 4.4 Responses indicating overall grade on medication administration safety

Percentage of responses					Mean	Standard Deviation	Association	
1. Excellent	2. Very good	3. Acceptable	4. Poor	5. Failing			Cramer's V	p-value
25.6%	35.9%	35.1%	1.9%	1.5%	2.18	0.890	0.24	0.000

One quarter of respondents deemed the overall medication administration safety grade in their units as excellent (25.6%, n = 67), while another third felt their units‟ medication administration safety was very good (35.9%, n = 94), while fewer than ten respondents felt that the overall grade on medication administration safety in their units were poor (1.9%, n = 5) or failing (1.5%, n = 4). The Cramer‟s V for the association between individual hospital and the perceptions of the overall safety grade of units was non-significant.

4.4.2.4 Descriptive statistics for causes of medication administration errors

Table 4.5 presents the descriptive statistics for the section on the causes of medication administration as derived from the systematic review in Chapter 2. Risk-perceptions were indicated on a four-point Likert-scale ranging between no risk, small risk, moderate risk and significant risk. Scores over three were discussed as mentionable risks.

Table 4.5 Causes of medication administration errors

Items	Percentage of responses				Mean	Standard Deviation	Association	
Causes of medication errors (Systematic Review)	1. No risk	2. Small risk	3. Moderate risk	4. Significant risk			Cramer's V	p-value
D1.1. Communication lapses between the physician and the medication administrator	25.7%	38.3%	21.7%	14.2%	2.25	.994	0.20	0.099
D1.2. Communication lapses between the pharmacist and the medication administrator	30.3%	31.5%	23.6%	14.6%	2.22	1.037	0.18	0.215
D1.3. Misunderstood orders	25.9%	31.1%	21.9%	21.1%	2.38	1.087	0.25	0.001
D1.4. Confusing instructions	21.4%	37.3%	19.0%	22.2%	2.42	1.059	0.22	0.021
D1.5 Frequent changes in prescriptions	25.2%	29.5%	28.7%	16.5%	2.37	1.035	0.21	0.024
D1.6. Use of abbreviations in prescriptions	16.9%	25.9%	21.6%	35.7%	2.76	1.113	0.16	0.498
D1.7. Illegible prescriptions	12.7%	18.3%	19.9%	49.0%	3.05	1.089	0.20	0.124
D1.8. Incomplete prescriptions	13.4%	20.1%	24.4%	42.1%	2.95	1.077	0.22	0.016
D1.9. Cultural or language barriers between health care professionals	35.9%	27.5%	17.1%	19.5%	2.20	1.129	0.18	0.274
D2.1. Knowledge, educational or training deficit	31.7%	27.6%	19.8%	21.0%	2.30	1.126	0.26	0.000
D2.2. Procedures or policy not followed (e.g. not checking the five rights of medication administration)	36.3%	24.5%	11.8%	27.3%	2.30	1.221	0.26	0.001
D2.3. Inexperience	31.0%	24.3%	16.3%	28.5%	2.42	1.199	0.21	0.080
D2.4. Slips or memory lapses	35.6%	20.3%	20.8%	23.3%	2.32	1.184	0.22	0.034
D2.5. Psychological factors (e.g. being stressed or emotionally exhausted)	21.7%	23.0%	25.4%	29.9%	2.64	1.127	0.21	0.060
D2.6. Physical factors (e.g. being too tired or hungry)	19.3%	23.0%	25.5%	32.1%	2.70	1.115	0.26	0.001
D2.7. Miscalculations of dosages	30.2%	23.8%	14.1%	31.9%	2.48	1.224	0.23	0.009
D2.8. Incorrect preparation of medications	33.6%	19.2%	19.2%	28.0%	2.42	1.217	0.24	0.005

D2.9. Incorrect labeling of medications	32.5%	21.8%	14.7%	31.0%	2.44	1.234	0.21	0.039
D2.10. Not documenting medication administration directly after administration	23.4%	25.0%	20.2%	31.5%	2.60	1.159	0.29	0.000
D3.1. Having to administer a large number of medications at peak times	17.6%	24.4%	29.2%	28.8%	2.69	1.070	0.25	0.002
D3.2. Interruptions or distractions	18.4%	25.3%	28.2%	28.2%	2.66	1.077	0.20	0.092
D3.3. Work overload	5.2%	11.9%	21.8%	61.1%	3.39	.888	0.16	0.560
D3.4. High patient to nurse ratio	4.8%	10.8%	19.7%	64.7%	3.44	.869	0.18	0.319
D3.5. High acuity level of patients (very ill patients)	7.6%	22.8%	22.4%	47.2%	3.09	1.000	0.22	0.015
D3.6. Inadequate staffing	5.5%	11.9%	23.7%	58.9%	3.36	.895	0.21	0.076
D3.7. High staff turnover (new staff)	12.4%	28.8%	27.0%	31.8%	2.78	1.029	0.20	0.137
D3.8. Lack of supervision	20.5%	26.8%	24.3%	28.5%	2.61	1.106	0.30	0.000
D3.9. Non-optimal learning climate	19.3%	25.1%	29.1%	26.5%	2.63	1.074	0.27	0.001
D3.10. Working more than 40 hours per week	28.2%	18.5%	20.6%	32.8%	2.58	1.212	0.27	0.000
D3.11. Lack of patient information	25.7%	23.2%	26.2%	24.9%	2.50	1.126	0.28	0.000
D3.12. Uncooperative or violent patients	11.4%	19.9%	24.2%	44.5%	3.02	1.052	0.18	0.374
D3.13. Technology failures (e.g. infusion pump problems)	17.0%	24.9%	19.7%	38.4%	2.79	1.130	0.28	0.000
D4.1. Look-alike medication labels or packaging	23.2%	32.8%	18.3%	25.7%	2.46	1.110	0.22	0.035
D4.2. Look-alike or sound-alike medication names	19.2%	33.3%	20.4%	27.1%	2.55	1.085	0.22	0.031
D4.3. Wrong medication provided by the pharmacy	30.9%	22.7%	12.0%	34.3%	2.50	1.250	0.23	0.024
D4.4. Stock distribution problems – certain medications are not available at your institution	9.2%	10.9%	33.1%	46.9%	3.18	.958	0.25	0.002
D4.5. There is a large variety of drugs in the medicine cabinet or the medication trolleys are overstocked	31.6%	28.3%	19.4%	20.7%	2.29	1.122	0.21	0.086
D4.6. Labels of medications are of poor quality or damaged	38.6%	23.7%	17.4%	20.3%	2.19	1.158	0.25	0.002
D4.7. Insufficient resources such as medication glasses, etc.	28.8%	24.2%	25.4%	21.6%	2.40	1.120	0.24	0.008
D4.8. The same medication is prescribed in different dosages	23.7%	27.5%	23.7%	25.0%	2.50	1.109	0.23	0.016
D4.9. Generic substitution of medications (Different names for one medication)	20.9%	26.8%	25.5%	26.8%	2.58	1.096	0.22	0.039

Regarding communication factors impacting on medication administration errors, illegible prescriptions (D1.7) was seen as one of the most common causes of medication errors, reported by half of respondents to be a serious threat to medication safety (49.0%, n = 123). While 19.9% (n = 50) of respondents felt illegible prescriptions was a moderate risk and another 18.3% (n = 46) felt it was a small risk to the occurrence of medication administration error, only 12.7% (n = 32) of respondents perceived illegible prescriptions to pose no risk.

Human factors were mostly seen to only pose a small risk in causing medication administration errors. None of these factors showed mean scores of above three.

Considering environmental factors impacting on medication administration safety, workload-related items were perceived to be the biggest risk to medication administration safety. The first workload-related item, high patient-to-nurse-ratio (D3.4), was seen by two-thirds of the respondents to pose a significant risk of causing medication administration errors (n = 161, 64.7%). A further 19.7% (n = 49) of respondents thought this ratio to be a moderate threat while only 4.8% (n = 12) of respondents did not think a high patient-to-nurse ratio had any impact on medication administration errors.

82.9% (n = 232) of considered work overload (D3.3) to pose either moderate to significant risk in causing medication administration errors. Only 5.2% (n = 14) of respondents did not connect any risk to work overload.

A further workload related item, inadequate staffing (D3.6), was mentioned by 58.9% (n = 139) of respondents to pose a great threat to medication administration safety, by 23.7% (n = 56) to pose a moderate risk, and by 5.5% (n = 13) to pose no risk.

The last workload related item, high patient acuity (D3.5), was mentioned by almost half of respondents (n = 118, 47.2%) to be a significant contributing factor in causing mediation administration errors, while a further 22.4% (n = 56) thought this contribution was moderate. Only 7.6% (n = 18) of respondents did not see any connection between patient acuity and medication administration errors.

Another environmental factor showing a mentionable risk was uncooperative or violent patients (D3.12). Two thirds of respondents indicated that uncooperative or

violent patients posed either moderate or significant risk in causing medication administration errors (68.7%, n = 187). 11.4% (n = 32) of respondents did not agree that uncooperative or violent patients contributed to medication administration error incidence.

With regards to medication related factors as risks in causing medication administration errors, stock distribution problems (D4.4) were seen as the second greatest risk of causing medication administration errors. 80.0% of respondents (n = 191) perceived stock distribution problems to pose moderate or significant risks of causing medication administration errors (n = 112, 46.9% significant and n = 79, 33.1% moderate). Only 9.2% (n = 22) of respondents did not experience stock distribution problems to pose a threat to medication administration safety.

Following this section, the three main causes of medication administration errors in public hospitals of the Gauteng Province were determined to be workload, stock distribution problems and illegible prescriptions.

No significant association between perceptions of any cause of medication administration errors and individual hospitals could be identified by means of Cramer‟s V values.

4.4.2.5 Descriptive statistics for the AHRQ hospital survey on medication safety (medication administration error reporting items)

Table 4.6 provides an overview of descriptive statistics and Cramer‟s V‟s and p-values of medication error reporting incidence. Respondents had a choice of five points on a Likert-scale ranging from never, rarely, sometimes, most of the times and always.

Table 4.6 Descriptive statistics for medication administration error reporting incidence

Severity of error to be reported	Percentage of responses					Mean	Standard Deviation	Association	
	1. Never	2. Rarely	3. Sometimes	4. Most of the time	5. Always			Cramer's V	p-value
Corrected before affecting the patient	13.4%	29.4%	14.7%	11.8%	30.7%	3.17	1.469	0.20	0.077
No potential harm to the patient	23.0%	23.4%	15.7%	15.3%	22.6%	2.91	1.487	0.20	0.100
Could harm the patient	15.8%	17.1%	20.1%	18.4%	28.6%	3.27	1.438	0.25	0.001
Harms the patient	14.3%	11.7%	10.0%	13.9%	50.2%	3.74	1.516	0.23	0.044

Most degrees of error severity were only reported sometimes, though the errors that did cause harm to the patient were reported more often, though not always. One third of respondents (32.9%, n = 78) indicated that errors that could harm the patient were rarely or never reported while only half of respondents (50.2%, n = 116) were confident that errors that caused definite harm to the patient were always reported.

The Cramer"s V"s calculated for the reporting incidence of medication administration error related to individual hospitals did not prove to be significant.

4.4.2.6 Descriptive statistics for the Wakefield survey items (reasons for non-report of medication administration errors)

The responses to the sixteen items withdrawn from the Wakefield survey of medication error reporting were provided in table 4.7. Responses were indicated on a six-point Likert-scale ranging between strongly disagree and strongly agree. The cut off score of four was used to identify significant reasons of non-report of medication administration errors.

Table 4.7 Reasons of non-report of medication administration errors

Items	Percentage of responses						Mean	Standard Deviation	Association	
Medication Administration Error Reporting Survey	1. Strongly Disagree	2. Moderately disagree	3. Slightly disagree	4. Slightly agree	5. Moderately agree	6. Strongly agree			Cramer's V	p-value
F1. Nurses disagree with the definition of medication error	45.5%	14.0%	13.1%	13.1%	5.9%	8.6%	2.45	1.676	0.16	0.812
F2. Nurses do not recognize an error occurred	53.1%	16.6%	14.1%	10.0%	1.7%	4.6%	2.04	1.399	0.17	0.482
F3. Filling out an incident report takes too much time	41.9%	15.0%	15.9%	9.3%	8.4%	9.7%	2.56	1.716	0.17	0.573
F4. Contacting physicians takes too much time	48.3%	12.9%	13.8%	12.5%	6.0%	6.5%	2.34	1.610	0.20	0.091
F5. Medication error is not clearly defined	42.0%	16.4%	17.2%	11.8%	7.6%	5.0%	2.42	1.545	0.18	0.277
F6. Nurses may not think that the error is important	52.5%	13.0%	10.9%	11.3%	7.1%	5.0%	2.23	1.580	0.23	0.002
F7. Nurses feel that other nurses will think they are incompetent if they make medication errors	37.8%	11.2%	10.0%	12.4%	12.4%	16.2%	2.99	1.928	0.20	0.080
F8. The patient or family might develop a negative attitude toward the nurse	20.3%	9.7%	8.5%	8.9%	11.4%	41.1%	4.05	2.020	0.21	0.025
F9. The expectation that medications be given exactly as ordered is unrealistic	43.0%	14.0%	11.9%	11.9%	7.7%	11.5%	2.62	1.785	0.25	0.000
F10. Nurses are afraid of physicians‟ reprimands	38.2%	11.6%	13.3%	13.3%	9.0%	14.6%	2.87	1.857	0.16	0.662
F11. Nurses fear adverse consequences	37.0%	9.4%	9.8%	12.8%	12.3%	18.7%	3.10	1.972	0.20	0.129
F12. The response by nursing administration does not match the severity of the error	28.6%	16.8%	16.8%	19.1%	7.7%	10.9%	2.93	1.674	0.22	0.023
F13. Nurses are blamed if something happens to patients	14.3%	5.7%	5.7%	14.8%	12.2%	47.4%	4.47	1.840	0.19	0.251
F14. No positive feedback is given for passing medications correctly	21.4%	7.0%	11.8%	12.2%	14.8%	32.8%	3.90	1.947	0.19	0.177
F15. Too much emphasis is placed on medication errors as a measure of the quality of nursing care	17.1%	10.8%	15.8%	14.0%	16.2%	26.1%	3.80	1.820	0.20	0.138
F16. When medication errors occur, administration focuses on individuals rather than systems	19.7%	5.2%	10.5%	12.7%	14.4%	37.6%	4.10	1.933	0.19	0.210

Three items regarding reasons for non-report were prominent, namely the nurse could be blamed if something happens to the patient (F13), when medication errors occur, administration focuses on individuals rather than systems (F16) and the patient or the patient"s family might develop a negative attitude toward the nurse (F8).

Three quarters of respondents (74.4%, n = 205) reported the reason for non-report of medication administration errors to be that the nurse could be blamed if something happened to the patient. 64.7% (n = 148) of respondents reported the administrative response towards the individual as the reason why medication administration errors were not reported more often. Lastly, two thirds of respondents acknowledged that they would not report medication administration errors due to risk of the patient or the patient"s family developing a negative attitude toward the nurse (61.4%, n = 145).

As no significant association between individual hospitals and the response to a specific hospital could be determined, the responses from different hospitals were accepted to be combinable as a unit of data and were further reported as independent of isolated hospitals.

4.4.3 Validity of the instrument

Construct validity was determined by means of exploratory and confirmatory factor analysis. Exploratory factor analyses were conducted for the two portions of the survey that have been obtained from the AHRQ hospital survey on patient safety, for the four subthemes of causes of medication errors as derived from the systematic review (Phase 1) and for the portion of the Wakefield survey on medication reporting.

4.4.3.1 Factor analysis for the AHRQ hospital survey on patient safety culture subscales concerning general safety culture

The principal component analysis with Oblimin rotation of the AHRQ hospital survey on patient safety culture extracted five factors in accordance with the literature. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for the analysis was found to be 0.677 (mediocre, bordering on middling) and 51% of the total variance was explained. During the pattern matrix, Kaiser"s criterion extracted subscales as presented in Table 4.8.

Table 4.8 Pattern matrix for the 16 AHRQ items (five factors)

Item no	Item	Factor	Component 1	2	3	4	5
A1	People support one another in this unit	Teamwork within units	.819				
A4	In this unit, people treat each other with respect	Teamwork within units	.782				
A3	When a lot of work needs to be done quickly, we work together as a team to get the work done	Teamwork within units	.680			.277	
A11	When one area in this unit gets really busy, others help out	Teamwork within units	.386		.337		.212
A12	When a medication administration error is reported, it feels like the person is being written up, not the problem	Non-punitive response		.722		-.248	
A15	Staff worry that mistakes they make are kept in their personnel file	Non-punitive response		.661	-.264		
A8	Staff feel like their medication administration errors are held against them	Non-punitive response	-.200	.645		.287	
A14	Medication administration safety is never sacrificed to get more work done	Overall perceptions of safety	.321	.515			
A2	We have enough staff to handle the workload	Staffing	.247		.661		
A7	We use more agency/temporary staff than is best for patient care	Staffing			.644	.227	
A16	We have medication administration safety problems in this unit	Overall perceptions of safety			.405		
A9	Mistakes have led to positive changes here	Organizational learning				.747	.218
A6	We are actively doing things to improve medication administration safety	Organizational learning	.235			.690	
A17	Our procedures and systems are good at preventing medication errors from happening	Overall perceptions of safety	.384			.411	
A10	It is just by chance that more serious medication administration mistakes don't happen around here	Overall perceptions of safety					.717
A13	We work in "crisis mode" trying to do too much, too quickly	Staffing					.605
A5	Staff in this unit work longer hours than is best for patient care	Staffing	.316		-.235		.545

a. Rotation converged in 14 iterations.

The content of the factors identified were analysed to determine to what extent it resembled the five subscales of the original instrument. Different colours in above table showed the theoretical subscales, with yellow indicating teamwork, red indicating non-punitive response to error, blue indicating staffing, green indicating organizational learning and pink indicating overall perceptions of safety. However, items did not load onto these subscales exactly as per theory. Items with double loadings were loaded onto the original subscales. The five factors as revealed in the pattern matrix will now be presented.

- Teamwork within units (factor one): 4 items: A1, A3, A4 and A11;
- Non-punitive response to error (factor two): 4 items: A8, A12, A14 and A15;
- Staffing (factor 3): 3 items: A2, A7 and A16;
- Organizational learning (factor 4): 3 items: A6, A9 and A17; and
- Overall perceptions of safety (factor 5): 3 items: A5, A10 and A13.

Based on the results of this analysis, some items included in specific factors in theory loaded onto other factors. These items, discussed in the order as they appear in the table, loaded onto other factors as follows:

- Item A14: *Medication administration safety is never sacrificed to get more work done*. This item did not load onto the overall perceptions of safety factor, but rather loaded onto the non-punitive response to error factor. The possibility exist that this question was misinterpreted or not read in full as it is difficult to explain the loading onto this subscale.
- Item A16: *We have medication administration safety problems in this unit.* This item did not load onto the overall perceptions of safety factor, but rather onto a portion of the staffing factor. As was seen in the descriptive statistics of the results, workload was seen as the most significant risk in causing medication administration errors. For this reason, the perception of experiencing medication administration safety problems in the unit could be directly linked to the experience of being under-staffed, which would explain the loading of this item onto the staffing factor.
- Item A17: *Our procedures and systems are good at preventing medication errors from happening*. This item loaded onto the organizational learning factor rather than onto the overall perceptions of safety factor. The reason for this

loading might be that the improvement and implementation of procedures and systems to prevent medication administration error from happening could be seen as an element of organizational learning or organizational commitment to positive change.

- Item A13: *We work in "crisis mode" trying to do too much, too quickly*. This item loaded onto the overall perceptions of safety factor rather than the staffing factor. The perception of working in crisis mode could be seen as the general perception a medication administrator has regarding his/her unit‟s functioning.
- Item A5: *Staff in this unit work longer hours than is best for patient care*. As with the above item, this item loaded onto the overall perceptions of safety factor rather the staffing factor. Again, working longer hours could be seen as a general safety concern within the unit, thus indicating a perception of the overall safety of a unit.

From the above analysis it is evident that the exploratory factor analysis subscales resemble the theoretical subscales. For this reason, confirmatory factor analysis was conducted in accordance with the theoretical subscales to further investigate the validity of these subscales. Figure 4.3 presents this factor analysis.

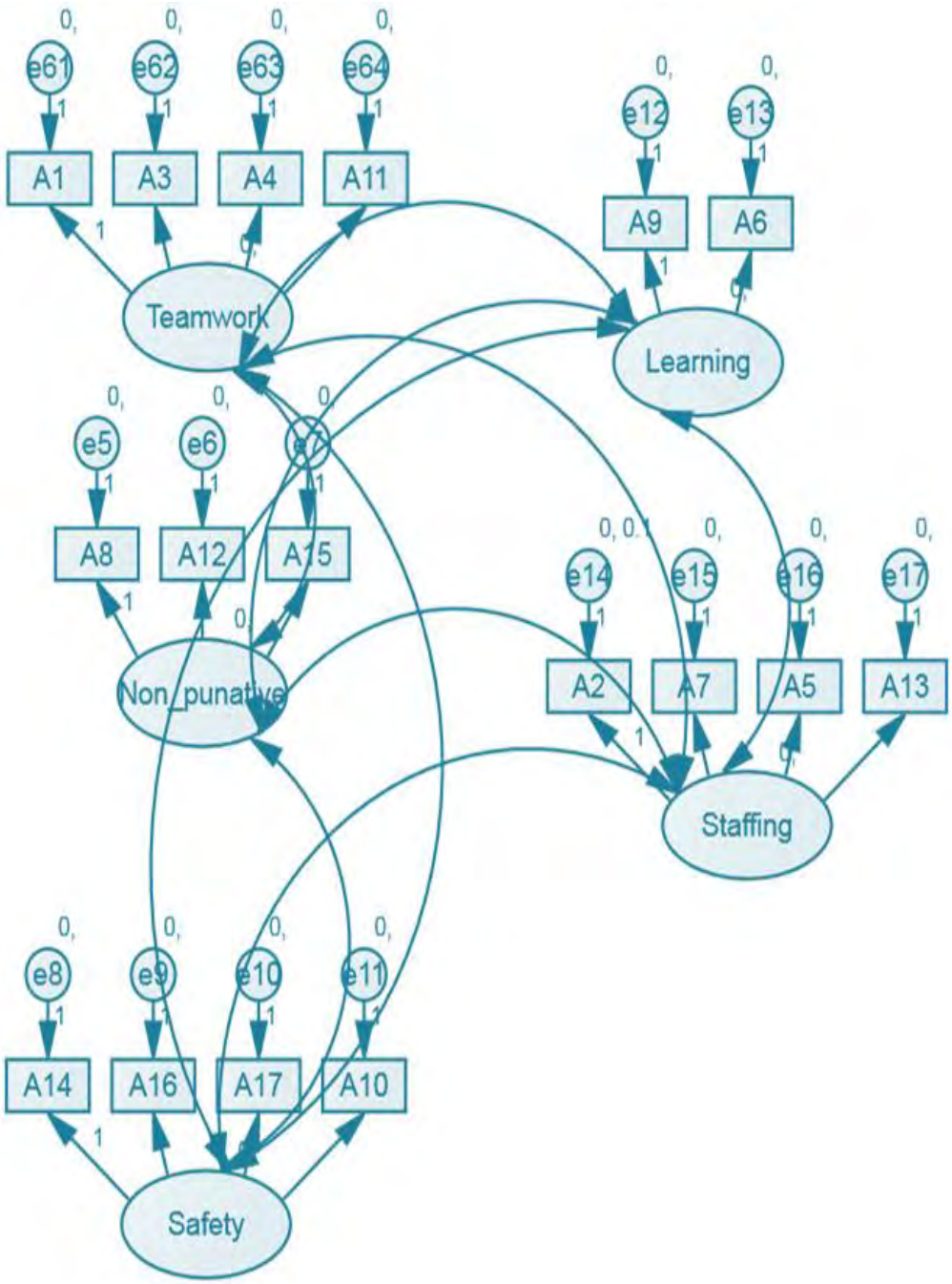


Figure 4.3: Confirmatory factor analysis of AHRQ items (five factors)

The standardised regression weights for the 17 AHRQ items were presented in table 4.9.

Table 4.9 Standardised regression weights for 17 AHRQ items

Item No	Item		Factor	Estimate	p-value
A1	People support one another in this unit	<---	Teamwork within units	.720	
A3	When a lot of work needs to be done quickly, we work together as a team to get the work done	<---	Teamwork within units	.740	<0.001
A4	In this unit, people treat each other with respect	<---	Teamwork within units	.697	<0.001
A11	When one area in this unit gets really busy, others help out	<---	Teamwork within units	.332	<0.001
A8	Staff feel like their medication administration errors are held against them	<---	Non-punitive response	.346	
A12	When a medication administration error is reported, it feels like the person is being written up, not the problem	<---	Non-punitive response	.974	.013
A15	Staff worry that mistakes they make are kept in their personnel files	<---	Non-punitive response	.316	<0.001
A14	Medication administration safety is never sacrificed to get more work done	<---	Overall perceptions of patient safety	.167	
A16	We have medication administration safety problems in this unit	<---	Overall perceptions of patient safety	-.022	.650
A17	Our procedures and systems are good at preventing medication errors from happening	<---	Overall perceptions of patient safety	.338	.002
A10	It is just by chance that more serious medication administration mistakes don't happen around here	<---	Overall perceptions of patient safety	.079	.134
A9	Mistakes have led to positive changes here	<---	Organizational learning	.363	
A6	We are actively doing things to improve medication administration safety	<---	Organizational learning	.765	<0.001
A2	We have enough staff to handle the workload	<---	Staffing	.951	
A7	We use more agency/temporary staff than is best for patient care	<---	Staffing	.191	.003
A5	Staff in this unit work longer hours than is best for patient care	<---	Staffing	-.133	.039
A13	We work in "crisis mode" trying to do too much, too quickly	<---	Staffing	-.190	.003

Not all items showed statistically significant regression weights, indicating that not all items loaded significantly on the theoretical subscales. A good fit for the teamwork and non-punitive subscales was determined, with regression weights above 0.316 for these two subscales. The correlation between subscales was summarised in

table 4.10. As the covariance matrix is not positive definite, two correlations greater than one were attained.

Table 4.10 Correlations between subscales of the seventeen AHRQ items

Factor		Factor	Estimate
Teamwork within units	<-->	Non-punitive response	-.146
Teamwork within units	<-->	Overall perceptions of patient safety	1.225
Teamwork within units	<-->	Organizational learning	.535
Staffing	<-->	Teamwork within units	.189
Non-punitive response	<-->	Overall perceptions of patient safety	.045
Non-punitive response	<-->	Organizational learning	-.257
Staffing	<-->	Non-punitive response	.041
Overall perceptions of patient safety	<-->	Organizational learning	1.261
Staffing	<-->	Overall perceptions of patient safety	.246
Staffing	<-->	Organizational learning	.001

Strong positive correlations were discovered between teamwork and overall perceptions of patient safety (r = 1.225), between teamwork and organizational learning (r = 0.535) and between overall perceptions of patient safety and organizational learning (r = 1.261).

Goodness of fit measures for these five subscales revealed a CMIN/DF of 1.879, which is good. The CFI was close to the good-fit index of 0.9 while the 0.056 RMSEA at 90% confidence interval (0.044: 0.068) rendered further proof of a good fit. Table 4.6 provides a summary of these goodness-of-fit measures.

Table 4.11 Goodness of fit measures for AHRQ items

Factors	Chi-square	CMIN/DF	CFI	RMSEA (90% CI)
5 (17 items)	206.671	1.879	0.806	0.056 [0.044; 0.068]

4.4.3.2 Factor analysis for the communication related causes of medication administration errors section

The exploratory factor analysis with Oblimin rotation of the ten items grouped as communication factors impacting on medication errors showed convergence of these

items into one subscale, in accordance with the original grouping. The KMO measure of sampling adequacy for the analysis was found to be 0.817 (meritorious).

4.4.3.3 Factor analysis for the human causes of medication administration errors section

The eleven items relating to human factors that could pose threats to medication administration were also found to blend into one factor with a KMO measure of sampling adequacy (0.937).

4.4.3.4 Factor analysis for the environmental causes of medication administration errors section

Fourteen items grouped together as environmental factors showed convergence into one factor. The KMO of these items was 0.664 (mediocre).

4.4.3.5 Factor analysis for the medication related causes of medication administration errors section

The last of the items related factors posing risks of medication administration error, medication-related factors, also revealed these ten items to be part of one factor. The KMO of these items were meritorious (0.833).

4.4.3.6 Exploratory factor analysis for the AHRQ hospital survey on patient safety culture subscales concerning reporting incidence

The items of E1 to E4 were compounded into one factor during exploratory factor analysis. These items were concerned with the incidence of medication administration error reporting. The KMO measure of sampling adequacy for these items was 0.813 (meritorious).

4.4.3.7 Factor analyses for the section derived from the Wakefield Medication Administration Error Reporting Survey

The principal component factor analysis with Oblimin rotation of the Wakefield medication administration error reporting survey extracted two factors, revealing convergence of the four factors identified in the literature into two. The KMO measure of sampling adequacy for the analysis was found to be 0.897 (close to

marvellous) and 53.5% of the total variance was explained. During the pattern matrix, Kaiser"s criterion extracted subscales as presented in Table 4.12.

Table 4.12 Pattern matrix for the 16 Wakefield survey items

Item no	Item	Factor	Component 1	2
F6	Nurses may not think that the error is important enough to be reported	Disagree with definition	.743	
F5	Medication error is not clearly defined	Disagree with definition	.741	
F2	Nurses do not recognize an error occurred	Disagree with definition	.715	
F3	Filling out an incident for a medication error takes too much time	Reporting effort	.701	
F4	Contacting the physician about a medication error takes too much time	Reporting effort	.646	
F1	Nurses do not agree with the hospital"s definition of a medication error	Disagree with definition	.628	
F10	Nurses are afraid the physician will reprimand them for the medication error	Fear	.627	-.247
F7	Nurses feel that other nurses will think they are incompetent if they make medication errors	Fear	.626	-.278
F9	The expectation that medications be given exactly as ordered is unrealistic	Administrative response	.563	
F11	Nurses fear adverse consequences from reporting medication errors	Fear	.497	-.410
F12	The response by nursing administration does not match the severity of the error	Administrative response	.431	-.417
F13	Nurses could be blamed if something happens to the patient as a result of the medication error	Fear		-.877
F16	When medication errors occur, nursing administration focuses on the individual rather than looking at the systems as a potential cause of the error	Administrative response		-.813
F14	No positive feedback is given for passing medications correctly	Administrative response		-.769
F15	Too much emphasis is placed on medication errors as a measure of the quality of nursing care provided	Administrative response		-.760
F8	The patient or family might develop a negative attitude toward the nurse, or may sue the nurse if a medication error is reported	Fear		-.672
a. Rotation converged in 6 iterations.				

The content of the factors identified were analysed to determine to what degree it resembled the four subscales identified in theory. The themes according to the

theoretical subscales assigned to the identified factors in this pattern matrix repeated as follows:

- Disagreement with the definition of medication error / Reporting effort / Fear / Administrative response (factor one): 11 items: F1, F2, F3, F4, F5, F6, F7, F9, F10, F11, and F12; and
- Fear / Administrative response (factor two): 5 items: F8, F13, F14, F15, and F16.

Based on the results of this analysis, some factors merged while some items included in specific factors in theory loaded onto other factors. These differences from the literature guideline will now be discussed in the order of appearance in the table:

The following items loaded onto the first factor:

- F6: Nurses may not think that the error is important enough to be reported;
- F5: Medication error is not clearly defined;
- F2: Nurses do not recognize an error occurred;
- F3: Filling out an incident for a medication error takes too much time;
- F4: Contacting the physician about a medication error takes too much time;
- F1: Nurses do not agree with the hospital"s definition of a medication error;
- F10: Nurses are afraid the physician will reprimand them for the medication error;
- F7: Nurses feel that other nurses will think they are incompetent if they make medication errors;
- F9: The expectation that medications be given exactly as ordered is unrealistic;
- F11: Nurses fear adverse consequences from reporting medication errors: and
- F12: The response by nursing administration does not match the severity of the error.

These items could be seen as a subscale as they represent a lack of urgency concerning medication errors. However, two items, viz. F10 "*Nurses are afraid the physician will reprimand them for the medication error"* and F7 "*Nurses feel that other nurses will think they are incompetent if they make medication errors"* do not fit into this grouping. This loading might have occurred because of misinterpretation of

the questions, as both of these questions included words that might not be part of the vocabulary of a respondent whose first language was not English, viz. reprimand and incompetent.

The following items loaded onto the second factor:

- F13: Nurses could be blamed if something happens to the patient as a result of the medication error;
- F16: When medication errors occur, nursing administration focuses on the individual rather than looking at the systems as a potential cause of the error;
- F14: No positive feedback is given for passing medications correctly;
- F15: Too much emphasis is placed on medication errors as a measure of the quality of nursing care provided; and
- F8: The patient or family might develop a negative attitude toward the nurse, or may sue the nurse if a medication error is reported.

These items could be grouped together as feedback to the nurse, explaining the loading of these items onto one factor. Although the items could all be loaded into above-mentioned two subscales, the original four subscales were used to load items onto, as sufficient loading weights within the original subscales were noted:

- Disagree with definition (factor 1): Four items: F1, F2, F5 and F6;
- Reporting effort (factor 2): Two items: F3 and F4;
- Fear (factor 3): Five items: F7, F8, F10, F11 and F13; and
- Administrative response (factor 4): Five items: F9, F12, F14, F15 and F16.

The confirmatory factor analysis that was performed to confirm the four subscales of the Wakefield survey of medication error reporting as presented in literature is represented by figure 4.4.

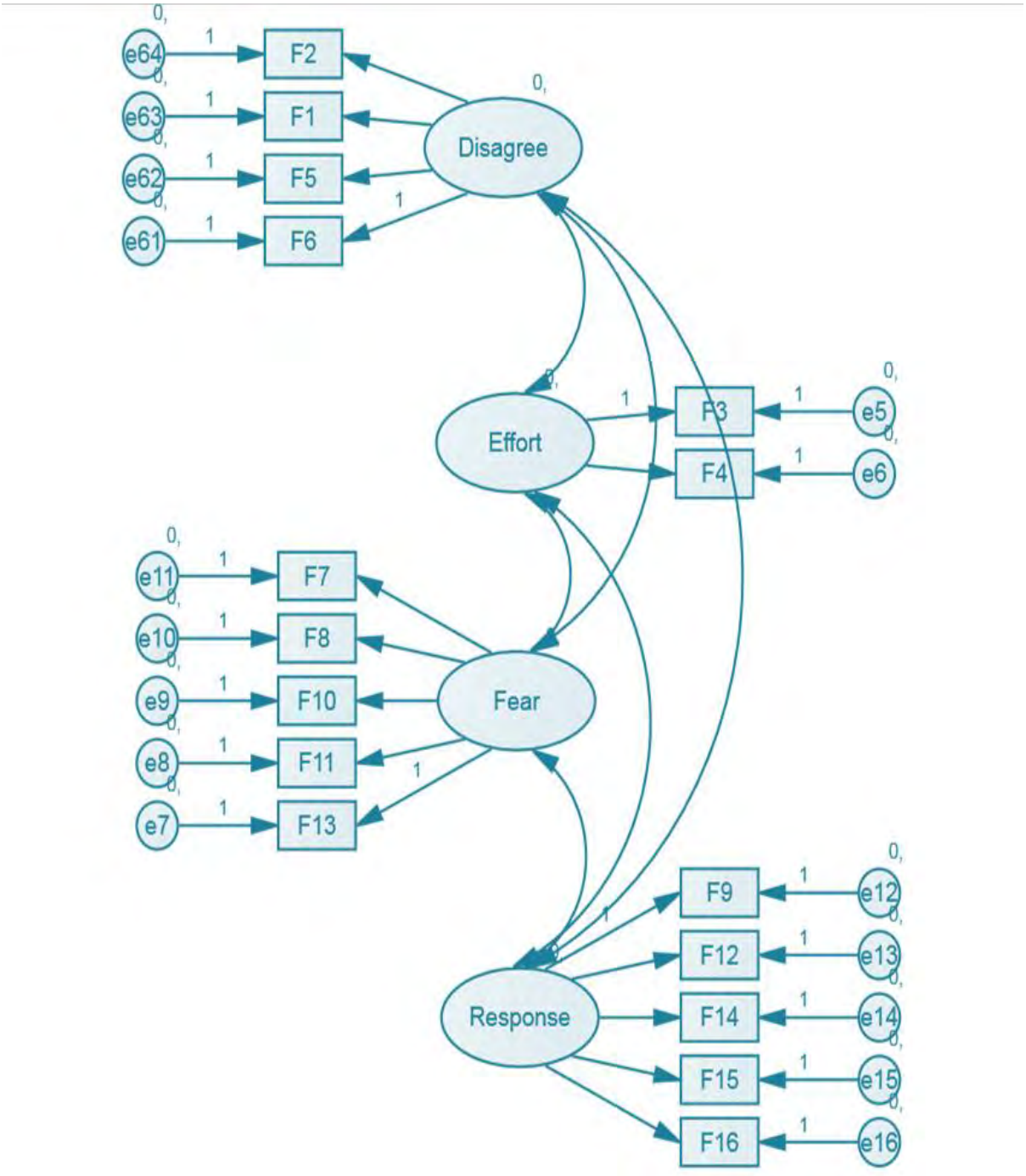


Figure 4.4: Confirmatory factor analysis of four subscales from the Wakefield survey

Statistical significant fit was revealed for all items in these subscales. Standard regression weights were more than 0.497, with a maximum score of 0.804. The standardised regression weights for the 16 Wakefield survey items were presented in table 4.13.

Table 4.13 Standardised regression weights of 16 Wakefield survey items

Item No	Item		Subscale	Estimate	p-value
F6	Nurses may not think that the error is important enough to be reported	<---	Disagree with definition	.699	
F5	Medication error is not clearly defined	<---	Disagree with definition	.687	<0.001
F1	Nurses do not agree with the hospital"s definition of a medication error	<---	Disagree with definition	.514	<0.001
F2	Nurses do not recognize an error occurred	<---	Disagree with definition	.595	<0.001
F3	Filling out an incident form for a medication error takes too much time	<---	Reporting effort	.804	
F4	Contacting the physician about a medication error takes too much time	<---	Reporting effort	.737	<0.001
F13	Nurses could be blamed if something happens to the patient as a result of the medication error	<---	Fear	.621	
F11	Nurses fear adverse consequences from reporting medication errors	<---	Fear	.755	<0.001
F10	Nurses are afraid the physician will reprimand them for the medication error	<---	Fear	.716	<0.001
F8	The patient or family might develop a negative attitude toward the nurse, or may sue the nurse if a medication error is reported	<---	Fear	.657	<0.001
F7	Nurses feel that other nurses will think they are incompetent if they make medication errors	<---	Fear	.751	<0.001
F9	The expectation that medications be given exactly as ordered is unrealistic	<---	Administrative response	.497	
F12	The response by nursing administration does not match the severity of the error	<---	Administrative response	.675	<0.001
F14	No positive feedback is given for passing medications correctly	<---	Administrative response	.648	<0.001
F15	Too much emphasis is placed on medication errors as a measure of the quality of nursing care provided	<---	Administrative response	.644	<0.001
F16	When medication errors occur, nursing administration focuses on individuals rather than looking at the systems as a potential cause of error	<---	Administrative response	.740	<0.001

Table 4.14 presents the correlations among these four subscales.

Table 4.14 Correlations among four subscales of the Wakefield survey

Factor		Factor	Estimate
Disagree with definition	<-->	Reporting effort	.805
Disagree with definition	<-->	Fear	.698
Administrative response	<-->	Disagree with definition	.535
Reporting effort	<-->	Fear	.690
Administrative response	<-->	Reporting effort	.609
Administrative response	<-->	Fear	.912

Strong correlations among all subscales were identified with r = 0.535 and higher. The strongest relationship was determined between administrative response and fear (r = 0.912). This strong relationship confirmed the earlier supposition that these two scales could have been perceived as one by the respondents, as did the second-strongest relationship between disagree with definition and reporting effort.

Considering measures of fit, the CMIN/DF was determined to be 3.980, indicating a good fit. The CFI of 0.812 was a bit below the targeted 0.9, while the RMSEA at 90% confidence interval (0.093 : 0.114) of 0.103 again showed doubtful fit though it almost made the 0.1 cut-off number. Measures of fit for these sixteen items were presented in table 4.15. Although two fit indices were lower than usually accepted, this model was accepted for data analysis, as this allowed comparison of data with international literature.

Table 4.15 Measures of fit for the 16 items from the Wakefield survey

Factors	Chi-square	CMIN/DF	CFI	RMSEA (90%)
4 (16 items)	390.050	3.980	0.812	0.103

4.4.4 Reliability of the instrument

Reliability of the instrument‟s subscales was determined by the calculation of Cronbach alpha scores. The calculated Cronbach alphas for the respective subscales were presented in Table 4.16. Negatively phrased items were reverse-scored.

Table 4.16 Cronbach alphas for the subscales of the instrument

Origin	Subscale	Cronbach alpha
AHRQ survey	Teamwork within units	0.691
	Non-punitive response to error	0.562
	Organizational learning	0.427
	Staffing	0.297
	Overall perceptions of patient safety	0.150
Derived from systematic review results	Communication-related causes of medication error	0.890
	Human factor-related causes of medication error	0.954
	Environment-related causes of medication error	0.802
	Medication-related causes of medication error	0.923
AHRQ survey	Incidence of reporting	0.889
Wakefield survey	Disagree with definition	0.743
	Reporting effort	0.746
	Fear	0.830
	Administrative response	0.758

Though 0.7 was seen as an acceptable value for Cronbach alpha, only one subscale from the first composite drawn from the AHRQ survey concerning safety climate reflected values close to acceptable (teamwork within units, Cronbach alpha = 0.691). Due to the unreliability of these subscales (non-punitive response to error, organizational learning, staffing and overall perceptions of patient safety) items comprising these subscales were reported as lone-standing.

The subscale drawn from the second composite of the AHRQ survey supplemented by the extra question, proved to be reliable (Cronbach alpha = 0.889). Therefore, this portion of the survey was reported and discussed as a subscale.

The questionnaires derived from the results of the systematic review had good Cronbach alpha scores ranging from 0.802 to 0.954. These subscales were thus seen as valid and reliable and items representing them were reported as subscales.

Reliability of the four subscales derived from the Wakefield survey was acceptable, ranging between 0.743 and 0.830). These subscales were seen as valid and reliable.

4.4.5 Subscale descriptive statistics

Respondents‟ perceptions will now be discussed with reference to the four subscales of causes of medication administration errors, reporting incidence of these errors and the four subscales of reasons of non-report of these errors. Table 4.17 presents the means and standard deviations derived from responses to subscales.

Table 4.17 Means and standard deviations for subscales

Subscale	Description of scale	Mean	Standard Deviation
Communication related causes of medication administration errors	Four point Likert scale indicating perceptions of how big a risk items posed in causing medication administration errors, ranging from no risk to significant risk.	2.51	0.786
Human factors causing medication administration errors		2.46	0.988
Environmental causes of medication administration error		2.89	0.723
Medication related causes of medication administration error		2.52	0.811
Reporting incidence of medication administration errors	Five point Likert scale ranging from never, rarely, sometimes, most of the times and always.	3.27	1.271
Disagreement with the definition of medication error	Six-point Likert-scale ranging between strongly disagree and strongly agree.	2.28	1.153
Reporting effort		2.46	1.510
Fear		3.47	1.487
Administrative response		3.42	1.370

4.4.6 Correlations between AHRQ items and subscales

Correlations between the items of the first composite of the AHRQ survey that could not reliably fit into the existing subscales and the confirmed reliable subscales of the instrument were investigated. The correlation matrix for the correlations between items and subscales was presented in table 4.18.

Table 4.18 Correlation matrix of the sample demographics, relevant individual items and subscales

	AHRQ Single Items										RN4CAST Items		AHRQ Subscales		Causes Subscales				Sub-scale	Wakefield Subscales			
	People support one another in this unit	Staff in this unit work longer hours than is best for patient care	We are actively doing things to improve medication safety	We use more temporary staff than is best for patient care	Mistakes have led to positive changes here	It is just by chance that more serious medication errors don't happen	We work in "crisis mode" trying to do too much, too quickly	Medication safety is never sacrificed to get more work done	We have medication safety problems in this unit	Our procedures and systems are good at preventing medication	Error incidence	Overall grade on medication administration safety	Teamwork	Non-punitive response	Communication related causes of medication error	Human factors related causes of medication error	Environment related causes of medication error	Medication related causes of medication error	Medication error reporting incidence	Disagree with definition of medication error	Reporting effort	Fear	Administrative response
People support one another in this unit																							
Staff in this unit work longer hours than is best for patient care	-.203**																						
We are actively doing things to improve medication safety	-.010	.126*																					
We use more temporary staff than is best for patient care	.252**	-.162**	-.017																				
Mistakes have led to positive changes here	.038	-.040	.312**	.016																			
It is just by chance that more serious medication errors don't happen	.001	.222**	.110	-.083	.226**																		
We work in "crisis mode" trying to do too much, too quickly	-.223**	.173**	-.031	-.140*	.090	.160*																	
Medication safety is never sacrificed to get more work done	.044	.049	.132*	.102	.108	.084	.102																
We have medication safety problems in this unit	.120	-.082	-.053	.089	-.113	-.028	.031	-.044															
Our procedures and systems are good at preventing medication	.083	.048	.444**	-.010	.248**	.125*	-.135*	.073	-.141*														
Error incidence	.051	-.141*	-.306**	.019	-.047	-.109	.115	.094	.140*	-.317**													
Overall grade on medication administration safety	.024	-.205**	-.270**	.054	-.182**	-.152*	.068	.006	.237**	-.489**	.409**												
Teamwork	.185**	.200**	.358**	.050	.199**	.115	-.078	.179**	-.053	.395**	-.185**	-.347**											
Non-punitive response	-.015	-.027	-.060	-.011	.116	.059	.164**	.221**	.087	-.034	.125*	.108	-.117										
Communication related causes of medication error	-.197**	-.051	-.071	.007	-.065	-.034	.048	-.020	.015	-.180**	.157*	.156*	-.013	.125*									
Human factors related causes of medication error	.007	-.115	.012	.091	-.115	-.124	-.149*	-.038	.114	.044	.090	.154*	.061	.092	.624**								
Environment related causes of medication error	-.184**	-.013	.047	.073	-.026	-.050	-.010	.025	.044	-.022	.081	.158*	-.055	.090	.533**	.661**							
Medication related causes of medication error	-.047	.000	.066	.020	.006	.000	-.082	.040	.032	-.030	.023	.077	.109	.069	.537**	.702**	.720**						
Medication error reporting incidence	-.139*	.240**	.078	-.031	.028	-.128	-.026	.180**	-.277**	.063	-.002	-.147*	.095	-.019	.229**	.086	.187**	.248**					
Disagree with definition of medication error	.067	-.170**	-.149*	.074	-.119	-.035	.006	-.041	.264**	-.289**	.168*	.285**	-.176**	.183**	.192**	.175**	.158*	.129*	-.181**				
Reporting effort	.069	-.097	-.051	.031	-.145*	-.043	.091	.020	.217**	-.207**	.147*	.229**	-.193**	.289**	.227**	.226**	.206**	.205**	-.145*	.624**			
Fear	.034	-.071	-.082	-.019	-.017	.015	.247**	.084	.101	-.189**	.160*	.156*	-.190**	.279**	.181**	.122	.123	.157*	-.101	.514**	.539**		
Administrative response	.006	.025	-.075	-.077	-.018	.021	.247**	.101	.021	-.144*	.158*	.133*	-.150*	.262**	.276**	.146*	.130*	.191**	.018	.427**	.471**	.746**	

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

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

With regards to the “people support one another in this unit” item, there was a medium positive correlation with “staff in this unit work longer hours than is best for patient care” ($r = 0.20$; $p<0.001$), “we use more temporary staff than is best for patient care” ($r = 0.25$; $p<0.001$), “we work in „crisis mode“ trying to do too much, in too little time” ($r = 0.22$; $p<0.001$), communication related causes of medication error ($r = 0.20$; $p<0.001$), environment related causes of medication error ($r = 0.18$; $p<0.001$) and a small positive correlation with teamwork (0.19; $p<0.001$). However, reporting incidence had a small negative correlation with “people support one another in this unit” ($r = -0.14$; $p<0.05$).

The following items and subscales had a small positive correlation with “staff in this unit work longer hours than is best for patient care”: “We are actively doing things to improve medication safety” ($r = 0.13$; $p<0.05$); “We use more temporary staff than is best for patient care” ($r = 0.16$; $p<0.001$); “We work in „crisis mode“ trying to do too much, in too little time ($r = 0.17$; $p<0.001$); and “Disagree with definition of medication error” ($r = 0.17$; $p<0.001$). Medium positive correlations with “staff in this unit work longer hours than is best for patient care” existed with “it is just by chance that more serious medication errors don't happen” ($r = 0.22$; $p<0.001$), overall grade on medication administration safety ($r = 0.21$, $p<0.001$), teamwork ($r = 0.20$; $p<0.001$), and medication error reporting incidence ($r = 0.24$; $p<0.001$). However, a small negative correlation between this subscale and error incidence was identified ($r = -0.14$; $p<0.05$).

Regarding “we are actively doing things to improve medication safety”, small positive correlations was identified with “mistakes have led to positive changes here” ($r = 0.31$; $p<0.001$), and “we have medication safety problems in this unit” ($r = 0.13$; $p<0.05$). Medium positive correlations was identified with error incidence ($r = 0.31$; $p<0.001$), the overall grade on medication administration safety ($r = 0.27$; $p<0.001$), and teamwork (0.36; $p<0.001$) while a large positive correlation was identified with “our procedures and systems are good at preventing medication errors” ($r = 0.44$; $p<0.001$). Lastly, “we are actively doing things to improve medication safety” had a small negative correlation with the disagree with definition of medication error subscale ($r = -0.15$; $p<0.05$).

Moving on to “we use more temporary staff than is best for patient care”, a small negative correlation with “we work in „crisis mode“ trying to do too much, too quickly” was identified ($r = -0.14$; $p<0.05$).

Considering the perception that “mistakes have led to positive changes here”, the “overall grade on medication administration safety” item showed a small positive correlation ($r = 0.18$; $p<0.001$) while the following medium positive correlations were identified: “It is just by chance that more serious medication errors don't happen” ($r = 0.23$; $p<0.001$); “Our procedures and systems are good at preventing medication errors” ($r = 0.25$; $p<0.001$); and teamwork 0.20 ($p<0.001$). Reporting effort had a small negative effect on this safety climate item ($r = -0.15$; $p<0.05$).

Continuing with safety climate items, the “it is just by chance that more serious medication errors don't happen” item had small positive correlation with “we work in „crisis mode“ trying to do too much, too quickly” ($r = 0.16$; $p<0.05$) and “our procedures and systems are good at preventing medication errors” ($r = 0.13$; $p<0.05$) while the “overall grade on medication administration safety” had a small negative correlation with this item ($r = -0.15$; $p<0.05$).

Moreover, the “we work in „crisis mode“ trying to do too much, too quickly” item had a small positive correlation with non-punitive response ($r = 0.16$; $p<0.001$) and a medium positive correlation with fear ($r = 0.25$; $p<0.001$) and administrative response ($r = 0.25$, $p<0.001$). The “we work in "crisis mode" trying to do too much, too quickly” item also had a small negative correlation with the human factors related causes of medication error subscale ($r = -0.15$; $p<0.05$) and the “our procedures and systems are good at preventing medication errors” item ($r = -0.14$; $p<0.05$).

Still on safety climate items, “medication safety is never sacrificed to get more work done” had a small positive correlation with the teamwork subscale ($r = 0.18$; $p<0.001$) and the medication error reporting incidence subscale ($r = 0.18$; $p<0.001$) while a medium positive correlation with the non-punitive response subscale was identified ($r = 0.22$; $p<0.001$).

“We have medication safety problems in this unit” had a small positive correlation with “error incidence” ($r = 0.14$; $p<0.05$) and a medium positive correlation with the following items and subscales: “Overall grade on medication administration safety”

(r = 0.24; p<0.001); "We have medication safety problems in this unit" (r = 0.27; p<0.001); Disagree with definition of medication error (r = 0.26; p<0.001); and Reporting effort (r = 0.22; p<0.001). "We have medication safety problems in this unit" also had a small negative correlation with "Our procedures and systems are good at preventing medication errors" (r = -0.14; p<0.05).

The last of the safety climate items, "our procedures and systems are good at preventing medication errors" had a small positive correlation with two subscales, viz. communication related causes of medication error (r = 0.18; p<0.001), and fear (r = 0.19; p<0.001), while medium positive correlations with the following items and subscales were identified: "Error incidence" (r = 0.32; p<0.001); Disagree with definition of medication error (r = 0.29; p<0.001); and Reporting effort (r = 0.21; p<0.001). Large positive correlations with "overall grade on medication administration safety" (r = 0.49; p<0.001) and teamwork (r = 0.40; p<0.001) was also identified while "our procedures and systems are good at preventing medication errors" had a small negative correlation with the administrative response subscale (r = -0.14; p<0.05).

Moving on to "error incidence", small positive correlations were seen with teamwork (r = 0.19; p<0.001), non-punitive response (r = 0.13; p<0.05), communication related causes of medication error (r = 0.16; p<0.05), disagree with definition of medication error (r = 0.17; p<0.05), reporting effort (r = 0.15; p<0.05), fear (r = 0.16; p<0.05) and administrative response (r = 0.16; p<0.05). "Error incidence" had a large positive correlation with "overall grade on medication administration safety" (0.49; p<0.001).

"Overall grade on medication administration safety" revealed small correlations with the following subscales: Communication related causes of medication error (r = 0.16; p<0.05); Human factors related causes of medication error (r = 0.15; p<0.05); Environment related causes of medication error (r = 0.16; p<0.05); fear (r = 0.16; p<0.05) and administrative response (r = 0.13; p<0.05). Medium positive correlations were identified with teamwork (r = 0.35; p<0.001), disagree with definition of medication error (r = 0.29; p<0.001), and reporting effort (r = 0.23; p<0.001) while reporting incidence revealed a small negative correlation (r = -0.15; p<0.05).

Teamwork had small negative correlations with disagree with the definition of a medication error ($r = 0.18$; $p<0.001$), reporting effort ($r = 0.19$; $p<0.001$), and fear ($r = 0.19$; $p<0.001$) while the small correlation with administrative response was negative ($r = -0.15$; $p<0.05$).

Non-punitive response had small positive correlations with communication related causes of medication error ($r = 0.13$; $p<0.05$) and disagree with definition of medication error ($r = 0.18$; $p<0.001$) while reporting effort ($r = 0.29$; $p<0.001$), fear ($r = 0.28$; $p<0.001$) and administrative response ($r = 0.26$; $p<0.001$) had medium positive correlations.

Communication related causes of medication error had small positive correlations with disagree with definition of medication error ($r = 0.19$; $p<0.001$) and fear ($r = 0.18$; $p<0.001$) while medium positive correlations was identified with medication error reporting incidence ($r = 0.23$; $p<0.001$), disagree with definition of medication error ($r = 0.23$; $p<0.001$) and administrative response ($r = 0.28$; $p<0.001$). Large positive correlations were seen with human factors related causes of medication error ($r = 0.62$; $p<0.001$), environment related causes of medication error ($r = 0.52$; $p<0.001$) and medication related causes of medication error ($r = 0.54$; $p<0.001$).

Human factors related causes of medication error had small positive correlations with disagree with definition of medication error ($r = 0.16$; $p<0.001$) and administrative response ($r = 0.15$; $p<0.05$), while a medium positive correlation was seen with reporting effort ($r = 0.23$; $p<0.001$). Human factors related causes of medication error had large positive correlations with environment related causes of medication error ($r = 0.66$; $p<0.001$) and medication related causes of medication error ($r = 0.70$; $p<0.001$).

Environment related causes of medication error had small positive correlations with medication error reporting incidence ($r = 0.19$; $p<0.001$), disagree with definition of medication error ($r = 0.16$; $p<0.05$) and administrative response ($r = 0.13$; $p<0.05$) while it had a medium positive correlation with reporting effort ($r = 0.21$; $p<0.001$). A large positive correlations with medication related causes of medication error was also noted ($r = 0.72$; $p<0.001$).

The last of the factors impacting on medication administration safety, viz. medication related causes of medication error, had small positive correlations with the following subscales: Medication error reporting incidence ($r = 0.25$; $p<0.001$); Disagree with definition of medication error; ($r = 0.13$; $p<0.05$); Fear ($r = 0.16$; $p<0.05$); and Administrative response ($r = 0.19$; $p<0.001$). It also had a medium positive correlation with reporting effort ($r = 0.21$; $p<0.001$).

Medication error reporting incidence had a small positive correlation with disagree with definition of medication error ($r = 0.18$; $p<0.001$) and a small negative correlation with reporting effort ($r = -0.15$; $p<0.05$).

Disagree with definition of medication error had large correlations with the following subscales: Reporting effort ($r = 0.62$; $p<0.001$); Fear ($r = 0.51$; $p<0.001$); and Administrative response ($r = 0.43$; $p<0.001$).

Reporting effort correlated had a large positive correlation with fear ($r = 0.54$; $p<0.001$) and administrative response ($r = 0.47$; $p<0.001$). Lastly, fear had a large positive correlation with administrative response ($r = 0.75$; $p<0.001$).

4.4.7 Associations between demographical data AHRQ items and subscales

Associations between responses and hospital demographics (hospital levels one two and three) and unit demographics (medical or surgical) were investigated. No practically significant associations between responses and unit type could be identified. One practical and statistical significant association was identified between two hospital levels on a single item. On the item “We use more agency/temporary staff than is best for patient care”, a practical and statistical significant association between level one and level two hospitals were noted (Cramer‟s $V = 0.66$; $p = 0.000$), with level two hospitals more often reporting this as a problem ($M = 2.17$ for level two respondents and $M = 1.35$ for level one respondents).

Regarding associations with respondent demographics (rank of the respondent, gender and full-time or part-time employment), only one association between a subscale and a single respondent demographic could be identified. A practically and statistically significant association between gender and error reporting incidence was

discovered with an effect size of 0.60 (p = 0.006). Females perceived errors to be reported more often than males (mean = 3.37 and 2.72 respectively).

4.4.8 Correlations between demographical data, AHRQ items and subscales

Correlations between demographical data of respondents including age, experience as medication administrator, experience as medication administrator within the specific hospital, and qualifications of the medication administrator were explored. No significant correlation between any of these variables could be determined.

4.5 DISCUSSION

The age distribution of the sample correlated with the age-distribution of provided by SANC (2015:4) of all the nurses registered in South Africa within 5% of each category, with the exception of the below 25 years category (represented 1.0% of the SANC population and 6.2% of the study sample) and the 60 years and above category which was represented by 12.8% of the SANC population and only 2.2% of the study sample. This discrepancy could be due to the fact that many nurses remain registered even after retirement and these nurses would not have been represented in the study sample.

The fact that most respondents had less than five years‟ experience in administrating medications was disconcerting as experience was correlated with perceptions of safety and quality of care (Ramanujam *et al.,* 2008:144). However, Seki and Yamazaki (2006:133) found that errors occurred with a significantly higher frequency when years of experience as a nurse were more, though years of experience at a specific unit decreased this frequency. This finding emphasised the fact that nurses should not get too comfortable and self-assured in their medication administration duties, as was also found in the previous phase of the study.

Experience was not the only medication administrator characteristic that influenced the safety of practice. Higher levels of knowledge were found to be protective against medication errors (Roughead & Semple, 2009:26). More international research indicated a clear link between qualifications of nurses and patient safety (Aiken *et al.*, 2003:1621). For this reason, it was encouraging to find that half of medication administrators responding to this study were registered nurses,

especially as rank was found to be a determinant of medication error in the previous phase of this study.

The mean of respondents‟ opinions of strongly and moderately disagreeing that they have enough staff to manage the workload is disconcerting, as staffing inadequacy was correlated with increased incidence of error (Scott *et al.*, 2014:174). However, most of the other items measuring safety culture in the unit were responded to positively. A safety culture is a characteristic of high-reliability organizations that are commonly advocated as the foundation of quality care and patient safety (Pham *et al.*, 2012:451).

Adding to this safety culture, the Institute of Medicine (2003:1) reported that the most important standard for patient safety is developing an environment that encourages the sharing of adverse incidents. Therefore the indication by participants that they mostly experienced reporting of medication errors to be non-punitive was very encouraging, though the reporting of these perceptions were more moderate than what was hoped for.

Teamwork is another important facet of safety culture. The lack of teamwork within a unit is seen as a very important issue leading to nursing errors (Mahmood *et al.*, 2011:233). For this reason, the mean value attributed to the teamwork subscale is worrying as it indicates middling perceptions of teamwork‟s existence.

Adding to the problem of inhibited teamwork was the addition of unknown members to the team by employment of temporary staff. Of all safety culture related items, the use of temporary staff was seen as the most important inhibiting factor to patient safety, with respondents strongly agreeing that more temporary staff was used than what was safe for the patients. Sanghera *et al*. (2007:58) and Tang *et al*. (2007:451) confirmed that new staff may contribute to higher medication error rates. Employing temporary staff is as good as employing new staff for every shift.

Continuing with the perceptions of unit safety, the mean of perceptions of the incidence of medication errors in units indicated that medication errors occurred between a few times a year and once a month or less and that overall medication administration safety in their units were very good, although the WHO (2008) estimated that tens of millions of patients worldwide suffer disabling injuries or death

every year due to unsafe medical practices and care, with the situation being exacerbated by poor infrastructure and shortage of resources in developing countries. This estimation was confirmed by the medication administration error incidence reported in the previous phase of the study, showing that the insight into medication administration safety problems are lacking in South African nurses.

Although perceptions of general safety were not found to be in touch with reality, respondents did not fail in identifying possible causes of medication error. Communication lapses causing errors were perceived to pose a moderate risk to medication administration errors occurring. Aljadhey *et al.* (2014:328) confirmed that communication barriers between healthcare professionals represented one of the most important challenges to better medication safety.

Though human factors were seen as the least prevalent cause of medication errors, Kazaoka *et al.* (2007:313) mentioned it as being a common thread of medication errors. Santell and Cousins (2005:531) elaborated that there were three specific human factors that were the most common causes of medication administration errors, namely performance deficit, knowledge deficit and failure to follow procedures and protocols.

Environmental factors impacting on medication administration safety showed the highest risk of causing medication errors. As part of environmental factors, workload related factors featured most often. If reasonable workloads exist, nurses are less likely to participate in unsafe behaviour when administrating medications (Fogarty & Mckeon, 2006:454). Respondents of a study conducted by Mahmood *et al.* (2011:233) agreed that work overload was the top organizational issue leading to nursing errors. In Jordan, heavy workload was also identified as the biggest cause of medication errors (Al-Shara, 2011:159).

Also an environment-related one, the only other factor impacting on medication administration safety with a mean score above three was uncooperative patients. International research reports verbal abuse towards professional nurses as a common or even daily problem (Jackson *et al*., 2013: 2066; Truman *et al*., 2013:6; and Stone *et al*., 2010:1365), and this validated the respondents‟ view of uncooperative patients being a major contributing factor to medication errors. Due to

the highly distressing nature of verbal abuse, medication administrators might tend to withdraw from the care of a verbally abusive patient, thereby leading to medication administration errors (Stewart et al., 2013:236; and Stone et al., 2010:1365), especially omissions or wrong-time errors.

Bohomol *et al*. (2009:1263), Fry and Dacey (2007:677), Günes *et al.* (2014:298), Kim *et al.* (2011:350), Latif *et al.* (2013:397), Maiden *et al.* (2011:342), Manias *et al.* (2014:74), Ozkan *et al.* (2011:140), Vazin and Delfani (2012:428), Smeulers *et al*. (2014:281) and Wolf *et al.* (2006:42) all agreed that problems in stock or distribution from the pharmacy could inhibit medication safety. This was the most important medication-related cause of error as identified by respondents, the second most prevalent overall cause of medication administration error.

The reason medication administrators were afraid to look into themselves to find causes for medication administration error was most likely due to fear of retribution. This was confirmed by the fact that most respondents felt that errors caught before happening are more often reported than errors that did indeed happen but did not cause harm to the patient. However, if there was a potential of harm to occur to the patient, concern for the patient seemed to override this fear, leading to higher report-rate, while definite harm was reported most often. Though this conscientiousness was seen in a positive light, it was disquieting to find that respondents felt that even potentially harmful errors were only reported sometimes, not even most of the times let alone always. O"Connor *et al.* (2010:371) confirmed the existence of a gap between ideal disclosure practices and reality, indicating that low report-rates of medication administration errors were not a problem unique to South Africa.

However, returning to the positivity of nurses" regard for the patient"s safety, it was clear to see that the greatest reason of non-report, fear, was more often associated with the patient than with the physicians, other nurses or hospital administration, as the greatest elements of fear were that nurses could be blamed if something happened to the patient or that the patient or his/her family might develop a negative attitude towards the nurse. Jones and Treiber (2010:245) confirmed this in quoting a nurse who stated that her first and major concern was for the patient"s safety and well-being. More than half of respondents from a study conducted by Toruner and

Uysal (2012:32) also mentioned that being blamed if something happened to a patient as the number one reason of not reporting a medication administration error.

Related to this fear, was the fear of the hospital administration‟s response. The practically significant relationship between fear and administrative response proved that fear, though primarily concerned with patient safety, has many facets, including the fear of punishment or loss of trust from management. This fear might be exacerbated by the discrepancy of what the medication administrator see as an error and what management perceive one to be as was indicated by the correlation between fear and the disagree with definition subscale. Both fear and this discrepancy added to the negative emotions surrounding medication administration error-reporting, which was seen by the correlation between the subscales that measured these factors.

Contrary to the feeling that medication error was understood differently by management and nurses, the practically significant correlation between all the factors associated with risk of medication errors indicated that respondents with a higher perception of risk will have a greater perception of all risks. Thus, these respondents more often identified all risks and could therefore better evade them. Hansen *et al.* (2011:607) agreed in stating that hospital staff perceptions of safety are associated with clinical outcomes of patients.

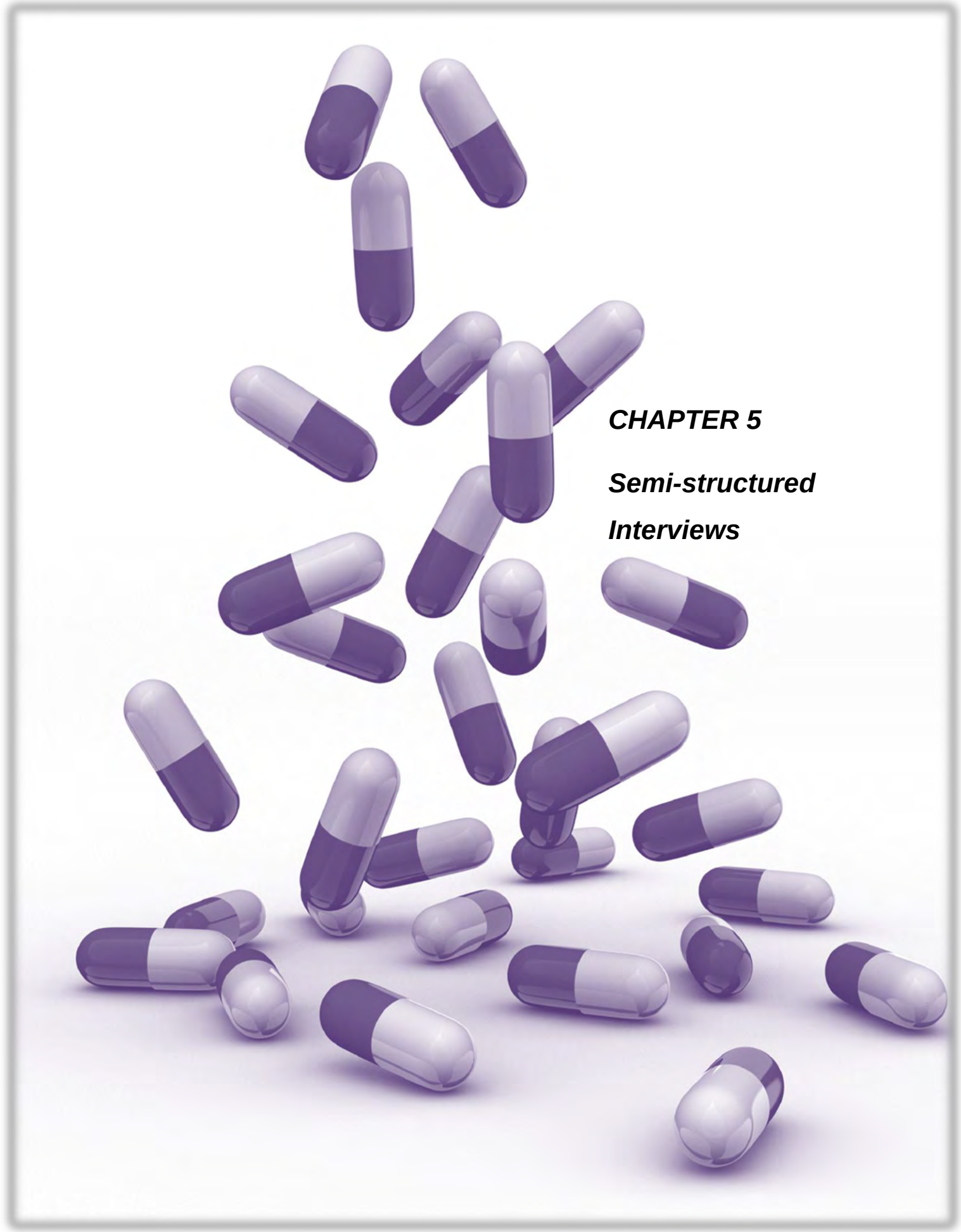
4.6 LIMITATIONS

This phase of the study was reliant on the perception of respondents. Though perceptions could relate reality, other or more prominent causes of medication error could be under-reported due to lack of insight on the respondents‟ part or respondents‟ fear of creating a negative image of their institution or unit. Though all measures were taken to ensure a representative sample of all hospitals and hospital-levels, the response rate from certain hospitals was very low, negatively impacting on the reliability of correlations drawn. However, by sampling more than one hospital of a certain level, this representativeness and reliability were again increased.

4.7 SUMMARY

This section completed the second step in the research cycle, namely determining causes. The causes of medication administration errors within medical and surgical units of public hospitals of the Gauteng Province were determined by surveys. Although the average perception of medication administration safety in units was very good, three main causes of medication administration error that posed significant risk in this regard were determined: Workload, stock distribution problems and illegible prescriptions. Respondents felt that medication administration errors were reported seldom. The main reason for non-report of errors was fear, especially due to administrative response.

The above-mentioned three main causes of medication administration errors were used in the following phase of the study. These causes were incorporated into the interview schedule to determine context-specific solutions for the problems.



CHAPTER 5

Semi-structured Interviews

5.1 INTRODUCTION

Rich (2005:11) identified the need for research that demonstrates that culture can be changed when nurses are empowered to improve patient safety. For this reason, this phase of the study was focussed on empowering unit-managers to contribute to solutions of improvement of medication administration safety and thus represented the third step in the research cycle in patient safety: identifying solutions.

In order to reduce the preventable harm caused by medication administration errors, health systems, institutions and providers must understand, implement and augment interventions to reduce these errors (Levine *et al.*, 2001:426). A plethora of research exists on interventions to reduce medication administration errors. These interventions were innovative and revealed positive effects in many different settings (Manias *et al.*, 2012:411).

However, Van Beuzekom *et al.* (2013:107) stated that strategies for improving patient safety should be tailored specifically for a particular setting. Therefore context-specific solutions to the problem of medication administration errors were explored by means of subject matter expert interviews, addressing the fourth objective of this study: To identify possible solutions for the problem of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa by means of subject expert interviews.

5.2 METHOD

Kvale (2008:1) defines the research interview as an interview where knowledge is constructed in the interaction between the interviewer and the interviewee. A qualitative interview is usually semi-structured; it has a sequence of themes to be covered, as well as some prepared questions, while at the same time there is openness to changes of sequence and question forms in order to follow up the answers given and the stories told by the interviewees (Kvale 2008:65).

Botma *et al.* (2010:206) state that the interviewer should be skilled in the required communication techniques such as minimal verbal responses, listening, paraphrasing, reflecting, clarifying, probing, summarising, encouraging and acknowledging in order to conduct an effective interview. Kvale (2008:91) elaborates on the qualification criteria for an interviewer by stating that he or she be

knowledgeable, structuring, clear, gentle, sensitive, open, steering, critical, remembering and interpreting (Kvale 2008:91).

Further determinants for the quality of an interview as mentioned by Kvale (2008:80) include:

- The extent of spontaneous, rich, specific and relevant answers from the interviewee;
- The shorter the interviewer‟s questions and the longer the subjects‟ answers, the better;
- The degree to which the interviewer follows up and clarifies the meaning of the relevant aspects of the answers;
- To a large extent the interview is interpreted throughout the interview;
- The interviewer attempts to verify his or her interpretations of the subject‟s answers in the course of the interview; and
- The interview is „self-reported‟ - it is a self-reliant story that hardly requires extra explanations.

These prerequisites were kept in mind during the conducting of the semi-structured interviews.

5.2.1 Population and sampling

Sandelowski (1995:179) explained that adequacy of sample size in qualitative research is relative and that a sample size of ten may be judged adequate for certain kinds of homogeneous sampling though too small to achieve maximum variation of a complex phenomenon. Thus, to ensure that an adequate sample could provide information on the complex problem of medication administration errors, an all-inclusive sample (N = 17) of unit managers from units as selected in phase two was chosen. Ten of these planned interviews realised on the first day of data collection: Three unit managers did not complete the informed consent letters, one was ill on the day of data collection and three were too busy with unit matters at the time of the scheduled appointments. Though data-saturation was reached after these ten interviews, the other seven interviews were re-scheduled to ensure that data saturation had indeed been achieved. Five of these interviews realised on the second data-collection date. Two unit-managers were again to caught-up in unit

managers to be interviewed. These five interviews confirmed themes already identified in the first ten interviews. Thus the final sample size was fifteen.

5.2.2 Data collection

The approach to interviewing as described by Denzin and Lincoln (2005:707-708) laid the foundation for the data collection process, viz. assessing the setting, understanding the language and culture of the respondents, deciding how to present oneself, locating an informant, gaining trust, establishing rapport and collecting empirical material. The setting was assessed in that the researcher already did data collection in the specific units for the previous three phases at the time the interviews were scheduled, which assisted the researcher to also understand the unit culture. The researcher presented herself as a registered nurse, to limit the possibility of participants feeling intimidated by the presence of an academic. Locating informants were done in collaboration with the nursing manager of the hospital who introduced the researcher to the unit-managers. Trust and report were built during the collaboration with the unit-manager throughout the previous phases of the research, where after the interviews were scheduled for empirical data collection.

The researcher did a pilot interview to assess the clarity of the questions and the time-frame needed to conduct the interviews. The interview schedule was found to be effective in reaching the aim of this phase of the study and no changes were required. The pilot-interview also indicated that the twenty minutes scheduled for each interview was adequate. This interview was conducted with a registered nurse from outside the study population and therefore was not included for analysis.

Informed consent forms were distributed to all sampled unit managers two weeks prior to the planned day of data collection. Unit telephone numbers and names of the unit managers were written down for the purpose of scheduling appointments. One week after distribution of the informed consent forms, the sampled unit managers were contacted on the unit phone to enquire about their willingness to participate in the study and a suitable time and place for the interview to be conducted. Venues for conducting the interviews were identified by the unit managers for their own convenience. Further verbal information was provided to prospective participants during a telephonic confirmation of the interviews as was

needed. Voluntary participation as well as confidentiality was confirmed during these telephonic conversations.

One day prior to the scheduled interviews, the prospective participants were again contacted telephonically on the unit telephone to remind them of the interviews and to ensure that they were still willing to participate. All sampled unit managers agreed to take part in the study and indicated that there would be a room within the unit where the interview could be conducted.

On the day of data collection, the signed informed consent letter of a specific participant was requested by the researcher prior to conducting the interview. Verbal consent was again confirmed and the recording of the interview was explained to the participant, confirming that confidentiality was to be ensured by the use of code names and that the recordings were to be destroyed as soon as it had been transcribed. Two participants agreed to be interviewed, but did not give consent to the recording of thereof. Detailed notes on these interviews were made. The average interview length was 17 minutes.

After conducting the interviews the participants were thanked and asked whether they had any questions or were uncertain about anything discussed in the interview. No participant raised any queries at this point. The researcher then left the unit to write field notes to ensure that the researcher remembered all contributing factors during the interviews.

5.2.3 Interview schedule

An interview schedule focussed on solutions for the top three causes of medication administration errors as identified in phase four was used. These three causes were workload, stock distribution problems and illegibility of prescriptions. Three general questions were added to the interview schedule. At the initiation of the interview, the interviewee was asked to give his/her opinion of what could cause medication administration errors in their units and what possible solutions to these causes might be. To end off the interview, the interviewee was asked whether there was anything else they wanted to add that could contribute to medication safety (Addendum XIV):

1. In your opinion, what would you say causes medication errors in your unit?
2. How would you say that we can limit this risk?
3. The medication administrators also gave me a few causes of medication errors. These were high workload, stock distribution problems and illegible prescriptions. What can we do to lessen our staff‟s workload?
4. What can we do to limit the stock distribution problems?
5. What would you say we can do about the illegible prescriptions?
6. Is there anything else you would like to add that we can do to improve medication administration safety?

5.2.4 Data analysis

Morse (1994:25) has summarised the cognitive processes involved in qualitative research during the analysis thereof as firstly comprehending the phenomenon under study, secondly synthesising a portrait of the phenomenon that accounts for relations and linkages within its aspects, thirdly theorising about how and why these relations appear as they do and lastly re-contextualising, or putting the new knowledge about the phenomena and relations back into the context of how others have articulated the evolving knowledge. In order to be able to apply these strategies to the obtained data, the 15 semi-structured interviews were transcribed verbatim and numbered. An example of such an interview was added as Addendum XV.

Following this, thematic content analysis as proposed by Holloway (2005:242) was used to analyse the data. Cresswell (2009:184) provides the following steps for thematic content analysis:

- Organise and prepare – Interviews were transcribe verbatim and field notes were typed.
- Develop a general sense – The researcher read through all the data to obtain a general sense of the information.
- Code the data - Coding is a method that enables one to organize and group similarly coded data into categories or "families" because they share some characteristics (Saldana, 2010:12). Coding is done to reduce the amount of data obtained into more manageable and comprehensible texts in order to make sense of the data collected (Welman *et al.*, 2011:213). Saldana

(2010:10) further explains that to codify is to arrange things in a systematic order, to make something part of a system or classification or to categorize while Grbich (2007:21) agrees that coding permits data to be grouped together to consolidate meaning.

- Describe and identify themes - Inducing themes involves inferring general rules or classes from specific instances (Terre Blance *et al.* (2012:323). Thus, themes are umbrella constructs (Welman *et al.* (2011:211) under which participants‟ inputs are categorised. After themes were determined, the contents of each of the themes was refined from the data and compared with data from other themes, as proposed by Rubin & Rubin (1995:17).
- Represent findings – Representation of findings was done according to the suggestion from Maykut and Morehouse (1994:8) who stated that each category should be refined by developing a rule for inclusion in the form of a propositional statement, coupled with sample data. Thus, a short explanation of each theme was provided, followed by statements extracted from the interviews. These excerpts was labelled according to theme, interview number, page number and line number, for example (1/7/1:77) would indicate theme one, interview number seven, page number one, line 77. (Lines were numbered continuously through all pages).
- Interpret the data – Data were embedded in literature and then discussed as contextualised to the South African setting.

Rigour was ensured throughout the data analysis process by means of approaches as described in 1.8.5.

5.3 RESULTS AND EMBEDDING OF RESULTS IN LITERATURE

Four themes were extracted during data analysis, each with its own sub-themes. The four main themes were other causes of medication administration errors, expansion on causes of medication administration errors determined in the survey, recommendations to reduce medication administration errors and despondency. These themes and their various sub-themes are presented in Table 5.1.

Table 5.1 Themes and sub-themes identified during the semi-structured interviews

Main themes	Sub-themes
1. Other causes of medication administration errors	1.1 Knowledge and skills
	1.2 Condition of the patient
2. Expansion on causes of medication administration errors determined in the survey	2.1 High workload ➢ Staff shortages ➢ Time management
	2.2 Stock distribution problems ➢ Availability ➢ Emergencies ➢ Communication
	2.3 Illegible prescriptions ➢ Attitudes
3. Recommendations to reduce medication administration errors	3.1 Adherence to existing protocols ➢ Identifying the patient ➢ Checking expiry dates of medications ➢ Ordering medications according to established schedules ➢ Adhering to the five rights of medication administration
	3.2 Audit
	3.3 Education and training ➢ Student nurses ➢ All medication administrators ➢ Doctors
	3.4 Collaboration and support ➢ Unit-staff helping one another ➢ Patient assisting in his/her own care ➢ Assistance from outside the unit ➢ Emotional support needed

	3.5 Communication ➢ Between nurses and doctors ➢ Between the pharmacy and the unit ➢ Between the doctor and the pharmacy or the patient ➢ With other related staff-members
	3.6 Awareness of changes ➢ The use of known products ➢ Keeping to the same distributor ➢ Known dosages
	3.7 Resources management ➢ Availability of medications ➢ Assisting devices for medication administration
	3.8 Time management
4. Despondency	-

These four themes will be discussed in detail, embedding the results obtained in correlating literature.

5.3.1 Theme 1: Other causes of medication administration errors

In the following paragraphs the researcher discusses the sub-themes that emerged from the data analysis under the theme "other causes of medication administration errors". Table 5.2 provides an overview of these sub-themes.

Table 5.2 Sub-themes of other causes of medication administration errors

Theme	Sub-themes
1. Other causes of medication administration errors	1.1 Knowledge and skills
	1.2 Condition of the patient

5.3.1.1 Sub-theme 1.1: Knowledge and skills

Knowledge and skills were mentioned to contribute to the incidence of medication administration errors. A student interviewed by Vaismoradi *et al*. (2014:434) stated

that students learned little about practical aspects of medication, and too long before their clinical placements, which showed a gap in the nursing curriculum. Bae *et al.* (2009:46) and Chang and Mark (2009:74) agreed that knowledge deficiency could sprout from educational deficits.

Though educational deficits could lead to a portion of the knowledge gaps, West *et al.* (2013:317) and Wolf *et al.* (2006:42) also mentioned that inexperience with an unfamiliar protocol could lead to accidental medication errors. No matter the cause, knowledge deficit was stated by several studies as a cause of medication administration errors (Cheragi *et al*., 2013:230; Sanghera *et al*., 2007:58; West *et al.*, 2013:317; Wolf *et al.*, 2006:42). In this study, specific gaps in pharmacological knowledge of the medication administrator were identified.

> *"…not having enough knowledge of the treatment that you are giving…" (1/2/4/103-104)*

> *"Or not understanding the prescription itself, it could also cause an error" (1/10/19/675-676)*

Specific pharmacological knowledge deficits were mentioned as pertaining to the name of the medication

> *"…and then inexperience also, if you don't know the medication; the generic and the what-what…" (1/7/14/467-468)*

> *"They don't concentrate on the generic names of the medication; they focus on the trade name of the treatment. So most companies use different trade names, but the generic names are the same. So what I've noticed, is that a person is looking for a certain medication, but now because it is a different company, he struggles or she struggles to find that medication." (1/8/15/501-505)*

or to the correct dosage of a medication

> *"It would be a problem if someone is not knowledgeable about the strength of a medication ne? (1/1/1/9-10)*

"Or maybe the one who is giving the medication does not know the correct doses" (1/3/7/210-211).

The relationship between knowledge and both wrong medication and wrong dose error was established in the second phase of this study when wrong medication and wrong dose errors were related to the rank of the administrator. In both relationships the student nurses made more medication administration errors than the other rank-groups, revealing that the medication administrators with less knowledge were more prone to make these errors (section 3.5.5.4). However, knowledge was reported to only be a small contributing factor in causing medication administration errors in the fourth phase of the study (section 4.4.3.4.2).

Competency or skills was mentioned and closely related to the knowledge of the medication administrator in causing medication administration errors. Deans (2005:31), Ozkan *et al.* (2011:140) and Treiber & Jones (2012:288) agreed that medication administration errors could occur due to slips resulting from a skills deficit. One of the participants reiterated this problem:

"Eh, the reason might be the staff competency, if the staff is not competent, they are not skilled enough to administer the medication" (1/5/10/345-346).

Though seen as a major concern by unit managers, in general medication administrators reported slips to only pose a small risk in medication administration error in phase four of this study (section 4.4.3.4.2).

5.3.1.2 Sub-theme 1.2: Condition of the patient

The condition of the patient, or the patient acuity was mentioned by participants to impact on medication administration safety. Shahrokhi *et al.* (2013:20), Treiber and Jones (2012:288) and Valentin *et al.* (2009:5) agreed that high acuity adds to the risk of medication administration errors while Breckenridge-Sproat *et al.* (2012:463) identified a statistical significant correlation ($p < 0.05$) between patient acuity and medication administration error rate. In this study the condition of the patient was most often referred to when the problem of a patient not being able to swallow oral medications was discussed:

"We've got patients that have difficulty swallowing, and we have to grind medication" (1/7/14/477-478).

"We don't have devices to crush those tablets for patients who are not able to swallow a pill like it is" (1/9/17/590-591).

In this study, the mean scores reported by medication administrators in phase four indicated that patient acuity posed a moderate risk of contributing to medication administration error incidence (section 4.4.3.4.3).

Another aspect of the patient's condition, viz. restlessness was mentioned as contributing to medication error incidence:

"Inclusive, which is also another challenge, it is the patient's condition. You sometimes find patients who are restless, so that is causing challenges with regards to the administration of medication" (1/4/263-265).

Deans, 2005:31; Manias *et al.*, 2014:74; and Valdez *et al*., 2013:225 all mentioned uncooperative patients to contribute to the risk of medication administration errors occurring. Again the study sample of phase four agreed that uncooperative patients posed a moderate risk in causing these errors (section 4.4.3.4.3).

5.3.2 Theme 2: Expansion on causes of medication administration errors determined in the survey

During the interviews, participants agreed and elaborated on the three main causes of medication administration errors as was determined in phase four of the research, namely high workload, stock distribution problems and illegible prescriptions. The elaboration and contextualisation of these causes will now be discussed. Table 5.3 provides an overview of the theme "Expansion on causes of medication administration errors determined in the survey" and its subscales.

Table 5.3 Sub-themes of expansion on causes of medication administration errors determined in the survey

Main theme	Sub-themes
2. Expansion on causes of medication administration errors determined in the survey	2.1 High workload ➢ Staff shortages ➢ Time management
	2.2 Stock distribution problems ➢ Availability ➢ Emergencies ➢ Communication
	2.3 Illegible prescriptions ➢ Attitudes

5.3.2.1 Sub-theme 2.1: High workload

High workload of nurses was not only due to the staff shortages evident in some hospitals, but also caused by a lack of time-management skills. In another developing country such as South Africa, Jordon, heavy workload was also identified as the biggest cause of medication errors (Al-Shara, 2011:159). Several studies directly associated work-load to understaffing (Deans, 2005:31; Maiden *et al.*, 2011:342; Mohamed & Gabr, 2010:29; Sanghera *et al*., 2007:58; Sears *et al*., 2013:354). From the response of the participants, it was clear that increased workload due to understaffing was adding to the problem of medication administration errors.

> *"I don't think there is anything we can do other than getting more hands…" (2/2/4/125-126);*
>
> *"We ask for more staff but we don't get them, because the government says we don't have a problem" (2/3/7/222-223);*
>
> *"There is only one person giving, so we started nearly half-an-hour before, but it is many patients" (2/9/17/584-585);*

"They must get more staff, that's the only answer. Because you see, sometimes we are only four on duty (2/11/21/739);

"And then the ratio between the nurses and the patients is poor (2/12/23/803/804).

Considering time-management, other studies related nurses' feelings that they are not competent in managing their time effectively (Aggar & Dawson, 2014:899; and Hirabayashi *et al*, 2009:63). Time-management as a causative factor related to medication administration errors was discussed as both a result of circumstances external to the nurse

"It is at times we want to give oral treatment at eight o'clock, as is expected, but you find that the breakfast is not yet available so that the patient can eat before" (2/4/8/269-270)

"Sometimes there are many patients and IV medication takes a lot of time, if you have to put up a drip first" (2/6/12/409-410)

or as result of poor time-management skills of the nurse

"You know, whatever what you start in time, it will help… We don't walk like nurses. That is why we say there is no time, but if you keep time, walk like a nurse, you will finish in time" (2/10/20/291-293)

"Time – the nurse just wants to finish the medication round as fast as possible" (2/6/12/408-409)."

Medication administrators participating in phase four of the study concurred that workload was the biggest threat to medication administration safety. Two aspects of work overload correlated with the results of this phase, namely inadequate staffing and high patient-to-nurse ratio (section 4.4.3.4.3).

5.3.2.2 Sub-theme 2.2: Stock distribution problems

Bohomol *et al*. (2009:1263), Fry and Dacey (2007:677), Günes *et al.* (2014:298), Kim *et al.* (2011:350), Latif *et al.* (2013:397), Maiden *et al.* (2011:342), Manias *et al.* (2014:74), Ozkan *et al.* (2011:140), Vazin and Delfani (2012:428), Smeulers *et al*.

(2014:281) and Wolf *et al.* (2006:42) all agreed that problems in stock or distribution from the pharmacy could lead to medication administration errors. This was also the most reported medication-related cause of medication administration error identified by respondents from phase four of the study, the second most prevalent overall cause of medication administration error (section 4.4.3.4.4). In this phase of the study, stock distribution problems were divided into three categories, viz. availability, emergencies and communication. Availability problems were identified from the following statements:

> *"There is no stock and then they brought something else" (2/1/2/62-63);*
>
> *"Like now we've got a problem where Perfalgon has been taken completely off the tender, and it's one of those drugs that you really need for your patients who are unable to swallow" (2/2/5/138-140);*
>
> *"There is no stock in the pharmacy" (2/3/7/233);*
>
> *"When maybe something is out of stock it is a problem because maybe the patient will not get treatment" (2/5/11/374-375);*
>
> *Sometimes we don't give the medication to the patient because we don't have ward-stock in the ward. We have to have ward-stock, like especially the things we use regularly like Amoxicillin. Rocephin, sometimes we have more than five patients who get it, we have to order with the prescription. If they can give and we can have it on ward-stock, otherwise we must wait. And we wait!" (2/7/14/484-489)*

Stock distribution problems often occur after hours or in emergency situations, where the pharmacy or doctor cannot be contacted immediately:

> *"But if you get a patient during the night and he has that prescribed and it's a motivation drug, so the pharmacist is at home, so it becomes a challenge" (2/2/5/147-148)*
>
> *"Sometimes the doctor prescribes something that isn't there, then it is after hours and the pharmacy is closed and then it is an emergency*

medication, then what do you do? You omit that dose until tomorrow when the pharmacy is open" (2/6/13/435-438).

Lastly, ineffective communication was found to aggravate the stock distribution problems:

"Because some of the doctors, even the frequencies of the medications, the dosages of the medications, they get them wrong and it comes back to you as the nurse. It's either you correct them or sometimes even you don't know the strength yourself. By the time you get it back from the pharmacy the doctor is long gone and you are the one sitting with the patient and you can't give them medications (2/2/5/172-177)

"So it limited our time cueing at pharmacy, calling again, because to pick up a phone and to go, it's a waste of time (2/9/18/603-604).

During the direct observation (phase three) stock distribution problems were observed to lead to medication administration errors (section 3.5.4.1). Although stock distribution problems were reported to be the second biggest cause of medication administration errors, medication administrators reported communication to only contribute a small risk to these errors in phase four of the study (section 4.4.3.4.1).

5.3.2.3 Sub-theme 2.3 Illegible prescriptions

Several other studies agreed that the illegibility of prescriptions contributed to the medication error problem (Latif *et al.*, 2013:397; Manias *et al.*, 2014:74; Mrayyan, 2012:223; Mrayyan *et al.*, 2007:665; Treiber & Jones, 2012:288; Ulanimo *et al.*, 2007:31; Unver *et al.*, 2012:322; and Wolf *et al.*, 2006:42). Attitudes were seen as an important factor impacting on medication administration safety related to illegible prescriptions:

"But you know different personalities with the people, you get doctors who are more friendlier to correction, then you get those that are like „you don't dare"" (2/2/6/190-192);

"Ja, we are addressing it every day in our mortality and morbidity meeting. About the handwriting. Asking the doctors about it because you are not writing for yourself. Somebody is going to read and take over (2/3/7/216-218);

"We have talked to the doctors about their handwriting, and then the other thing that we do to show we are concerned about the handwriting, is we do audit and then after auditing, we just give comments to the HOD" (2/4/9/285-287).

Illegible prescriptions was reported by medication administrators participating in phase four of the study to be the third biggest risk factor in leading to medication administration errors (section 4.4.3.4.1). This problem was also observed during phase three of the study (section 3.5.4.1).

5.3.3 Theme 3: Recommendations to reduce medication administration errors

Eight sub-themes focused on strategies of medication administration error prevention were uncovered. These sub-themes are presented in Table 5.4.

Table 5.4 Sub-themes of recommendations to reduce medication administration errors

Main theme	Sub-themes
3. Recommendations to reduce medication administration errors	3.1 Adherence to existing protocols ➢ Identifying the patient ➢ Checking expiry dates of medications ➢ Ordering medications according to established schedules ➢ Adhering to the five rights of medication administration
	3.2 Audit
	3.3 Education and training ➢ Student nurses ➢ All medication administrators ➢ Doctors
	3.4 Collaboration and support ➢ Unit-staff helping one another ➢ Patient assisting in his/her own care ➢ Assistance from outside the unit ➢ Emotional support needed
	3.5 Communication ➢ Between nurses and doctors ➢ Between the pharmacy and the unit ➢ Between the doctor and the pharmacy or the patient ➢ With other related staff-members
	3.6 Awareness of changes ➢ The use of known products ➢ Keeping to the same distributor ➢ Known dosages
	3.7 Resources management ➢ Availability of medications ➢ Assisting devices for medication administration
	3.8 Time management

5.3.3.1 Sub-theme 3.1: Adherence to existing protocols

Adherence to existing protocols was mentioned by several participants as a key contributing factor in enhancing medication safety. These protocols might include properly identifying the patient, checking expiry dates of medications, ordering medications according to established schedules, correct documentation and mostly adhering to the five rights of medication administration.

> *"We just need to follow the protocols and procedures as it is stipulated" (3/4/10/337);*
>
> *"If I am dedicated and just do the right thing that you are expected to do, then it (medication safety) will improve" (3/6/13/454-455);*
>
> *"If they did not identify the patient correctly, then they will continue with many errors." (3/10/19/674-675);*
>
> *"…like you first check the expiries…" (3/9/16/556);*
>
> *"Whoever is responsible for the ordering, if they order then there wouldn't be any problems…" (3/6/13/432-433);*
>
> *"There are the same five rights, they still work for us" (3/7/14/491).*

The five rights were still seen as the basis of medication administration safety protocols. The need for checking the five rights was emphasized by Choo *et al.* (2010:853). Other protocols mentioned in literature that needed adherence to, included the preparation of medications directly before administration thereof (Kim *et al.*, 2011:346) and the identification of the patient (O'Connel *et al.*, 2007:377). Errors occurred when medication administrators slacked in following protocols. Reid-Searl *et al.* (2008:2751) agreed that medication errors occurred when complacency took over from meticulous and safe practice while Eisenhauer *et al.* (2007:82) reiterated the need for commitment from nurses in order for safe practice to be achieved and maintained.

5.3.3.2 Sub-theme 3.2: Audit

In order to up-keep the careful attendance to protocol, some form of supervision is required. Auditing was mentioned as a method of monitoring medication administration processes and thus also the adherence to existing procedures or protocols.

> *"We have to do the audit…" (3/10/9/287);*
>
> *"The HOD (head of department) is coming to the ward checking…" (3/4/9/288);*
>
> *"We are addressing it on our mortality and morbidity meeting" (3/3/7/216-217).*

Unit managers play a central role in the management of medication administration errors (Kagan & Barnoy, 2008:353) as they have a strong influence on nurses‟ conduct (Chiang & Pepper, 2006:392). For this reason, audits on medication administration might improve medication administration safety.

5.3.3.3 Sub-theme 3.3: Education and training

Education and training were other categories mentioned as solutions to medication administration errors. Education and training were mentioned with relation to student nurses,

> *"That is education, education, education, that‟s it" (3/3/8/248);*
>
> *"We really have to pin down on the knowledge part" (3/2/6/199);*

all medication administrators,

> *"I think there must be on-going, continuous learning. You see, we have to always see that nursing staff goes for education, because some people get too comfortable, they think, „no, I‟m used to this, I‟ve been doing this‟ and that is where now the mistakes are going to be done" (3/8/16/537-540);*
>
> *"We have to learn further knowledge of the trade names" (3/2/4/109);*

"I think there has to be some pamphlets so that everybody must be able to know and see every time" (3/1/3/92-93);

and also doctors, especially for the legibility of their handwriting:

"Because with us nurses, they teach us to write like this and like that, but to them (doctors), it is as if they don't teach that" (3/9/18/627-628).

Supervision of new staff or student nurses was seen to be another important category of education and training:

"When the new staffs come to the ward, they need the orientation" (3/5/11/348-349);

"I tell them to ask if they don't understand…" (3/1/2/40);

"We try to get them to ask more questions and to give them like homework to go and research a specific treatment…" (3/2/4/114-115);

"…then you will be observing when they are giving the medication, and you can see that maybe if there is a lack of knowledge then we can then do the in-services" (3/5/11/354-356);

"We don't get time for these little ones to teach them properly. Maybe this will minimize this medication error. Even every error will be minimized if there is someone following them" (3/9/23/665-667).

The recognition of nurses' lack of knowledge should be taken into consideration when revising the curriculum in nursing education and training at work (Simonsen *et al.,* 2011:175). Leufer and Cleary-Holdforth (2013:216) suggested that educational initiatives could address both extrinsic and intrinsic factors leading to medication administration errors. Strengthening nursing students' theoretical pharmacological knowledge will help them to recognize medication errors and nursing educators have the responsibility to teach all required skills to their students in order to avoid medication administration error being made (Efstratios, 2012:777; Warburton, 2010:42; Paparella, 2005:373; and Luk *et al.*, 2008:28).

5.3.3.4 Sub-theme 3.4: Collaboration and support

Though supervision of students might help them to grow professionally, help among the unit-staff was stated to lighten the burden of the workload. The assistance was not only limited to unit staff helping one another;

> *"We have to help each other…"* (3/1/2/35);

but also including the patient assisting in his/her own care:

> *"If you have patients who are okay, then they can just be reminded about the time, and they can take their own medication" (3/4/10/324-325).*

The assistance within the unit could be supplemented by assistance from outside the unit, especially from doctors:

> *"If we can work collaboratively with the doctors, then the doctors insert the drip for the medication prescribed, then the nurses are going to administer" (3/5/11/369-371).*

Furthermore, the help required was said to be more than physical, but also emotional:

> *"Maybe if there can be someone who can council them about the work stress, that might maybe help" (3/8/15/515-516).*

With the growing focus on patient safety and nursing quality, workloads are increased to unacceptable levels and this diminishes the appeal of clinical jobs for young people. Creation of a positive working environment, deployment of sufficient personnel, and retention of young nurses will provide the best guarantee of patient safety and nursing quality (Liu *et al.*, 2012:307). Bohomol *et al.* (2009:1259) mentioned interdisciplinary cooperation as a factor of this positive work environment that needed consideration in medication administration safety. Choo *et al.* (2010:853) confirmed the importance of cooperation of doctors, nurses and pharmacists in order to reduce the incidence of medication errors.

5.3.3.5 Sub-theme 3.5: Communication

Collaboration is based on good communication. Communication, especially between nurses and doctors, was seen by several participants as key in upgrading medication administration safety, though some included communication between the pharmacy and the unit, or between the doctor and the pharmacy or the patient, and even with other related staff-members. Communication is also not only verbal, but clarity and timeous written communication was also required. Firstly, communication between doctors and nurses was addressed:

> *"All you can do is talk to them…" (3/2/6/181);*

> *"It is up to the sister who is doing the rounds to remind the doctor to say, „remember, they don't keep this dose, they have this dose"" (3/4/9/312-313).*

Communication between the unit and the pharmacist is also important,

> *"Inform the pharmacy first. If they say they don't have the medication, then they make alternative, but they write us a letter" (3/1/2/59-60);*

as well as between the doctor and the pharmacist,

> *"And the pharmacists comes down on you, they don't even call the doctor…" (3/2/6/193-194);*

or between the doctor and the patient,

> *"So the thing is communication and giving the patient information" (3/5/12/399-400);*

as was communication between the unit and other staff members involved:

> *"My suggestion was communication with the kitchen people to at least deliver breakfast early" (3/4/9/277-278).*

Clarity of written communication was also emphasised:

> *"We have to print our names" (3/1/3/76);*

"But if it is not legible then we do ask, „Doctor, what is it that you have written here?" then they will come and tell you or print it on the side" (3/1/3/82-83);

"Even with the legal prescription, you get doctors who don't even fill it in properly" (3/2/6/192-193).

Several factors could influence the clarity of communication (Allinson *et al.*, 2005:78) and therefore confirmation of orders and prescriptions are often required (Cohen & Shastay, 2008:39; and Lambert *et al.*, 2010:1599). However, communication strengthening should not only be advocated between nurses and doctors or pharmacists, as communication between patients and nurses during medication administration was found by Walrath and Rose (2008:345) to also improve medication safety.

5.3.3.6 Sub-theme 3.6: Awareness of changes

The lack of communication regarding change in medication suppliers led to confusion. This frequent change in medication or medication providers was mentioned by a few participants to be a frustration. They all suggested the use of known products, keeping to the same distributor and known dosages as solution to this problem. As part of keeping to what was known, it was suggested that doctors prescribed generic names so that the nurses could get used to a specific name and not get confused about the different names.

"Doctors could prescribe medication using generic names it will make it much simpler for the staff" (3/7/15/507).

The following was said about keeping to the same distributor:

"You have different tenders almost every six months, so the labelling, the packaging, is different from the previous one and you tend to think that you don't have that product, but you have it in a different packaging" (3/2/4/104-105).

Confusion about dosages could be limited if standardised dosing was incorporated:

"Maybe if there is new policy to limit types of medications, it should be a protocol to give a common script, so that people with the same type of disease can be given the same type of treatment and the nurses can become accustomed to these protocols" (3/6/13/422-425).

Weir (2005:27) advocated the minimizing of the variety of products used and standardization of concentrations used. Thomas *et al.* (2011:50) also determined standardizing processes to be an effective measure in reducing medication administration errors.

5.3.3.7 Sub-theme 3.7: Resources management

Known medication was not the only resource that was mentioned to have to be managed properly though the availability of certain medications at needed times could contribute to the betterment of medication administration safety, especially if pharmacists could provide alternatives to prescribed medications that were not available. Furthermore, certain tools for medication administration could help nurses to more effectively complete their tasks. Human resources, for example a unit messenger could also lighten the load of the medication administrators. Thus, effective resource management was proposed as a possible problem solver. On availability of medications, the following comments were made:

"Like now we've got a problem where Perfalgon has been taken completely off the tender, and it is one of those drugs that you really need for your patients who are unable to swallow" (3/2/5/138-140);

"When we get an influx of patients who have to get drugs that we don't use in the ward, we don't have that drug at night, the pharmacist is at the home, so it becomes a challenge, so maybe an emergency drug room whereby they stock those items and you can go and the matrons dispense to the wards…" (3/2/5/145-148);

"They (the pharmacists) can dispense, I mean if I want Panado and you want Paracetamol, it's the same thing!" (3/2/5/158);

"If they (the pharmacists) can give us what they have, or an alternative." (3/3/6/243-244).

The following resources that could ease the medication administrator"s work, were proposed:

> *"If at least we can have two trolleys in the ward, then the other one can start this side" (3/7/14/476-477);*
>
> *"A recon device is quicker, but the management would not go for it" (3/9/17/587-588);*
>
> *"We used to have this things to help us crush (indicating the use of a mortar and pestle)" (3/9/17/593-594);*
>
> *"And even in the wards, we don"t have a messenger…" (3/9/18/606).*

Though the variety of medication should be limited, resources required for medication administration should not be restrained. Basic resources such as reconstruction devices that could ease and speed up mixing of intravenous medications or a mortar and pestle for the crushing of medications that cannot be swallowed whole can go a long way in alleviating the workload of medication administrators, thereby building safer practice, especially with regards to medications being administered at the right time. Semple and Roughead (2009:24) confirmed that a lack of resources impedes medication administration safety. The need for human resources was also mentioned by the WHO (2008:1) as a detrimental factor contributing to medication administration error incidence in developing countries.

5.3.3.8 Sub-theme 3.8: Time management

Lastly, another factor that needed management, time, was mentioned. Time-management could assist medication administrators to finish their tasks more effectively.

> *"I think if you utilize your times properly, to manage your time in order for you to have enough time for administration of medication" (3/2/4/26-27);*
>
> *"You know, whatever what you start in time, it will help… We don"t walk like nurses. That is why we say there is no time, but if you keep time, walk like a nurse, you will finish in time" (3/10/20/691-692).*

Referring to the last quote, time management could also be linked to the attitude of the nurse, walking like a nurse, owning the attitude of pride in ones‟ work. Returning to the right time of administration, time-management in nursing could contribute to medications being administered according to this right. Fisher and Parolin (2000:21) found that novice nurses lacked in the area of time-management. Two other studies related students‟ feelings of being unprepared with regards to time-management skills (Aggar & Dawson, 2014:899; and Hirabayashi *et al*, 2009:63). Time management will not only improve perceptions of workload, but will also build improved insight into time-related aspects of medication administration.

5.3.4 Theme 4: Despondency

Another prominent theme was identified, though not a solution to medication safety issues: Despondence was often seen in participants‟ body language and verbal responses when talking about the related problems:

> "*I don‟t think there is anything we can do other than getting more hands…" (3/2/4/126-127);*
>
> *"…because the government say we don‟t have a problem. I don‟t know how we are going to solve it now, because really it is a problem" (3/3/7/222);*
>
> *"If there are no hands, there is nowhere to go" (3/3/7/228);*
>
> *"With us there is nothing that we can do…" (3/11/22/754-755).*

Mokoka *et al.* (2010:484) agreed that South African nurses are despondent due to the difficult working conditions. Despondency was identified by Chambers (2008:33) as a symptom of burnout. There are many contributing factors leading to burnout, of which one is criticism (Scholes, 2013:263) and another response to disruptive behaviour from colleagues (Leiper, 2014:1). Criticism from doctors or colleagues, recurring complaints about workload and the example of procedures not followed may all contribute to the experience of despondency by nurses who tried to follow the correct route and failed. For this reason, nurses need greater support in standing up against the tide when it comes to following prescribed protocols and

upholding the safety of the patients amidst impossible workloads, peer pressure and burnout.

Thus, the eight themes identified were adherence to existing protocols, auditing, education and training, collaboration, communication, use of known products, resource management and time management.

5.4 DISCUSSION

Knowledge and skills deficiency was seen by unit managers to be a cause of medication administration errors, although it appeared that medication administrators themselves did not perceive this as a significant threat to medication administration safety. This confirmed the lack of insight into the situation of medication administration error as was also determined in phase four of the research when exploring medication administrators‟ perceptions of medication administration error incidence (section 4.5). It is important to build the insight of medication administrators regarding contributing causative factors of these errors as well as possible solutions, as Miracle (2009:52) explained that steps of prevention could only be developed once awareness of the potential of errors was created.

Overall, more insight is required into the true effect of patient acuity on medication administration safety. Patient acuity was correlated with wrong-route errors in section 3.5.7. As staff required for a specific shift is reliant on the amount of patients and their acuity levels, it might be of value to determine if skills mix should also be adjusted according to the patient acuity.

Although the three most prevailing causes of medication administration errors were identified in phase four, a few insights regarding these causes within the South African causes were identified in this phase. Firstly, high workload was not only perceived by unit managers to be caused by staff shortages, but also due to the staff not being proficient in time management skills. Therefore, even in the face of staff shortages, medication administration errors could still be limited to a greater extent should medication administrators become more competent in managing their time. Secondly, although some stock distribution problems are caused by medication availability which there is limited solution for at the nursing level, solutions could be implemented at this level to ensure that more emergency medications could

somehow be made available to the unit during times that the pharmacy is not functioning (such as keeping emergency medication stock in casualties to be locked out by the night matron) or simply identifying communication lapses between the pharmacy and the doctor and the nurse serving as mediator to breach these lapses. Thirdly, the problem of illegible prescriptions could either be alleviated or aggravated by the attitudes of nurses and doctors. Therefore, with better collaboration between nurses and doctors, this problem should also be limited to some extent.

Another aspect of medication administration safety that could be impacted by attitude is adherence to existing protocol. Adherence to these protocols could be promoted by regular reminders. For this reason, education and training should be ongoing. Anselmi *et al.* (2007:1839) explained that educational programmes with pharmacology topics and the provision of educational opportunities involving the use of medication were strategies to prevent medication errors. Tzeng *et al.* (2013:16) agreed that professional education and clinical in-services with individual and system focuses on patient safety issues were essential in limiting medication errors.

Insurance that objectives of training opportunities were met could be determined by means of auditing. Though the response to medication administration errors should be non-punitive, publicizing error rates might help the medication administrators to become more aware of errors, which in turn might prevent errors. Publicizing error rates was mentioned by Alemanni *et al.* (2010:920) and Leonard *et al.* (2006:e1124) as a successful measure in reducing medication errors. However, it should be reiterated that it is the error rates that need publicizing, not the identity of the person who committed the errors. Alagha *et al.* (2011:e169) found performance feedback to be effective in reducing these errors. All of these elements were converged in auditing of the medication administration process. Thomas *et al.* (2008:360) found a 17% medication error reduction after six weeks of implementing audit cycles with a standardized audit tool.

Auditing should not only be focussed on nursing, but also on all the other members of the multi-professional team involved in medication administration. Optimal medication administration safety could only be achieved by multi-professional collaboration. Certain studies even proposed the collaboration of pharmacists in pre-mixing medications in order to limit the workload of nurses (McMullan, 2010:10).

This could be particularly useful if the dosage prescribed needed calculation, as it was determined in phase two of the study that many nurses struggle with dosage calculations. Both Otero *et al.* (2008:e737) and Kaushal *et al.* (2008:1254) found increased pharmacist participation in medication therapy to be effective in reducing medication administration errors.

Collaboration is built on effective communication. Methods for simplifying communication could greatly impact on medication administration safety. Though not mentioned by any of the respondents (possibly due to the mental framework not accommodating it), computerized prescriptions and the use of bar-codes in medication prescribing, dispensing and administrating, were often referred to in literature as a successful intervention in limiting medication errors (Ali *et al.*, 2010:119; Bradley *et al.*, 2006:46; De Young *et al.*, 2009:1110; Shulman *et al.*, 2005:R516; and Weant *et al.*, 2007:526).

With implementation of health information technology, resources could also be managed more effectively and changes in available resources could be communicated to several entities within the hospital at the same time, limiting the need of walking or calling back and fro for information or prescription changes. With the time saved by the implementation of such strategies, nurses will find it easier to prioritise other nursing duties within the available time left.

The eight themes identified for the improvement of medication administration safety in Gauteng Province public hospitals were supported by international literature, and therefore found to be acceptable for inclusion in the intervention. However, implementing change into units managed by despondent nurses might prove precarious.

Despondency was identified by Chambers (2008:33) as a symptom of burnout. There are many contributing factors leading to burnout, of which one is criticism (Scholes, 2013:263) and another response to disruptive behaviour from colleagues (Leiper, 2014:1). Criticism from doctors or colleagues, recurring complaints about workload and the example of procedures not followed may all contribute to the experience of despondence by nurses who tried to follow the correct route and failed. For this reason, nurses need great support in standing against the tide when

it comes to following prescribed protocols and upholding the safety of the patients amidst impossible workloads, peer pressure and burnout.

Akella and Kabay (2007:2) mentions a few strategies in preventing burnout in employees, of which two could be easily implemented in the medical or surgical unit, viz. ensuring autonomy for the employee with increased ownership and responsibility, and supporting employee efforts and providing recognition for good work. De Gieter *et al*. (2006:15) agreed that appreciation and compliments from others were very highly valued by nurses. They compared the value of appreciation and complimenting to that of financial rewards (De Gieter *et al.*, 2006:15).

To conclude, eight strategies for limiting medication administration errors were identified, though despondency amongst nurses should be addressed as parallel strategy for improving medication administration safety.

5.5 LIMITATIONS

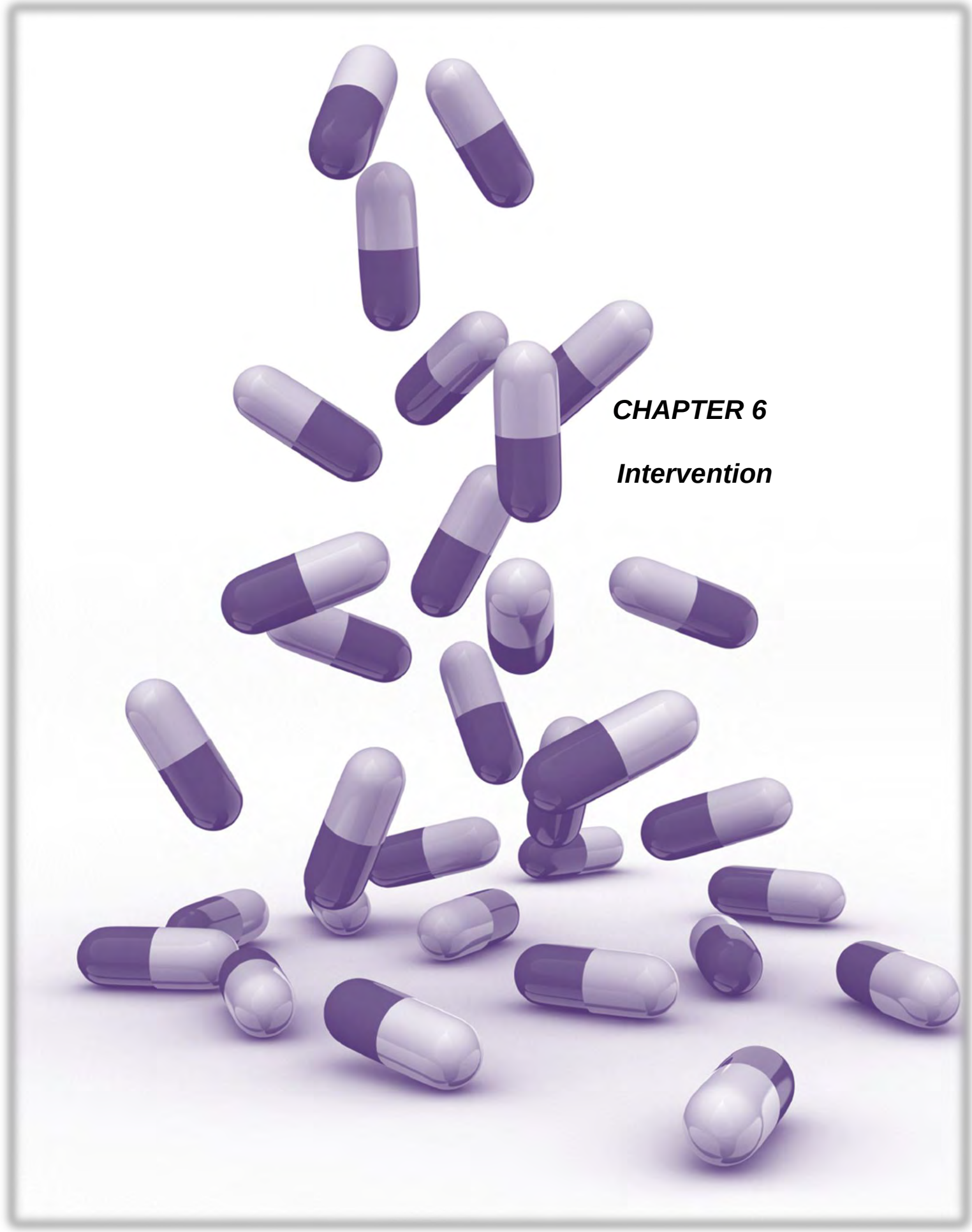
Only nurses were involved in the interviews, though the solutions given for problems were mostly multi-dimensional and reaching beyond the scope of practice for the unit manager or nurses within her units. It could have added to the evidence if comments from doctors, pharmacists and hospital management were included. Furthermore, the patient as part of the health-care team was not included in the interviews. However, the aim of this part of the study was to identify possible solutions to the problem of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa. As nurses are the primary medication administrators, they were seen as the subject matter experts.

5.6 SUMMARY

Unit managers were interviewed as subject matter experts to identify context-specific solutions for the medication administration error problem in public hospitals of the Gauteng Province of South Africa. Though a negative theme of despondence was identified from these interviews, eight thematic solutions to the problem were identified, viz. adherence to existing protocols, auditing, education and training, collaboration, communication, use of known products, resource management and

time management. These themes were measured against international literature and were found to be relevant.

In the final stage of this study, the results of this phase and all previous phases will be amalgamated into the intervention aimed at improving medication administration safety.



CHAPTER 6

Intervention

6.1 INTRODUCTION

Identifying solutions is the third step in the research cycle in patient safety (Bates, 2013:2). The harm of medication administration errors was measured through direct observation; causes of these errors were determined by systematic review, knowledge testing and survey administration; and solutions to this problem were explored using semi-structured interviews of subject experts. The requirement of using different methodologies to each shed light on particular aspects of the medication administration problem (Fogarty & McKeon, 2006:445) was thus fulfilled. This illumination served as foundation to interventions focused on improving medication administration safety.

Due to the multi-faceted nature of medication administration, it would be close to impossible to comprehensively address this issue with only one intervention. Tzeng *et al*. (2013:16) affirmed that promoting patient safety should have multi-factorial approaches. Furthermore, influence of the intervention-cluster would be stunted if it focused solely on one level of care. Jones and Treiber (2010:241) agreed that medication errors result from a number of diverse factors reflecting the individual- and system-level and therefore recommendations for improvement in any patient safety endeavour should be aimed at the correct level of the health care system, implying a collaborative effort of all stakeholders (Wu *et al.*, 2008:685).

Zimlichman and Bates (2012:20) explained that there are three key steps which are important in any national patient safety agenda, viz. using health information technology, broad use of checklists and measuring patient safety over time at a national level. These pointers were incorporated in the "what" of the intervention-cluster, in order to address the objective of this portion of the study: To develop an intervention to reduce medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.

6.2 SYNTHESIZED RESULTS

Results of the five phases of the study were synthesized by means of deductive logic in order to obtain main themes. These themes were then divided into the four domains according to the patient safety model for healthcare (Emanuel *et al.*, 2008:15), viz. those who work in health-care, health-care receivers, health care

delivery processes and systems for continuous improvement (see Figure 1.1, section 1.6.2). These themes are presented in table 6.1. Colours indicate thematic groupings. Red indicates findings related to education and training, pink indicates findings on workload and time-management, blue shows findings on collaboration and communication, green on adherence to existing protocols and audits while purple points out findings related to stock and supplies.

Table 6.1 Results of five phases divided into four domains of the patient safety model for healthcare

Domain	Phase 1: Systematic review	Phase 2: Direct observation	Phase 3: Knowledge test	Phase 4: Survey	Phase 5: Interviews
Those who work in health-care	Causes of medication administration errors: ➢ Human factors: knowledge deficit, inexperience, not following procedures, psychological or physical factors, miscalculations, or incorrect techniques used. ➢ Communication factors: communication lapses, misunderstood orders, illegible prescriptions, incomplete prescriptions or cultural/ language barriers between health care professionals.	➢ Medication administrators most often committed wrong-time errors and errors of omission. ➢ Illegible prescriptions led to 3% of omissions. ➢ Failure to review charts timeously led to 2% of omissions. ➢ In one hospital, enrolled nurses more often gave medications at the wrong time than registered nurses did. ➢ Nurses did not label parenteral medication in 32% of parenteral doses administered. ➢ 77% of patients‟ wristbands were not read. ➢ Nurses did not ask 71% of patients to confirm their name. ➢ Half of nurses did not disinfect their hands prior to medication administration. ➢ Hands were not disinfected for an adequate time-period and all areas of the hands were not cleaned. ➢ Sterility of intravenous sets or needles of 21% of patients were not maintained ➢ Nurses failed to document the actual time of administration in a third of cases. ➢ 28% of medication administrations were recorded prior to administration.	➢ A third of calculations were answered incorrectly. ➢ Registered nurses were more knowledgeable about dose-calculations than enrolled nurses.	➢ Nurses lacked insight in the incidence of medication administration errors. ➢ Communication lapses posed a moderate risk in causing medication administration errors. ➢ Respondents rather looked outside of themselves for causes of medication administration error. ➢ Errors were not reported often. ➢ Fear was the primary reason for non-report of errors.	➢ Adherence to existing protocols. ➢ Auditing. ➢ Education and training. ➢ Collaboration. ➢ Communication (also including illegible prescriptions). ➢ Time management. ➢ Understaffing caused medication administration errors ➢ Stock distribution problems could be limited by better communication and better resource management.

Table 6.1 continued…

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Health-care receivers	Causes of medication administration errors: ➢ Uncooperative or violent patients.	➢ Uncooperative behaviour of patients led to 4% of omissions. ➢ 3% of omissions were due to the patient not being in the unit during medication rounds while 2% of omissions were due to patients vomiting. ➢ Patient acuity was correlated with more wrong route errors.		➢ Uncooperative patients were rated as significant risk to medication administration errors.	➢ Communication. ➢ Collaboration. ➢ Patients‟ conditions influenced medication safety.
Health care delivery processes	Causes of medication administration errors: ➢ Environmental factors: interruptions, work overload, too few nurses, high patient acuity, inadequate staffing, lack of supervision, non-optimal learning climate, working overtime, lack of patient information and technology failures. ➢ Medication factors: look-alike or sound alike medication names or packaging, stock distribution problems, large variety of medications, labels not clear, insufficient resources, different therapeutic dosages, or generic substitution.	➢ Units were severely understaffed. ➢ Tds or qid prescriptions were often treated as prn prescriptions. ➢ Stock distribution problems caused 15% of all omissions. ➢ Anti-infective medications and pain-relief medications were associated with increased medication administration error incidence. ➢ Wrong time errors were associated with individual hospitals. ➢ In one hospital, more wrong time errors occurred in medical units than in surgical units.		➢ A shortage of staff existed. ➢ Stock distribution problems caused medication errors. ➢ Environmental factors impacting on medication safety had the greatest effect on error incidence. ➢ Workload was the primary environmental cause of medication administration error. ➢ Fear and response from hospital administration were major reasons of non-report of error. ➢ Communication, human, environmental and medication related causes of medication errors were inter-correlated. ➢ Reasons of non-report of medication errors were inter-correlated.	➢ Resource management. ➢ Use of known products. ➢ Collaboration. ➢ Auditing.

Table 6.1 continued…

Domain	Phase 1: Systematic review	Phase 2: Direct observation	Phase 3: Knowledge test	Phase 4: Survey	Phase 5: Interviews
Elements of continuous improvement proposed	➢ Education and training; ➢ Ensuring adherence to existing protocol (auditing); ➢ Bridging communication gaps and building collaboration; ➢ Lightening workload; ➢ Supervisory input; ➢ Promoting a positive learning climate; ➢ Limit stock-distribution problems; and ➢ Obtain needed resources.	➢ Education and training; ➢ Ensuring adherence to existing protocol (auditing); ➢ Bridging communication gaps and building collaboration; ➢ Lightening workload; and ➢ Resource management.	➢ Education and training.	➢ Education and training; ➢ Bridging communication gaps and building collaboration; ➢ Ensuring adherence to existing protocol (auditing); ➢ Lightening workload; and ➢ Limit stock-distribution problems.	➢ Ensuring adherence to existing protocol (auditing); ➢ Education and training; ➢ Bridging communication gaps and building collaboration; ➢ Resource management; ➢ Use of known products; and ➢ Time management.

Following above color code for themes, results were grouped together and linked to one of two domains in health care that needed to be addressed in order to alleviate the medication administration error problem. Figure 6.1 provides a schematic illustration of themes to be addressed as related to the domains of the patient safety model targeted for interventions.

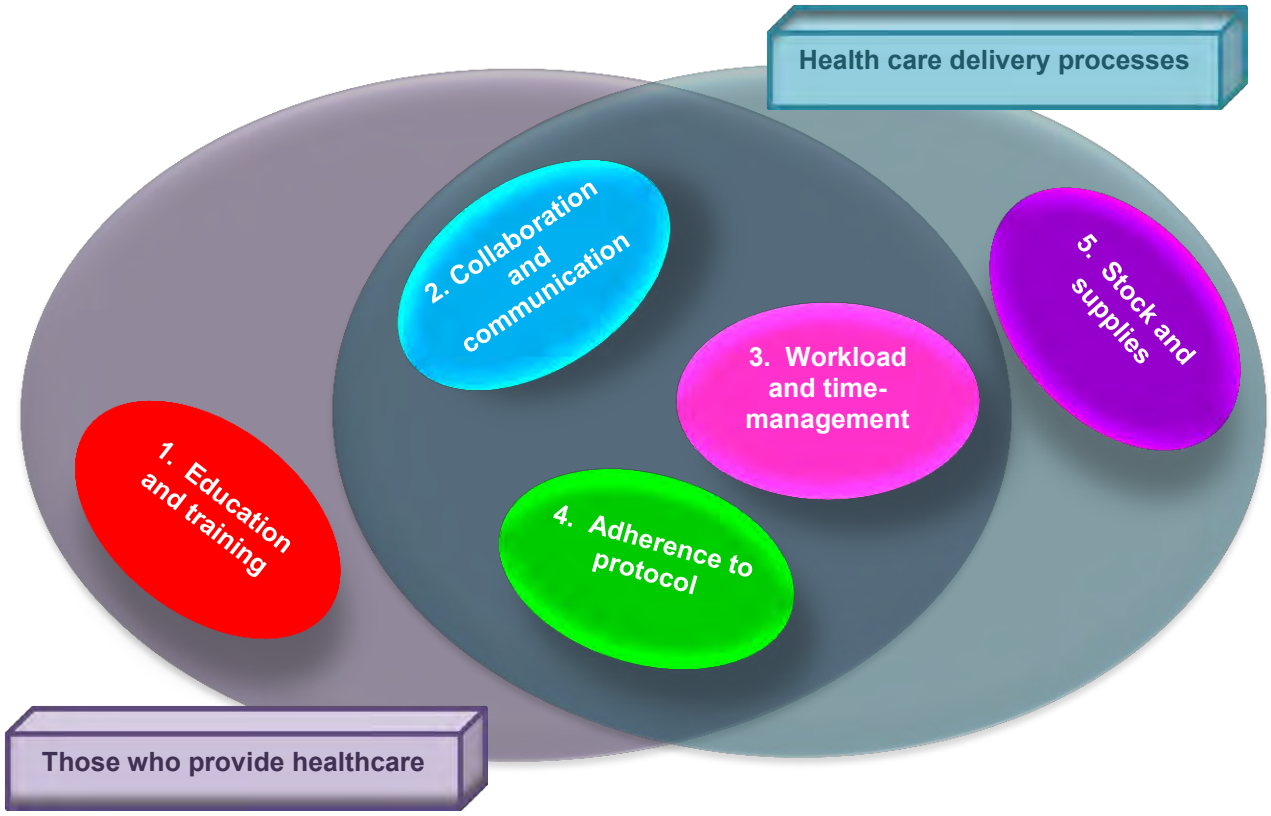


Figure 6.1 Themes for improvement as related to intervention strategies

Addressing the obstacles with regards to those who work in health-care and health care delivery processes might deliver the biggest effect. As a result, improvement in collaboration and communication within the health-care team may also bring forth improved collaboration and communication between the patient and the health-care providers, which was the only area of impact presented for the patients (those receiving health-care). For this reason, the intervention was focused on only the health-care workers and the health-care delivery processes involved in medication administration.

Using inductive and deductive logic possible interventions for each theme were developed. The following interventions could target theme 1, education and training:

- Health information technology (computerized medication systems);
- Medication administration audits;
- In-service training;
- Orientation of new staff;
- Bulletin board notifications; and
- Availing information leaflets and pamphlets.

The following interventions could improve theme 2, collaboration and communication:

- Health information technology (computerized medication systems);
- Medication administration team rounds;
- Pharmacist assistance in units; and
- Implementing a medication administration error reporting system.

These interventions could assist with theme 3, workload and time-management:

- Health information technology (computerized medication systems); and
- Dividing the workload of specific rooms within a unit to more than two medication administrators so as to optimize time-management and prevent wrong-time errors.

The following interventions could improve on theme 4: adherence to existing protocols:

- Health information technology (computerized medication systems);
- Medication administration audits;
- In-service training; and
- Bulletin board notifications.

Lastly, these interventions could address theme 5: stock and supplies:

- Health information technology (computerized medication systems); and
- Medication administration audits.

Following this, two interventions that addressed the most of these themes were proposed for implementation. Firstly, medication administration audits could be implemented immediately with no needed resources. This intervention would address theme 1 (education and training), theme 4 (adherence to existing protocols) and theme 5 (stock and supply problems). Secondly, the implementation of health information technology in the form of a computerized medication system, would address all themes for improvement, though resources and financial investment are required to launch this intervention. These two interventions will now be discussed in more detail.

6.3 INTERVENTION

With consideration of the resource limited setting of the research, a stepwise intervention was developed to initiate improved medication administration safety even in the absence of ideal resources while planning for the gradual implementation of health technology resources that might optimally improve medication administration safety.

6.3.1 Medication administration audits

Implementing medication administration audits should be the intervention to be implemented to reduce medication administration errors. The second and third key steps in building improved patient safety, broad use of checklists and measuring patient safety over time (Zimlichman & Bates, 2012:20), were seen as the basis for audits to improve medication administration safety in public hospitals of the Gauteng Province. The implementation of medication administration error evaluation is focused on those who provide healthcare as aspect of the patient safety model for healthcare and if done adequately, will remind the medication administrator about adherence to protocol, will audit medication administration practices, and serve as training tool. To summarize, collaboration and communication and stock and supplies are themes not addressed by this intervention.

The checklists used in this study need to be provided to the hospitals. These checklists will be used as an audit tool, incorporating the second and third key steps in building

safe patient care, viz. dissemination and broad use of checklists and measuring patient safety.

Once a week, the unit-manager together with a medication administrator, will evaluate one medication administrator on two medication administrations. The medication administrator who is being evaluated will also complete a checklist as self-evaluation. However, it is very important that the unit manager and the other evaluator maintain a non-punitive attitude towards the medication administrator being evaluated. Though peer-assessment alone might feel less threatening, it could easily be skipped over as a "favour" to the medication administrator who is to be evaluated, thus it is necessary for the unit manager to be a part of the evaluation. After the evaluation, the three nurses should come together and compare results. The medication administration skills of both evaluators should improve as the assessment of another makes oneself aware of possible problem areas. It would also be a good learning opportunity for the medication administrator who is being evaluated.

Though the completion of these checklists might be perceived as an added workload at first, nurses should soon realize that it only took about ten minutes of their time to complete it, and the benefits of the in-service training occurring during these sessions should be seen in a positive light.

Once a month, the unit manager should give feedback on medication safety as a whole in the unit, pointing out general mistakes and also positive elements of medication safety improvement. A "medication-administrator-of-the-month" should be appointed. The name of this medication administrator should be communicated to the nursing manager, who should congratulate the medication administrator in person.

De Gieter *et al*. (2006:15) found that appreciation for their work by others and compliments from others were very highly valued by nurses. In fact, the value connected to these psychological rewards was similar to the value of financial rewards (De Gieter *et al.*, 2006:15). Thus, the mere mention and appreciation for good work should encourage medication administrators to betterment in their medication administration. However, to emphasize the value placed on safe medication

administration, a plaque could be put in the unit to indicate the medication administrator of the month (figure 6.2).

Figure 6.2: Example of recognition plaque

This proposed intervention requires no resources other than photocopies of the checklists and ten minutes of time every week. Furthermore, it incorporates the following methods for continuous improvement: Adherence to existing protocols, auditing, and education and training.

6.3.2 Implementing health information technology

The first key step in building improved patient safety, using health information technology (Zimlichman & Bates, 2012:20), was seen as the basis for long-term

improvement of medication administration safety in public hospitals of the Gauteng Province. The implementation of health information technology is focused on the health care delivery processes aspect of the patient safety model for healthcare and if done adequately, will remind the medication administrator about adherence to protocol, will automatically and instantly audit medication administration practices, will facilitate simplified collaboration and effective communication between the medication administrator and the doctor, as well as between the doctor and the pharmacist and the medication administrator and the pharmacist, will lead to betterment in resource management while standardizing names and doses prescribed (use of known products) and save the medication administrator a vast amount of time (time-management). To summarize, the only method for feedback and continuous improvement not covered by the implementation of this technology, is education and training, which will be needed to accommodate the new technology. An outline of technology needed and the objectives for the use thereof follow.

Technology for computerized prescribing already exists, though it should be adapted for the study context. Specifications of the needed technology are listed:

- It should be mobile;
- It should be designated for medication purposes, thus not compatible for general use, so as to limit the attraction of misappropriating the equipment;
- Bar-code scanning should be possible;
- Fingerprint scanning abilities should be introduced;
- Storage capacity should allow data-storage of all unit patient‟s medication record data and available stock data;
- Internet compatibility for connection after each medication round is required;
- Bluetooth compatibility needed;
- Wireless use, though not battery operated but rather rechargeable;
- Design should allow cleaning with abrasive cleaning agents;
- Ease of use is imperative;
- Easily exchangeable parts that are prone to heavy wear and tear;
- Durability; and

- Easy and cost-effective maintenance.

A smart-phone application for medication administrators was considered, though the thought was rejected for the following reasons: Forgetful or tired medication administrators might fail to upload data to a central point, thus leading to a break in continuity of care, the phone that leaves the hospital might subject patients to privacy and confidentiality breach, and internet access for communication with the central information point might be costly and if it should be subsidized, it might be used for alternate purposes, frustrating the efficacy in workflow.

For this reason, examples of three existing technological assets that adhere to all the above-mentioned specifications were identified, a mobile computer and scanner, a toughbook laptop and a toughbook tablet. Figure 6.3 provides an example from one supplying company‟s mobile computer and scanner.

Figure 6.3: Honeywell‟s wearable scanner and mobile computer (Honeywell, 2015:1)

The wearable scanner and mobile computer unit is lightweight and built for comfort and hygiene. The rubber watchband style armbands stretch slightly as the arm moves, and therefore remain tight to prevent sliding down or spinning around the arm. The rubber materials do not absorb perspiration and are easily cleaned. Hands can easily be cleaned in between patients. An integrated keyboard designer is included that allows creation of popup keypads that are appropriate for the operation at hand, such as warning notifications or confirming a medication administration. Users see only the keys they need when they need them, thus limiting confusion and increasing user-friendliness. Microsoft Windows is used as operating system, thus eases

programmability. This computer can withstand multiple 1.2m drops to concrete on all axis and is therefore durable. Lastly, the standard battery can last for four hours and the extended battery for eight, allowing more than enough time to complete a medication administration round. Full specifications of this computer and scanner are attached in Addendum XVIII.

The cost of this equipment is a disadvantage, with one unit costing between R18 000 and R20 000. Another disadvantage is the touch-screen operation that might complicate prescribing. This computer can also not read fingerprints, thus another identification system for doctors, nurses and pharmacists should be incorporated (such as bar-coded identification) which could lead to a breach in security.
Figure 6.4 provides an example of a Toughbook laptop.

Figure 6.4: A Toughbook laptop (Panasonic 2015a:1)

The Toughbook laptop is a rugged wireless laptop that can convert from a notebook personal computer to a tablet with a swivel action of the screen. The keyboard provides easy access to change prescriptions. It features a full magnesium alloy case capable of withstanding 1.8m drops, shock, vibration, rain, dust, sand, altitude and extreme temperatures. Thus, it could easily be cleaned as it is waterproof. The screen film can also be replaced if damaged. The operating system is also Microsoft, thus easily

programmable. The battery can last for 10 hours, thus almost a complete shift duration. Fingerprint readers are optional extras. A further attractive aspect of this laptop is that it was already implemented satisfactorily in South Africa by a private hospital group.

Disadvantages of this laptop include the weight (2.2kg), the bulky nature thereof and the absence of a barcode reader which leads to the need for a separate patient identification system. This laptop is also very attractive as it could be used for several other functions other than medication administration, thus making it desirable to steal or posing the temptation of distraction for staff-members. However, internet access could be limited to minimize this temptation. Lastly, it is quite costly at R28 000 to R32 000 per laptop.

Figure 6.5 provides an example of a tablet that could be used for medication administration.

Figure 6.5: Toughbook tablet (Panasonic 2015b:1)

The Panasonic Toughpad is the world"s thinnest and lightest fully-rugged tablet. Powered by Windows, this tablet is easily programmable. It can also withstand drops, shock, vibration, rain, dust, sand, altitude, and extreme temperatures. Thus it could be easily cleaned without damage. The battery can last for 8 hours, more than required for

the duration of a medication round. Furthermore, the on-screen keyboard will assist in ease of prescribing. A barcode reader is an optional extra, as is a fingerprint reader.

On the downside, this tablet is easy to conceal and can easily be stolen or applied for actions other than medication administration. The price of this tablet is comparable to that of the wearable computer and scanner.

Though software for medication administration already exists, new software for the South African context should be considered as most existing software is costly and owned by specific hospital groups. Also, these software solutions do not incorporate all the warning systems needed for the South African context.

Firstly, it should be easily programmable with new patient prescriptions. The software should allow for physician, pharmacist or nurse use, automatically opening the relevant screen for administering, dispensing or prescribing after fingerprint or barcode identification of the user.

The physician should be able to prescribe new or different medication at any time of day, while these changes need to automatically and instantly update on all of these systems within the unit via Bluetooth. Prior to prescribing, the patient‟s wristband and file needs to be scanned. An automated warning system should caution the physician should the file and wristband not correlate (Figure 6.6), where after a reminder message “Ask your patient‟s name” should flash twice on the screen (Figure 6.7).

Figure 6.6: Proposed wrong bar-code alert (Wooddel, 2013:2)

Figure 6.7: Example of identification reminder

The medication name, route, interval and dosage should all be considered compulsory fields for a specific medication, not allowing the physician to continue to prescribe another medication or for another patient until all fields are completed. Should the doctor prescribe a trade-name medication, the software should immediately and automatically replace it with the generic name. Another automated warning should caution the physician if the patient is allergic to any composites of the medication (Figure 6.8) or if the dosage or interval of the medication is unconventional, providing information on regular prescribing of the specific medication as well as the option to override in out-of-the-ordinary circumstances (Figure 6.9).

Figure 6.8: Proposed allergy alert

Figure 6.9: Proposed unconventional dose alert

In an attempt to further limit incomplete or confusing prescriptions, another alert should notify the prescribing physician should the interval be unconventional (Figure 6.10) or if prescribed medications are expected to interact (Figure 6.11). With the interval, the software should also prompt the physician to indicate how many doses should be administered.

Figure 6.10: Proposed unconventional interval alert

Figure 6.11: Proposed drug-interaction alert

As the physician starts to write the medication name, the software should automatically suggest medication names from a drop-down menu in order to save the physician time. Also, once the medication, interval and dose have been prescribed, a choice between all possible routes should be presented. Hereby, communication challenges between physicians and nurses are limited. After all medication information has been added, the prescription will need fingerprint approval from the physician before the prescription could be finalized. A designated person from the human resources department of the hospital would be able to add physicians to the database by password-protected maintenance. Figure 6.12 proposes the final prescription view the nurse or pharmacist can view:

Mrs X	**10/10/15**			**Allergy:**
820621	**09:30**			**Penicilin**
Ceftriaxone	**1g**	**bd**	**IVI**	**4 doses left**
Paracetamol	**1g**	**tds**	**p.o.**	**10 doses left**
NaCl 0.9%	**1l**	**tds**	**IVI**	**5 doses left**
Doctor Z fingerprint approved:				√

Figure 6.12: Proposed prescription view

The medication administrator should be able to activate the system by fingerprint scanning. The unit manager or the designated person from human resources should be able to add medication administrator fingerprints to the database. After activation, the screen should flash red with an image of hand-washing (Figure 6.13):

Figure 6.13: Hand-washing reminder (Clipartbest, 2015:1)

After each patient has received his/her medications, this image should flash twice in order to remind the medication administrator of the correct procedure to follow. Both the barcode scanner and the computer of the first hardware could be washed or sprayed with antiseptic spray and thus will not hinder the implementation of antiseptic principles.

As soon as the medication administrators initiate their rounds, the system should provide pop-up messages of *stat* doses prescribed. The medication administrator should be given the choice of either immediately administering these doses or to postpone them for 30 minutes (Figure 6.14). However, postponement should not be possible more than twice.

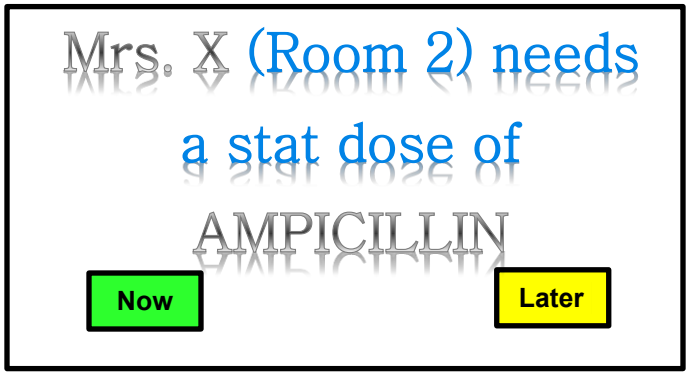


Figure 6.14: Example of a stat dose reminder

The barcode on both the patient‟s wristband and file should be scanned while an automated warning message should caution the medication administrator if the two barcodes do not co-inside (see Figure 6.6) There-after, the reminder message, “Ask your patient‟s name” should flash twice (see Figure 6.7).

The software should automatically distinguish those medications that should be given within a 60 minute period of the round and only show them to the administrator in order to limit wrong-time errors. These medications should be scanned. If the wrong medication is scanned, an automated warning sign should restrain the medication administrator by providing an error message (Figure 6.15).

Figure 6.15: Example of wrong medication notification (Wooddel, 2013:2)

After the medication label has been scanned and if it is the right medication, the dose needs to be projected on the screen until the medication administrator chooses the "done" option in order to limit wrong-dose errors, e.g.:

OR

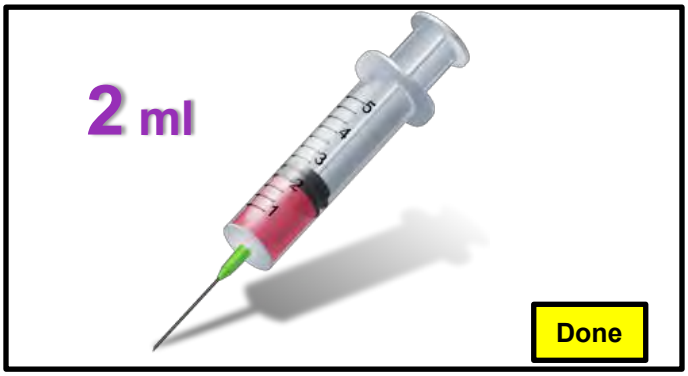


Figure 6.16 and 6.17: Examples of dosage indication (Fitness, 2015:1 and IconArchive 2015:1)

Should the nurse not know the generic name of a medication, she could select the medication name from the prescription, whereby it will provide the trade-names for that medication. Pharmacists could programme the system to show what suppliers are used

and what the packaging of that specific medication looks like at that moment, example provided in Figure 6.17. This should limit wrong medication errors.

Figure 6.18: Example of generic name provision (Allmedtech 2015:1)

If eating prior to the consumption of the medication is required, a warning should inform the medication administrator of this prerequisite. If the patient has not eaten yet, the administration of the indicated dose could be postponed for 30 minutes where-after the software should remind the medication administrator of the postponed dosage in the same manner as that of stat medication doses prescribed (Figure 6.14). Figure 6.19 provides an example of this warning.

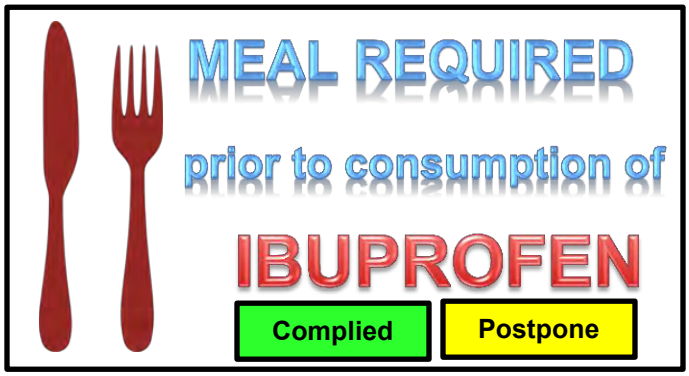


Figure 6.19 Proposed meal required notification (Clker cliparts, 2015:1)

It is proposed that there should be two of these computers available for medication administration purposes, one for the medication administrator responsible of parenteral medication and one for the enteral medication administrator. In this way, the software can be programmed to only show either parenteral or enteral medications to be administrated, ensuring that the correct route for administration is used.

Once a medication has been administered successfully, the prescribed medication will turn green on the prescription chart, and the medication administrator"s credentials as well as the date and time will appear on the prescription, indicating who administered the medication. Figure 6.20 provides an example of this proposed action:

Mrs X	**10/10/15**			**Allergy:**
820621	**09:30**			**Penicilin**
Ceftriaxone	**1g**	**bd**	**IVI**	**4 doses left**
Paracetamol	**1g**	**tds**	**p.o.**	**10 doses left**
NaCl 0.9%	**1l**	**tds**	**IVI**	**5 doses left**
Doctor Z fingerprint approved:				√
Administered by A. Blignaut RN				**10/10/15 10:00**

Figure 6.20: Proposed prescription view after administration

Medication administrators should be warned if they are about to omit a dose, with the option of warranted omissions recorded, as indicated by the proposed screenshot in Figure 6.21:

Figure 6.21: Proposed omission alert

Should a patient be discharged or a new patient admitted, thus changing the sequence in patients to receive medications, a discharge or admission screen would be made available if the patient"s name is to be selected on the prescription chart. Figure 6.22 presents the proposed discharge and admission screen. Should the patient information not correlate with the information provided by the bar-code system, it should be alterable by browsing through the identity items. If a patient is discharged on this screen by accident or if the patient is re-admitted within three days, the “restore” option will allow the restoration of the patient records to the system.

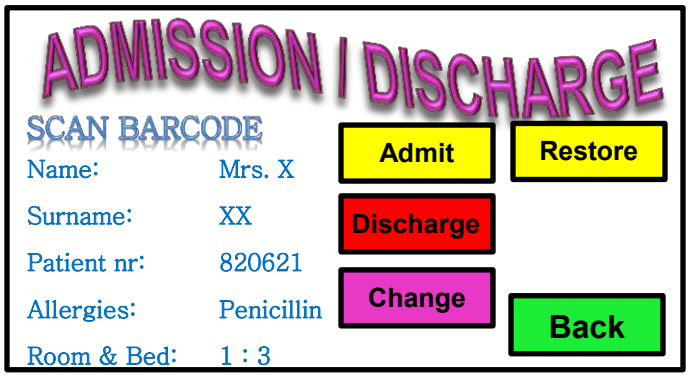


Figure 6.22: Proposed admission and discharge screen

The system will keep track of all medications administrated and store a stock availability schedule. After a medication administration round is completed, the computer/s is connected to the internet. As soon as a connection is established, an automatic update is sent to the pharmacy to notify the pharmacists on the stock-levels in that specific unit, so that it could be replenished if needed. Being responsible for the stock distribution, the nurses‟ duty is then limited to do a stock-take once a month and not having to order medications every week.

On the pharmacy‟s side, a notification could be placed on the system should any medication be out of stock or not part of the hospital medication variety. If this medication was then prescribed, a notification would provide suggestions for alternatives (Figure 6.23).

Figure 6.23: Out of stock notification (Webalive, 2015:1)

As discussed, the following methods for continuous improvement were covered by the proposed implementation of a computerized prescribing/administration and barcode system: Adherence to protocol, collaboration, faster and more effective communication

between doctors and nurses, between doctors and pharmacists and between nurses and pharmacists, time saved (time-management), stock and supplies, and the use of known products. An audit on medication administration could also easily be done by obtaining archive information. However, there are some resource requirements for the initial implementation of this system:

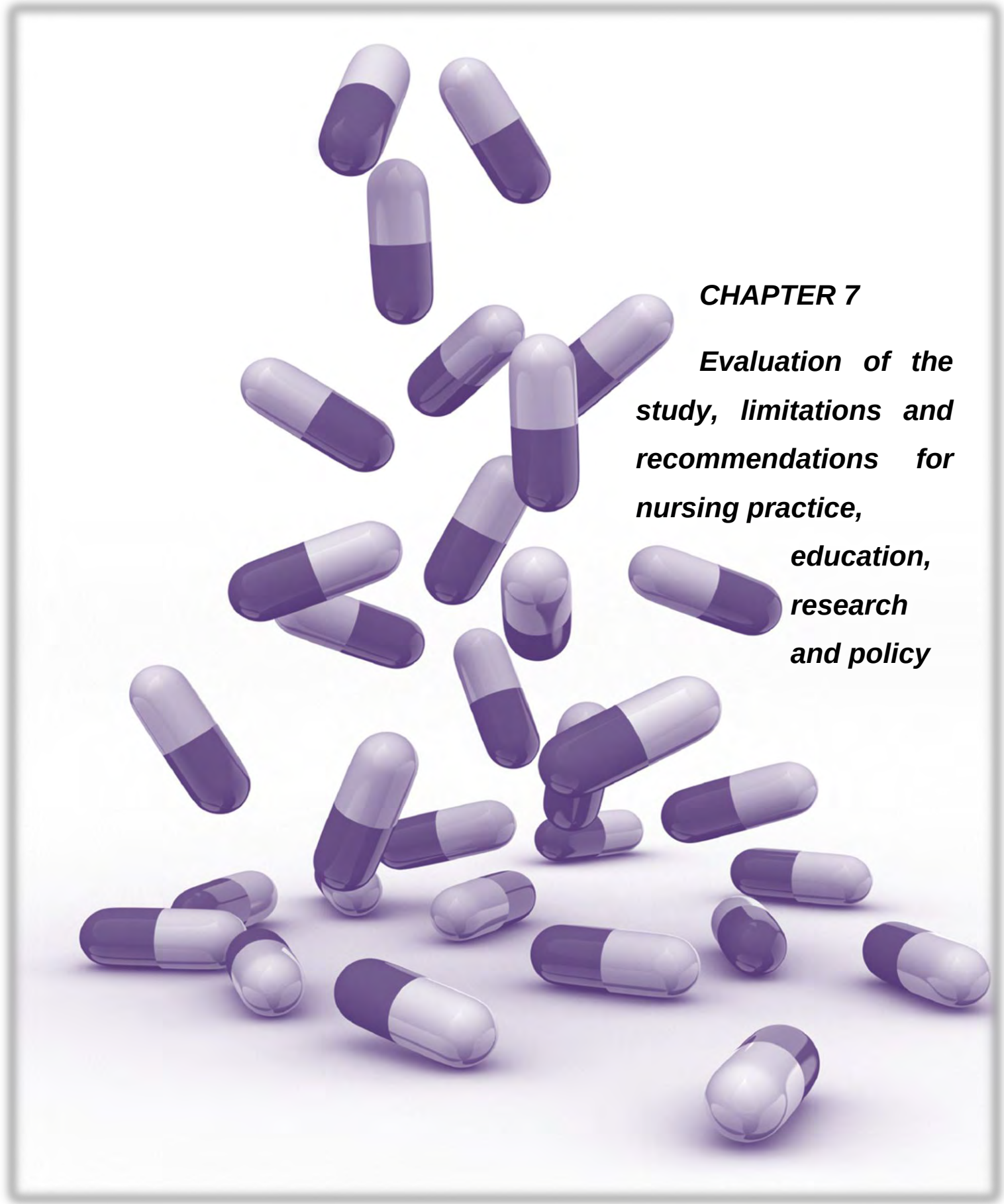
- At least three wearable computers/laptops/tablets with scanners per unit (one for the physician, one for parenteral medication administrators and one for enteral medication administrators) and a software-compatible computer for the pharmacy;
- Internet connectivity;
- A bar-coding system for patients and medications;
- Information technology maintenance assistants (one could be appointed as traveling consultant for the entire Gauteng Province);
- A human resource consultant dedicated to upload staff onto software; and
- Training opportunities for staff.

The following themes of continuous improvement were covered by the health care technology intervention: Adherence to existing protocol, collaboration and communication between the medication administrator and the doctor, as well as between the doctor and the pharmacist and the medication administrator and the pharmacist, stock and supplies, and workload and time-management. Thus, between the two discussed interventions, all themes for continuous improvement as deduced from the study were incorporated.

6.4 SUMMARY

Results from all the phases of the study were converged, from where an intervention with two legs, namely awareness strategies and implementation of health care technology was fashioned. Firstly, awareness strategies includes access to information on bulletin boards, regular in-service training and orientation and weekly medication round audits. Secondly, the implementation of health information technology will add to building safer medication administration practices. Between these two legs of the intervention, all identified strategies for continuous improvement of medication

administration safety as identified in the study, were addressed. The evaluation of the study, recommendations and limitations follow in the last chapter of the study.



CHAPTER 7

Evaluation of the study, limitations and recommendations for nursing practice, education, research and policy

7.1 INTRODUCTION

In Chapter 6 the results of the study were synthesized and an intervention was derived to address the overall aim of the study: *To develop an intervention to improve medication administration safety practiced by professional nurses, enrolled nurses and nursing students in medical and surgical units of public hospitals in the Gauteng Province of South Africa.*

To attain this aim, certain objectives were set as discussed in Chapters 2 to 5:

- To develop a survey list to determine the causes of medication administration errors based on international literature, as assessed during a systematic literature review.
- To determine the incidence of medication administration errors by means of direct observation and knowledge testing in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
- To determine, by means of a survey, the perceived causes and incidence of medication administration errors, as well as the perceived incidence and reasons for non-report of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
- To identify possible solutions for the problem of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa by means of subject expert interviews.
- To develop an intervention to reduce medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.

In this chapter the study is evaluated and the significance, limitations and recommendations for nursing practice, nursing education, research and policy as derived from the study are presented.

7.2 EVALUATION OF THE STUDY

The study was performed in fulfillment of the requirements for a PhD degree. The central theoretical statement, aim and objectives of the study will be used to evaluate the study by determining whether they were indeed realized.

The central theoretical statement is recapped: *The focus of this study was on medication administration errors as a threat to patient safety. Research revealed that many contributing causes of medication administration errors existed, as did a plethora of suggestions on how to minimise medication administration errors. Determining the incidence and contributing causes and identifying solutions with the assistance of subject matter experts, led to the development of intervention that could improve safe medication administration in the Gauteng Province of South Africa.*

During phase two of the study, direct observation (Chapter 3), the incidence of medication administration errors was determined in line with the central theoretical statement. Furthermore, contributing causes to these errors were determined in phase one of the study, the systematic review (Chapter 2) and by means of surveys (phase four, Chapter 4). Solutions to the high incidence of medication administration errors were explored by means of semi-structured interviews with unit-managers (phase five, Chapter 5) and an intervention was developed that could be implemented in order to build better medication administration safety in public hospitals of the Gauteng Province of South Africa. Thus, the priorities set out in the central theoretical statement were achieved. More detail on each of the elements mentioned in the central theoretical statement will now be discussed in correlation with the objectives of the study.

The first objective, to develop a survey list to determine the causes of medication administration errors based on national and literature, as assessed during a systematic review, was accomplished. This phase of the research incorporated three of the four domains of the patient safety model for health care, namely health care workers, systems for therapeutic action and recipients of care. A systematic literature review was conducted and N = 16525 studies were identified for possible inclusion into the review. n = 70 studies were included for analysis after applying exclusion criteria. The CASP critical appraisal tool for qualitative studies and the Johns Hopkins critical appraisal tool for research studies were used to ensure rigor. The EPPI-reviewer software was used to analyze data. From these studies, four subscales of causes of nursing-practice related medication administration errors were derived, viz.

communication factors, human factors, environmental factors and medication related factors (Phase 1, Chapter 2).

The incidence of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa was determined by means of direct observation and knowledge testing in accordance with the second objective (phases two and three, Chapter 3). Here the healthcare workers domain of the patient safety model for healthcare was addressed. This was done during phase 2 of the research. 296 errors were observed during the administration of medications to 315 patients. The most common types of errors were wrong-time errors and errors of omission, followed by wrong-dose errors. Wrong-medication and wrong-route errors affected 2% of patients observed during one medication round, while wrong-patient errors occurred seldom.

Wrong time errors and several deviations from safe practice (not labeling medication immediately after preparation thereof, not reading syringe markings at eye-level, not reading the patient‟s wristband, parenteral supplies not disinfected, infection site not disinfected and the actual time of administration not being recorded) were practically and statistically associated with individual hospitals. The administration route was practically and statistically significantly associated with not disinfecting hands prior to medication administration, with hands less often disinfected prior to the administration of oral medications. Wrong dose errors were practically and significantly inversely correlated with interruptions (OR -2.56, $p < 0.05$) while patient acuity was practically and significantly correlated with wrong route errors (OR 10.55, $p < 0.05$).

For phase 3 (Chapter 3) of the research, 25 medication administrators agreed to participate in the knowledge testing (N = 36). Of these participants, 13 were enrolled nurses and 12 were registered nurses. They completed two questions on dosage calculation, of which one was addressing enteral medication dosage calculation and the other parenteral medication dosage calculation. Calculation error incidence was determined at 32%, with 88% (n = 14) of these errors being committed by enrolled nurses. Parenteral medication dosages were more often incorrectly calculated than

enteral medication dosages (n = 11, 69% of wrong calculations were made during calculation of parenteral medication dosages).

Results from phase 4 (Chapter 4) of the study, the survey conducted in order to determine the perceived causes and incidence of medication administration errors, as well as the perceived incidence and reasons for non-report of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa, in accordance with the third objective were presented. 280 completed surveys were returned from 683 surveys distributed (41.1% response rate). The following were revealed: Nurses perceived environmental factors, especially work-load related problems to be the main cause of medication administration errors, followed by communication factors (specifically illegible prescriptions) and medication error problems in terms of stock-distribution challenges. Medication administrators thought medication administration errors occurred only a few times a year or less, and rated the overall safety of their units as very good. However, if medication errors did occur, respondents experienced them to only be reported sometimes. The main reason for non-report of medication administration errors was fear, followed by administrative response. Based on the discussion above, the study hypothesis as mentioned in Chapter 1 was evaluated:

H_a1: Self-reported incidence of medication administration errors by medication administrators within medical and surgical units of public hospitals in the Gauteng Province of South Africa was not comparable with observed incidences.

This hypothesis was accepted as medication administrators‟ self-reported incidence of medication administration errors indicated that these errors occurred a few times a year or less; while the observed incidence of these errors showed that these errors did in-fact occur several times during each medication round. Thus, in phase four, workers of healthcare and systems for therapeutic action were the two domains of the model of patient safety in healthcare addressed.

Possible solutions for the problems of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa were identified

by means of semi-structured interviews with subject experts, as required by objective four (phase 5, Chapter 5). An all-inclusive sample of unit managers of units as selected in phase two was chosen (N = 17). Fifteen interviews were conducted. All four domains of the patient safety model for healthcare were addressed in this phase of the study. Four main themes were identified from the semi-structured interviews, viz. other causes of medication administration errors; causes of medication administration errors derived from the survey results; recommendations for the prevention of medication administration errors; and despondency. Eight sub-themes were identified as measures to improve medication administration safety, namely adherence to existing protocols, auditing, education and training, collaboration, communication, use of known products, stock and supplies and time management. All subthemes were confirmed in literature.

The last objective, to develop an intervention to reduce medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa, was attained by developing an intervention focussing on the health-care delivery processes (systems for therapeutic action) and health-care workers‟ domains of the model of patient safety. Firstly, health information technology was proposed to address the system problems for the idealistic intervention, where-after an auditing programme was suggested to address health-care worker issues as interim intervention. To conclude, all the domains of the patient safety model for healthcare were addressed in the study, viz. continuous quality improvement strategies, workers of healthcare, systems for therapeutic action and recipients of care.

All these phases and coinciding objectives merged to address the main aim of the study: To develop an intervention to improve medication administration safety practised by professional nurses, enrolled nurses and nursing students in medical and surgical units of public hospitals in the Gauteng Province of South Africa. Figure 7.1 provides a graphic representation of the amalgamation of results into the intervention that was developed

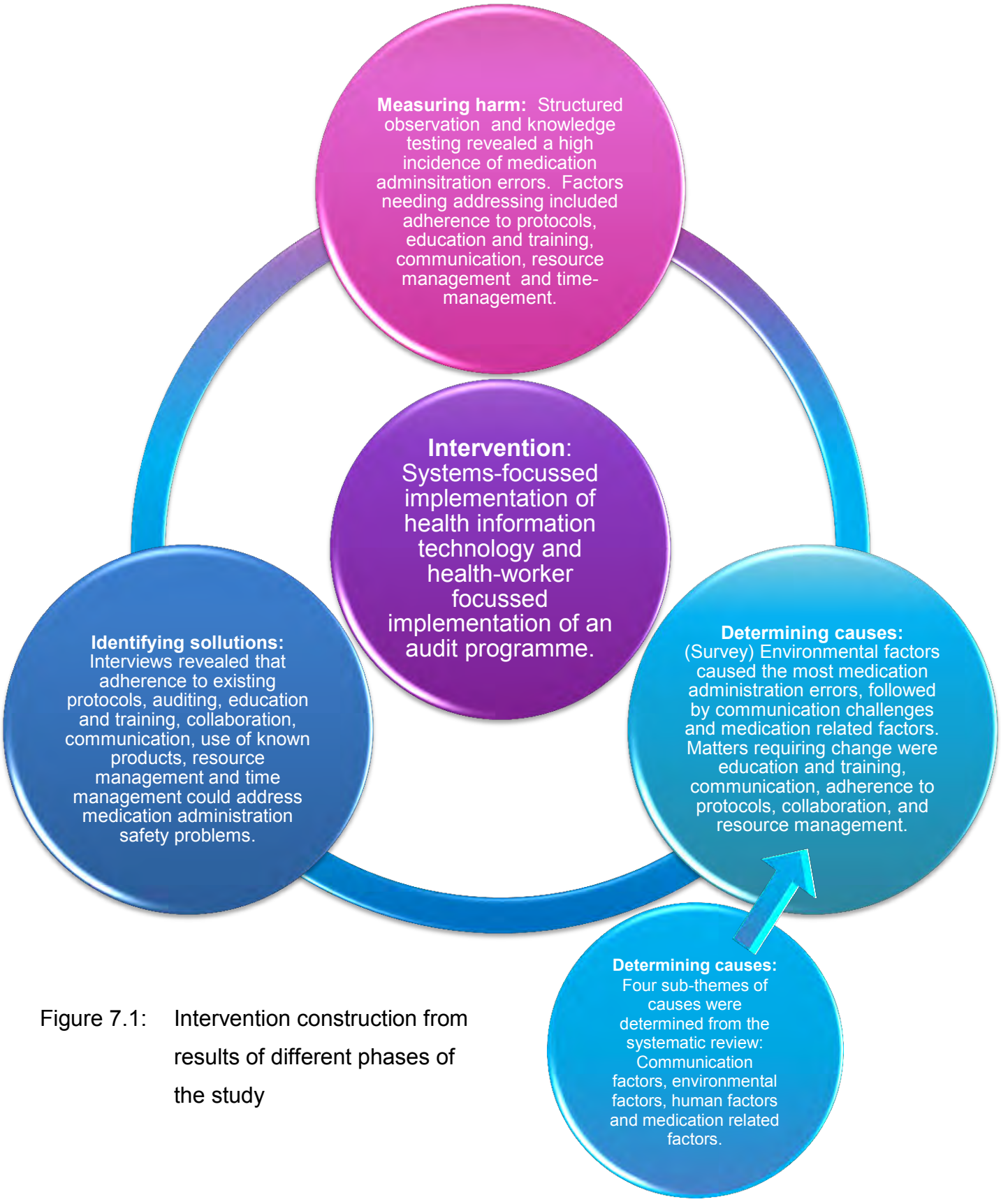


Figure 7.1: Intervention construction from results of different phases of the study

7.3 SIGNIFICANCE OF THE STUDY

In South Africa, no information of public hospitals was available on the incidence of medication administration errors. This study added to the knowledge base in that it provides an account of true incidence of these errors as observed in medical and surgical units of public hospitals of the Gauteng Province of South Africa. This observed incidence was higher than the perceived medication administration error incidence reported by respondents.

As perceptions mold what is considered reality, it was important to fill the gap in knowledge regarding what medication administrators within the study context perceived to be the main causes of medication administration errors. This contextualization proved to be significant as causes of medication administration were ordered in different priority from what was seen in most other international literature. An example hereof is seen in the reporting of interruptions and distractions as a moderate cause of medication administration error by study respondents, while interruptions and distractions were found to be the most often reported cause of medication administration error in international literature. The perception of interruptions as a non-significant threat to medication administration safety was confirmed by the finding that interruptions were not significantly correlated with medication administration errors and that interruptions in fact had an alleviating effect on wrong dose errors. This was a significant finding as it contradicted many international research studies.

Due to the proved need for contextualization, internationally implemented interventions were explored with caution, since they could not address the problem of medication administration in this unique setting as effectively as in the original setting. For this reason, solutions tailored to the specific setting were explored, adding new information to the knowledge base by providing contextual solutions for medication administration errors in medical and surgical units of a developing country with distinctive safety culture challenges.

On international front, a systematic review was conducted on in-hospital nursing practice related causes of medication administration errors. This adds to the knowledge

base in that previous systematic reviews related to this theme were either limited to attitudes of the medication administrator, or incorporating general in-hospital causes of medication error, relating causes relevant to all multi-disciplinary team members and all types of medication errors (dispensing, prescribing and administering errors).

A pilot-study on dosage calculation knowledge was conducted. It was found that one third of dosages were calculated incorrectly. More research into the dosage calculation knowledge of medication administrators is indicated.

Furthermore, an instrument for determining general views on medication administration safety, causes of medication administration error, medication administration error incidence and reporting incidence as well as reasons of non-report was developed. This instrument could be used in other studies as the reliability and validity thereof was confirmed in this study.

Lastly, an intervention was created for the public health-care hospital setting of South Africa aimed at reducing medication administration errors. This intervention included awareness strategies and the implementation of health-care technology. The implementation of this study could contribute to the safety of South African medical and surgical patients and the relevance could be tested in similar setting countries.

7.4 LIMITATIONS OF THE STUDY

Although this study contributed significantly to the body of knowledge regarding the incidence, causes and solutions related to medication administration errors in public hospitals of South Africa, some limitations of this study were noted:

- In conducting the systematic review, exclusion of articles written in any other language than English could have led to the exclusion of relevant studies, especially studies from countries with developmental status similar to that of South Africa that might experience difficulty in research dissemination. However, the results of the study appeared to have been saturated, a particular nursing practice related cause of medication administration error always mentioned in more than one study, leading

to the conclusion that no new data would have been extracted should these articles have been available and includible.

- During the direct observation phase, medication administrations were observed by only one observer. It could be possible that the observer did not identify all medication errors, though all observed medication errors were confirmed by means of double-checking to ensure that results were not skewed in revealing an exaggerated medication administration error incidence.
- The Hawthorne effect, another limitation of direct observational studies, was also mitigated by the single observer, since one observer is less intimidating than two. The observer further moderated the Hawthorne effect by allowing the medication administrator to become familiar with the observation prior to starting the recorded observations.
- The small sample of the knowledge testing phase was seen as another limitation, although the results of this phase still confirmed that the lack of competence in dosage calculations could contribute to medication administration errors.
- The results from the survey phase of the research were reliant on perceptions of respondents, which could have led to more prominent causes of medication administration error being under-reported, either due to fear of putting their hospitals in a bad light or due to a lack of insight. However, the similarities in response between units and hospitals contributed to reassurance that the results were in fact a reflection of the reality.
- Adding to the limitations of the survey phase, the response rate from certain hospitals was very low, negatively impacting on the reliability of relationships determined between hospital level and perceptions. However, by sampling more than one hospital of a certain level, the representativeness and reliability of results were again built.
- Only nurses were involved in creating solutions for the problem of medication administration errors, though other health team members could have added to the answers explored. However, as nurses are seen as the primary agents in the business of medication administration, they were in fact seen as the experts in this field who had the best insight into the problems associated therewith.

7.5 RECOMMENDATIONS

Recommendations include ideas that emerged from the present study and previous studies in the same area that can provide direction in the future (Burns & Grove, 2013:718). Recommendations are provided to improve medication administration safety in the Gauteng Province of South Africa in nursing practice, education, research and policy.

7.5.1 Recommendations for nursing practice:

The following recommendations for practice were derived from the study findings:

- Health care technology should be implemented in public hospitals of the Gauteng Province, as all preventative strategies identified in this research could be incorporated in using this technology for the development of a safer medication administration environment;
- Medication administration auditing should be implemented to raise awareness of medication administration errors;
- Unit managers and nursing directors should recognize and award safe medication administration practices;
- Nurses should keep to existing protocols. Many mistakes occurred due to veering from standard procedures such as checking the five rights, identifying the patient and hand-washing;
- Hand-washing initiatives should be encouraged in units, as the lack of hand sanitation prior to medication administration was seen as a major concern;
- Time-management should be practised by medication administrators. Tasks that are less time-sensitive than medication administration should be fitted in between medication administration times;
- Nurses should pursue effective communication with pharmacists and physicians. Omissions could be limited if stock problems were communicated to the physician in time or medications were ordered from the pharmacy in time;
- A supportive culture needs to be built within medical and surgical units of the Gauteng Province of South Africa where nurses support and help one another and

where health-care professionals from different domains assist and support one another.

- Incomplete or illegible prescriptions should be audited and physicians should be addressed by hospital administration. The serious nature of prescriptions that are not executable should be reinforced, firstly by friendly warning, but also by disciplinary action if necessary;
- A non-punitive environment for the reporting of medication administration errors should be created. This could possibly be done through an anonymous reporting system;
- Menial tasks such as fetching stock from the pharmacy should be done by a messenger or porter so as to limit unnecessary time wastage by nurses;
- More equipment is needed that could assist medication administrators in their tasks. The consideration of reconstitution devices could ease the nurses‟ workload;
- Medications should be available 24 hours a day. If a pharmacist is not available after hours for the dispensing of stat medications, stock should be kept in a safe storage space for easy access by the medication administrators when needed; and
- The medication ordering system should be adhered to. If possible, unit stock should be replenished by a pharmacist assistant.

7.5.2 Recommendations for nursing education

- Pharmacology should be included from the first year of study for nurses, as first-year nursing students are already held responsible for medication administration;
- Pharmacological training should include generic and trade name knowledge;
- Dosage calculations should be part of the curriculum of each year of study also for enrolled nurse education, and should be assessed regularly;
- The curriculum of enrolled nurses should be updated to include more in-depth pharmacological knowledge and safe practices;
- Supervision for student nurses is paramount. As unit nurses already experience work-overload, this supervisory role should be filled by nurse educators. The availability of preceptors and clinical accompanists should be increased;

- Supervisors should uphold a non-punitive response towards medication safety deviances;
- Regular assessments of medication administration competence should be enforced, not only for student nurses but also for enrolled or registered nurses. This could be done in the form of audits with timeous feedback on progress;
- Workshops and in-service training should occur on a regular basis to support the level of medication administrators‟ pharmacological knowledge and their understanding of safe practice protocols;
- New staff should be orientated in the unit and the hospital regarding safe medication administration protocol and procedures; and
- Pharmacological information should be readily available in all units. Package inserts for medications could be kept in a file for easy reference if books are unavailable.

7.5.3 Recommendations for research

- This research focused on the medication administration issues of medical and surgical units. However, some other units, such as emergency departments, intensive care units and paediatric units are at even greater risk for medication administration errors occurring. Research is needed to address the same knowledge gaps that were addressed in this study as applicable for other health-care and unit settings;
- Research on the efficacy of a variety of interventions launched to minimize medication administration errors could add to the foundation of building an intervention effective for the South-African public hospital context;
- The financial resources required for the implementation of the proposed health information technology will be the greatest hurdle in the success of the intervention. Research is needed to determine the extent of financial support needed;
- A variety of health information technology is available. Inquiry research can determine the best equipment and technology to be used for the implementation of the intervention;
- As with any change, the implementation of new technology will probably be met by resistance from nurses and other health-care professionals involved. Research to

determine the most acceptable methods of intervention implementation could lead to effective change management application;

- Research should also be conducted to investigate the role of patients and other multi-professional team members in the incidence of medication adminsitration errors.

7.5.4 Recommendations for policy

- Medication safety is a big threat to our patients‟ safety and needs to be assessed on a regular basis. A policy for fixed medication administration auditing should be developed;
- We need more nurses. Employment and work-schedules should be founded on international standards for safe patient-to-nurse ratios and shortening of shift duration should be considered in accordance with international trends;
- Policies focused on medication stock control should be revisited to ensure that these policies do not limit the efficacy of medication distribution and administration to the patients rather than build a patient safe environment;
- The need for information technology in the public health sector cannot be deferred for much longer. The severe shortage of staff observed in some units drives us to either find answers that will alleviate the work overload (such as health information technology) or to abandon the safety of our patients;
- The standards set for the Gauteng Province should inform decisions made around national standards set for medication administration safety in public hospitals.

7.6 SUMMARY

This was the final chapter of the study. The study was evaluated and its significance captured. The ultimate criterion for a PhD, namely developing a unique contribution, was fulfilled in that an intervention was developed to reduce medication administration errors in public hospitals of the Gauteng Province of South Africa. Limitations of the study were mentioned, as were recommendations for nursing practice, nursing education, nursing research and policy.

This study has therefore successfully addressed all the objectives set at the outset of the project.

REFERENCE LIST

Aggar, C. & Dawson, S. 2014. Evaluation of student nurses‟ perception of preparedness for oral medication administration in clinical practice: a collaborative study. *Nurse education today,* 34(6):899-903.

Agyemang, R.E.O. & While, A. 2010. Medication errors: types, causes and impact on nursing practice. *British journal of nursing*, 19(6):380-385.

Aiken, L.H., Clarke, S.P. & Sloane, D.M. 2002. Hospital staffing, organization, and quality of care: cross-national findings. *International Journal for Quality in Health Care,* 14(1):5-13.

Aiken, L.H., Clarke, S.P., Cheung, R.B., Sloane, D.M. & Silber, J.H. 2003. Educational levels of hospital nurses and surgical patient mortality. *Journal of the American Medical Association,* 290(12):1617-1623.

Akella, M. & Kabay, M.E. 2007. CSIRT Management: Fighting Burnout. http://www.mekabay.com/nwss/585_fighting_burnout_(akella).pdf. Date of access: 12 Nov. 2015.

Alagha, H.Z., Badary, O.A., Ibrahim, H.M. & Sabri, N.A. 2011. Reducing prescribing errors in the paediatric intensive care unit: an experience from Egypt. *Acta paediatrica,* 100(10):e169-e174.

Alberani, V., Pietrangeli, P.D.C., Mazza, A.M.R. 1990. The use of grey literature in health sciences: a preliminary survey. *Bulletin of the Medical Library Association,* 78(4): 358-363.

Alemanni, J., Touzin, K., Bussiéres, J.F., Descoteaux, R. & Lemay, M. 2010. An assessment of drug administration compliance in a university hospital centre. *Journal of evaluation in clinical practice,* 16(5):920-926.

Ali, J., Barrow, L. & Vuylsteke, A. 2010. The impact of computerized physician order entry on prescribing practices in a cardiothoracic intensive care unit. *Anaesthesia*, 65:119-123.

Aljadhey, H., Mahmoud, M.A., Hassali, M.A., Alrasheedy, A., Alahmad, A., Saleem, F., Sheikh, A., Murray, M. & Bates, D.W. 2014. Challenges to and the future of medication safety in Saudi Arabia: a qualitative study. *Saudi pharmaceutical journal*, 22:326-332.

Allinson, T.T., Szeinbach, S.L. & Schneider, P.J. 2005. Perceived accuracy of drug orders transmitted orally by telephone. *American journal of health systems pharmacy,* 62(1):78-83.

Allmedtech. 2015. Ceftriaxone Sodium 250mg/10ml injection single dose vial. http://ep.yimg.com/ay/yhst-12533177228474/ceftriaxone-sodium-250-mg-10-ml-injection-single-dose-vial-10x10-ml-apotex-60505075004-3.gif. Date of access: 7 Oct. 2015.

Alp, E., Lebliebicioglu, H., Doganay, M. & Voss, A. 2011. Infection control practice in countries with limited resources. *Annals of clinical microbiology and antimicrobials*, 10(1):36.

Al-Shara, M. 2011. Factors contributing to medication errors in Jordan. *International journal of nursing management and research,* 16(2):158-161.

Altman, D.G. 1991. Practical statistics for medical research. London: Chapman & Hall. 611p.

American Nurses Association. 2015. Johns Hopkins Nursing Evidence-Based Practice. http://www.nursingworld.org/research-toolkit/johns-hopkins-nursing-evidence-based-practice. Date of access: 14 Jul. 2015.

Andermann, A., Wu, A.W., Lashoher, A., Norton P., Arora, N.K., Bates, D.W. & Larizgoitia, I. 2013. Case studies of patient safety research classics to build research capacity in low- and middle-income countries. *Joint commission journal of quality and patient safety*, 39(12):553-560. Dec.

Anderson, P. & Townsend, T. 2010. Medication errors: don't let them happen to you. *American Nursing Today,* 5(3):23–27.

Anney, V.N. 2014. Ensuring the quality of the findings of qualitative research: looking at trustworthiness criteria. *Journal of emerging trends in educational research and policy studies*, 5(2):272-281.

Anselmi, M.L., Peduzzi, M. & Dos Santos, C.B. 2007. Errors in the administration of intravenous medication in Brazilian hospitals. *Journal of clinical nursing*, 16(10):1839-1847.

Anthony, K., Wiencek, C., Bauer, C., Daly, B. & Anthony, M.K. 2010. No interruptions please - Impact of a no interruption zone on medication safety in intensive care units. *Critical Care Nursing,* 30(3):21–29.

Arford, P.H. 2005. Nurse-physician communication: and organizational accountability. *Nursing economics,* 23(2):72-77. Mar.-Apr.

Armitage, G. & Knapman, H. 2003. Adverse events in drug administration: a literature review. *Journal of Nursing Management,* 11(2):130-140.

Armutlu, m., Foley, M., Surette, J., Belzile, E. & McCusker, J. 2008. Survey of nursing perceptions of medication administration practices, perceived sources of errors and reporting behaviours. *Healthcare Quarterly*, 11:58-65.

Ary, D., Jacobs, L.C., Razavieh, A. & Sorensen, C.K. 2010. Introduction to research in education. 8th ed. New York: Holt Rinehart & Winston. 596p.

Associations of the United Kingdom University Hospital (AUKUH). 2015. Patient care portfolio – AUKUH acuity/dependency tool: Implementation resource pack. http://www.aukuh.org.uk/index.php/component/ docman/doc_download/42-implementation-resource-pack. Date of access: 27 Aug. 2015.

Australian Council for Safety and Quality in Healthcare. 2002. 2nd National report on Patient safety: Improving Medication Safety. http://www.safetyandquality. health.wa.gov.au/medication/. Date of use: 2 Apr 2013.

Babbie, E., Mouton, J., Vorster, P. & Prozesky, B. 2005. The practice of social research. Cape Town: Oxford University Press.

Bae, S., Mark, B. & Fried, B. 2009. Impact of nursing unit turnover on patient outcomes in hospitals. *Journal of Nursing Scholarship*, 42(1):40-49.

Bailey, K.D. 1994. Methods of social research. 4th ed. New York: Free Press. 588p.

Ball, J. 2010. Royal College of Nursing guidance on safe nurse staffing levels in the UK. http://www.rcn.org.uk/__data/assets/pdf_file/0005/353237/003860.pdf. Date of access: 3 Sep. 2015.

Barret, P. 2007. Structural equation modelling: Adjudging model fit. *Personality and individual differences,* 42:815-824.

Bates, D.W. 2010. Getting in Step: Electronic Health Records and their Role in Care Coordination. *Journal of General Internal Medicine,* 25(3):174-176.

Bates, D.W. 2013. Principles of Patient Safety Research: An Overview. http://www.who.int/patientsafety/research/ps_online_course_session2_intro_2in1_english_2010_en.pdf. Date of use: 04-04-2013.

Baxter, J. & Eyeles, J. 1997. Evaluating qualitative research in social geography: establishing „rigour" in interview analysis. *Transactions of the Institute of British Geographers*, 22(4):505-525.

Beaudoin, F.L., Merchant, R.C., Anicki, A., MacKaig, D.M. & Babu, K.M. 2015. Preventing iatrogenic overdose: a review of in-emergency department opioid-related adverse drug events and medication errors. *Annals of emergency medicine*, 65(4):423-431.

Beavers, A.S. Lounsbury, J.W., Richards, J.K., Huck, S.W., Skolits, G.J. & Esquivel, S.L. 2013. Practical considerations for using exploratory factor analysis in educational research. *Practical assessment, research and evaluation*, 18(6):1-13.

Beckett, R.D., Sheehan, A.H. & Reddan, J. 2012. Factors associated with reported preventable adverse drug events: a retrospective, case-control study. *The Annals of Pharmacotherapy*, 46:634-641. May.

Ben-Yehuda, A., Bitton, Y., Sharon, P., Rotfeld, E., Arnon, T. & Muszkat, M. 2011. Risk factors for prescribing and transcribing medication errors among elderly patients during acute hospitalisation - a cohort, case-control study. *Drugs aging,* 28(6): 491-500.

Berdot, S., Sabatier, B., Gillaizeau, F., Caruba, T., Prognon, P. & Durleux, P. 2012. Evaluation of drug administration errors in a teaching hospital. *Biomed central health service research,* 12:59-57.

Bergh, D.D. & Ketchen, D.J. 2006. Research methodology in strategy and management, Volume 3. Bingley: Emerald Group Publishing. 407 p.

Bertsche, T., Niemann, D., Mayer, Y., Ingram, K., Hoppe-Tichy, T. & Haefeli, W. 2015. Prioritising the prevention of medication handling errors. *Pharmacy world and science*: 1-9.

Biron, A.D., Lavoie-Tremblay, M & Loiselle, C.G. 2009a. Characteristics of work interruptions during medication administration. *Journal of nursing scholarship,* 41(4):330-336.

Biron, A.D., Loiselle, C.G. & Lavoie-Tremblay. 2009b. Work interruptions and their contribution to medication administration errors: an evidence review. *Worldviews on Evidence-Based Nursing*, 6(2):70-86.

Bitsch, V. 2005. Qualitative research: A grounded theory example and evaluation criteria. *Journal of agribusiness,* 23(1):75-91.

Blignaut, A.J., Coetzee, S.K. & Klopper, H.C. 2014. Nurse qualifications and perceptions of patient safety and quality of care in South Africa. *Nursing and Health Sciences*, 16(2):224-231.

Bohomol, E., Ramos, H. & D"Innocenzo, M. 2009. Medication errors in an intensive care unit. *Journal of Advanced Nursing*, 65(6):1259-1267.

Borenstein, M., Hedges, L.V., Higgins, J.P.T. & Rothstein, H.R. 2009. Introduction to Meta-Analysis. Wiltshire: Wiley. 421 p.

Botma, Y., Greeff, M., Mulaudzi, F.M. & Wright, S.C.D. 2010. Research in Health Sciences. Heinemann: Cape Town. 370 p.

Bowen, G.A. 2009. Supporting a grounded theory with an audit trail: An illustration. *International journal of social research methodology*, 12(4):305-316.

Bowns, J.A. & Gill, A. 2012. Prescribing errors in paediatrics. *Archives of disease in childhood*, 97(5):20-21. May.

Bradley, V., Steltenkamp, C. & Hite, K. 2006. Evaluation of reported medication errors before and after implementation of computerized practitioner order entry. *Journal of healthcare information management*, 20:46-53.

Breckenridge-Sproat, S., Johantgen, M. & Patrician, P. 2012. Influence of unit-level staffing on medication errors and falls in military hospitals. *Western Journal of Nursing Research*, 34(4):455-474.

Brink, H. 2006. Fundamentals of research methodology for health care professionals. 2nd ed. Cape Town: Juta. 226p.

Brink, H., Van der Walt, C. & Van Rensburg, G. 2013. Fundamentals of Research Methodology for Healthcare Professionals. 3rd ed. Cape Town: Juta. 242 p.

Bruce, N., Pope, D. & Stanistreet, D. 2008. Quantitative Methods for health research – a practical interactive guide to epidemiology and statistics. Wiltshire: John Wiley & Sons Ltd. 538p.

Brunetti, L., Santell, J.P. & Hicks, R.W. 2007. The impact of abbreviations on patient safety. *The Joint Commission Journal on Quality and Patient Safety*, 33(9):576-583.

Buckley, M.S., Harinstein, L.M, Clark, K.B., Smithburger, P.L., Eckhardt, D.J., Alexander, E., Devabhakthuni, S., Westley, C.A., David, B. & Kane-Gill, S.L. 2013. Impact of a clinical pharmacy admission medication reconciliation program on medication errors in high-risk patients. *The annals of pharmacotherapy*, 47(12):1599-1610. Dec.

Burns, N. & Grove, S.K. 2013. The practice of nursing research – Appraisal, synthesis, and generation of evidence. 7th ed. New York : Saunders Elsevier. 732p.

Chambers, D.W. 2008. Stress. *Journal of American college of dentists*, 75(3):33-39.

Chang, Y. & Mark, B.A. 2009. Antecedents of severe and nonsevere medication errors. *Journal of Nursing Scholarship*, 41(1):70-78.

Chang, Y. & Mark, B. 2011. Effects of learning climate and registered nurse staffing on medication errors. *Nursing Research*, 60(1):32-39.

Cheragi, M.A., Manoocheri, H., Mohammadnejad, E. & Ehsani, S.R. 2013. Types and causes of medication errors from nurse‟s viewpoint. *Iranian Journal of Nursing and Midwifery Research*, 18(3):228-231. May-Jun.

Chiang, H.Y. & Pepper, G.A. 2006. Barriers to nurses‟ reporting of medication administration errors in Taiwan. *Journal of nursing scholarship,* 38(4):392-399.

Chilisa, B. & Preece, J. 2005. African perspective in adult learning: research methods for adult educators. Hamburg: UNESCO Institute of Education. 185 p.

Choi, I., Lee, S.M., Flynn, L., Kim, C.M., Lee, S., Kim, N.K. & Suh, D.C. 2015. Incidence and treatment costs attributable to medication errors in hospitalized patients. *Research in social and administrative pharmacy*: 1934-1850. Aug.

Choo, J., Hutchinson, A. & Bucknall, T. 2010. Nurses‟ role in medication safety. *Journal of nursing management*, 18(7):853-861.

Clipartbest. 2015. Image of hand washing. http://www.clipartbest.com/cartoon-pictures-of-handwashing. Date of use: 7 Oct. 2015.

Clker Cliparts. 2015. Knife and fork cartoon. http://www.clker.com/cliparts/i/L/m/X/N/y/fork-and-knife-md.png. Date of use: 30 Oct. 2015.

Cohen, H. & Shastay, A.D. 2008. Getting to the root of medication errors. *Nursing,* 38(12):39-47.

Cohen, M.R. 2013. Medication Errors. *Nursing,* 43(3):72.

Conrad, C., Fields, W., McNamara, T., Cone, M. & Atkins, P. 2010. Medication room madness calming the chaos. *Journal of Nursing Care Quality,* 25(2):137–144.

Conroy, S., Appleby, K., Bostock, D., Unsworth, B. & Cousins, D. 2007. Medication errors in a children‟s hospital. *Paediatric perinatal drug therapy,* 8:18-25.

Cottney, A. & Innes, J. 2014. Medication-administration errors in an urban mental health hospital: A direct observation study. *International Journal of Mental Health Nursing*, 24:65-74.

Cresswell, J.W. & Planoclark, V.L. 2007. Designing and conducting mixed method research. USA: Sage Publications.

Cresswell, J.W. 2009. Research design: Qualitative, quantitative, and mixed methods approaches. 3rd ed. Thousand Oaks: Sage.

Critical Appraisal Skills Programme (CASP). 2013. CASP Checklists. http://www.casp-uk.net/#!casp-tools-checklists/c18f8. Date of access: 14 Jul. 2015.

Cullinen, K. 2006. Health services in South Africa, a basic introduction. health-e.org.za. Date of access: 23 Oct. 2015.

Dalton, B., Sabuda, D.M., Bresee, L.C. & Conly, J.M. 2015. Use of an electronic medication administration record (eMAR) for surveillance of medication omissions results of a one year study of antimicrobials in the inpatient setting. *Public library of science,* 10(4):1-12.

Dancy, C.P., Reidy, J.G. & Rowe, R. 2012. Statistics for the health sciences: a non-mathematical introduction. Los Angeles: Sage. 563p.

Deans, C. 2005. Medication errors and professional practice of registered nurses. *Collegian*, 12(1):29-33.

Denzin, N.K. & Lincoln, Y.S. 2005. The sage handbook of qualitative research. 3rd ed. California: Sage.

De Gieter, S., De Cooman, R., Peppermans, R., Caers, R., Du Bois, C. & Jegers, M. 2006. Identifying nurses‟ rewards: a qualitative categorization study in Belgium. *Human resources for health*, 4:15-25.

Department of Health. 2002. A district hospital service package for South Africa – a set of norms and standards. kznhealth.gov.za. Date of access: 23 Oct. 2015.

Department of Health. 2003. Strategic framework for the modernisation of tertiary hospital systems. kznhealth.co.za. Date of access: 23 Oct. 2015.

Department of Health. 2011. Human resources for health South Africa. www.gov.za/documents/download.php?f=152486. Date of use: 2 August 2014.

Department of Health. 2014. Hospitals in the Gauteng Province. http://www.health.gpg.gov.za/Pages/Hospital.aspx. Date of use: 9 August 2014.

De Young, J.L., Vanderkooi, M.E. & Barletta, J.F. 2009. Effect of bar-code-assisted medication administration on medication error rates in an adult medical intensive care unit. *American journal of health system pharmacology,* 66:1110-1115.

Dickinson, A., McCall, E., Twomey, B. & James, N. 2010. Paediatric nurses‟ understanding of the process and procedure of double-checking medications. *Journal of clinical nursing*, 19:728-735.

Doherty, C. & McDonnel, C. 2012. Tenfold medication errors: 5 Years‟ experience at a university-affiliated pediatric hospital. *Pediatrics*, 129(5):1-9.

Dolansky, M.A., Druschel, K., Helba, M. & Courtney, K. 2013. Nursing students medication errors: a case study using root cause analysis. *Journal of professional nursing*, 29(2):102-108.

Donaldson, N., Aydin, C., Fridman, M. & Foley, M. 2014. Improving medication administration safety: Using naïve observation to assess practice and guide improvements in process and outcomes. *Journal for Healthcare Quality*, 36(6):58-68.

Dougherty, L., Sque, M. & Crouch, R. 2011. Decision-making processes used by nurses during intravenous drug preparation and administration. *Journal of advanced nursing*, 68(6):1302-1311.

Duffield, C., Diers, D., O‟Brien-Palla, L., Aisbett, C., Roche, M. & King, M. 2011. Nursing staffing, nursing workload, the work environment and patient outcomes. *Applied nursing research*, 24:244-255.

Duffield, C.M., Roche, M.A., Dimitrelis, S., Homer, C. & Buchan, J. 2015. Instability in patient and nurse characteristics, unit complexity and patient and system outcomes. *Journal of advanced nursing*, 71(8):1288-1298. Jun.

Durlak, J.A. 2009. How to select, calculate and interpret effect sizes. *Paediatric Psychology*, 34(9): 917-928.

Endacott, R., Jevon, P. & Cooper, S. 2009. Clinical nursing skills – core and advanced. Italy: Oxford university press. 629p.

Efstratios, A. 2012. Prevention of medication errors made by nurses in clinical practice. *Health science journal,* 6(4):773-783.

Ehsani, S.R., Cheraghi, M.A., Nejati, A., Salari, A., Esmaeilpoor, A.H. & Nejad, E.M. 2013. Medication errors of nurses in the emergency department. *Journal of Medical Ethics and History of Medicine*, 6(11):1-7.

Eisenhauer, L.A., Hurley, A.C. & Dolan, N. 2007. Nurses‟ reported thinking during medication administration. *Journal of nursing scholarship*, 1:82-87.

Elfering, A., Grebner, S. & Ebener, C. 2015. Workflow interruptions, cognitive failure and near-accidents in health care. *Psychology, health and medicine,* 20(2):139-147.

Elfering, A., Semmer, N.K. & Grebner, S. 2006. Work stress and patient safety: observer-rated work stressors as predictors of characteristics of safety-related events reported by young nurses. *Ergonomics*, 49(5-6):457-469. Apr.-May.

Ellis, P.D. 2010. What are some conventions for interpreting different effect sizes? http://effectsizefaq.com/2010/05/30/what-are-some-conventions-for-interpreting-different-effect-sizes/. Date of use: 15 April 2015.

Ellis, S.M. & Steyn, H.S. 2003. Practical significance (effect sizes) versus or in combination with statistical significance (p-values), *Management Dynamics,* 12(4): 51-53.

Emanuel, L., Berwick, D., Conway, J., Combes, J., Hatlie, M., Leape, L., Reason, J., Schyve, P., Vincent, C. & Walton, M. 2008. What exactly is patient safety? *Advances in Patient Safety: New Directions and Alternative Approaches.* 1-18

eppi-Centre. 2008. eppi-Reviewer 4 Features. http://eppi.ioe.ac.uk/cms/Default.aspx?tabid=3396. Date of access: 20 Feb. 2015.

Evans, A.N. & Rooney, B.J. 2011. Methods in psychological research. 2nd ed. London: Sage publications. 385p.

Fasolino, T. & Snyder, R. 2012. Linking nurse characteristics, team member effectiveness, practice environment and medication error incidence. *Journal of nursing care and quality,* 27(2):E9-E16.

Fisher, M. & Parolin, M. 2000. The reliability of measuring nursing clinical performance using a competency based assessment tool: a pilot study. *Collegian*, 7(3):21-27.

Fitness. 2015. Bee-pollen weight-loss pills. http://fitnessingym.blogspot.co.za/2015/02/bee-pollen-weight-loss-pills-reviews.html. Date of access: 7 Oct. 2015.

Flanders, S. & Clark, A.P. 2010. Interruptions and medication errors. *Clinical Nurse Specialist,* 24(6):281–285.

Fleming, S., Brady, A. & Malone, A. 2014. An evaluation of the drug calculation skills of registered nurses. *Nurse education in practice*, 14:55-61.

Fogarty, G.J. & McKeon, C.M. 2006. Patient safety during medication administration: The influence of organizational and individual variables on unsafe work practices and medication errors. *Ergonomics*, 49(5-6):444-456. Apr-May.

Fourth International Conference on Grey Literature. 1999. New Frontiers in Grey Literature. Washington DC, USA: GreyNet, Grey Literature Network Service.

Freeman, R., McKee, S., Lee-Lehner, B. & Pesenecker, J. 2013. *Journal of nursing care quality*, 28(2):176-185.

Friel, C.M. 2015. Factor analysis principal components – use of extracted factors in multivariate dependency models. Sam Houston State University. 45 p. http://www.bama.ua.edu/~jcsenkbeil/gy523/Factor%20Analysis.pdf. Date of access: 30 Sep. 2015.

Fry, M.M. & Dacey, C. 2007. Factors contributing to incidents in medicine administration. Part 2. *British Journal of Nursing*, 16(11):676-681.

Geyer, N. 2013. Record Keeping. Juta: Cape Town. 89 p.

Glaister, K. 2005. Exploring the impact of instructional approaches on the learning and transfer of medication dosage calculation competency. *Contemporary Nurse*, 20(1):3-13.

Gliem, A. & Gliem, R. 2003. Calculating, interpreting and reporting Cronbach‟s Alpha Reliability Coefficient for Likert-Type scales. Midwest Research to Practice Conference in Adult, Continuing, and Community Education. https://scholarworks.iupui.edu/bitstream/handle/1805/344/Gliem+&+Gliem.pdf?sequence=1. Date of use: 15 April 2015.

Government of Ireland. Houses of the Oireachtas Joint Committee on Health and Children. 2007. The Adverse Side Effects of Pharmaceuticals. 8th Report. Stationary Office, Dublin. http://www.oireachtas.ie/documents/committees 29thdail/committee reports2007/side-effects.pdf. Date of use: 02-04-2013.

Gravetter, F.J. & Forzano, L.B. 2012. Research methods for the behavioural sciences. 4th ed. Wadsworth: Cengage learning. 618p.

Grbich, C. 2007. Qualitative data analysis: An introduction. Thousand Oaks, CA: Sage. 344p.

Günes, Ü.Y., Gürlek, Ö. & Sönmez, M. 2014. Factors contributing to medication errors in Turkey: nurses‟ perspectives. *Journal of Nursing Management*, 22:295-303.

Håkonsen, H., Hopen, H., Abelsen, L., Ek, B. & Toverud, E. 2010. Generic substitution: A potential risk factor for medication errors in hospitals. *Journal of Advanced Therapy*, 27(2):118-126.

Hamel, J.L. & Janssen, PW. 1988. On an average: the rural hospital in sub-Saharan Africa. *Tropical Doctor*, 18(3):139-142.

Hardy, M. & Bryman, A. 2004. Handbook of data analysis. London: SAGE Publications. 704 p.

Härkänen, M., Turunen, H., Saano, S. & Vehviläinen-Julkunen, K. 2013. Medication errors: what hospital reports reveal about staff views. *Nursing Management*, 19(10):32-37.

Härkänen, M., Ahonen, J., Kervinen, M., Turunen, H. & Vehviläinen-Julkunen, K. 2014. The factors associated with medication errors in adult medical and surgical inpatients: a

direct observation approach with medication record reviews. *Scandinavian Journal of Caring Sciences*, 1-10.

Hartley, GM. & Dhillon, S. 1998. Observational study of the prescribing and administration of intravenous drugs in a general hospital. *International journal of pharmacy practice*, 6:38-45.

Hartwig, S.C., Denger, S.D., & Schneider, P.J. 1991. Severity-indexed, incident report-based medication error-reporting program. *American journal of hospital pharmacy*, 48:2611-2616.

Hassen, P. 2010. No. 5, October 2010, WHO Patient Safety Newsletter: Progress in quality and patient safety: Are we at a tipping point*? International Journal of Risk & Safety in Medicine*, 23: 51–61.

Hemingway, P. & Brereton, N. 2009. What is a systematic review? http://www.medicine.ox.ac.uk/bandolier/painres/download/whatis/syst-review.pdf. Date of access: 13 Nov. 2015.

Hemingway, S., McCann, T., Baxter, H., Smith, G., Burgess-Dawson, R. & Dewhirst, K. 2014. The perceptions of nurses towards barriers to the safe administration of medicines in mental health settings. *International Journal of Nursing Practice*, 21(6):733-40.

Higgins, J.P.T. & Green, S. 2011. Cochrane handbook for systematic reviews of interventions. The Cochrane Collaboration. http://handbook.cochrane.org/chapter_ 10/10_3_2_including_unpublished_studies_in_systematic_reviews.htm. Date of access: 14 Jul. 2015.

Hirabayashi, Y., Matsutani, M., Sakyo, Y., Unoki, T., Ibe, T., Takaya, T., Iida, M., Terada, A., Nishino, R & Sato, E. 2009. Anticipating professional nursing practice: the improvement and the evaluation of a bridge program for graduating students: from the practice by using the clinical place, and the evaluation by the experiment. *Journal of St. Luke"s society for nursing research*, 13(2):63-70.

Holloway, I. 2005. Qualitative research in health care. London: Open University Press. 300p.

Honeywell. 2015. Wearable solution for the Dolphin 70e mobile computer. http://www.honeywellaidc.com/en-US/Pages/Product.aspx?category=wearable-scanner-and-mobile-computer&cat=HSM&pid=wearablesolution. Date of access: 7 Oct. 2015.

Hopkins, W.G. 2008. Quantitative research design. Sportsci.org. Date of access: 7 Oct. 2015.

Hurst, K. 2002. Selecting and Applying Methods for Estimating the Size and Mix of Nursing Teams. http://www.who.int/hrh/tools/size_mix.pdf. Date of access: 27 Aug. 2015.

IconArchive. 2015. Equipment syringe full icon. http://www.iconarchive.com/show/medical-icons-by-icons-land/Equipment-Syringe-Full-icon.html. Date of access: 7 Oct. 2015.

Institute of Medicine. 2003. Patient safety: Achieving a new standard of Care. http://www.nap.edu/openbook.php?isbn=0309090776. Date of access: 2 Oct.2015.

Institute of Medicine. 2006. Preventing Medication Errors. National Academy Press, Washington DC. http://www.iom.edu/Reports/2006/Preventing-Medication-Errors-Quality-Chasm-Series.aspx.

ISMP. 2011. ISMP Acute Care Guidelines for timely administration of scheduled medications. http://www.ismp.org/tools/guidelines/acutecare/tasm.pdf. Date of access: 27 Aug. 2015.

ISMP. 2015. Historical timeline. https://www.ismp.org/about/timeline.asp. Date of access: 13 Nov. 2015.

Jackson, D., Hutchinson, M., Luck, L. & Wilkes, L. 2013. Mosaic of verbal abuse experienced by nurses in their everyday work. *Journal of advanced nursing*, 69(9):2066-2075.

Jackson, S.L. 2012. Research methods and statistics – a critical thinking approach. 4th ed. Wadsworth: Cengage learning. 510p.

Jennings, B.M., Sandelowski, M. & Mark, B. 2011. The nurse's medication day. *Qualitative Health Research,* 21(10):1441–1451.

Joanna Briggs Institute. 2013. Comprehensive Systematic Review – Training Programme. Module 1. Introduction to Evidence-based healthcare. The University of Adelaide.

Jones, J.H. & Treiber, L. 2010. When the 5 rights go wrong – medication errors from the nursing perspective. *Journal of nursing care quality,* 25(3):240-247. Jul-Sep.

Jylhä, V., Saranto, K. & Bates, D.W. 2011. Preventable adverse drug events and their causes and contributing factors: the analysis of register data. *International journal for quality in health care*, 23(2):187-197.

Kagan, I. & Barnoy, S. 2008. Factors associated with reporting of medication errors by Israeli nurses. *Journal of nursing care quality,* 23(4):353-361.

Kaushal, R., Bates, D.W., Abramson, E.L., Soukup, J.R. & Goldmann, D.A. 2008. Unit-based clinical pharmacists" prevention of serious medication errors in pediatric inpatients. *American journal of health systems pharmacology,* 65(1254-1260).

Kazaoka, T., Ohtsuka, K., Ueno, K. & Mori, M. 2007. Why nurses make medication errors: a simulation study. *Nurse education today,* 27:312-317.

Keers, R., Williams, S.D., Cooke, J. & Ashcroft, D.M. 2013a. Causes of medication administration errors in hospitals: a systematic review of quantitative and qualitative evidence. *Drug safety*, 36:1045-1067.

Keers, R.N, Williams, S.D., Cooke, J & Ashcroft, D.M. 2013b. Prevalence and nature of medication administration errors in health care settings: A systematic review of direct observational evidence. *The annals of pharmocotherapy*, 47:237-256.

Kenny, D.A. 2014. Measuring model fit. http://davidakenny.net/cm/fit.htm. Date of access: 30 Sep. 2015.

Keohane, C.A., Bane, A.D., Featherstone, E., Hayes, J., Woolf, S., Hurley, A., Bates, D.W., Gandhi, T.K. & Poon, E.G., 2008. Quantifying nursing workflow in medication administration. *Journal of nursing administration,* 38(1)19-26.

Kim, J., & Bates, D.W. 2013. Medication administration errors by nurses: adherence to guidelines. *Journal of clinical nursing,* 22(3-4):590-598.

Kim, K.S., Kwon, S., Kim, J. & Cho, S. 2011. Nurses‟ perceptions of medication errors and their contributing factors in South Korea. *Journal of Nursing Management*, 19:346-353.

Kliger, J. 2010. Giving medication administration the respect it is due. *Archives of Internal Medicine*, 170(8):690–692.

Klopper, H.C. 2008. The qualitative research proposal. *Curationis*, 31(4):62-72.

Klopper, H.C. & Knobloch, S. 2010. Validity, reliability and trustworthiness. In K. Jooste, (Ed.). The principles and practice of nursing and health care (pp. 317-325). Pretoria: Van Schaik.

Kozier, B., Erb, G., Berman, A. & Snyder, S.J. 2004. Fundamentals of nursing. 7th ed. New Jersey: Pearson Prentice Hall.

Kvale, S. 2008. Doing interviews. London: Sage. 160p.

Lambert, B.L., Dickey, L.W., Fisher, W.M., Gibbons, R.D., Lin, S.J., Luce, P.A., McLennan C.T., Senders, J.W. & Yu, C.T. 2010. Listen carefully: the risk of error in spoken medication orders. *Social science and medicine,* 70(10):1599-1608.

Latif, A., Rawat, N., Pustavoitau, A., Pronovost, P.J. & Pham, J.C. 2013. National study on the distribution, causes and consequences of voluntarily reported medication errors between the ICU and Non-ICU settings. *Critical Care Medicine*, 41(2):389-398.

Leiper, J. 2014. The context, content, and consequences of disruptive behavior among nurses through participant observation and interviews. University of North Carolina, Doctoral thesis. 134 p.

Leonard, M.S., Cimino, M., Shaha, S., McDougal, S., Pilliod, J. & Brodsky, L. 2006. Risk reduction for adverse drug events through sequential implementation of patient safety initiatives in a children‟s hospital. *Pediatrics,* 118(4):e1124-e1129.

Leufer, T. & Cleary-Holdforth, J. 2013. Let's do no harm: Medication errors in nursing: Part 1. *Nurse education in practice*, 13(3):213-216.

Levine, S.R., Cohen, M.R., Blanchard, N.R., Frederico, F., Magelli, M., Lomax, C., Greiner, G., Poole, R.L., Lee, C.K.K. & Lesko, A. 2001. Guidelines for preventing medication errors in pediatrics. *Journal of pediatric pharmacology and therapeutics*, 6: 426–442.

Lincoln, Y.S. & Guba, E.G. 1985. Naturalistic inquiry. London: Sage Publications.

Lingaratnam, S., Aranda, S., Pearce, T. & Kirsa, S. 2013. A controlled before and after study to evaluate a patient and health professional partnership model towards effective medication reconciliation. *Journal of oncology pharmacy practice,* 19(1):48-56.

Liu, L., Lee, S., Chia, P., Chi, S. & Yin, Y. 2012. Exploring the association between nurse workload and nurse-sensitive patient safety outcome indicators. *The journal of nursing research*, 20(4):300-309.

Loh, J. 2013. Inquiry into issues of trustworthiness and quality in narrative studies: a perspective. *The qualitative report*, 18(65):1-15.

Lorenzo-Seva, U. 2013. How to report the percentage of explained common variance in exploratory factor analysis. Technical Report. Department of Psychology, Universitat

Rovira i Virgili, Tarragona. http://psico.fcep.urv.cat/utilitats/factor/. Date of access: 29 Oct. 2015.

Luk, L.A., Ng, W.I., Ko, K.K. & Ung, V.H. 2008. Nursing management of medication errors. *Nursing ethics*, 15(1):28-39.

Maaskant, J., Bosman, D., Van Rijn-Bikker, P., Van Aalderen, W. & Vermeulent, H. 2014. Preventable errors with non-opioid analgesics and antiemetic drugs may increase burden in surgical pediatric patients. *European journal of pediatric surgery*, 24(5):381-388.

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. 1996. Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods*, 1:130-149.

Mahmood, A., Chaudhury, H. & Valente, M. 2011. Nurses‟ perceptions of how physical environment affects medication errors in acute care settings. *Applied nursing research,* 24:229-237.

Maiden, J., Georges, J.M. & Connelly, C.D. 2011. Moral distress, compassion fatigue and perceptions about medication errors in certified critical care nurses. *Dimensions of Critical Care Nursing*, 30(6):339-345.

Maitoko, M., Kanda, K. & Nihon, K.K.S. 1993. Factors effecting medication errors. *Journal of Japan academy of nursing science,* 13(2):29-36.

Manias, E., Kinney, S., Cranswick, N. & Williams, A. 2014. Medication errors in hospitalised children. *Journal of Paediatrics and Child Health*, 50:71-77.

Manias, E., Williams, A. & Liew, D. 2012. Interventions to reduce medication errors in adult intensive care: a systematic review. *British journal of clinical pharmacology*, 74(3):411-423.

Maycut, E, & Morehouse, R. 1994. Beginning qualitative research: A philosophic and practical guide. London: Falmer Press. 194 p.

Mazzocchi, M. 2008. Statistics for marketing and consumer research. Singapore: SAGE publications. 407 p.

McGrath, J.M. 2010. People factors that contribute to patient safety. *Journal of perinatal and neonatal nursing*: 5-6. Jan-Mar.

McLeod, M.C., Barber, N. & Franklin, B.D. 2013. Methodological variations and their effects on reported medication administration error rates. *BMJ Quality & Safety,* 22(4):278-289.

McMullan, M. 2010. Exploring the numeracy skills of nurses and students when performing drug calculations. *Nursing times,* 106(34):10-12.

Metsälä, E. & Vaherkoski, U. 2013. Medication errors in elderly acute care – a systematic review. *Scandinavian Journal of Caring Sciences*, 28:12-28.

Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health. 2003. 7th ed. Saunders.

Miles, M.B. & Huberman, A.M. 1994. Qualitative data analysis: an expanded sourcebook. London: Sage Publications. 338 p.

Miracle, V.A. 2009. Medication errors. *Dimensions of critical care nursing,* 28(1):51-52. Jan/Feb.

Mohamed, N. & Gabr, H. 2010. Quality improvement techniques to control medication errors in surgical intensive care units at emergency hospital. *Journal of Medicine and Biomedical Sciences*, ISSN: 2078-0273. May.

Mokoka, E., Oosthuizen, M.J. & Ehlers, V.J. 2010. Retaining professional nurses in South Africa: Nurse managers" perspectives. *Health SA Gesondheid*, 15(1):484-193.

Moore, T.M. 1982. The unmasking of modern science. Clearing house of the international conference of Christian higher education. Circular no 27. Potchefstroom, South Africa. 92p.

Morrow, S.L. 2005. Quality and trustworthiness in qualitative research in counselling psychology. *Journal of counselling psychology*, 52(2):250-260.

Morse, J.M. 1994. Emerging from the data: the cognitive processes of analysis in qualitative inquiry. In: J.M. Morse, editor. Critical issues in qualitative research methods. Thousand Oaks, Sage, 1994:23-43.

Mouton, J. & Marais, J.C. 1994. Basic concepts in the methodology of the Social Sciences. Human Sciences Research Council. 269 p.

Mouton, J. 1996. Understanding social research. Pretoria: JL van Schaik.

Mpundu, M. 2000. The burden of HIV/AIDS on the Zambian health system. *AIDS Anals Africa*, 10(5):6.

Mrayyan, M.T. 2012. Reported incidence, causes, and reporting of medication errors in teaching hospitals in Jordan: A comparative study. *Contemporary Nurse*, 41(2):216-232.

Mrayyan, M.T. & Al-Atiyyat, N. 2011. Medication errors in University-Affiliated Teaching Hospitals as compared to Non-University-Affiliated Teaching Hospitals in Jordan. *Nursing Forum*, 46(4):206-217.

Mrayyan, M.T., Shishani, K. & Al-Faouri, I. 2007. Rate, causes and reporting of medication errors in Jordan: nurses‟ perspectives. *Journal of Nursing Management*, 15:659-670.

Murphy, M. & While, A. 2012. Medication administration practices among children‟s nurses: a survey. *British Journal of Nursing*, 21(15):928-933.

Nabhan, M, Elraiyah, T., Brown, D.R., Dilling, J., LeBlanc, A., Montori, V.M., Morgenthaler, T., Naessens, J., Prokop, L., Roger, V., Swensen, S., Thompson, R.L. & Murad, M.H. 2012. What is preventable harm in healthcare? A systematic review of definitions. *Biomed central health services research*, 12:128-139.

National Patient Safety Agency. 2010. Reducing harm from omitted and delayed medicines in hospitals. http://www.nrls.npsa.nhs.uk/alerts/?entryid45=66720. Date of use: 02-04-2012.

Neale, J. 2009. Research methods for health and social care. China: Palgrave Macmillan. 308p.

NFER. 2015. Developing young researchers. www.nfer.ac.uk. Date of access: 23 Oct. 2015.

Nguyen, E.E., Connolly, P.M. & Wong, V. 2010. Medication safety initiative in reducing medication errors. *Journal of nursing care quality*, 25(3):224–230.

Nichols, P., Copeland, T., Craib, I.A. & Bruce, D.G. 2008. Learning from error: identifying contributory causes of medication errors in an Australian hospital. *Medical Journal of Australia*, 188(5):276-279.

O"Connel, B., Crawford, S., Tull, A. & Gaskin, C.J. 2007. Nurses" attitudes to single checking medications: before and after its use. *International journal of nursing practice*, 13(6):377-382.

O'Connor, E., Coates, H.M., Yardley, I.E. & Wu, A.W. 2010. Disclosure of patient safety incidents: a comprehensive review. *International Journal For Quality In Health Care,* 22(5):371-379.

Oguz, E., Alasehirli, B. & Demiryurek, A.T. 2015. Evaluation of the attitudes of the nurses related to rational drug use in Gaziantep University Sahinbey Research and Practice Hospital in Turkey. *Nurse education today*, 35(2):395-401.

O"Hare, M.C.B., Bradley, A.M., Gallagher, T. & Shields, M.D. 1995. Errors in administration of intravenous drugs. *British Medical Journal,* 310:1536-1537.

O"Loughlin, M. 1999. Telling stories: Narrative as methodology in the human sciences. *Education as change,* 3(1):48-58. Aug.

Olds, D.M. & Clarke, S.P. 2010. The effect of work hours on adverse events and errors in health care. *Journal of Safety Research*, 41:153-162.

Onwuegbuzie, A.J. & Leech, N.L. 2007. Validity and qualitative research: an oxymoron? *Quality and quantity*, 41:233-249.

Oshikoya, K.A., Oreagba, I.A., Ogunleye, O.O., Senbanjo, I.O., MacEbong, G.L. & Olayemi, S.O. 2013. Medication administration errors among paediatric nurses in Laos public hospitals: An opinion survey. *International Journal of Risk & Safety in Medicine*, 25:67-78.

Otero, P., Leyton, A., Mariani, G. & Ceriani, C.J.M. 2008. Patient safety committee. Medication errors in pediatric inpatients: prevalence and results of a prevention program. *Pediatrics,* 122(3):e737-e743.

Ozkan, S., Kocaman, G, Ozturk, C. & Seren, S. 2011. Frequency of pediatric medication administration errors and contributing factors. *Journal of Nursing Care Quality*, 26(2):136-143.

Panasonic. 2015a. Toughbook laptop specifications. us.panasonic.com/toughbook/19. Date of access: 12 Nov. 2015.

Panasonic. 2015b. Toughbook tablet specifications. us.panasonic.com/Toughbook/tablet. Date of access: 12 Nov. 2015.

Paparella, S. 2005. A safe haven for nurses to report medication errors? Clarian and Spectrum Health Systems prove it is possible. *Journal of emergency nursing,* 31(4):373-375.

Pape, T. 2003. Applying airline safety practices to medication administration. *MEDSURG nursing,* 12(2):77-93.

Pape, T.M., Guerra, D.M. & Muzquiz, M. 2005. Innovative approaches to reducing nurses' distractions during medication administration. *Journal of Continuing Education in Nursing,* 36(3):108–116.

Paquet, M., Courcy, F., Lavoie-Tremblay, M., Gagnon, S. & Maillet, S. 2013. Psychosocial work environment and prediction of quality of care indicators in one Canadian health center. *Worldviews on Evidence-Based Nursing*, 10(2):82-94.

Parry, A.M., Barriball, K.L & While, A.E. 2015. Factors contributing to registered nurse medication administration error: A narrative review. *International Journal of Nursing Studies*, 52:403-420.

Parshuram, C.S., To, T., Seto, W., Trope, A., Koren, G. & Laupacis, A. 2008. Systematic evaluation of errors occurring during the preparation of intravenous medication. *Canadian medical association journal*, 178(1):42-48. Jan.

Patrician, P.A. & Brosch, L. 2009. Medication error reporting and the work environment in a military setting. *Journal of Nursing Care Quality*, 24(4):277-286. Oct-Dec.

Patrician, P.A., Loan, L., McCarthy, M., Fridman, M., Donaldson, N., Bingham, M. & Brosch, L.R. 2011. The association of shift-level nurse staffing with adverse patient events. *The Journal of Nursing Administration*, 41(2):64-70.

Paulson, D.L. 2004. Comparison of wait times and patients leaving without being seen when licensed nurses versus unlicensed assistive personnel perform triage. *Journal of Emergency Nursing*, 30(4):307-311.

Pazokian, M., Tafreshi, M.Z. & Rassouli, M. 2014. Iranian nurses‟ perspectives on factors influencing medication errors. *International Nursing Review*, 61:246-254.

Peat, J., Mellis, C., Williams, K. & Xuan, W. 2002. Health Science Research – a handbook of quantitative methods. Singapore: South Wind Productions. 313 p.

Pham, J.C., Aswani, M.S., Rosen, M., Lee, H., Huddle, M., Weeks, K. & Pronovost, P.J. 2012. Reducing medical errors and adverse events. *Annual review of medicine,* 63:447-463.

Pham, J.C., Story, J.L., Hicks, R.W., Shore, A.D., Morlock, L.L., Cheung, D.S., Kelen, G.D. & Pronovost, P.J. 2008. National study on the frequency, types, causes, and

consequences of voluntary reported emergency department medication errors. *The Journal of Emergency Medicine*, 40(5):485-492.

Picone, D.M., Titler, M.G., Dochterman, J., Shever, L., Kim, T., Abramowitz, P., Kanak, M. & Qin, R. 2008. Predictors of medication errors among elderly hospitalized patients. *American Journal of Medical Quality*, 23(2):115-127. Mar/Apr.

Pitney, W.A. & Parker, J. 2001. Qualitative inquiry in athletic training: Principles, possibilities and promises. *Journal of athletic training*, 36(2):185-189.

Polit, D.F. & Hungler, B.P. 1997. Essentials of nursing research: methods, appraisal, and utilization. 4th ed. Philadelphia: Lippingcott.

Prakash, V., Koczmara, C., Savage, P., Trip, K., Stewart, J., McCurdie, T., Cafazzo, J. & Trbovich, P. 2014. Mitigating errors caused by interruptions during medication verification and administration: interventions i a simulated ambulatory chemotherapy setting. *British Medical Journal of Quality and Safety*, 23:884-892.

Quélennec, B., Beretz, L., Paya, D., Blicklé, J.F., Gourieux, B., Andrès, E. & Michel, B. 2013. Potential clinical impact of medication discrepancies at hospital admission. *European Journal Of Internal Medicine:* 530-535.

Ramanujam R, Abrahamson K, Anderson J. 2008. Influence of workplace demands on nurses‟ perception of patient safety. *Nursing and health science,* 10:144–150.

Reid-Searl, K., Moxham, L., Walker, S. & Happell, B. 2008. Shifting supervision: implications for safe administration of medication by nursing students. *Journal of clinical nursing*, 17:2750-2757.

Relihan, E., O'Brien, V., O'Hara, S. & Silke, B. 2010. The impact of a set of interventions to reduce interruptions and distractions to nurses during medication administration. *Quality and Safety in Health Care,* doi:10.1136/qshc.2009.036871.

Rentero, L., Iniesta, C., Urbieta, E., Madrigal, M. & Pérez, M.C. 2014. Causes and factors associated with reconciliation errors in medical and surgical services. *Farmacia Hospitalaria*, 38(5):398-404.

Rich, V.L. 2005. How we think about medication errors – a model and a charge for nurses. *American journal of nursing,* Supplement: 10-11.

Rinke, M.L., Shore, A.D., Morlock, L., Hicks, R.W. & Miller, M.R. 2007. Characteristics of pediatric chemotherapy medication errors in a national error reporting database. *Cancer*, 110(1):186-195.

Roche, M., Diers, D., Duffield, C. & Catling-Paul, C. 2010. Violence toward nurses, the work environment and patient outcomes. *Journal of nursing scholarship,* 42(1):13-22.

Rolfe, G. 2004. Methodological issues in nursing research: Validity, trustworthiness and rigour – quality and the idea of qualitative research. *Blackwell publishing journal compilation*: 304-310.

Roughead, E.E. & Semple, S.J. 2009. Medication safety in acute care in Australia: where are we now? Part 1: a review of the extent and causes of medication problems 2002-2008. Australian and New Zealand Health Policy.

Rubin, H. J., & Rubin, I. S. 1995. Qualitative data: the art of hearing data. Thousand Oaks, CA: Sage. 288 p.

Saintsing, D, Gibson, L.M. & Pennington, A.W. 2011. The novice nurse and clinical decision-making: how to avoid errors. *Journal of nursing management*, 19:354-359.

Saks, M. & Allsop, J. 2013. Researching Health: Qualitative, Quantitative and Mixed Methods. 2nd ed. London: Sage Publications. 489 p.

Saldana, J. 2010. The coding manual for qualitative researchers. London: SAGE publications. 224 p.

Sandelowski, M. 1995. Sample size in qualitative research. *Research in nursing and health*, 18:179-183.

Sanghera, S., Franklin, B.D. & Dhillon, S. 2007. The attitudes and beliefs of healthcare professionals on the causes and reporting of medication errors in a UK Intensive care unit. *Anaesthesia*, 62:53-61.

Santell, J.P. & Cousins, D.D. 2005. Medication errors involving wrong administration technique. *Joint Commission journal on quality and patient safety,* 31(9):528-532.

SANC. 2015. Annual statistics. http://www.sanc.co.za/stats.htm. Date of access: 2 Oct. 2015.

Scholes, J. 2013. Building emotional resilience: small steps towards big change. *Critical care,* 18(6):263-265. Nov/Dec.

Scott-Cawiezell, J.S., Pepper, G.A., Madsen, R.W., Petroski, G., Vogelsmeier, A. & Zellmer, D. 2007. Nursing home error and level of staff credentials. *Clinical Nursing Research*, 16(1):72-78. Feb.

Scott, M.B., Considine, J. & Botti, M. 2014. Medication errors in ED: do patient characteristics and the environment influence the nature and frequency of medication errors? *Australasian emergency nursing journal*, 17(4):167-175.

Sears, K., O"Brien-Palla, L., Stevens, B. & Murphy, G.T. 2013. The relationship between the nursing work environment and the occurrence of reported paediatric medication administration errors: a Pan Canadian study. *Journal of Pediatric Nursing*, 28:351-356.

Seki, Y. & Yamazaki, Y. 2006. Effects of working conditions on intravenous medication errors in a Japanese hospital. *Journal of nursing management,* 14(2):128-139.

Semple, S.J. & Roughead, E.E. 2009. Medication safety in acute care in Australia: where are we now? Part 2: a review of strategies and activities for improving medication safety 2002-2008. *Australia and New Zealand health policy* 6:24.

Shahrokhi, A., Ebrahimpour, F. & Ghodousi, A. 2013. Factors effective on medication errors: A nursing view. *Journal of Research in Pharmacy Practice*, 2(1):18-23.

Shaw, K.N., Lillis, K.A., Ruddy, R.M., Mahajan, P.V., Lichenstein, R., Olsen, C.S. & Chamberlin, J.M. 2013. Reported medication events in a paediatric emergency research network: sharing to improve patient safety. *Emergency Medicine Journal*, 30:815-819.

Shandiva, S., Nizamuddin, K., Faisal, M.W., Noor, S. & Abraham, S. 2015. Omitted medications: a continuing problem. *Clinical medicine,* 15(1):12-14. Feb.

Shehata, Z.H., Sabri, N.A. & Elmelegy, A.A. 2015. Descriptive analysis of medication errors reported to the Egyption National Online Reporting System during six months. *Journal of the American medical informatics association.* Aug.

Shenton, A.K. 2004. Strategies for ensuring trustworthiness in qualitative research projects. *Education for information*, 22:63-73.

Shulman, R., Singer, M., Goldstone, J. & Bellingan, G. 2005. Medication errors: a prospective cohort study of hand-written and computerized physician order entry in the intensive care unit. *Critical care*, 9:R516-R521.

Sills, E. 2013. Integrated patient acuity monitoring system. http://albatross-fs.com/wp-content/uploads/2014/03/iPAMS-Brochure.pdf. Date of access: 3 Sep. 2015.

Sim, J. & Wright, C. 2002. Research in health care – concepts, designs and methods. London: Nelson Thornes. 402 p.

Simonsen, B.O., Daehlin, G.K., Johansson, I. & Farup, P.G. 2014. Differences in medication knowledge and risk of errors between graduating nursing students and working registered nurses: comparative study. *BioMed central health services research*, 14:580-591.

Simonsen, B.O., Johansson, I., Daehlin, G., Osvik, L.M. & Farup, P.G. 2011. Medication knowledge, certainty, and risk of errors in health care: a cross-sectional study. *Health services research,* 11:175-184.

Sinkovics, R.R., Penz, E. & Ghauri, P.N. 2008. Enhancing the trustworthiness of qualitative research in international business. *Management international review*, 48(6):689-714.

Smeulers, M., Onderwater, A.T., Van Zwieten, M.C.B. & Vermeulen, H. 2014. Nurses‟ experiences and perspectives on medication safety practices: an explorative qualitative study. *Journal of Nursing Management*, 22:276-285.

Sorra, J.S. & Dyer, N. 2010. Multilevel psychometric properties of the AHRQ hospital survey on patient safety culture. *Biomed central health services research,* 10:199-207.

South Africa info. 2013a. The nine Provinces of South Africa. http://www.southafrica.info/about/geography/provinces.htm. Date of use: 10 Jan 2013.

South Africa Info. 2013b. Health Care in South Africa. http://www.southafrica.info/about/health/health.htm. Date of use: 10 Jan 2013.

South African Nursing Council. 2013. Professional Misconduct Cases - July 2003 to June 2008. http://www.sanc.co.za/pdf/PC%20Cases%202003-8.pdf. Date of use: 4 Apr 2013.

Speroni, K.G., Fisher, J., Dennis, M. & Daniel, M. 2013. What causes near-misses and how are they mitigated? *Nursing*, 43(4):19-24.

Statistics South Africa. 2015. Mid-year population estimates 2014. statssa.gov.za. Date of access: 10 Sep. 2015.

Stavroudis, T.A., Shore, A.D., Morlock, L., Hicks, R.W., Bundy, D. & Miller, M.R. 2010. NICU medication errors: identifying a risk profile for medication errors in the neonatal intensive care unit. *Journal of Perinatology*, 30:459-468.

Stewart, D., & Bowers, L. 2013. Inpatient verbal aggression: content, targets and patient characteristics. *Journal of psychiatric and mental health nursing*, 20(3):236-243.

Stokowski, L.A. 2012. Timely medication administration guidelines for nurses: Fewer wrong time errors? http://www.medscape.com/viewarticle/772501_2. Date of access: 27 Aug. 2015.

Stone TE, McMillan M, Hazelton M. 2010. Swearing: Its prevalence in health care settings and impact on nursing practice. *Journal of psychiatric and mental health nursing*, 17:1365-2850.

Suhr, D.D. 2006. Exploratory or confirmatory factor analysis? *Statistics and data analysis,* 31. http://www2.sas.com/proceedings/sugi31/200-31.pdf. Date of access: 19 Sep. 2015.

Tang, F., Sheu, S., Yu, S., Wie, I. & Chen, C. 2007. Nurses relate the contributing factors involved in medication errors. *Journal of Clinical Nursing*, 16:447-457.

Teixeira, A.T.C. & De Bortoli Cassiani, S.H. 2014. Root cause analysis of falling accidents and medication errors in *hospital. Acta paulista de enfermagem, 27(2):100-107. Mar.-Apr.*

Terre Blanche, M., Durrheim, K. & Painter, D. 2012. Resaerch in Practice: Applied methods for the social sciences. 2nd ed. UCT Press: Cape Town. 594 p.

Thomas, A., Boxall, E., Laha, S., Day, A. & Grundy, D. 2008. An educational and audit tool to reduce prescribing error in intensive care. *Quality and safety in health care,* 17:360-363.

Thomas, C., Kamalanathan, A.N. & Subhedar, N.V. 2011. The impact of the introduction of a gentamicin pathway. *Archives of diseases in childhood,* 96 (Supplement 1):50-51.

Thomas, J. Brunton, J. & Graziosi, S. 2010. EPPI-Reviewer 4: software for research synthesis. EPPI-Centre Software. London: Social Science Research Unit, UCL Institute of Education.

Tobin, G.A. & Begley, C.M. 2004. Methodological rigour within a qualitative framework. *Journal of advanced nursing*, 48(4):388-396.

Toruner, E.K. & Uysal, G. 2012. Causes, reporting, and prevention of medication errors from a pediatric nurse perspective. *Australian journal of advanced nursing,* 29(4):28-35.

Trbovich, P., Prakash, V., Stewart, J., Trip, K. & Savage, P. 2010. Interruptions during the delivery of high-risk medications. *Journal of Nursing Administration,* 40(5):211–218.

Treiber, L.A. & Jones, J.H. 2012. Medication errors, routines, and differences between perioperative and non-perioperative nurses. *Association of Perioperative Registered Nurses Journal*, 96(3):285-294.

Treiber, L.A. & Jones, J.H. 2010. Devastatingly Human: An analysis of registered nurses‟ medication error accounts. *Qualitative Health Research*, 20(10):1327-1342.

Truman A, Goldman M, Lehna C, Berger J, Topp R. 2013. Verbal abuse of pediatric nurses by patients and families. *Journal of advanced nursing,* 61:6-8.

Tumuga. 2010. Maps of South Africa. http://www.tumuga.com/african-maps.php. Date of access: 7 Oct 2015.

Tzeng, H., Yin, C. & Schneider, T.E. 2013. Medication error-related issues in nursing practice. *Medsurg nursing*, 22(1):13-16.

Ulanimo, V.M., O‟Leary-Kelley, C. & Connolly, P.M. 2007. Nurses‟ perceptions of causes of medication errors and barriers to reporting. *Journal of Nursing Care Quality*, 22(1):28-33.

Unver, V., Tastan, S. & Akbayrak, N. 2012. Medication errors: Perspectives of newly graduated and experienced nurses. *International journal of nursing practice*, 18:317-324.

Uys, L.R. 2004. Fundamental nursing. Cape Town: Maskew Miller Longman. 445 p.

Vaismoradi, M., Jordan, S., Turunen, H. & Bondas, T. 2014. Nursing students‟ perspectives of the cause of medication errors. *Nurse education today*, 34:434-440.

Valdez, L.P., De Guzman, A. & Escolar-Chua, R. 2013. A structural equation modelling of the factors affecting student nurses‟ medication errors. *Nurse education today*, 33:222-228.

Valentin, A., Capuzzo, M., Guidet, B., Moreno, R., Metnitz, B., Bauer, P. & Metnitz, P. 2009. Errors in administration of parenteral drugs in intensive care units: multinational prospective study. *British medical journal*, 338:b814.

Van Beuzekom, M., Boer, F., Akerboom, S. & Dahan, A. 2013. Perception of patient safety differs by clinical area and discipline. *British journal of anaesthesia,* 110(1): 107-114. Jan.

Van der Walt, J.L. 2002. Scholarship in a changing intellectual climate. Metatheoretical perspectives in a changing socio-epistemological landscape. PU for CHE: Potchefstroom. 117p.

Van Rensburg, H.C.J. 2004. Health and health care in South Africa. Pretoria: Van Schaik Publishers. 626 p.

Van Wagtendonk, I., Smits, M., Merten, H., Heetveld, M.J. & Wagner, C. 2010. Nature, causes and consequences of unintended events in surgical units. *British journal of surgery,* 97:1730-1740.

Vazin, A. & Delfani, S. 2012. Medication errors in an internal intensive care unit of a large teaching hospital: a direct observation study. *Acta medica iranica*, 50(6):425-432.

Vazin, A., Zamani, Z. & Hatam, N. 2014. Frequency of medication errors in an emergency department of a large teaching hospital in southern Iran. *Drug healthcare and patient safety*, 6:179-184.

Volpe, C.R.G., Pinho, D.L.M., Stival, M.M. & De Olivera Karnikowski, M.G. 2014. Medication errors in a public hospital in Brazil. *British journal of nursing*, 23(11):552-559.

Wakefield, B.J., Uden-Holman, T. & Wakefield, D.S. 2005. Development and Validation of the Medication Administration Error Reporting Survey. In: Henriksen K, Battles JB, Marks ES, et al., editors. Advances in Patient Safety: From Research to Implementation (Volume 4: Programs, Tools, and Products). Rockville (MD): Agency for Healthcare Research and Quality (US); 2005 Feb. Available from: http://www.ncbi.nlm.nih.gov/books/NBK20599/.

Walrath J.M. & Rose, L.E. 2008. The medication administration process: patient‟s perspective. *Journal of nursing care quality*, 23:345-352.

Warburton, P. 2010. Numeracy and patient safety: the need for regular staff assessment. *Nursing standard*, 24(27):42-44.

Warne, S., Endacott, R., Ryan, H., Chamberlain, W., Hendry, J., Boulanger, C. & Donlin, N. 2010. Non-therapeutic omission of medications in acutely ill patients. *Nursing in critical care*, 15(3):112-117. May-Jun.

Watts, H., Nasim, M.U., Sweis, R., Sikka, R. & Kulstad, E. 2013. Further characterization of the influence of crowding on medication errors. *Journal of emergencies, trauma and shock,* 6(4):264-270. Oct.-Dec.

Watts, R.G. & Parsons, K. 2013. Chemotherapy Medication Errors in a Pediatric Cancer Treatment Center: Prospective Characterization of Error Types and Frequency and Development of a Quality Improvement Initiative to Lower the Error Rate. *Pediatric blood & cancer,* PMID: 23519908. (In print)

Weant, K.A., Cook, A.M. & Armitstead, J.A. 2007. Medication-error reporting and pharmacy resident experience during implementation of computerized prescriber order entry. *American journal of health systems pharmacology*, 64:526-530.

Webalive. 2015. Dealing with out-of-stock products and maintaining a good standing with Google. https://www.webalive.com.au/dealing-with-out-of-stock-products-and-maintaining-a-good-standing-with-google/. Date of access: 7 Oct. 2015.

Weir, V.L. 2005. Best-practice protocols: preventing adverse drug events. *Nursing management*, 36(9):24-30.

Welman, C., Kruger, F. & Mitchell, B. 2011. Research Methodology. 3rd. ed. Cape Town: Oxford University Press. 342 p.

West, G., Patrician, P.A. & Loan, L. 2012. Staffing matters – every shift. *American journal of nursing,* 112(12):22-28. Dec.

West, N., Nilforushan, V., Stinson, J., Ansermino, J.M. & Lauder, G. 2014. Critical incidents related to opioid infusions in children: a five year review and analysis. *Canadian Journal of Anaesthesia*, 61:312-321.

Westbrook, J.I. & Li, L. 2013. Interruptions are significantly associated with the frequency and severity of medication administration errors. *Research in Nursing & Health*, 36(2):116-119.

Westbrook, J., Rob, M., Woods, A. & Parry, D. 2011. Errors in the administration of intravenous medications in hospital and the role of correct procedures and nurse experience. *British medical journal of quality and safety,* 20:1027-1034.

Westbrook, J.I., Woods, A., Rob, M.I., Dunsmuir, W.T.M. & Day, R.O. 2010. Association of interruptions with an increased risk and severity of medication administration errors. *Archives of Internal Medicine*, 170(8):683-690.

WHO. 2008. World Alliance for Patient Safety: Research for patient safety, better knowledge for safer care. Geneva: WHO Press.

WHO. 2013. Patient safety. http://www.euro.who.int/en/what-we-do/health-topics/Health-systems/patient-safety. Date of use: 10 January 2013.

WHO. 2015. The research cycle: measuring harm. http://www.who.int/patientsafety/research/strengthening_capacity/measuring_harm/en/. Date of access: 27 Aug 2015.

Whitley, E. & Ball, J. 2002. Statistics review 3: Hypothesis testing and *P* values. *Biomedcentral*, 6(3): 222-225.

Williams, M. & Vogt, W.P. 2011. The SAGE Handbook of innovation in social research methods. Cornwall: SAGE Publications. 638 p.

Willmot, R. 1999. School effectiveness research: An ideological commitment? *Journal of philosophy of education,* 33(2):253-268. Jul.

Wilson, S., Bremner, A., Hauck, Y. & Finn, J. 2011. The effect of nurse staffing on clinical outcomes of children in hospital: a systematic review. *International Journal of Evidence-Based Healthcare*, 9:97-121.

Wolf, Z.R. 1989. Medication errors and nursing responsibility. *Holistic Nursing Practice,* 4(1):8-17.

Wolf, Z.R., Hicks, R. & Serembus, J.F. 2006. Characteristics of medication errors made by students during the administration phase: a descriptive study. *Journal of Professional Nursing*, 22(1):39-51.

Wong, I.C.K., Wong, L.Y.L. & Cranswick, N.E. 2009. Minimising medication errors in children. *Archives of disease in childhood*, 94:161-164.

Wooddell, J. 2013. It"s not just wrong, it"s illegal! http://forchristandculture.com/2013/03/21/its-not-just-wrong-its-illegal/. Date of access: 7 Oct 2015.

Wu, A.W., Lipshutz, A.K.M. & Pronovost, P.J. 2008. Effectiveness and Efficiency of Root Cause Analysis in Medicine. *Journal of the American Medical Association,* 299(6):685-687.

Yang, K. 2010. Making sense of statistical methods in social research. Los Angeles: SAGE publications. 198 p.

Zimlichman, E., & Bates, D.W. 2012. National patient safety initiatives: Moving beyond what is necessary. *Israel journal of health policy research,* 1(1):20-21.

ADDENDUM I ETHICAL CLEARANCE CERTIFICATE - NWU

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Private Bag X6001, Potchefstroom
South Africa 2520

Tel: (018) 299-4900
Faks: (018) 299-4910
Web: http://www.nwu.ac.za

Ethics Committee
Tel +27 18 299 4849
Email Ethics@nwu.ac.za

ETHICS APPROVAL OF PROJECT

The North-West University Research Ethics Regulatory Committee (NWU-RERC) hereby approves your project as indicated below. This implies that the NWU-RERC grants its permission that provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title: MEDICATION ADMINISTRATION SAFETY IN MEDICAL AND SURGICAL UNITS OF THE GAUTENG PROVINCE

Project Leader: Dr SK Coetzee

Ethics number:

N	W	U	-	0	0	1	8	2	-	1	4	-	A	1
Institution				Project Number						Year			Status	

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Approval date: 2014-11-26 **Expiry date**: 2015-12-31

Special conditions of the approval (if any): None

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- *The project leader (principle investigator) must report in the prescribed format to the NWU-RERC:*
  - *annually (or as otherwise requested) on the progress of the project,*
  - *without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.*
- *The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-RERC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.*
- *The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-RERC and new approval received before or on the expiry date.*
- *In the interest of ethical responsibility the NWU-RERC retains the right to:*
  - *request access to any information or data at any time during the course or after completion of the project;*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the project are revealed or suspected,*
    - *it becomes apparent that any relevant information was withheld from the NWU-RERC or that information has been false or misrepresented,*
    - *the required annual report and reporting of adverse events was not done timely and accurately,*
    - *new institutional rules, national legislation or international conventions deem it necessary.*

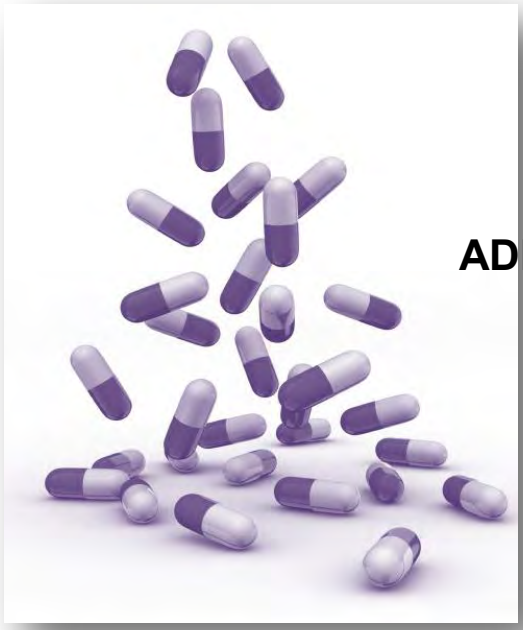
The Ethics Committee would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the Ethics Committee for any further enquiries or requests for assistance.

Yours sincerely

Linda du Plessis

Digitally signed by Linda du Plessis
DN: cn=Linda du Plessis, o=NWU, Vaal Triangle Campus, ou=Vice-Rector: Academic, email=linda.duplessis@nwu.ac.za, o=US
Date: 2014.12.02 18:44:13 +02'00'

Prof Linda du Plessis
Chair NWU Research Ethics Regulatory Committee (RERC)



ADDENDUM II: ETHICAL CLEARANCE – GAUTENG DOH

GAUTENG PROVINCE

HEALTH
REPUBLIC OF SOUTH AFRICA

OUTCOME OF PROVINCIAL PROTOCOL REVIEW COMMITTEE (PPRC)

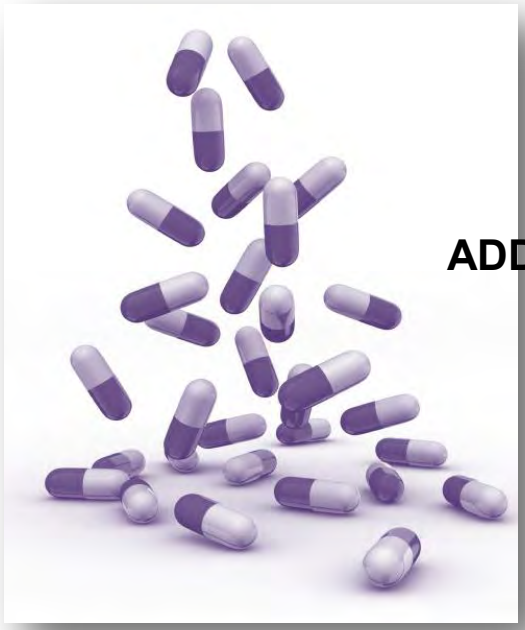
Researcher's Name (Principal investigator)	Alwiena Blignaught
Organization / Institution	North West University
Research Title	Medication Administration Safety in Medical and Surgical Units of the Gauteng Province
Contact number	Address: N/A Contact no: N/A Cell: 072 590 5794 Email: alwiena.blignaught@nwu.ac.za
Protocol number	P06012015
Date submitted	27/01/2015
Date reviewed	February 2015
Outcome	APPROVED
Date resubmitted	N/A
Date of second review	N/A
Final outcome	APPROVED

It is a pleasure to inform that the Gauteng Health Department has approved your research on "Protocol Title: Medication Administration Safety in Medical and Surgical Units of the Gauteng Province. The Provincial Protocol Review Committee kindly requests that you to submit a report after completion of your study and present your findings to the Gauteng Health Department.

Approves / not approves

Dr R Lebethe
Acting DDG: Hospital Services

Date 23 02 2015



ADDENDUM III: ETHICAL CLEARANCE – INCLUDED HOSPITALS

(Names blacked out to maintain confidentiality)

GAUTENG PROVINCE

HEALTH
REPUBLIC OF SOUTH AFRICA

[redacted]
PRIVATE BAG [redacted]
PRETORIA
0001
7 APRIL 2015

ENQUIRIES :
TEL :
FAX :

[redacted]

To Ms A. Blignaut

RE: PERMISSION TO CONDUCT RESEARCH

Title: Medication administration safety in medical and surgical units of the Gauteng Province.

Permission is hereby granted for the research to be conducted at [redacted] Hospital. This approval is given on the condition that ethics clearance will be obtained from the training institution ethics committee.

Upon completion of the project. Please send a copy of the research report to my office.

GAUTENG PROVINCIAL GOVERNMENT
[redacted] HOSPITAL / HOSPITAAL
07 APR 2015
PRIVATE BAG / PRIVAATSAK [redacted] RETORIA 0001
SUPERINTENDENT'S OFFICE

DR [redacted]
MEDICAL MANAGER
[redacted]

=

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

[redacted] HOSPITAL
PRIVATE BAG [redacted] 0117

Telephone: [redacted]
Fax:
Enquiries:

1 June 2015

Ms Alwiena Blignaut

Dear Ms Blignaut

REQUEST TO CONDUCT RESEARCH AT [redacted] HOSPITAL

Approval is hereby granted for you to conduct research titled: Medication Administration Safety in Medical and Surgical Units of the Gauteng Province at [redacted] Hospital as requested.

Please communicate with the Family Physician, Dr [redacted] telephone number: [redacted]

Regards

CEO
[redacted] HOSPITAL
03/06/2015

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

PERMISSION TO CONDUCT RESEARCH

PERIOD OF RESEARCH: 01 April 2015

NAME OF RESEARCH WORKER: Alwiena Blignaut

TITLE OF RESEARCH PROJECT: Medication administration safety in medical & surgical units of Gauteng province

OBJECTIVES OF STUDY(Brief or include a protocol) : Protocol Attached

METHODOLOGY (Brief or include a protocol) : : Protocol attached

THE APPORVAL BY THE CEO/DELEGATE IS STRICTLY ON THE BASIS OF THE FOLLOWING:

(I) CONSENT OF PATIENT TO BE SECURED

(II) CONFIDENTIALITY OF PATIENTS MAINTAINED AT ALL TIMES: strict confidentiality to be maintained

(III) NO COSTS TO THE HOSPITAL: There will be no cost to the hospital

(V) APPROVAL OF HEAD OF DEPARTMENT /CLINICAL MANAGER : [redacted] Approved

(IV) APPROVAL BY ETHICS COMMITTEE OF UNIVERSITY,: attached

CEO/DELEGATION PERMISSION

Signature: [redacted] Date: 20/03/2015

SUBJECT TO ANY RESTRICTIONS:

[redacted]

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

OFFICE OF THE CEO
[redacted] Hospital
[redacted]

MEMO

To : Alwiena Blignaut

From : [redacted] Chief Executive Officer

Date : 30 March 2015

Subject : **Request to Carry Out Research at [redacted] Hospital**

This serves to grant permission to Alwiena Blignaut to carry out a research study: *Medication Administration Safety in Medical and Surgical Units in Gauteng* at [redacted] Hospital. This permission is granted in light of improving the skill capacity of the Gauteng Department of Health.

The permission is granted in line with the code of ethics or research.

The information of the Gauteng Health Department will be used for the purpose of research and it will be utilized discreetly and that confidentiality will be maintained at all times.

The permission is granted in good faith with the notion and understanding that the abovementioned clause is upheld.

Furthermore, there should be no financial implication to the hospital.

The collection of data will [redacted] onsibility of the researcher.

Thank you

[redacted] Hospital
2015 -03- 30
CEO
GAUTENG PROVINCIAL GOVERNMENT

Chief Executive Officer

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

[redacted]

TO: ALWIENA JOHANNA BLIGNAUT
NORTH WEST UNIVERSITY

DATE 10 JUNE 2015

SUBJECT: APPROVAL TO CONDUCT RESEARCH STUDY AT [redacted] HOSPITAL

TITLE OF THE RESEARCH STUDY:

MEDICATION ADMINISTRATION SAFETY IN MEDICAL AND SURGICAL UNITS OF THE GAUTENG PROVINCE

Approval is hereby granted to conduct a research Study in [redacted] in the medical and the surgical departments.

To be noted

- A written informed consent should be requested from the official to be interviewed and observed.
- Leading staff should be asked to consent to data collection and validation.
- Strict confidentiality procedures of the documents and patient files must be followed and observed.

Thank you

[redacted] 10 June 2015

[redacted]

From: [redacted]
To: Alwiena.Blignaut@nwu.ac.za
Date: 2015/06/01 03:41 PM
Subject: RE: Requesting permission to conduct research
CC: [redacted]
Attachments: image002.jpg; image003.jpg

Dear Ms Blignaut

Approval is hereby granted for you to conduct research titled: Medication Administration Safety in Medical and Surgical Units of the Gauteng Province at [redacted] Hospital as requested.

Please communicate with the Family Physician, [redacted] on telephone number: [redacted]

Regards

[redacted] HOSPITAL

Annexure 1

Declaration of intent from the clinic manager or hospital CEO

I give preliminary permission to [redacted] (name of researcher) to do his or her research on Medication administration safety (research topic) in

_____ (name of clinic) or

_____ (name of CHC) or

[redacted] (name of hospital).

I know that the final approval will be from the [redacted] Research Ethics Committee and that this is only to indicate that the clinic/hospital is willing to assist.

Other comments or conditions prescribed by the clinic or CHC manager or hospital CEO:

Approved

[redacted]

Signature
Clinic Manager/CHC Manager/CEO

04/05/15

Date

Annexure 1

Declaration of intent from the clinic manager or hospital CEO

I give preliminary permission to Mr Bigwant Alwiene Tshoma (name of researcher) to do his or her research on Medication Administration Safety in Medical and Surgical Units of the Gauteng Province (~~name of clinic~~) or

_____ (name of CHC) or

[redacted] Hospital (name of hospital).

I know that the final approval will be from the Tshwane/Metsweding Regional Research Ethics Committee and that this is only to indicate that the clinic/hospital is willing to assist.

Other comments or conditions prescribed by the clinic or CHC manager or hospital CEO:

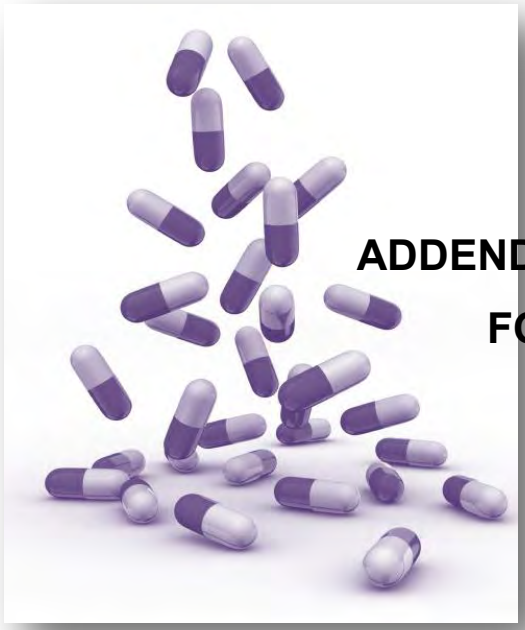
Approval is given with a view that outcome results will be shared with appropriate teams in the Hospital.

[redacted]

Signature
Clinic Manager/CHC Manager/CEO

2015-06-05

Date



ADDENDUM IV: INFORMED CONSENT FORM FOR STUCTURED OBSERVATION AND KNOWLEDGE TEST PHASES

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

HREC Stamp

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

Version 4: 21 November 2014

TITLE OF THE RESEARCH PROJECT: Medication administration safety in medical and surgical units of the Gauteng Province

REFERENCE NUMBERS: NWU-00182-14-A1

PRINCIPAL INVESTIGATOR: Alwiena J. Blignaut

ADDRESS:
North-West University
Faculty of Health Sciences
Private Bag X6001
Potchefstroom
2531

CONTACT NUMBER: 018 299 1835

You are being invited to take part in a research project that forms part of my PhD in Professional Nursing. Please take some time to read the information presented here, which will explain the details of this project. Please ask the researcher any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the Health Research Ethics Committee of the Faculty of Health Sciences of the North-West University (**NWU-00182-14-S1) and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki ad the ethical guidelines of the National Health Research Ethics Council. It might be necessary for the research ethics committee members or relevant authorities to inspect the research records.**

What is this research study all about?

- *This study will be conducted in the Gauteng Province of South Africa and will involve direct observation and knowledge testing with experienced health researchers trained in nursing. A minimum of 40 and a maximum of 80 participants will be included in this study.*
- *The objectives of this research are:*

  - To develop a survey list to determine causes of medication administration errors based on international literature as assessed during a systematic literature review.
  - To determine the incidence of medication administration errors by means of direct observation and knowledge testing in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
  - To determine by means of a survey the perceived causes and incidence of medication administration errors, as well as the perceived incidence and reasons for non-report of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
  - To identify possible solutions for the problem of medication administration errors within medical and surgical units of public hospitals in the Gauteng Province of South Africa by means of subject expert interviews.
  - To develop an intervention aimed at limiting medication administration errors to reduce medication administration errors within medical and surgical units of public hospitals in the Gauteng Province of South Africa.

Why have you been invited to participate?

- *You have been invited to participate because you are a medication administrator who as part of your daily routine administers medication and therefore are an important role-player in the medication safety in your ward.*
- *You have also complied with the following inclusion criteria: You are either a professional or enrolled nurse or nursing student who are qualified to administer medication and willing to participate in this study.*
- *You will be excluded if you are not willing to participate in this study.*

What will your responsibilities be?

- *You will be expected to be observed once during one medication administration round for the administration of medication to eight or sixteen patients.*
- *You will be asked to complete two questions on dosage calculations.*
- *This will be done during the first six months of 2015.*

Will you benefit from taking part in this research?

- *There will be no direct benefits for you.*
- *The indirect benefit will be knowledge gain and bargaining for policies to create a better safety culture in hospitals.*

Are there risks involved in your taking part in this research?

- *The risks in this study are that you might feel anxious about being observed and that you might feel vulnerable to punishment should you make mistakes. What is observed will be held strictly confidential, you will not be held liable for any mistakes seen and there will be no way of tracing research results back to your actions.*

- *The benefits outweighs the risk.*

What will happen in the unlikely event of some form of discomfort occurring as a direct result of your taking part in this research study?

- *Should you have the need for further discussions after being observed and tested, an opportunity will be arranged for you to be counselled.*

Who will have access to the data?

- *Anonymity will be assured by not writing any identifying measures on the checklists and tests used and not divulging any information that could be connected to you. Confidentiality will be ensured by locking away completed checklists and tests and not reporting on specific wards or hospitals. Reporting of findings will be anonymous by not mentioning names of people or wards or hospitals. Only the researchers will have access to the data. Data will be kept safe and secure by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected. Data will be stored for 5 years. The researcher or postgraduate students may use the data for secondary data analysis, but all such data will be anonymous and will receive ethical clearance for secondary data analysis.*

Will you be paid to take part in this study and are there any costs involved?

No, you will not be paid to take part in the study. The researcher will conduct the research at your place of work. There will thus be no costs involved for you if you do take part.

Is there anything else that you should know or do?

- You can contact Alwiena Blignaut at 018 299 1835 if you have any further queries or encounter any problems.
- You can contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 2094; carolien.vanzyl@nwu.ac.za if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records.

How will you know about the findings?

- The findings of the research will be shared with you by scientific research article and a workshop should the intervention be effective.

Declaration by participant

By signing below, I ……..……. agree to take part in a research study entitled: "Medication administration safety in medical and surgical units of the Gauteng province".

I declare that:

- I have read this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to both the person obtaining consent, as well as the researcher and all my questions have been adequately answered.

- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of participant **Signature of witness**

Declaration by person obtaining consent

I *(name)* ……..…… declare that:

- I explained the information in this document to ……..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of person obtaining consent **Signature of witness**

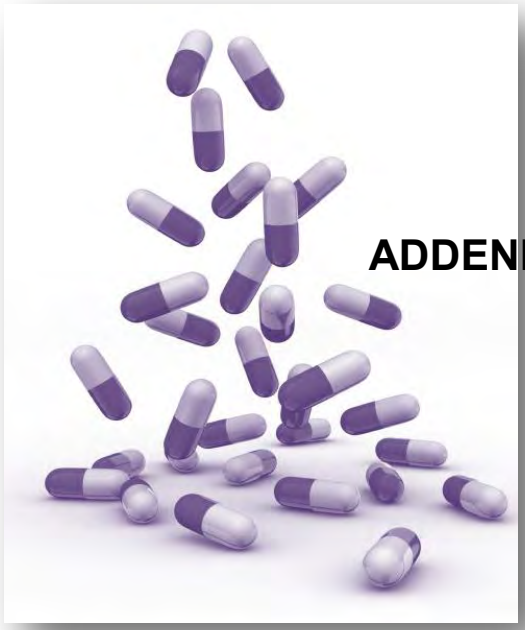
Declaration by researcher

I, Alwiena Blignaut, declare that:

- I explained the information in this document to ……..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of researcher **Signature of witness**



ADDENDUM V: INFORMED CONSENT FORM FOR SURVEY PHASE

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

HREC Stamp

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

Version 4: 21 November 2014

TITLE OF THE RESEARCH PROJECT: Medication administration safety in medical and surgical units of the Gauteng Province

REFERENCE NUMBERS: NWU-00182-14-A1

PRINCIPAL INVESTIGATOR: Alwiena J. Blignaut

ADDRESS:
North-West University
Faculty of Health Sciences
Private Bag X6001
Potchefstroom
2531

CONTACT NUMBER: 018 299 1835

You are being invited to take part in a research project that forms part of my PhD in Professional Nursing. Please take some time to read the information presented here, which will explain the details of this project. Please ask the researcher any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the Health Research Ethics Committee of the Faculty of Health Sciences of the North-West University (**NWU-00182-14-A1) and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki ad the ethical guidelines of the National Health Research Ethics Council. It might be necessary for the research ethics committee members or relevant authorities to inspect the research records.**

What is this research study all about?

- *This study will be conducted in the Gauteng Province of South Africa and will involve completing a survey with experienced health researchers trained in nursing. A minimum of 300 participants will be included in this study.*
- *The objectives of this research are:*

  - To develop a survey list to determine causes of medication administration errors based on international literature as assessed during a systematic literature review.
  - To determine the incidence of medication administration errors by means of direct observation and knowledge testing in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
  - To determine by means of a survey the perceived causes and incidence of medication administration errors, as well as the perceived incidence and reasons for non-report of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
  - To identify possible solutions for the problem of medication administration errors within medical and surgical units of public hospitals in the Gauteng Province of South Africa by means of subject expert interviews.
  - To develop an intervention aimed at limiting medication administration errors to reduce medication administration errors within medical and surgical units of public hospitals in the Gauteng Province of South Africa.

Why have you been invited to participate?

- *You have been invited to participate because you are a medication administrator who as part of your daily routine administers medication and therefore are an important role-player in the medication safety in your ward.*
- *You have also complied with the following inclusion criteria: You are either a professional or enrolled nurse or nursing student who are qualified to administer medication and willing to participate in this study.*
- *You will be excluded if you are not willing to participate in this study.*

What will your responsibilities be?

- *You will be expected to complete a survey that will take approximately 20 minutes of your time.*
- *This will be done during the first six months of 2015.*

Will you benefit from taking part in this research?

- *There will be no direct benefits for you.*
- *The indirect benefit will be knowledge gain and bargaining for policies to create a better safety culture in hospitals.*

Are there risks involved in your taking part in this research?

- *The risks in this study are that you might feel anxious about reporting on the medication safety or lack thereof in your ward. However, your survey will be sealed in an envelope and your response will be held strictly confidential.*
- *The benefits outweighs the risk.*

What will happen in the unlikely event of some form of discomfort occurring as a direct result of your taking part in this research study?

- *Should you have the need for further discussions after completing the survey, an opportunity will be arranged for you to be counselled.*

Who will have access to the data?

- *Anonymity will be assured by not writing any identifying measures on the surveys used and not divulging any information that could be connected to you. Confidentiality will be ensured by locking away completed surveys and not reporting on specific wards or hospitals. Reporting of findings will be anonymous by not mentioning names of people or wards or hospitals. Only the researchers will have access to the data. Data will be kept safe and secure by locking hard copies in locked cupboards in the researcher"s office and for electronic data it will be password protected. Data will be stored for 5 years. The researcher or postgraduate students may use the data for secondary data analysis, but all such data will be anonymous and will receive ethical clearance for secondary data analysis.*

Will you be paid to take part in this study and are there any costs involved?

No, you will not be paid to take part in the study. The researcher will conduct the research at your place of work. There will thus be no costs involved for you if you do take part.

Is there anything else that you should know or do?

- You can contact Alwiena Blignaut at 018 299 1835 if you have any further queries or encounter any problems.
- You can contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 2094; carolien.vanzyl@nwu.ac.za if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records.

How will you know about the findings?

- The findings of the research will be shared with you by scientific research article and a workshop should the intervention be effective.

Declaration by participant

By signing below, I ……..……. agree to take part in a research study entitled: "Medication administration safety in medical and surgical units of the Gauteng province".

I declare that:

- I have read this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to both the person obtaining consent, as well as the researcher and all my questions have been adequately answered.

- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of participant **Signature of witness**

Declaration by person obtaining consent

I *(name)* ……..…… declare that:

- I explained the information in this document to ……..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of person obtaining consent **Signature of witness**

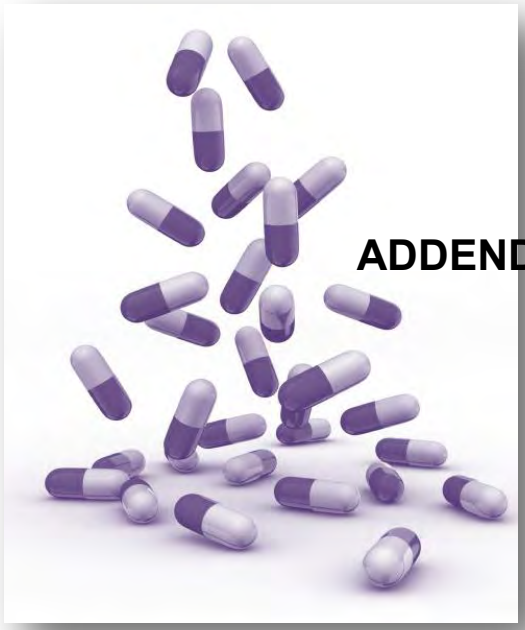
Declaration by researcher

I, Alwiena Blignaut, declare that:

- I explained the information in this document to ……..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of researcher **Signature of witness**



ADDENDUM VI: INFORMED CONSENT FORM FOR INTERVIEW PHASE

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

HREC Stamp

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

Version 4: 21 November 2014

TITLE OF THE RESEARCH PROJECT: Medication administration safety in medical and surgical units of the Gauteng Province

REFERENCE NUMBERS: NWU-00182-14-A1

PRINCIPAL INVESTIGATOR: Alwiena J. Blignaut

ADDRESS:
North-West University
Faculty of Health Sciences
Private Bag X6001
Potchefstroom
2531

CONTACT NUMBER: 018 299 1835

You are being invited to take part in a research project that forms part of my PhD in Professional Nursing. Please take some time to read the information presented here, which will explain the details of this project. Please ask the researcher any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the Health Research Ethics Committee of the Faculty of Health Sciences of the North-West University (**NWU-00182-14-S1) and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki ad the ethical guidelines of the National Health Research Ethics Council. It might be necessary for the research ethics committee members or relevant authorities to inspect the research records.**

What is this research study all about?

- *This study will be conducted in the Gauteng Province of South Africa and will involve semi-structured interviews with experienced health researchers trained in nursing. A minimum of 10 participants will be included in this study.*
- *The objectives of this research are:*

  - To develop a survey list to determine causes of medication administration errors based on international literature as assessed during a systematic literature review.
  - To determine the incidence of medication administration errors by means of direct observation and knowledge testing in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
  - To determine by means of a survey the perceived causes and incidence of medication administration errors, as well as the perceived incidence and reasons for non-report of medication administration errors in medical and surgical units of public hospitals in the Gauteng Province of South Africa.
  - To identify possible solutions for the problem of medication administration errors within medical and surgical units of public hospitals in the Gauteng Province of South Africa by means of subject expert interviews.
  - To develop an intervention aimed at limiting medication administration errors to reduce medication administration errors within medical and surgical units of public hospitals in the Gauteng Province of South Africa.

Why have you been invited to participate?

- *You have been invited to participate because you are a unit manager who oversees medication administrators and therefore is an important role-player in the medication safety in your ward.*
- *You have also complied with the following inclusion criteria: You are a unit manager in a medical or surgical ward who are willing to participate in this study.*
- *You will be excluded if you are not willing to participate in this study.*

What will your responsibilities be?

- *You will be expected to participate in a semi-structured interview which will take about 30 minutes of your time.*
- *This will be done during the first six months of 2015.*

Will you benefit from taking part in this research?

- *There will be no direct benefits for you.*
- *The indirect benefit will be knowledge gain and bargaining for policies to create a better safety culture in hospitals.*

Are there risks involved in your taking part in this research?

- *The risks in this study are that you might feel anxious about being interviewed and losing rapport with your colleagues. However, nothing that you share during the interview will be divulged in such a manner as to implicate you. Your attribution to this study will be kept completely confidential.*
- *The benefits outweighs the risk.*

What will happen in the unlikely event of some form of discomfort occurring as a direct result of your taking part in this research study?

- *Should you have the need for further discussions after being interviewed, an opportunity will be arranged for you to be counselled.*

Who will have access to the data?

- *Anonymity will be assured by not connecting you in any way to the recording or transcription of the interview and by not divulging any information that could be connected to you. Confidentiality will be ensured by locking away transcriptions and not reporting on specific wards or hospitals. Reporting of findings will be anonymous by not mentioning names of people or wards or hospitals. Only the researchers will have access to the data. Data will be kept safe and secure by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected. As soon as data has been transcribed it will be deleted from the recorders. Data will be stored for 5 years.*

Will you be paid to take part in this study and are there any costs involved?

No, you will not be paid to take part in the study. The researcher will conduct the research at your place of work. There will thus be no costs involved for you, if you do take part.

Is there anything else that you should know or do?

- You can contact Alwiena Blignaut at 018 299 1835 if you have any further queries or encounter any problems.
- You can contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 2094; carolien.vanzyl@nwu.ac.za if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records.

How will you know about the findings?

- The findings of the research will be shared with you by scientific research article and a workshop should the intervention be effective.

Declaration by participant

By signing below, I ……..……. agree to take part in a research study entitled: "Medication administration safety in medical and surgical units of the Gauteng province".

I declare that:

- I have read this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to both the person obtaining consent, as well as the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.

- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of participant **Signature of witness**

Declaration by person obtaining consent

I *(name)* ……..…… declare that:

- I explained the information in this document to ……..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of person obtaining consent **Signature of witness**

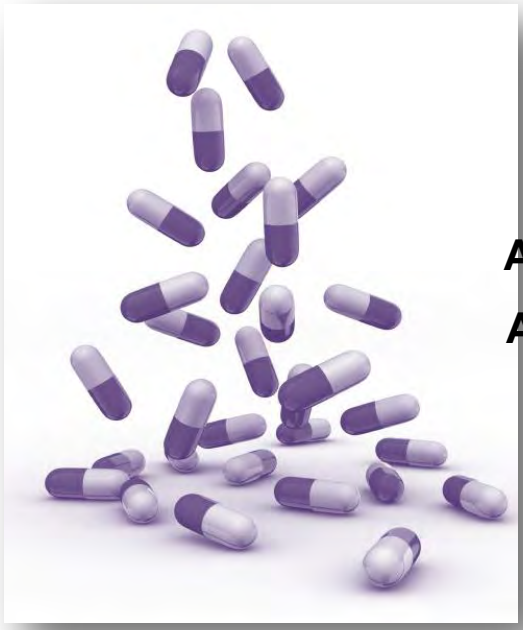
Declaration by researcher

I, Alwiena Blignaut, declare that:

- I explained the information in this document to ……..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .....…….. on (*date*) ……...…….. 20....

....
Signature of researcher **Signature of witness**



ADDENDUM VII: THE CASP CRITICAL APPRAISAL TOOL FOR QUALITATIVE STUDIES

10 questions to help you make sense of qualitative research

How to use this appraisal tool

Three broad issues need to be considered when appraising the report of a qualitative research:

- **Are the results of the review valid?**
- **What are the results?**
- **Will the results help locally?**

The 10 questions on the following pages are designed to help you think about these issues systematically. The first two questions are screening questions and can be answered quickly. If the answer to both is "yes", it is worth proceeding with the remaining questions.

There is some degree of overlap between the questions, you are asked to record a "yes", "no" or "can't tell" to most of the questions. A number of italicised prompts are given after each question. These are designed to remind you why the question is important. Record your reasons for your answers in the spaces provided.

These checklists were designed to be used as educational tools as part of a workshop setting

There will not be time in the small groups to answer them all in detail!

Screening Questions

1. Was there a clear statement of the aims of the research?

❑ Yes ❑ Can't tell ❑ No

HINT: Consider

- What was the goal of the research?
- Why it was thought important?
- Its relevance

---

2. Is a qualitative methodology appropriate?

❑ Yes ❑ Can't tell ❑ No

HINT: Consider

- If the research seeks to interpret or illuminate the actions and/or subjective experiences of research participants
- Is qualitative research the right methodology for addressing the research goal?

Is it worth continuing?

Detailed questions

3. Was the research design appropriate to address the aims of the research?

❒ Yes ❒ Can't tell ❒ No

HINT: Consider

- If the researcher has justified the research design (e.g. have they discussed how they decided which method to use)?

---

4. Was the recruitment strategy appropriate to the aims of the research?

❒ Yes ❒ Can't tell ❒ No

HINT:Consider

- If the researcher has explained how the participants were selected
- If they explained why the participants they selected were the most appropriate to provide access to the type of knowledge sought by the study
- If there are any discussions around recruitment (e.g. why some people chose not to take part)

5. Was the data collected in a way that addressed the research issue?

❑ Yes ❑ Can't tell ❑ No

HINT: Consider

- If the setting for data collection was justified
- If it is clear how data were collected (e.g. focus group, semi-structured interview etc.)
- If the researcher has justified the methods chosen
- If the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews were conducted, or did they use a topic guide)?
- If methods were modified during the study. If so, has the researcher explained how and why?
- If the form of data is clear (e.g. tape recordings, video material, notes etc)
- If the researcher has discussed saturation of data

---

6. Has the relationship between researcher and participants been adequately considered?

❑ Yes ❑ Can't tell ❑ No

HINT: Consider

- If the researcher critically examined their own role, potential bias and influence during
  (a) Formulation of the research questions
  (b) Data collection, including sample recruitment and choice of location
- How the researcher responded to events during the study and whether they considered the implications of any changes in the research design

7. Have ethical issues been taken into consideration? ❑ Yes ❑ Can't tell ❑ No

HINT: Consider

- If there are sufficient details of how the research was explained to participants for the reader to assess whether ethical standards were maintained
- If the researcher has discussed issues raised by the study (e.g. issues around informed consent or confidentiality or how they have handled the effects of the study on the participants during and after the study)
- If approval has been sought from the ethics committee

---

8. Was the data analysis sufficiently rigorous? ❑ Yes ❑ Can't tell ❑ No

HINT: Consider

- If there is an in-depth description of the analysis process
- If thematic analysis is used. If so, is it clear how the categories/themes were derived from the data?
- Whether the researcher explains how the data presented were selected from the original sample to demonstrate the analysis process
- If sufficient data are presented to support the findings
- To what extent contradictory data are taken into account
- Whether the researcher critically examined their own role, potential bias and influence during analysis and selection of data for presentation

9. Is there a clear statement of findings?

❒ Yes ❒ Can't tell ❒ No

HINT: Consider

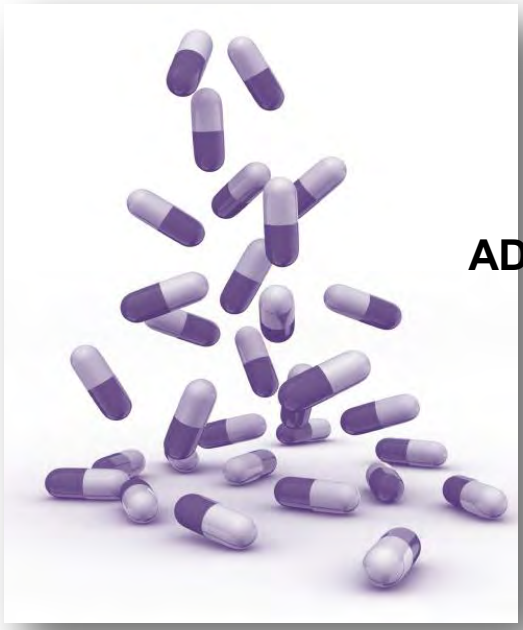
- If the findings are explicit
- If there is adequate discussion of the evidence both for and against the researchers arguments
- If the researcher has discussed the credibility of their findings (e.g. triangulation, respondent validation, more than one analyst)
- If the findings are discussed in relation to the original research question

---

10. How valuable is the research?

HINT: Consider

- If the researcher discusses the contribution the study makes to existing knowledge or understanding e.g. do they consider the findings in relation to current practice or policy?, or relevant research-based literature?
- If they identify new areas where research is necessary
- If the researchers have discussed whether or how the findings can be transferred to other populations or considered other ways the research may be used



ADDENDUM VIII: THE JOHNS HOPKINS CRITICAL APPRAISAL TOOL FOR RESEARCH STUDIES

Johns Hopkins Nursing Evidence-Based Practice
Appendix E: Research Evidence Appraisal Tool

Evidence Level and Quality:_____

Article Title:			Number:
Author(s):			Publication Date:
Journal:			
Setting:		Sample (Composition & size):	
Does this evidence address my EBP question?	☐Yes	☐No Do not proceed with appraisal of this evidence	

Level of Evidence (Study Design)

A. Is this a report of a single research study? ***If No, go to B.***		☐Yes	☐No
1. Was there an intervention?		☐Yes	☐No
2. Was there a control group?		☐Yes	☐No
3. Were study participants randomly assigned to the intervention and control groups?		☐Yes	☐No
If Yes to all three, this is a Randomized Controlled Trial (RCT) or Experimental Study →	☐ LEVEL I		
If Yes to #1 and #2 and No to #3, OR Yes to #1 and No to #2 and #3, this is Quasi Experimental (some degree of investigator control, some manipulation of an independent variable, lacks random assignment to groups, may have a control group) →	☐ LEVEL II		
If Yes to #1 only, OR No to #1, #2, and #3, this is Non-Experimental (no manipulation of independent variable, can be descriptive, comparative, or correlational, often uses secondary data) **or Qualitative** (exploratory in nature such as interviews or focus groups, a starting point for studies for which little research currently exists, has small sample sizes, may use results to design empirical studies) →	☐ LEVEL III		
NEXT, COMPLETE THE BOTTOM SECTION ON THE FOLLOWING PAGE, "STUDY FINDINGS THAT HELP YOU ANSWER THE EBP QUESTION"			

Johns Hopkins Nursing Evidence-Based Practice
Appendix E: Research Evidence Appraisal Tool

B. Is this a summary of multiple research studies? ***If No, go to Non-Research Evidence Appraisal Form.***		☐Yes	☐No
1. Does it employ a comprehensive search strategy and rigorous appraisal method (**Systematic Review)?** ***If No, use Non-Research Evidence Appraisal Tool; if Yes:***		☐Yes	☐No
a. Does it combine and analyze results from the studies to generate a new statistic (effect size)? (**Systematic review with meta-analysis**)		☐Yes	☐No
b. Does it analyze and synthesize concepts from qualitative studies? (**Systematic review with meta-synthesis**)		☐Yes	☐No
If Yes to either a or b, go to #2B below.			
2. For Systematic Reviews and Systematic Reviews with meta-analysis or meta-synthesis:			
a. Are all studies included RCTs? →	☐ LEVEL I		
b. Are the studies a combination of RCTs and quasi-experimental or quasi-experimental only? →	☐ LEVEL II		
c. Are the studies a combination of RCTs, quasi-experimental and non-experimental or non-experimental only? →	☐ LEVEL III		
d. Are any or all of the included studies qualitative? →	☐ LEVEL III		
COMPLETE THE NEXT SECTION, "STUDY FINDINGS THAT HELP YOU ANSWER THE EBP QUESTION"			

STUDY FINDINGS THAT HELP YOU ANSWER THE EBP QUESTION:

NOW COMPLETE THE FOLLOWING PAGE, "QUALITY APPRAISAL OF RESEARCH STUDIES", AND ASSIGN A QUALITY SCORE TO YOUR ARTICLE

Johns Hopkins Nursing Evidence-Based Practice
Appendix E: Research Evidence Appraisal Tool

Quality Appraisal of Research Studies			
• Does the researcher identify what is known and not known about the problem and how the study will address any gaps in knowledge?	☐Yes	☐No	
• Was the purpose of the study clearly presented?	☐Yes	☐No	
• Was the literature review current (most sources within last 5 years or classic)?	☐Yes	☐No	
• Was sample size sufficient based on study design and rationale?	☐Yes	☐No	
• If there is a control group:			
○ Were the characteristics and/or demographics similar in both the control and intervention groups?	☐Yes	☐No	☐NA
○ If multiple settings were used, were the settings similar?	☐Yes	☐No	☐NA
○ Were all groups equally treated except for the intervention group(s)?	☐Yes	☐No	☐NA
• Are data collection methods described clearly?	☐Yes	☐No	
• Were the instruments reliable (Cronbach's α [alpha] ≥ 0.70)?	☐Yes	☐No	☐NA
• Was instrument validity discussed?	☐Yes	☐No	☐NA
• If surveys/questionnaires were used, was the response rate ≥ 25%?	☐Yes	☐No	☐NA
• Were the results presented clearly?	☐Yes	☐No	
• If tables were presented, was the narrative consistent with the table content?	☐Yes	☐No	☐NA
• Were study limitations identified and addressed?	☐Yes	☐No	
• Were conclusions based on results?	☐Yes	☐No	

Quality Appraisal of Systematic Review with or without Meta-Analysis or Meta-Synthesis		
• Was the purpose of the systematic review clearly stated?	☐Yes	☐No
• Were reports comprehensive, with reproducible search strategy?	☐Yes	☐No
○ Key search terms stated	☐Yes	☐No
○ Multiple databases searched and identified	☐Yes	☐No
○ Inclusion and exclusion criteria stated	☐Yes	☐No
• Was there a flow diagram showing the number of studies eliminated at each level of review?	☐Yes	☐No
• Were details of included studies presented (design, sample, methods, results, outcomes, strengths and limitations)?	☐Yes	☐No
• Were methods for appraising the strength of evidence (level and quality) described?	☐Yes	☐No
• Were conclusions based on results?	☐Yes	☐No
○ Results were interpreted	☐Yes	☐No
○ Conclusions flowed logically from the interpretation and systematic review question	☐Yes	☐No
• Did the systematic review include both a section addressing limitations and how they were addressed?	☐Yes	☐No

QUALITY RATING BASED ON QUALITY APPRAISAL

A **High quality:** consistent, generalizable results; sufficient sample size for the study design; adequate control; definitive conclusions; consistent recommendations based on comprehensive literature review that includes thorough reference to scientific evidence

B **Good quality:** reasonably consistent results; sufficient sample size for the study design; some control, and fairly definitive conclusions; reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence

C **Low quality or major flaws:** little evidence with inconsistent results; insufficient sample size for the study design; conclusions cannot be drawn

ADDENDUM IX: SYSTEMATIC REVIEW INCLUDED STUDIES SUMMARY

Summary of quantitative research studies included

Authors, Year Published and Title	Purpose of the Study	Research Design (Research method; Sample, Data Collection and Analysis)	In-hospital nursing-practice-related causes of medication error identified in the study	Johns Hopkins Score
Armutlu, M., Foley, M., Surette, J., Belzile, E. & McCusker, J. 2008. Survey of nursing perceptions of medication administration practices, perceived sources of errors and reporting behaviours.	To describe nurses‟ perceptions of medication administration practices, reporting of errors and sources of medication errors and to describe the relationships between nurses‟ perceptions and their years of experience and the patient care unit on which they worked.	**Sample:** All registered nurses regardless of status or shift and in all patient care areas in a hospital in Quebec were asked to participate. 386 nurses were targeted. **Data collection:** A questionnaire consisting of multiple-choice and open-ended questions directed toward current practice, perceptions of sources of error, error reporting practices and demographic information was used. **Data analysis:** Principal components analysis was used to reduce questions into a smaller number of sub-scales.	➢ Prescribing legibility; ➢ Confusing order or instructions; ➢ Misunderstood verbal order; ➢ Distractions; ➢ Miscalculations; ➢ Procedure/policy not followed; ➢ Knowledge deficit; ➢ Labels of medications look alike; and ➢ Names of medications look alike.	10/12
Bae, S., Mark, B.	To examine how	**Sample:** All registered nurses and	➢ Lack of coordination with physicians	10/12

& Fried, B. 2009. Impact of nursing unit turnover on patient outcomes in hospitals.	nursing unit turnover affects key workgroup processes and how these processes mediate the impact of nursing turnover on patient outcomes.	ten randomly selected patients from each of 268 units from 141 randomly selected hospitals in the United States were invited to participate. **Data collection:** Secondary data analysis was conducted with data from the Outcomes Research in Nursing Administration Project II. **Data analysis:** Workgroup cohesion, relational coordination, workgroup learning, patient satisfaction and work complexity were measured individually and aggregated to unit level. Linear and count models were used in the statistical analysis while the Poisson regression model was used to analyse patient falls and medication errors.	and pharmacists; and ➢ Insufficient educational level.	
Beckett, R.D., Sheehan, A.H. & Reddan, J.G. 2012.	To review medication error data from a large health system to	**Sample:** Cases as obtained from a file detailing all medication errors reported through a local voluntary electronic incident-reporting	➢ Technology failures; and ➢ Nursing staff inexperience.	9/10

Factors associated with reported preventable adverse drug events: A retrospective, case-control study.	identify independent factors affecting the risk of reported preventable adverse drug events compared to medication errors that did not contribute to patient harm.	system from three hospitals in the Indiana health system were chosen for the sample. Cases were matched to resemble no harm controls versus harm cases. **Data collection:** Review of the original incident report completed by nursing, pharmacy, and risk management staff, as well as the electronic medical record for each patient. **Data analysis:** Categorical data forms were used to enter factors into univariate analysis. Factors suggesting potential for interaction were evaluated for inclusion in the multivariate logistic regression model.		
Bohomol, E., Ramos, L.H. & D'Innocenzo, M. 2009. Medication errors in an intensive	To investigate the incidence, types and causes of medication errors and the consequences for	**Sample:** Forty-four adults representing all inpatients in an ICU during the 30-day research period were sampled. In this time period, 305 medication errors were detected.	➢ Drug not available at the institution; ➢ Problems in stock or distribution in the pharmacy; ➢ Failure in transcription of the prescription to pharmacy; ➢ Communication failure among	6/8

care unit.	patients.	**Data collection:** Medication errors were detected by using anonymous self-reports, staff interviews and a review of patient records. **Data analysis:** Data were described as absolute and per cent figures. The Mann-Whitney-Wilcoxon test for non-parametric distributions was applied. To compare the relative frequencies of medication errors per day in the two groups	services; ➢ Problems related to prescriptions; ➢ Slips, memory lapses, and failure to check medication; ➢ Work overload and disruptions; ➢ Infusion pump problems; and ➢ Failure in following protocols.	
Breckenridge-Sproat, S., Johantgen, M. & Patrician, P. 2012. Influence of unit-level staffing on medication errors and falls in military hospitals.	To examine the influence and relationship of nurse staffing and workload factors on medication errors and patient falls at the unit level in Army hospitals and to explore the effect of the practice	**Sample:** 506 nurses from four Army hospitals in the continental United States of America were sampled. **Data collection:** Two sources were used: A shift-level data set from the 23 units and an annual survey of direct care staff nurses. **Data analysis:** Data were examined for frequencies, distributions, descriptive statistics,	➢ High acuity level; and ➢ Nursing skill mix.	11/12

	environment on these relationships.	missing data, outliers and multivariate assumptions, using SPSS 17.0.		
Brunetti, L., Santell, J.P. & Hicks, R.W. 2007. The impact of abbreviations on patient safety.	To provide further evidence about patient safety risks that result from using abbreviations.	**Sample:** 18153 medication error reports were reviewed. **Data collection:** All error records submitted during the study period that contained "Abbreviation" as one of the causes of error were identified and exported to a worksheet format. **Data analysis:** Descriptive statistics were used to analyse the data.	➢ Abbreviation use.	9/11
Chang, Y. & Mark, B.A. 2009. Antecedents of severe and non-severe medication errors.	To examine nursing-unit characteristics contributing to medication errors at acute-care hospitals and investigate whether medication errors of different levels of	**Sample:** 1671 observations were used. **Data collection:** Data were derived from the Outcomes Research in Nursing Administration Project. This data were collected for six months from 146 hospitals randomly selected. **Data analysis:** Generalized estimating equations with a	➢ Educational insufficiency.	7½/9

	severity have different antecedents.	negative binomial distribution were used to model the two types of medication errors during 6 months.		
Chang, Y. & Mark, B. 2011. Effects of learning climate and registered nurse staffing on medication errors.	To investigate whether learning climate moderates the relationship between error-producing conditions and medication errors.	**Sample:** Nurses eligible to participate were registered nurses employed in medical-surgical units for not less than three months (*n*=4954). **Data collection:** Nurses completed three different questionnaires. **Data analysis:** Medication errors were modelled using the Poisson regression with random effects. Statistical analyses using SAS Version 9.2. Post hoc tests were used to determine whether the slope of the simple regression lines significantly differed from zero.	➢ Lack of registered nurses; ➢ Education deficit; and ➢ Non-optimal learning climate.	10/12
Cheragi, M.A., manoocheri, H., Mohammadnejad,	To evaluate the types and causes of nursing	**Sample:** 237 nurses were randomly selected from nurses with a bachelor‟s degree in nursing	➢ Use of abbreviations instead of full names of medications in prescriptions;	8½/12

E. & Ehsani, S.R. 2013. Types and causes of medication errors from nurse's viewpoint.	medication errors.	who were working in Imam Khomeini Hospital Complex in Teheran. **Data collection:** The data collection tool was a self-made questionnaire adjusted based on a literature review, including ten questions about demographic characteristics and seven specific items about medication errors. **Data analysis:** Data analyses were performed by descriptive statistics and inferential statistics. SPSS for Windows 16.0 was used.	➢ Similarities in drug names; ➢ Large variety of drugs in the medicine cabinet; ➢ Different medicinal dosages; ➢ Being too busy and tired from excessive work; ➢ Inadequate staffing; ➢ Inadequate training of the staff; ➢ Lack of pharmacological knowledge; ➢ Incorrect medicinal calculations; and ➢ Illegible data card or prescriptions.	
Cottney, A. & Innes, J. 2014. Medication-administration errors in an urban mental health hospital: A direct	To provide a broader investigation of the incidence, type, and severity of medication administration errors that occur throughout a UK	**Sample:** 4177 medication administration occurrences were observed in 43 wards of the East London National Health Service Foundation Trust hospitals. **Data collection:** Data collection was carried out by 22 members of pharmacy staff who followed the nurse for the duration of the	➢ Interruption of medication administration to attend to another activity; ➢ "Prn" prescriptions; and ➢ Increased numbers of patients in the ward during medication administration.	8/9

observation study.	mental health hospital, and to investigate the factors that might predict an increased risk of error.	medication round, watching the preparation and administration of each dose and recording details of administration errors. **Data analysis:** Poisson regression was used to determine the best combination of predictors and the relative risk of these predictors with regards to the occurrence of an administration error. Data were analysed using SAS software.		
Deans, C. 2005. Medication errors and professional practice of registered nurses.	To identify and describe the incidence, type and causes of medication errors and impact that the administration of medications has on professional practice of registered nurses at	**Sample:** 154 registered nurses employed in a regional hospital in Victoria were surveyed. **Data collection:** The Medication Error Questionnaire was used, containing sections on medication errors occurring in the previous four weeks, perceptions of causes of medication errors, reporting of medication error and impact thereof.	➢ Illegible handwriting; ➢ Misreading of orders; ➢ Misinterpretation of orders; ➢ Misplaced decimal in orders; ➢ Misunderstood abbreviations; ➢ Proprietary name confusion; ➢ Similar name confusion; ➢ Incorrect patient identification; ➢ Similar packaging confusion; ➢ Stress/high workload; ➢ Fatigue/lack of sleep;	9/12

	a major regional hospital in Victoria.	**Data analysis:** There was no mention of data analysis in the article, though descriptive statistical analysis was evident.	➢ Knowledge deficit; ➢ Dose miscalculation; ➢ Skill deficit; ➢ Confronting/intimidating behaviour; ➢ Interruptions and distractions; ➢ Poor communication between nurses and doctors; ➢ Insufficient staffing; ➢ Inexperience; ➢ Inadequate training; and ➢ A non-optimal work environment.	
Doherty, C. & McDonnell, C. 2012. Tenfold medication errors: 5 years' experience at a university-affiliated pediatric hospital.	To identify the drug classes and medications most frequently implicated in paediatric 10-fold error, and to examine the mechanisms and enabling factors that lead to such errors.	**Sample:** 252 10-fold medication errors were identified from 6643 medication-related safety reports. **Data collection:** All medication-related safety reports submitted to the voluntary patient safety reporting database between July 2004 and June 2009 were identified and hand searched retrospectively by both authors. Reports were analysed by collecting data that described the	➢ Calculation errors; ➢ Incorrect equipment programming; ➢ Writing errors; ➢ Misinterpretation of order; ➢ Incorrect preparation of medication; ➢ Incorrect labelling; ➢ Omitted or misplaced decimal point in the prescription; ➢ Added or omitted zero in the prescription; ➢ Knowledge gap; ➢ Incorrect strength or drug	8/9

		individual medication and class of drug involved, as well as whether an under-dose or overdose had occurred and what outcome the error led to. **Data analysis:** . Data were transferred to a Microsoft Excel database for quantification and analysis. No further information about data analysis was discussed in the article.	formulation used; and ➢ Distractions.	
Donaldson, N., Aydin, C., Fridman, M. & Foley, M. 2014. Improving medication administration safety: Using naïve observation to assess practice and guide	To describe the Collaborative Alliance for Nursing Outcomes (CALNOC) naïve observation medication administration assessment method, to examine nurse adherence to six safe practices during medication	**Sample:** 333 Medication administration accuracy assessment studies (minimum 100 doses each) were drawn from 43 CALNOC hospitals and 157 units. **Data collection:** Observers watched staff nurses prepare, administer and document medications dose by dose. Observations were coded noting safe practices and the incidence of distractions and interruptions, plus the specifics of the medication	➢ Safe practice deviations such as medication not compared with the medication administration record, medication not labelled, administered medication not charted or documented immediately after administration, two forms of identification not checked, medication not explained to the patient, and distractions or interruptions.	8/11

improvements in process and outcomes.	administration, to examine the prevalence of medication administration errors in adult acute care, and to explore associations between nurse deviation from fundamental safe practices and medication errors in adult acute care.	dose, route, timing and technique. Medical records were reviewed and compared with observations. **Data analysis:** Descriptive statistics for both safe practice deviations and medication administration errors were used, followed by an examination of the effect of selected safe practice deviations on errors.		
Ehsani, S.R., Cheraghi, M.A., Nejati, A., Salari, A., Exmaeilpoor, A.H. & Nejad, E.M. 2013. Medication errors of nurses in the emergency	To conduct a study on medication errors and their causes in order to find out the number of recalled committed medication errors per nurse over the course of his/her	**Sample:** 94 nurses from the emergency department of Imam Khomeini Hospital in Teheran, Iran were selected. **Data collection:** A questionnaire consisting of two parts (a demographics section and a section related to the type and causes of medication errors) were used.	➢ Large variety of drugs in the ward; ➢ Use of abbreviated names; ➢ Similarities in drug names; ➢ Using some drugs in rare cases; ➢ Different medicinal dosages; ➢ Fatigue resulting from hard work; ➢ High patient-to-nurse ratio; ➢ Insufficient education; ➢ Insufficient pharmacological knowledge;	9/12

department.	nursing career, and rate of medication errors reported to nurse managers, in the nurses of the emergency department.	**Data analysis:** Descriptive and inferential statistical analyses were conducted. The SPSS software version 16 was used.	➢ Incorrect dosage calculations; ➢ Illegibility of patients‟ records; and ➢ Illegibility of physicians‟ prescriptions.	
Freeman, R., Lee-Lebner, B. & Pesenecker, J. 2013. Reducing interruptions to improve medication safety.	To determine whether the implementation of a bundle of interventions would reduce interruptions during the medication administration process.	**Sample:** 59 medication preparation and administration incidents pre-intervention and 40 post-intervention. **Data collection:** Direct observation using a tool to tabulate the number and types of interruptions and whether the nurse followed the five rights of medication administration. **Data analysis:** Descriptive frequencies were used to analyse the impact of the interventions on interruptions.	➢ Interruptions.	9/11
Fry, M.M. & Dacey, C.	To establish the views of nurses in	**Sample:** A purposive sample of 244 registered nurses employed as	➢ Illegible medication charts; ➢ Medications not being available;	8½/12

2007. Factors contributing to incidents in medicine administration. Part 2.	the medicine directorate of a large London teaching hospital on the importance of a list of factors potentially contributing to medication incidents and to explore their professional and personal views of the consequences of reporting such incidents.	permanent staff within fifteen medicine wards of a London teaching hospital was chosen. **Data collection:** The questionnaire used could be divided into six parts: work details; environment; training and education; products; prescriptions; and medication incidents. **Data analysis:** The SPSS 12.0.01 for Windows was used. Chi-square and Fisher"s exact test were used to compare sets of values. Responses to open questions were initially coded and grouped and then sorted into more general themes.	➢ Incomplete prescription; ➢ Medication charts waiting to be rewritten; ➢ Medication delivery to the ward; ➢ Over-stocked medication trolleys; ➢ Over-stocked medication cupboards; ➢ Distractions in the working environment; ➢ Inability to perform calculations; and ➢ Look-alike or sound-alike medications.	
Günes, Ü.Y., Gürlek, Ö. & Sönmez, M. 2014. Factors contributing to medication errors	To determine the experience of nurses concerning medication errors and to establish why these errors might have	**Sample:** Nurses were recruited from two state hospitals in the provinces of Izmir and Afyonkarahisar in Turkey. 324 questionnaires were distributed and 243 were returned. **Data collection:** The	➢ Physicians not writing the order for medication in time; ➢ Physicians not writing the order; ➢ Physicians writing interactive drugs at the same time; ➢ Physicians not writing drug route; ➢ Not specifying the time period for	9½/12

in Turkey: nurses' perspectives.	occurred, what the factors contributing to medication errors were, and how often nurses came across these factors.	questionnaire used had sections on the nurses‟ socio-demographic details, medical errors that the nurses had experienced, the frequency with which they had encountered factors that could have resulted in medication errors and the reporting of medication errors. **Data analysis:** SPSS version 16.0 was used for descriptive statistics, chi-squared, Cronbach‟s alpha and Kuder-Richardson 20 reliability analysis were implemented.	the administration of an intravenous fluid; ➢ A verbal order being given in a non-emergency situation; ➢ Physicians not writing drug dose clearly and exactly; ➢ Physicians not updating medication orders; ➢ Drug not delivered from the pharmacy in time; ➢ Problems in stock in the pharmacy; ➢ Not preparing the drugs on behalf of the patient in the pharmacy; ➢ Not having an alert label indicating patient name and expiration date on the drugs coming from the pharmacy; ➢ Not having an alert label on the high alert drugs coming from the pharmacy; ➢ Receiving a lower or higher dose of drugs from the pharmacy than what the physician ordered; ➢ Most physicians not writing orders

			for medications legibly; ➢ Not having a suitable environment for drug preparation; ➢ Interruptions; ➢ Unauthorised drug administration; ➢ Having to write an order in place of a physician; ➢ Having poor mathematical skills for drug dose calculation; ➢ Not verifying the patient identification from the arm band of the patient; ➢ Preparing drugs too early; and ➢ Not recording the administered drug on the patient‟s record.	
Håkonsen, H., Hopen, H., Abelsen, L., Ek, B. & Toverud, E. 2010.	To investigate how generic substitution is carried out in hospitals based on hospital nurses‟	**Sample:** 100 nurses who had been working in a large regional public hospital in the south of Norway. **Data collection:** Interviews using	➢ Generic substitution.	8½/12

Generic substitution: A potential risk factor for medication errors in hospitals.	experiences with generic substitution, and to explore the nurses‟ views on this as a risk factor for medication errors.	semi-structured questionnaire consisting of 34 closed and 24 open-ended questions, as well as eight statements to consider on a five-point Likert scale. **Data analysis:** Descriptive analyses were performed using SPSS statistical software v.16.0.		
Härkänen, M., Ahonen, J., Kervinen, M., Turunen, H. & Vehviläinen-Julkunen, K. 2014. The factors associated with medication errors in adult medical and surgical inpatients: a direct observation approach.	To describe the frequency, types and severity of observed medication errors in adult medical and surgical inpatients, as well as to study the relationship between medication errors and the factors associated with their occurrence.	**Sample:** A convenience sample of 32 registered nurses were recruited for the study and observed during 1058 medication administrations. **Data collection:** A structured medication observation form was developed. Additional information regarding the registered nurse‟s experience and patient-nurse ratio was gathered. Patient-specific factors were taken into account and the patients‟ medication records were evaluated. **Data analysis:** Data were processed using SPSS for	➢ Interruptions by other health professionals during medication administration; ➢ Rush; and ➢ Increased number of medications to be administered.	9½/11

		Windows 19.0. Associations between medication errors and related factors were analysed using logistic regression analysis.		
Kim, K.S., Kwon, S., Kim, J. & Cho, S. 2011. Nurses' perceptions of medication errors and their contributing factors in South Korea.	To identify the types of medication errors that occur in nursing practice, the contributing factors for medication errors and the nurses‟ perceptions of medication errors and reporting.	**Sample:** 330 questionnaires were disseminated to four teaching hospitals, two private hospitals and one government hospital in South Korea by means of snowball sampling. **Data collection:** A questionnaire consisting of five parts were used. The different parts focussed on demographic information, the nature of medication errors, contributing factors, consequences of the medication errors and nurses‟ perceptions of preventing medication errors. **Data analysis:** Data were analysed descriptively using SPSS version 17.0.	➢ Personal neglect including unfamiliarity with the drug, advanced drug preparation and administration without rechecking, failure to be alert while checking the prescription, missed double-checking of patient identification and insufficient training in medication delivery devices; ➢ Miscommunication; and ➢ Environmental factors such as heavy workload, similar drug names/ packaging, busy environment, delayed drug delivery from the pharmacy and faulty computer interfaces.	10/12
Latif, A., Rawat, N., Pustavoitau,	To compare the distribution, causes,	**Sample:** 839553 errors reported from 537 hospitals were included	➢ Problems with documentation; ➢ Procedure/protocol not followed;	8/9

A., Pronovost, P.J. & Pham, J.C. 2013. National study on the distribution, causes and consequences of voluntarily reported medication errors between the ICU and non-ICU settings.	and consequences of medication errors in the Intensive Care Unit (ICU) compared with those in the non-ICU settings.	for analysis. **Data collection:** All records submitted to MEDMARX between 1999 and 2005 from hospitals that had an ICU were abstracted. Specific data regarding hospital (size, pharmacist availability, computerized provider order entry availability, hospital type, type of medication dispensing system, and drug administration volume) and medication error characteristics (Node, type, cause, contributing factors, shift and day of occurrence, staff who committed the error, action taken and consequence) were used. **Data analysis:** Univariate and multivariate regression analyses were conducted to identify the difference in prevalence between ICU errors and non-ICU errors in relation to various aspects of medical errors, with and without	➢ Communication deficiencies; ➢ Written order deficiencies; ➢ Use of abbreviations; ➢ Inaccurate or omitted transcription; ➢ Calculation errors; ➢ Verbal order problems; ➢ Dispensing device challenges; ➢ Handwriting illegible/unclear; ➢ Deficiencies in the drug distribution system; ➢ Performance deficit; ➢ Knowledge deficit; ➢ Labelling and packaging problems; and ➢ Drug name confusion.

		adjusting for hospital characteristics.		
Manias, E., Kinney, S., Cranswick, N. & Williams, A. 2014. Medication errors in hospitalised children.	To explore characteristics of reported medication errors occurring among children in an Australian children"s hospital, and to examine the types, causes, and contributing factors of medication errors.	**Sample:** 2753 medication errors reported at an Australian tertiary children"s hospital from 1 July 2006 to 30 June 2010 were evaluated. **Data collection:** Data were extracted from an online voluntary incident reporting system as well as from medical records of children. **Data analysis:** Data were analysed using SPSS version 19. Descriptive data analyses were used, including frequency counts and percentages.	➢ Misread or unread order; ➢ Bedside communication; ➢ Handover; ➢ Misinterpretation of order; ➢ Incorrect placement or misinterpretation of the decimal point; ➢ Confusing units of measurement; ➢ Telephonic communication; ➢ Illegible handwriting; ➢ Ward rounds; ➢ Generic name confusion; ➢ Trade name confusion; ➢ Incorrect labelling; ➢ Performance deficit; ➢ Miscalculation of dose or infusion rate; ➢ Knowledge deficit; ➢ Wrong amount of active medication used; ➢ Wrong medication added to infusion;	8/11

			➢ Failure to activate delivery system properly; ➢ Wrong diluent used for infusion; ➢ Wrong amount of diluent used; ➢ Inadequate screening of patient; ➢ Error in stocking; ➢ Intimidating behaviour; and ➢ Stress.	
Mohamed, N. & Gabr, H. 2010. Quality improvement techniques to control medication errors in surgical intensive care units at an emergency hospital.	To assess nurses; views of the factors contributing to medication errors and suggestions to facilitate quality improvements to medication administration processes in the surgical intensive care units.	**Sample:** 26 nurses who administered medication to 82 patients were observed during administration of about 214 medications. **Data collection:** Direct observation of medication administration was done using an observation sheet for the medication administration process. The affinity chart was used to organize the output of the brainstorming session. **Data analysis:** Descriptive statistics (number, percentage and standard deviations) were used to	➢ Factors related to the pharmacy; ➢ Medications not available; ➢ Insufficient number of professional nurses; ➢ Decrease in resources; ➢ Poor communication between pharmacists and nurses; ➢ Absence of guidelines for drug administration in the unit; ➢ Many patients in the unit; ➢ Care for a large number of critical patients; ➢ A large number of medications to be administered at the same time; ➢ Physician handwriting not clear; ➢ Physician not available for	7½/10

		describe data.	medication clarification; ➢ Lack of knowledge regarding drugs; ➢ Lack of job satisfaction; ➢ High workload; ➢ Still administrating medications when stopped by physician; ➢ Interruptions during administration; ➢ Nurses giving more than three drugs at the same time for more than three patients; ➢ Poor communication between physicians and nurses; ➢ Lack of experience; ➢ Lack of supervision from head nurses; ➢ Transcribing medication during shift changes; ➢ Nurse shortages; ➢ Not following the five rights of medication administration; and ➢ Confusing similar drugs.	
Mrayyan, M.T. 2012. Reported	To investigate the reported incidence, causes, and	**Sample:** 212 Registered nurses from four teaching hospitals in the Jordan completed the survey.	➢ Labels/packaging are of poor quality or damaged; ➢ The nurse sets up or adjusts an	11/12

incidence, causes, and reporting of medication errors in teaching hospitals in Jordan: A comparative study.	reporting of medication errors, as perceived by the registered nurses and to compare these variables between ICUs and wards of teaching hospitals.	**Data collection:** A modified Gladstone"s scale was used to collect data, including sections on nurses" self-reported perceptions of causes of medication errors, incidence of reported medication administration errors, six clinical scenarios and nurses" views on reporting medication errors. A demographics page was also included. **Data analysis:** Data were analysed using the SPSS Inc. 2008. Descriptive statistics were generated. Non-parametric statistics were used. Chi-square tests were used to generate comparisons.	infusion device incorrectly; ➢ The nurses are confused by the different types and functions of infusion devices; ➢ The nurse fails to check the patient"s name band with the Medication Administration Record; ➢ The nurses are distracted by other patients, co-workers or events in the unit; ➢ The physician prescribes the wrong dose; ➢ The nurses are tired and exhausted; ➢ The physician"s writing is difficult to read or illegible; and ➢ There is confusion between two medications with similar names.	
Mrayyan, M.T. & Al-Atiyyat, N. 2011. Medication errors in University-Affiliated	To investigate medication errors in teaching hospitals in Jordan as perceived by registered nurses.	**Sample:** 171 nurses from University-Affiliated Teaching Hospitals and 98 nurses from Non-University-Affiliated Teaching Hospitals completed the survey. **Data collection:** A modified	➢ Medication labels/packaging are of poor quality or damaged; ➢ Nurses set up or adjust an infusion device incorrectly; ➢ Nurses are confused by the different types and functions of infusion	10/12

Teaching Hospitals as compared to Non-University-Affiliated Teaching Hospitals in Jordan.	More specifically, to compare medication errors in university-affiliated teaching hospitals with those in non-university affiliated teaching hospitals.	Gladstone‟s scale was used to assess medication errors measuring nurses‟ perceived causes of medication errors, knowledge of medication error and views on reporting of medication errors. A demographics section was also included. **Data analysis:** SPSS 16.0 for Windows was used to render descriptive statistics. Comparisons were made between the two hospital groups.	devices; ➢ Nurses fail to check the patient‟s name band with the medication administration record; ➢ Nurses are distracted by other patients, co-workers or events in the unit; ➢ Physicians prescribe the wrong dose; ➢ Nurses are tired and exhausted; ➢ Physician‟s writing on the doctor‟s order form is difficult to read or illegible; ➢ Nurses miscalculate the dose; and ➢ There is confusion between two medications with similar names.	
Mrayyan, M.T., Shishani, K. & Al-Faouri, I. 2007. Rate, causes and reporting of medication errors in Jordan:	To describe Jordanian nurses‟ perceptions about various issues related to medication errors.	**Sample:** A convenient sample of 799 Jordanian registered nurses was recruited from governmental teaching hospitals, eleven government and eleven private hospitals in Jordan. **Data collection:** The Modified Gladstone‟s scale was used to	➢ Medication labels/packaging are of poor quality or damaged; ➢ Nurses are confused by different types and functions of infusion devices; ➢ Nurses are distracted by other patients, co-workers or events on the unit;	9/12

nurses' perspectives.		collect data on rate, causes and reporting of medication errors. A demographics form was developed to identify demographic characteristics of the sample. **Data analysis:** Data were analysed using SPSS version 11.5. Descriptive statistics were generated for all variables. A total score for medication errors was calculated and different types of hospitals and areas of work were compared using chi-squared tests.	➢ Infusion devices are set up or adjusted incorrectly; ➢ Nurses being tired and exhausted; ➢ Nurses fail to check the patient"s name band with the medication administration record; ➢ The wrong dose is prescribed; ➢ Medications with similar names are confused; ➢ The physician"s handwriting is difficult to read or illegible; and ➢ Miscalculation of dosages.	
Murphy, M. & While, A. 2012. Medication administration practices among children's nurses: a survey.	To examine the medication administration practices of children"s nurses in one children"s hospital.	**Sample:** All 140 children"s nurses from the sampled hospital. **Data collection:** A survey consisting of five sections related to medication administration practices, reporting errors, causes of medication errors, practice and administration of medications and demographics were used. **Data analysis:** SPSS: v16.0 was used while and open-ended	➢ Trade name confusion; ➢ Similar names of medications; ➢ Similar packaging of medications; ➢ Incorrect patient identification on medication order; ➢ Limited knowledge about medication; ➢ Limited confidence with new equipment/skill; ➢ Miscalculation of dosage; ➢ Workload stress;	9½/12

		question was analysed thematically. No further information on data analysis was provided in the article.	➢ Fatigue/lack of sleep; ➢ Lighting inadequacies; ➢ Noise level; ➢ Frequent interruptions and distractions; ➢ Staffing; ➢ Junior nurses lacking confidence in challenging more senior staff; and ➢ Poor communications across the multidisciplinary team (nurse, pharmacist and doctor).	
Olds, D.M. & Clarke, S.P. 2010. The effect of work hours on adverse events and errors in health care.	To explore links between work hours and both adverse events and errors experienced by patients and healthcare workers.	**Sample:** 11516 registered nurses from 188 Pennsylvania hospitals. **Data collection:** Secondary analysis of anonymous surveys from 1999. **Data analysis:** Descriptive analyses were used. Logistic regression was used to obtain odds ratios for nurse-reported occurrence of events in the previous year in relation to work	➢ Working over 40 hours in the average week.	10/12

		hours. Stata versions 9.0 and 10.0 were used for all analyses.		
Oshikoya, K.A., Oreagba, I.A., Ogunleye, O.O., Senbanjo, I.O., MacEbong, G.L. & Olayemi, S.O. 2013. Medication administration errors among paediatric nurses in Laos public hospitals: An opinion survey.	To investigate the self-reported experience of medication administration errors (MAEs) among nurses working in paediatric units of the public hospitals in Lagos, Nigeria.	**Sample:** 75 nurses working in public hospitals in Lagos. **Data collection:** A questionnaire focusing on demographic information, MAEs experienced by nurses, medication error reporting and possible interventions to reduce occurrence of MAEs were used. **Data analysis:** No information disclosed in article. Statistical analysis was evident.	➢ Increased workload due to high patient-to-nurse ratio; ➢ Not double-checking of drug doses by another nurse; ➢ Lack of detailed information about the patient; ➢ Working long shift hours; ➢ Handling drugs or patients with similar names; ➢ Distractions and interruptions; ➢ Unclear/ambiguous prescriptions; ➢ Preparing many medications for many patients; ➢ Wrong medication supplied by the pharmacy; ➢ Insufficient knowledge about the medication; and ➢ Malfunctioning dispensing equipment.	8½/12
Paquet, M., Courcy, F., Lavoie-Tremblay,	To link the field of evidence-based knowledge	**Sample:** 795 healthcare workers from 13 different care units of an affiliated health centre in the	➢ Staff absenteeism; ➢ Nurse/patient ratio; and ➢ Overtime.	9½/12

M., Gagnon, S. & Maillet, S. 2013. Psychosocial work environment and prediction of quality of care indicators in one Canadian health center.	production via research to the field of decision making, by providing an effective model of intervention to improve safety and quality indicators.	province of Quebec, Canada. **Data collection:** A survey packet including the psychological climate questionnaire, the Siegrist‟s effort/reward imbalance questionnaire, social support subscales from the Job Content Questionnaire, administrative and patient outcome data as well as a demographics section were used. **Data analysis:** Descriptive analyses and data transformation were conducted using SPSS 17.0. Structural equation modelling was used to describe relationships between sets of variables.		
Patrician, P.A. & Brosch, L. 2009. Medication error reporting and the work environment in a	To assess civilian and military nurses‟ perceptions of the reasons for medication errors, reasons for not reporting errors,	**Sample:** All civilian, military and contract nurses who worked at least two days per week at a large military medical centre were invited to participate, of which 43 completed the survey and 11% completed daily coupons for four	➢ Frequent change in physicians‟ orders; ➢ Interruptions while administering medications; ➢ Lack of knowledge of new medications; ➢ Similarly named medications;	9/12

military setting.	and extent of underreporting; to assess the differences between anonymous reports of medication errors and the reports generated via the current formal unusual occurrence reporting system; and to examine the relationship of the nursing work environment and error reporting.	weeks. **Data collection:** A cross-sectional survey, longitudinal surveys, formal unusual occurrence reports and an existing database containing shift-based staffing information were used. **Data analysis:** Statistical analysis including bivariate analysis of factors that predict medication errors using generalized estimating equations and logistic regression analysis of factors that predict medication errors.	➢ Incorrect dosages delivered to the patient care unit; ➢ Legibility of physician"s orders; ➢ Lack of adherence to proper procedure; ➢ Abbreviations; ➢ Lack of knowledge of allergies; ➢ Equipment malfunction; ➢ Inability to administer medications in the allotted time; and ➢ Low nurse-to-patient ratio.	
Patrician, P.A., Loan, L., McCarthy, M. & Fridman, M., Donaldson, N., Bingham, M. & Brosch, L.R.	To demonstrate the association between nurse staffing and adverse events at the shift level.	**Sample:** 115062 consecutive shifts were evaluated. **Data collection:** At the end of every shift, a designated unit staff member entered hours worked by each provider type and staff category into a standardized	➢ Staffing level, especially low levels of registered nurses per shift; ➢ High patient-to-nurse ratio; and ➢ High acuity levels.	9½/10

2011. The association of shift-level nurse staffing with adverse patient events.		database housed on a unit computer. The institutional incident reports were reviewed by trained on-site nurses. **Data analysis:** Bayesian hierarchical logistic regression modelling was used to examine associations between staffing and adverse events.		
Pham, J.C., Story, J.L., Hicks, R.W., Shore, A.D., Morlock, L.L., Cheung, D.S., Kelen, G.D. & Pronovost, P.J. 2008. National study on the frequency, types, causes, and consequences of voluntary reported	To examine the frequency, types, causes, and consequences of voluntarily reported ED medication errors in the United States.	**Sample:** 13932 medication errors were evaluated. **Data collection:** All records from MEDMARX that occurred in the Emergency Department from 2000 and 2004 were used to obtain specific data on hospital and medication error characteristics. **Data analysis:** Descriptive statistics were used to summarize hospital and medication error characteristics.	➢ Procedure/protocol not followed; ➢ Communication lapses; ➢ Abbreviation use; ➢ Transcription inaccurate/omitted; ➢ Calculation errors; ➢ Dispensing device involved; ➢ Computer entry; ➢ Handwriting illegible/unclear; ➢ Verbal orders; ➢ Performance deficit; ➢ Knowledge deficit; ➢ Distractions; ➢ An increase in workload; ➢ Emergency situations; ➢ Inexperienced staff;	8/9

emergency department medication errors.			➢ Patient transfers; ➢ No pharmacy assistance available; ➢ No access to patient information; and ➢ Shift changes.	
Picone, D.M., Titler, M.G., Dochterman, J., Shever, L., Kim, T., Abramowitz, P., Kanak, M. & Qin, R. 2008. Predictors of medication errors among elderly hospitalized patients.	To describe the type and number of medication errors experienced by hospitalized elderly patients and to determine what factors are predictive of medication errors, considering patients‟ characteristics, patients; clinical conditions, interventions, and characteristics of the nursing unit.	**Sample:** 10187 hospitalizations of patients at risk for falling were evaluated. **Data collection:** Data were abstracted from six electronic data repositories at the sampled medical centre: The Medical Record Abstract File, Nursing Information System, Census, Nursing Staffing System, Pharmacy Billing and Incident Reporting System. **Data analysis:** Generalized Estimating Equations were applied using SAS/Stat software, Version 9 of SAS.	➢ Patient-to-nurse ratio.	8½/10
Rinke, M.L.,	To identify patterns	**Sample:** 310 paediatric	➢ Performance deficit;	8/9

Shore, A.D., Morlock, L., Hicks, R.W. & Miller, M.R. 2007. Characteristics of pediatric chemotherapy medication errors in a national error reporting database.	in paediatric chemotherapy errors, including the types of medications involved, types of errors created, causes, level of harm of errors, location of errors, and characteristics of associated facilities.	chemotherapy medication errors reported on the MEDMARX database from January 2005 to December 2004 were evaluated. **Data collection:** Data were retrieved from the USP MEDMARX database, a voluntary, internet-accessible error reporting system. **Data analysis:** Minitab software was used for analysis. Significance of trends across categorical variables was tested with chi-square tests and STATA 8.0 statistical software.	➢ Equipment and medication delivery devices; ➢ Knowledge deficit; ➢ Written order errors; ➢ Miscommunication; ➢ Brand name similarities; and ➢ Stress or high workload.	
Roche, M., Diers, D., Duffield, C. & Catling-Paul, C. 2010. Violence toward nurses, the work environment and patient outcomes.	To relate nurses‟ self-rated perceptions of violence (emotional abuse, threat, or actual violence) on medical-surgical units to the nursing working environment and to	**Sample:** 3099 nurses and 94 randomly selected medical and surgical wards in 21 public hospitals across two Australian states were sampled. **Data collection:** Two self-reported surveys, viz. individual nurse data and the Environmental Complexity Scale were used. Staffing data were obtained from	➢ Physical violence towards nurses; ➢ Emotional abuse towards nurses; and ➢ Threat of violence towards nurses.	8½/12

	patient outcomes.	the ward roster-schedule records while adverse events data were collected from medical records or adverse events reporting mechanisms. **Data analysis:** SPSS version 16 was used for statistical analysis, comprising of descriptive statistics, statistical modelling and Poisson regression models.		
Scott-Cawiezell, J.S., Pepper, G.A., Madsen, R.W., Petroski, G., Vogelsmeier, A. & Zellmer, D. 2007. Nursing home error and level of staff credentials.	To determine the impact of various levels of credentialing among nursing home staff who deliver medications.	**Sample:** 3194 medication dosages were observed in five mid-western nursing homes. **Data collection:** Naïve observation of medication administration was conducted. **Data analysis:** Statistical comparison of error rates by credentialing was done using the generalized linear modelling package.	➢ Interruptions.	6½/8
Sears, K., O'Brien-Palla, L., Stevens, B. &	To determine the factors within the nursing work	**Sample:** 372 nurses from eighteen randomly selected units in three tertiary university-affiliated	➢ Workload; ➢ Distractions; ➢ Ineffective communication;	9½/12

Murphy, G.T. 2013. The relationship between the nursing work environment and the occurrence of reported paediatric medication administration errors: a Pan Canadian study.	environment that contributed to the occurrence of paediatric medication administration errors.	paediatric health care centres in Canada participated in the study. **Data collection:** A paediatric medication administration error survey tool including questions on the type of error, the medication administration right violated, the environmental factors that contributed to the error and the level of severity of the error was used. Unit level objective data on the nursing work environment were also collected weekly to bi-weekly. **Data analysis:** No clear description of data analysis was provided, though evidence from descriptive and inferential statistics were presented, as were results from a factor analysis and Poisson regression.	➢ Documentation; ➢ Inadequate staffing; ➢ Fatigue; ➢ Lack of information; ➢ Inexperienced staff; ➢ Shift change/hand over; ➢ Equipment/supplies; ➢ Knowledge deficit; ➢ Insufficient training; and ➢ Overtime.	
Shahrokhi, A., Ebrahimpour, F. & Ghodousi, A. 2013.	To determine contributing factors of medication errors from the viewpoint	**Sample:** 150 registered nursed who worked in different wards of four teaching hospitals of Qazvin University of Medical Sciences	➢ Nurse-related factors such as inadequate attention; tiredness due to excessive overtime work; inadequate pharmacologic	10½/12

Factors effective on medication errors: A nursing view.	of nurses in affiliated teaching hospitals in Qazvin University of Medical Sciences.	were selected through proportional random sampling. **Data collection:** A researcher-made questionnaire was used: The first part focussing on demographic information while the second part asked for the nurses‟ viewpoint about what influences medication errors. **Data analysis:** The SPSS software was used to compare means of effect scores. Freidman tests for one-way repeated measures analysis of variance between ranks of different factors were done.	knowledge; no assessment before drug administration; shortage of time; inadequate experience; nurses‟ affective and mood problems; personal and familial problems; no job interest; and financial/economic problems; ➢ Management-related factors such as incorrect transfer of medication orders from the patient‟s file; illegibility of physician‟s orders; low nurse-patient ratio; inadequate number of staff in each working shift; and working in different shifts; and ➢ Ward environment-related factors such as heavy workload in the ward; lack of required equipment; similar drug name and label; similar drug packaging; arrangement of drugs on shelves; deviating from the ward‟s medication protocols; noise; variety of drugs used by patients; overcrowding of the treatment room;

			inadequate lighting; and the patient"s physiological condition.	
Shaw, K.N., Lillis, K.A., Ruddy, R.M., Mahajan, P.V., Lichenstein, R., Olsen, C.S. & Chamberlin, J.M. 2013. Reported medication events in a paediatric emergency research network: sharing to improve patient safety.	To create a standardised method to share and analyse medication events and subsequently describe paediatric medication errors reported in a national research network.	**Sample:** 597 incidence reports from eighteen emergency departments within the Paediatric Emergency Care Applied Research Network, were reviewed. **Data collection:** De-identified emergency department incident reports were sent to the central data coordinating centre where responses from reviewers, including incident type, subtype, severity and staff involved were reviewed. **Data analysis:** Descriptive statistics were presented from SAS/STAT software while Cochran-Mantel Haenszel Tests were used to test for associations between type of medication error and severity of patient injury.	➢ Incorrect patient information such as weight; ➢ Calculation errors; ➢ Look-alike/sound-alike medications; ➢ Failure to comply with established procedures; ➢ Communication failures; ➢ Lack of supervision; ➢ Allergies not checked; and ➢ Errors in judgement.	6½/9
Stavroudis, T.A., Shore, A.D.,	To further expand our knowledge of	**Sample:** 6749 NICU medication error reports from 163 facilities that	➢ Human factors such as human performance deficit, transcription	7½/9

Morlock, L., Hicks, R.W., Bundy, D. & Miller, M.R. 2010. NICU medication errors: identifying a risk profile for medication errors in the neonatal intensive care unit.	medication errors that affect the care of the neonate by reviewing medication errors reported to MEDMARX with the goal of identifying a risk profile for harmful medication errors in the Neonatal Intensive Care Unit (NICU).	were reported between January 1999 and 31 December 2005 were reviewed. **Data collection:** Data were collected from the United States Pharmacopeia MEDMARX reporting system. **Data analysis:** Error type, error cause and medications reported each was divided into relevant groups for analysis. Data analyses were conducted using SAS version 9.1. The significance of associations across categorical variables was tested with the Rao-Scott modified x^2 test.	error, stress and high workload; ➢ Miscommunication; ➢ Equipment and medication delivery devices; ➢ Documentation; ➢ Labelling/packaging/reference materials; ➢ Name/dosage form confusion; ➢ Contraindication; and ➢ Drug shortage.	
Tang, F., Sheu, S., Yu, S., Wei, I. & Chen, C. 2007. Nurses relate the contributing factors involved in medication	To identify and understand the contribution of errors in medication administration from a nursing perspective, so that improvements can	**Sample:** 90 female nurses identified by snowball-sampling were invited to participate. 72 participated. **Data collection:** Questionnaires were used that included three parts: Narrative description of the incident, nurse"s background and	➢ Personal neglect; ➢ Heavy workload; ➢ New staff; ➢ Unfamiliarity with medication; ➢ Complicated doctor-initiated order; ➢ Unfamiliarity with patient"s condition; ➢ Complicated prescription; and ➢ Insufficient training.	8½/12

errors.	be implemented.	contributing factors. **Data analysis:** SPSS statistical software was used for descriptive analysis of backgrounds and demographics while narrative statements were analysed through coding.		
Ulanimo, V.M., O'Leary-Kelley, C. & Connolly, P.M. 2007. Nurses' perceptions of causes of medication errors and barriers to reporting.	To describe medical-surgical nurses" perceptions of frequent causes of medication errors, of what constitutes a medication error, and of what are the barriers and empowerments to reporting. Also to explore nurses" perceptions of the	**Sample:** A convenience sample of 61 registered nurses at Veterans Affairs Medical Centre in Northern California who were working in medical-surgical units was included. **Data collection:** A modified Gladstone questionnaire was adapted for this study. It included sections on possible causes of medication errors, what percentage of all medication errors are reported, what a medication error constitutes, when reporting is	➢ Failure to check the patient"s name band with the medication administration record; ➢ Exhaustion; ➢ Wrong dose prescribed; ➢ Miscalculation of dosages; ➢ Similar drug names; ➢ Physician"s writing is illegible; ➢ Distractions by patients, co-workers or events in the unit; ➢ Difficulty in setting up, adjusting or choosing functions on the infusion device; and ➢ Medication labels/packaging is of	10½/12

	effect of physician order entry and barcode medication administration of medication errors.	required, views on medication errors and demographic information. **Data analysis:** No information given though statistical analysis was evident.	poor quality or damaged.	
Unver, V., Tastan, S. & Akbayrak, N. 2012. Medication errors: Perspectives of newly graduated and experienced nurses.	To investigate newly graduated and experienced nurses‟ perspectives concerning medication errors.	**Sample:** 87 newly graduated and 82 experienced nurses working in a military education and research hospital in Turkey were included in the study. **Data collection:** A questionnaire consisting of a demographics section and a section on nurses‟ perspectives of medication errors (rate of errors reported, reporting medication errors, causes of medication errors and the nurse‟s views about reporting medication errors) was used. **Data analysis:** The SPSS 15.0 software was used for analyses. Descriptive statistics was provided. The chi-squared test and t-test was	➢ Nurses being tired and exhausted; ➢ Distractions by patients, co-workers or events in the unit; ➢ Nurses failing to check the patient‟s name band with the medications; ➢ Confusion between drugs with similar names; ➢ Dose miscalculations; ➢ Prescription of wrong dosages; ➢ Incorrect use of an infusion device; ➢ Nurses are confused by different types and functions of infusion devices; ➢ Physician‟s writing on the doctor‟s order form is difficult to read or illegible; and ➢ Medication labels/packaging are of poor quality or damaged.	8½/12

		used to compare the newly graduated nurse perspectives with those of the experienced nurses.		
Valdez, L.P., De Guzman, A. & Escolar-Chua, R. 2013. A structural equation modelling of the factors affecting student nurses' medication errors.	To explore the determinants of student nurses" medication error.	**Sample:** 400 randomly selected junior and senior nursing students who completed the course in pharmacology and routinely administer medications within a university-based tertiary hospital in the Philippines. **Data collection:** A questionnaire containing a section on human and system causes of student medication error and a section measuring the adherence to the "five rights" of medication administration was used. **Data analysis:** Data were analysed with frequency, percentage and factor analysis using the SPSS version 19. Simultaneous relationships between and among latent and measured variables were	➢ Non-adherence to the five rights of medication administration; ➢ Non-adherence to the approved medication procedure; ➢ Not checking the medication card against the standing order sheet, physician"s order sheet and medication sheet; ➢ Inability to access information on medications; ➢ Incorrect dosage calculations; ➢ Medications cannot be given within an acceptable time frame; ➢ Doctor"s orders do not give clear instructions; ➢ Doctor"s orders are not legible; ➢ Abbreviations are used instead of writing medication orders completely; ➢ Medication documentation sheet is not clear;	11½/12

	examined through structural equation modelling.	➢ The medication documentation sheet is signed before medication is administered; ➢ Patients are not in the ward during medication administration rounds, thus leading to missed dosages; ➢ Drugs are prepared for many patients; ➢ High patient-to-nurse ratio; ➢ Many patients should receive the same medications; ➢ Distractions and interruptions; ➢ Several tasks are done simultaneously during medication administration; ➢ The patient"s chart is unavailable during medication administration; ➢ Look-alike medications; ➢ Look-alike medication packaging; ➢ Sound-alike medications; ➢ Mental lapses; ➢ Limited knowledge about medications; ➢ Insecurities about clinical

			competencies; ➢ Exhaustion; ➢ Communication between healthcare personnel is poor; and ➢ Interpersonal problems with patients.	
Valentin, A., Capuzzo, M., Guidet, B., Moreno, R., Metnitz, B., Bauer, P. & Metnitz, P. 2009. Errors in administration of parenteral drugs in intensive care units: multinational prospective study.	To assess on a multinational level the frequency, characteristics, contributing factors, and preventive measures of administration errors in parenteral medication in intensive care units.	**Sample:** All nurses and physicians on duty during the study period in 113 participating units from 27 countries were asked to participate. All patients staying in the participating units during the 24 hours study period were included. **Data collection:** A questionnaire related to parenteral medication error was completed by participating nurses and physicians. Demographic information and information regarding the severity of illness of each patient were determined. Characteristics of hospital size, type and size of intensive care unit, shift schedule for nurses and	➢ Workload; ➢ Stress; ➢ Fatigue; ➢ Recently changed drug name; ➢ Communication (written and oral); ➢ Experience deficit; ➢ Knowledge deficit; ➢ Lack of supervision; ➢ Violation of protocol; ➢ Equipment failures; ➢ High patient acuity; ➢ Higher levels of care required; and ➢ High patient-to-nurse ratio.	8½/9

		physicians, numbers of nurses and physicians appointed to each shift, number of occupied beds, maximum number of patients in each shift, and number of admitted and discharged patients in each shift were recorded. **Data analysis:** SAS version 9.1 was used for statistical analysis. Odds ratios were calculated with a dichotomous outcome variable and univariate logistic regression were used to evaluate associations between unit and patient characteristics and outcomes.		
Vazin, A. & Delfani, S. 2012. Medication errors in an internal intensive care unit of a large teaching hospital: a direct	To reveal the frequency, type and consequences of all types of medication errors in an ICU of a large teaching hospital.	**Sample:** 307 doses of prescribed medications (5785 opportunities for error) administered to 38 patients through 38 shifts were observed in a teaching hospital in Shiraz, Iran. **Data collection:** Data were collected by direct observation utilizing a data collection form designed for the study.	➢ Rule violations; ➢ Slips and memory lapses; ➢ Lack of knowledge; ➢ Preparation error; ➢ Faulty dose checking; ➢ Communication lapses between health services; ➢ Lack of patient information; ➢ Drug stocking and delivery	8/9

observation study.		**Data analysis:** Data were processed using SPSS software version 11.0. Chi-squared, Fisher, or t-tests were conducted to identify associations while logistic regression was used to determine the impact of parameters on drug error.	problems; ➢ Transcription error; ➢ Inadequate monitoring; and ➢ Infusion pump problems.	
Vazin, A., Zamani, Z. & Hatam, N. 2014. Frequency of medication errors in an emergency department of a large teaching hospital in southern Iran.	To assess medication error rates, and types of medication errors occurring in the emergency department in a teaching hospital in Iran.	**Sample:** A total of 202 patients were studied over a three-month period. The total number of prescriptions ordered for these patients was 1031 doses. **Data collection:** Disguised direct observation was used to identify medication errors. In addition, data were collected with regards to the patients‟ demographic information as well as the nurses‟ personal information. **Data analysis:** SPSS-21 software was used to determine percentages, means, and standard deviations.	➢ Nurse-to-patient ratio; and ➢ Lack of experience.	8½/10

Volpe, C.R.G., Pinho, D.L.M., Stival, M.M. & De Olivera Karnikowski, M.G. 2014. Medication errors in a public hospital in Brazil.	To describe the analysis of the frequency, type and risk factors related to errors in the preparation and administration of medications in patients admitted to a public hospital in the Federal District capital of Brazil.	**Sample:** Sixteen nurse technicians and eight nurses were observed while administering 484 medication doses in the clinical medicine unit of the Regional Hospital Ceilándia. **Data collection:** Data about the unit was gathered regarding the profile of drug use and the profile of workers. Direct observation was recorded using a semi-structured protocol including sections on nurse socio-demographic data, observation period, medication data, administration data and prescription data. **Data analysis:** SPSS version 18.0 was used to derive descriptive statistical data. Chi-squared and Mann-Whitney tests were conducted to determine associations between variables.	➢ Interruptions; ➢ Not labelling medications; and ➢ High patient-to-nurse ratio.	6½/9
West, N.,	To use the	**Sample:** 906 patients on patient-	➢ Communication;	8/9

Nilforushan, V., Stinson, J., Ansermino, J.M. & Lauder, G. 2014. Critical incidents related to opioid infusions in children: a five year review and analysis.	collected information to make recommendations to support changes in practice in order to improve the safety and quality of analgesia for children receiving opioid infusions in the future and to determine whether involvement of the acute pain service team in a child"s care had any influence on these critical incidents.	controlled analgesia, 479 patients on epidural infusions, 389 patients receiving other pain management techniques managed on the APS database as well as 2086 orders for continuous opioid infusion were included. **Data collection:** Lists of potential critical incidents in children receiving opioid infusions were obtained from the Patient Safety and Learning System and from the pharmacy department. Demographic data, body weight, patient comorbidities, opioid indication, analgesic orders, and administration details were recorded. Charts were evaluated to determine the nature of the critical incidents where after these were classified according to a safety assessment code. **Data analysis:** Incidences were classified according to a safety	➢ Training; ➢ Environment/equipment; and ➢ Rules, policies/procedures not adhered to.

		assessment code. High rating incidents were included for root cause analysis.		
Westbrook, J.I., Woods, A., Rob, M.I., Dunsmuir, W.T.M. & Day, R.O. 2010. Association of interruptions with an increased risk and severity of medication administration errors.	To test the hypothesis that interruptions increase the risk of medication administration errors in hospitals.	**Sample:** Medication administrations to 720 patients were observed. **Data collection:** Direct observation was done by two researchers observing the same nurse and then comparing results. **Data analysis:** Logistic regression was performed to obtain the risk of at least one failure or error occurring as a function of interruptions using an equation. Further logistic regression was used to model binary outcomes for major errors.	➢ Interruptions.	8½/11
Wolf, Z.R., Hicks, R. & Serembus, J.F. 2006. Characteristics of medication errors	To describe the characteristics of medication errors made by nursing students during the administration	**Sample:** A convenience sample of student-made medication errors was obtained from reports voluntarily submitted to the USP MEDMARX database of medication errors from January	➢ Performance deficit; ➢ Procedure/protocol not followed; ➢ Knowledge deficit; ➢ Communication; ➢ Documentation; ➢ Dose form confusion;	8/9

made by students during the administration phase: a descriptive study.	phase of the medication use process as reported to MEDMARX.	1999 to December 2003. N = 1305. **Data collection:** Reports of medication errors involving students were extracted from the MEDMARX program using Crystal Report Writer (Version 9). **Data analysis:** Descriptive statistics were calculated on pick list selections to determine the corresponding percentages.	➢ Calculation error; ➢ Written order; ➢ Drug distribution system; ➢ Handwriting illegible/unclear; ➢ Dispensing device involved; ➢ Packaging/container design; ➢ Abbreviations; ➢ Brand names look alike; ➢ Brand names sound alike; ➢ Generic names look alike; ➢ Wrong use of the decimal point; and ➢ Pump malfunction;

Summary of qualitative research studies included

Authors, Year Published and Title	Purpose of the Study	Research Method (Research design; Sample, Data Collection and Analysis)	In-hospital nursing-practice-related causes of medication error identified in the study	CASP Score	Johns Hopkins Score
Aljadhey, H., Mahmoud, M.A., Hassali, M.A., Alrasheedy, A., Alahmad, A.,	To explore the perspectives of healthcare practitioners on current issues	**Sample:** Nine round table discussion groups from experts in the medication safety area were invited to participate in a one-day meeting. Participants came from government hospitals, private hospitals, academia,	➢ Absence of medication safety programs in hospitals; ➢ Multilingualism and different backgrounds of	9/10	6½/8

Saleem, F., Sheikh, A., Murray, M. & Bates, D.W. 2014 Challenges to and the future of medication safety in Saudi Arabia: A qualitative study.	about medication safety in hospitals and community settings in Saudi Arabia in order to identify challenges to improving it and explore the future of medication safety practice.	pharmaceutical industries and the Ministry of Health and included professionals from different backgrounds (nurses, pharmacists, physicians, etc.) **Data collection:** Group discussions lead to completion of a form where after a plenary discussion was conducted wherein a moderator facilitated comments and additions as well as questions. **Data analysis:** The plenary discussion was videotaped, transcribed verbatim and coded. Common themes were generated using thematic content analysis.	healthcare professionals leading to communication lapses, especially during verbal orders; ➢ Lack of communication between health-care professionals; and ➢ Work-load or inadequate number of staff.		
Nichols, P., Copeland, T., Craib, I.A., Hopkins, P. & Bruce, D.G. 2008. Learning from error: identifying contributory causes of	To study the clinical contexts contributing to harmful medication errors.	**Sample:** 45 staff members from the Fremantle Hospital, Western Australia, were approached from convenience sampling and 26 agreed to be interviewed: fifteen doctors, seven nurses and four pharmacy staff members. **Data collection:** Interviews were carried out by a single researcher, taped and transcribed, removing identifiable features. Interviews included open-ended questions and prompting for context-specific details regarding	➢ Stress; ➢ Fatigue; ➢ Being busy; ➢ Distractions; ➢ Personal or family health issues; ➢ Poor communication within the team; ➢ Lack of guidance from senior colleagues; ➢ Unfamiliar medications;	9½/10	6½/10

medication errors in an Australian hospital.		recollections of the error, contributory events and conditions, the interviewee‟s perception of the impact of the error on the patient and on him/herself and suggestions for reducing future errors. **Data analysis:** Transcripts were entered into the NUD*IST qualitative analysis software program, version 4. The first four interviews‟ transcripts were read and coded by at least two investigators to establish consistency in theme identification and to assess the validity of the interview style.	➢ Wrong drugs at the patient; ➢ Under-staffing; and ➢ Similar looking packaging.		
Pazokian, M., Tafreshi, Z. & Rassouli, M. 2014. Iranian nurses' perspectives on factors influencing medication errors.	To explore and obtain deep insight into the factors affecting medication errors based on nurses‟ perspectives and their perception of medication errors.	**Sample:** Purposeful sampling of twenty nursing staff with at least two years of work experiences on different shifts. **Data collection:** In-depth, semi-structured interviews were used, recorded and transcribed verbatim. **Data analysis:** Deductive content analysis was used: Major categories were identified first followed by development of a categorization matrix. Data were then coded into these categories.	➢ Psychological and physical issues of the nurse; ➢ Workload; ➢ Inexperience; ➢ Insufficient knowledge; and ➢ Similarity in shape packaging or name of medications.	8½/10	6½/8
Sanghera, S.,	To explore the	**Sample:** Fifteen members of staff were	➢ Interruptions;	9/10	8/9

Franklin, B.D. & Dhillon, S. 2007. The attitudes and beliefs of healthcare professionals on the causes and reporting of medication errors in a UK Intensive care unit.	attitudes and beliefs of healthcare professionals relating to the causes and reporting of medication errors in a United Kingdom (UK) intensive care unit.	purposively sampled due to their involvement in medication errors. **Data collection:** Semi-structured interviews were conducted to explore the reasons for the error, why it was reported or not and general attitudes to medication errors and their reporting. Interviews were taped and transcribed verbatim. **Data analysis:** Reason‟s accident causation model was used as a theoretical framework. Themes were identified and verified by a second researcher.	➢ Inadequate staffing; ➢ New staffing; ➢ Heavy workload; ➢ Verbal communication; ➢ Written communication; ➢ Physical health (tiredness and hunger); ➢ Knowledge deficiency; ➢ Lack of experience; ➢ Unfamiliar protocol; ➢ Not referring to protocol; ➢ Unfamiliar drug; and ➢ Unfamiliar drug chart.		
Smeulers, M., Onderwater, A.T., Van Zwieten, M.C.B. & Vermeulen, H. 2014. Nurses' experiences and perspectives on medication safety practices:	To explore nurses‟ experiences with and perspectives on preventing medication administration errors.	**Sample:** Purposive and snowball sampling used to obtain a high level of heterogeneity in twenty sampled registered nurses. **Data collection:** Semi-structured individual interviews were conducted until data saturation occurred. Interviews were recorded and transcribed verbatim. **Data analysis:** $MAX_{QDA}10$ software was utilized to code interviews independently. Consensus was reached on a coding tree.	➢ Lack of knowledge; ➢ Lack of experience; ➢ Work pressure; ➢ Nurses‟ work environment; ➢ Failure to comply with established safety practices; ➢ Written communication; and ➢ Interruptions and distractions.	8/10	7/8

an explorative qualitative study.					
Treiber,.A. & Jones, J.H. 2010. Devastatingly human: An analysis of registered nurses' medication error accounts.	To investigate the perceived causes of medication administration errors and to better understand how nurses deal with them.	**Sample:** Random sample of registered nurses in a specific state. **Data collection:** Open-ended survey questions about the error, including a description of the incident, what caused it, the feelings associated with it and any other concluding comments completed written or via e-mail. **Data analysis:** Thematic content analysis.	➢ Accurate information not provided; ➢ Business; ➢ Working double shifts; ➢ Failure to follow the five rights or protocol; ➢ Inexperience; and ➢ Failing technology.	8/10	6½/9
Vaismoradi, M., Jordan, S., Turunen, H. & Bondas, T. 2014. Nursing students' perspectives of	To describe nursing students‟ perspectives of the cause of medication errors.	**Sample:** Twenty-four nursing students from a nursing faculty in an urban area of Iran were chosen by purposeful sampling to include 2nd, 3rd and 4th year students. **Data collection:** Four focus groups were conducted. Data were captured by audio-tape, note-taking and observing of interpersonal interactions. Interviews were	➢ Under-developed skills in medication management; ➢ Knowledge deficiency; ➢ Staffing pattern – understaffing; and ➢ Verbal and written communication.	9/10	7/8

the cause of medication errors.	transcribed verbatim. **Data analysis:** Transcripts were read through several times to obtain the sense of the whole, and then subjected to content analysis.

Summary of mixed method studies included

Author, Year Published and Title	Purpose of the Study	Research Design (Research method; Sample, Data Collection and Analysis)	In-hospital nursing-practice-related causes of medication error identified in the study	Johns Hopkins Score
Hemingway, S., McCann, T., Baxter, H., Smith, G., Burgess-Dawson, R. & Dewhirst, K. 2014. The perceptions of nurses towards barriers to the safe administration of medicines in	To investigate perceptions of barriers to safe administration of medicines in mental health settings.	**Sample:** 827 registered nurses employed by South-West Yorkshire Partnership Foundation Trust, and 44 end-of-final-year mental health students from the University of Huddersfield. **Data collection:** A self-administered survey questionnaire containing seventeen closed-response items and five open-response questions was used. **Data analysis:** Mainly descriptive analyses were conducted using the APSS (Version 18). Chi-square	➢ Environmental distractions; ➢ Work-related pressure; ➢ Insufficient pharmacological knowledge; ➢ Poorly written and/or incomplete medication documentation; ➢ Inability to calculate medication dosage correctly; ➢ Poor adherence to medication regimes; and ➢ Cultural and linguistic communication barriers.	9/12

mental health settings.		analysis was carried out to assess differences in responses between mental health and student nurses. Written responses to the open-ended questions were transcribed verbatim and analysed by deductive content analysis.		
Jylhä, V., Saranto, K. & Bates, D.W. 2011. Preventable adverse drug events and their causes and contributing factors: the analysis of register data.	To answer the following questions: What are the causes of adverse drug events, and in which phase of the medication management process are the causes for adverse drug events present? How does information management affect the origin of adverse drug events? What are	**Sample:** 67 statements of the National Supervisory Authority for Welfare and Health from 2001-2007 were used. **Data collection:** A copy of all relevant patient records and information regarding the event, health care organization, health professional, reasons for complaint, outcomes of complaint and conclusions were collected. **Data analysis:** Content analysis revealed seven themes of causes of adverse drug events and ten themes of contributing factors. These themes were quantified and descriptive statistics were used to examine the	➢ Human factors such as technical and calculation errors, look-alike drugs and documentation of medication data; ➢ Poor communication; and ➢ Failure to use the guidelines.	8/9

	the contributing factors for adverse drug events in information management?	characteristics of these adverse drug events. Cross tabulation was used to represent the joint frequency distributions of variables. SPSS for Windows version 14.0 was used for statistical analysis.		
Maiden, J., Georges, J.M. & Connelly, C.D. 2011. Moral distress, compassion fatigue and perceptions about medication errors in certified critical care nurses.	To describe the levels of moral distress, compassion fatigue, perceptions about medication errors and nurse characteristics in a national sample of certified critical care nurses, to examine the relationships between moral distress, compassion fatigue, perceptions	**Sample:** A purposive sample of 1000 certified critical care nurses who were members of the American Association of Critical-Care Nurses and involved in patient care delivery within the previous twelve months were sent quantitative mailed surveys, while a subset of the sample consisting of five certified critical care nurses were recruited to participate in a one-time focus group. **Data collection:** Materials for collecting quantitative data included a nurse demographic questionnaire, the Moral Distress Scale, the Professional Quality of Life Scale, and the Medication Administration	➢ Physician communication; ➢ Medication packaging; ➢ Nurse staffing; ➢ Transcription related errors; and ➢ Pharmacy process.	9/12

	about medication errors and nurse characteristics in this group and to obtain a deepened understanding of the certified critical care nurses‟ experience of moral distress, compassion fatigue and perceptions about medication errors.	Error Survey. Qualitative data were collected during a focus group session. **Data analysis:** Descriptive and correlational statistics were used to analyse quantitative data while themes were identified from the transcribed focus group session.		
Ozkan, S., Kocaman, G, Ozturk, C. & Seren, S. 2011. Frequency of pediatric medication administration errors and	To use an Organizational Accident Model systems approach to identify the frequency of paediatric medication administration errors and factors	**Sample:** 2344 medication doses administrated by nurses were observed, while 25 nurses were interviewed. **Data collection:** An observation sheet indicating the date and time of observation, name of the patient, medication, dose, route and time of administration, and errors were used. Observations covered all the	➢ Procedures not followed; ➢ Slips; ➢ High workload; ➢ Absence of protocols; ➢ Late arrival of medications from the pharmacy; ➢ Interruptions; ➢ Inexperience; ➢ High patient acuity; ➢ Equipment problems such as the	8/10

contributing factors.	that contribute to errors in the working environment.	medication that were prepared and administered by each of the 25 nurses during one day and one night shift. The physician"s order, nurse"s medication administration record and medication cards were compared with each other. A semi-structured interview guide containing questions on management mechanisms, the working environment and the individual was used during the interviews. **Data analysis:** Frequencies of errors were described as percentages. Observation data were used to describe unsafe acts and contributing factors and classified by two researchers. Themes were developed from the interview data.	infusion pump not being suitable for the administration; and ➢ Misinterpretation of protocols.	
Prakash, V., Koczmara, C., Savage, P., Trip, K., Stewart, J., McCurdie, T.,	To assess the effects of interruptions on medication verification and	**Sample:** Eighteen and nineteen oncology nurses were respectively observed during the pre-intervention and post-intervention high-fidelity simulation experiments while nine	➢ Interruptions.	8/10

Cafazzo, J. & Trbovich, P. 2014. Mitigating errors caused by interruptions during medication verification and administration: interventions in a simulated ambulatory chemotherapy setting.	administration errors, and design and test the effectiveness of targeted interventions at reducing these errors.	oncology nurses participated in the focus groups and iterative design. **Data collection:** Observers documented errors on an Excel worksheet containing a list of all tasks to be performed by the participants during the high-fidelity simulation experiments. Observers compared notes after each session to ensure consensus. Qualitative input regarding nurses‟ impressions of the potential effectiveness, uptake and feasibility of implementation of interventions were gathered during each focus-group session. **Data analysis:** Statistical analyses of quantitative data were performed using SPSS V.18.0. McNemar‟s x^2 test and Fisher‟s exact test were used to assess differences in error rates between different conditions in the experiment phase. No information regarding qualitative analysis was provided.

Treiber, L.A. & Jones, J.H. 2012. Medication errors, routines, and differences between perioperative and non-perioperative nurses.	To understand registered nurses‟ perceptions of the causes and context of and emotional responses to medication errors.	**Sample:** A random sample of 2500 nurses drawn from a list of the names and mailing addresses of all registered nurses in Georgia was used. **Data collection:** Survey booklets with non-traceable return envelopes were sent out. The option of completing the survey online at a password-secured site was given to the participants. Reminder postcards were sent within six weeks of the initial mailing. The survey contained basic demographics and a section of multiple-choice items, as well as qualitative items with a request to describe the medication errors and situational context. **Data analysis:** Descriptive statistics were used to compare survey responses by nurses in perioperative roles with those given by nurses in non-perioperative roles. Qualitative written accounts were analysed using	➢ Illegible or unclear handwriting by the physician; ➢ Unclear oral orders; ➢ Look-alike/sound-alike medications; ➢ Not following the five rights; ➢ Insufficient staffing; ➢ High patient acuity levels; ➢ High patient-nurse ratio; ➢ Nurse incompetence; ➢ Insufficient training; ➢ New graduate status; and ➢ A large number of medication to be administered at peak times.	8½/12

Benner"s interpretive model.

Summary of systematic reviews included

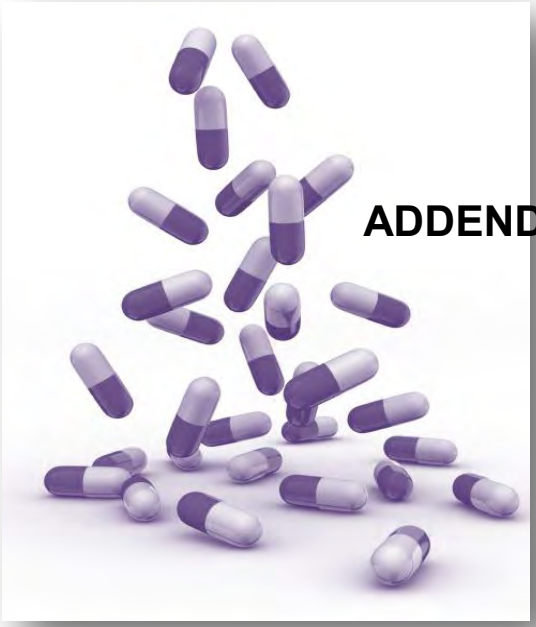
Author, Year Published and Title	Purpose of the study	Search strategy (key words, databases used, sample size and sources overlapping with current study)	In-hospital nursing-practice-related causes of medication error identified in the study	Johns Hopkins Score
Biron, A.D., Loiselle, C.G. & Lavoie-Tremblay. 2009b. Work interruptions and their contribution to medication administration errors: an evidence review.	To review the evidence on the rates, characteristics, and potential contribution of work interruptions to medication administration errors.	**Key words:** Distractions, interruptions, task performance and analysis, nursing care, decision making, nursing process, system analysis, time and motion studies, medication systems, medication errors, safety management, medication administration, drug administration, nursing staff, health personnel, nurses, personnel, hospital. **Databases used:** Embase Ovid, Medline Ovid, Psychinfo Ovid, CINAHL Ebsco. **Sample size:** 23 studies. **Overlapping sources:** ➢ Scott-Cawiezell, J.S., Pepper, G.A., Madsen, R.W., Petroski, G., Vogelsmeier, A. & Zellmer, D. (2007).	**Already identified:** ➢ Interruptions. **Newly-identified causes:** None.	6½/7
Keers, R.,	To	**Key words:** Errors, medication errors,	**Already identified:**	6/7

Williams, S.D., Cooke, J. & Ashcroft, D.M. 2013a. Causes of medication administration errors in hospitals: a systematic review of quantitative and qualitative evidence.	systematically review and appraise the empirical evidence available relating to the causes of medication administration errors in hospital settings.	treatment errors, medication safety, drug safety, preventable adverse event, adverse event, medical error, clinical incident, adverse drug event, adverse health care event, health care error, medication incident, cause, factor, reason, aetiology, causality, predictor, association, drug/medication/medicine delivery, omission, drug utilisation, commission, drug/medication/medicine supply, drug/medication/medicine handling, self-medication, and self-administration, **Databases used:** MEDLINE, EMBASE, International Pharmaceutical Abstracts, Cumulative Index for Nursing and Allied Health Literature, PsycINFO, Health Management Information Consortium, Social Science Citation Index, British Nursing Index and Applied Social Sciences Index and Abstracts. **Sample size:** 22 studies. **Overlapping sources:** ➢ Sanghera, S., Franklin, B.D. & Dhillon, S. (2007).	➢ Slips and lapses; ➢ Look-alike, sound-alike medications; ➢ Being too busy; ➢ Not documenting directly after administration of medication; ➢ Heavy workload; ➢ Poor staffing; ➢ Stress; ➢ Knowledge-deficiency; ➢ Violations of protocol; ➢ High patient acuity; ➢ Poor supervision; ➢ Calculation errors; ➢ Difficulties with infusion equipment; ➢ Non-cooperation from patients; ➢ Absence of a policy; ➢ Problems with equipment; ➢ Fatigue, tiredness or sleep deprivation; ➢ Lack of training; ➢ Little experience; ➢ Communication lapses;

		➢ Tang, F., Sheu, S., Yu, S., Wei, I. & Chen, C. (2007). ➢ Treiber,.A. & Jones, J.H. (2010). ➢ Vazin, A. & Delfani, S. (2012).	➢ Illegible prescriptions; ➢ Distractions; ➢ Interruptions; ➢ Lack of ward stock; ➢ Incorrect dispensing or delayed pharmacy dispensing; and ➢ Working overtime. **Newly-identified causes:** ➢ None.	
Metsälä, E. & Vaherkoski, U. 2013. Medication errors in elderly acute care – a systematic review.	To determine what kind of medication errors happen in elderly acute care.	**Key words:** Pharmacy, drugs, medical error, medical deviation, elderly, nursing, acute care, intensive care. **Databases used:** CINAHL, Medline, Cochrane, JBI Connect+, Medic and Ohtanen. **Sample size:** Twenty studies. **Overlapping sources:** ➢ Picone, D.M., Titler, M.G., Dochterman, J., Shever, L., Kim, T., Abramowitz, P., Kanak, M. & Qin, R. (2008). ➢ Tang, F., Sheu, S., Yu, S., Wei, I. & Chen, C. (2007).	**Already identified:** ➢ Staff shortage; ➢ Lack of knowledge; ➢ Lack of skills; ➢ Lack of experience; ➢ Lack of education (especially mathematical skills and pharmaceutical knowledge); ➢ Polypharmacy; ➢ Unclear handwriting; ➢ Wrong dose prescriptions; ➢ Interruptions; ➢ Problems with use of technology; ➢ High workload; ➢ Neglect of guidelines and	5/7

			procedures; ➢ Deficiencies in policies; ➢ Lack of resources; and **Newly-identified causes:** ➢ None.	
Parry, A.M., Barriball, K.L & While, A.E. 2015. Factors contributing to registered nurse medication administration error: A narrative review.	To explore the factors contributing to registered nurse medication administration error behaviour.	**Key words:** Registered Nurse, contributing factors, and medication (administration) error. **Databases used:** Cochrane, MEDLINE, CINAHL, BNI, Embase and PsycINFO. **Sample size:** 26 studies. **Overlapping sources:** ➢ Chang, Y. & Mark, B. (2011); ➢ Picone, D.M., Titler, M.G., Dochterman, J., Shever, L., Kim, T., Abramowitz, P., Kanak, M. & Qin, R. (2008.) ➢ Unver, V., Tastan, S. & Akbayrak, N. (2012); ➢ Valentin, A., Capuzzo, M., Guidet, B., Moreno, R., Metnitz, B., Bauer, P. & Metnitz, P. (2009); and ➢ Westbrook, J.I., Woods, A., Rob, M.I., Dunsmuir, W.T.M. & Day, R.O. (2010).	**Already identified:** ➢ Staffing; ➢ High workload; ➢ Interruptions and distractions; ➢ Communication problems; ➢ Lack of experience; ➢ Educational deficiencies; ➢ Fatigue; and ➢ Stress; **Newly-identified causes:** ➢ None	6/7

Wilson, S., Bremner, A., Hauck, Y. & Finn, J. 2011. The effect of nurse staffing on clinical outcomes of children in hospital: a systematic review.	To identify any association between nurse staffing and clinical outcomes in hospitalised children.	**Key words:** Paediatric, adolescent, child, nurse, skills mix, patient ratio, workload, health manpower, workforce, outcome and process assessment, treatment outcome, fatal outcome, outcome assessment, patient outcome, patient satisfaction, adverse event, nosocomial infection, healthcare-associated infection, and mortality. **Databases used:** AMED, APAIS-Health, ATSIhealth, CINAHL, Clinical evidence, Cochrane Library, EMBASE, Informaworld, Health and Society, MEDLINE, Proquest Health and Medical, Science Direct, and Web of Knowledge. **Sample size:** Eight studies. **Overlapping sources:** None.	**Already identified:** ➢ Inadequate staff-levels. **Newly-identified causes:** ➢ None.	6/7

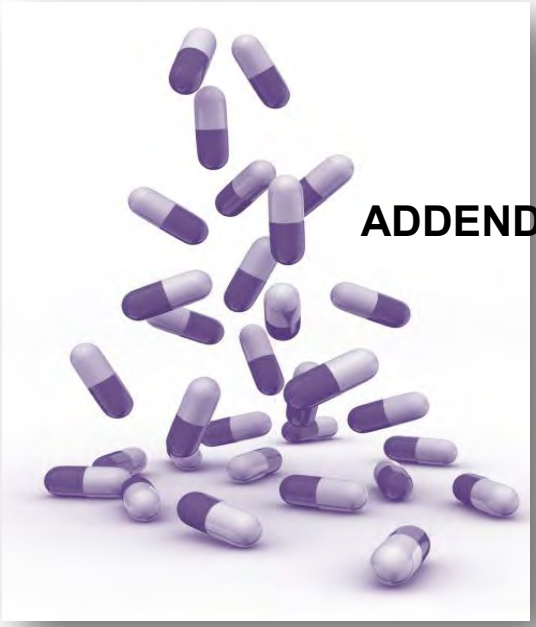


ADDENDUM X: ORIGINAL CHECKLIST FROM KIM AND BATES (2013:591)

Checklist for observing medication administration safety

		YES	NO
Right medication	Read the name of the medication indicated on the label at least once for at least one second.		
	Read the name of the medication indicated on the medication prescription at least once for at least one second.		
	The correct generic medication is chosen for administration.		
	Medication is prepared by the clinical nurse who will administer it.		
	Label the medication immediately after preparation		
Right Dose	Verify the amount of medication indicated on the label of the medication prescription at least once for at least one second.		
	Verify the amount of medication indicated on the medication prescription at least once for at least one second.		
	When using a syringe, read the markings at the eye level.		
	The correct dosage is administered		
Right Patient	Read the name of the patient on the wristband worn by the patient.		
	Ask the patient to confirm the patient‟s name.		
	Before the administration, read the name of the patient indicated on the medicine chart for at least one second.		
Right Route	Read the medication route indicated on the medicine chart at least once for at least one second.		
	The route is applicable for the relevant substance		
	Medication is administered via the correct route		
Right Time	Administer the medication at the correct time.		
	Prepare the medication right before the administration.		
Adherence to Basic infection control principles	Disinfect the hands before administering medication		
	Duration of cleaning (15-30 seconds)		
	Area of washing (Palm, wrist, back of hands, between fingers and all fingernails)		
	IV fluid bottles, bags and vials disinfected before use.		
	Sterility of needles and IV sets maintained.		
	Disinfect injection site before administering drugs.		
Recording	Administering nurse records the event		
	The actual time of the administration is accurately recorded.		
	The event is recorded only after the administration is completed.		

Notes:



ADDENDUM XI: UPDATED CHECKLIST USED FOR MEDICATION ADMINISTRATION OBSERVATIONS

Checklist for observing medication administration safety

Did an error or deviation from safe practice occur?		YES	NO
Omission	Omission		
Right medication	Label not read: Name of medication		
	Prescription not read: Name of medication		
	Wrong-medication error		
	Medications prepared and administered by different administrators		
	Medication not labelled immediately		
Right Dose	Label not read: Dose		
	Prescription not read: Dose		
	Markings of syringe not read at eye level		
	Wrong-dose error		
Right Patient	Wristband not read		
	Patient‟s name not asked		
	Patient name not read on prescription		
	Wrong-patient error		
Right Route	Prescription not read: Route		
	Route is not applicable		
	Wrong-route error		
Right Time	Wrong-time error		
	Medication not prepared directly before administration		
Adherence to Basic infection control principles	Hands not disinfected		
	Hands disinfected for less than 15 seconds		
	All areas of hands were not washed		
	IV bottles, bags and vials were not disinfected		
	Sterility of needles and IV-sets were not maintained		
	Did not disinfect the injection site		
Recording	Administering nurse did not record		
	Actual time not recorded		
	Recorded before administration was completed		

Number of medications prescribed:

Rank:

Interruptions:

Notes:

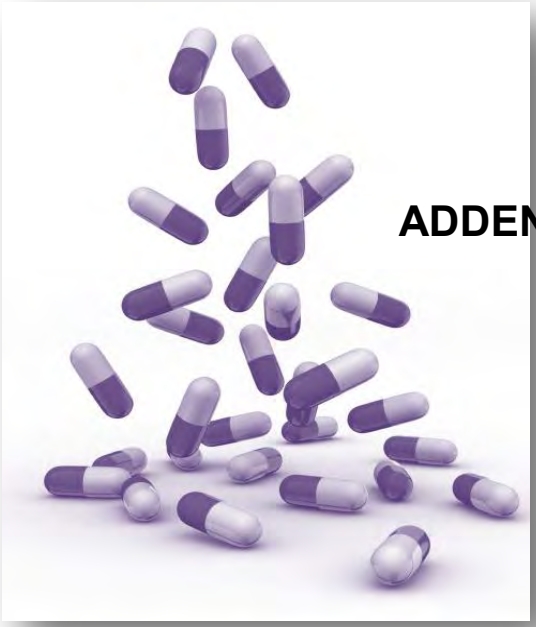
ADDENDUM XII: CALCULATIONS USED DURING KNOWLEDGE TESTING

Please answer the following questions:

1. The doctor prescribed 750 mg Rocephin IV to a patient. The vial contains 1 g. You dilute the substance with 4ml sterile water. How many millilitres will you administer?

2. Aterax 25mg / 25 kg is prescribed. One tablet = 25 mg. Your patient weighs 80kg, how many tablets will you administer?

Thank you for your time!



ADDENDUM XIII: SURVEY ADAPTED FROM AHRQ AND WAKEFIELD SURVEYS

Survey on Medication Administration Safety

This survey asks for your opinions about medication administration safety in your hospital and will take about 10 to 15 minutes to complete.

If you do not wish to answer a question, or if a question does not apply to you, you may leave your answer blank.

A. Please indicate your agreement or disagreement with the following statements about your unit.

Think about your hospital work area/unit…	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. People support one another in this unit	☐1	☐2	☐3	☐4	☐5
2. We have enough staff to handle the workload	☐1	☐2	☐3	☐4	☐5
3. When a lot of work needs to be done quickly, we work together as a team to get the work done	☐1	☐2	☐3	☐4	☐5
4. In this unit, people treat each other with respect	☐1	☐2	☐3	☐4	☐5
5. Staff in this unit work longer hours than is best for patient care	☐1	☐2	☐3	☐4	☐5
6. We are actively doing things to improve medication administration safety	☐1	☐2	☐3	☐4	☐5
7. We use more agency/temporary staff than is best for patient care	☐1	☐2	☐3	☐4	☐5
8. Staff feel like their medication administration errors are held against them	☐1	☐2	☐3	☐4	☐5
9. Mistakes have led to positive changes here	☐1	☐2	☐3	☐4	☐5
10. It is just by chance that more serious medication administration mistakes don't happen around here	☐1	☐2	☐3	☐4	☐5
11. When one area in this unit gets really busy, others help out	☐1	☐2	☐3	☐4	☐5
12. When a medication administration error is reported, it feels like the person is being written up, not the problem	☐1	☐2	☐3	☐4	☐5
13. We work in "crisis mode" trying to do too much, too quickly	☐1	☐2	☐3	☐4	☐5
14. Medication administration safety is never sacrificed to get more work done	☐1	☐2	☐3	☐4	☐5
15. Staff worry that mistakes they make are kept in their personnel file	☐1	☐2	☐3	☐4	☐5
16. We have medication administration safety problems in this unit	☐1	☐2	☐3	☐4	☐5
17. Our procedures and systems are good at preventing medication errors from happening	☐1	☐2	☐3	☐4	☐5

B. In your unit, how often would you say medication errors occur?

Never	A few times a year or less	Once a month or less	A few times a month	Once a week	A few times a week	Every day
☐1	☐2	☐3	☐4	☐5	☐6	☐7

C. Please give your unit in this hospital an overall grade on medication administration safety.

☐1	☐2	☐3	☐4	☐5
Excellent	Very Good	Acceptable	Poor	Failing

D. Reasons why medication errors might occur in your unit.

D1. Please indicate how much of a risk the following communication factors pose in causing medication administration errors in your unit:	**No risk**	**Small risk**	**Moderate risk**	**Significant risk**
1. Communication lapses between the physician and the medication administrator	☐1	☐2	☐3	☐4
2. Communication lapses between the pharmacist and the medication administrator	☐1	☐2	☐3	☐4
3. Misunderstood orders	☐1	☐2	☐3	☐4
4. Confusing instructions	☐1	☐2	☐3	☐4
5 Frequent changes in prescriptions	☐1	☐2	☐3	☐4
6. Use of abbreviations in prescriptions	☐1	☐2	☐3	☐4
7. Illegible prescriptions	☐1	☐2	☐3	☐4
8. Incomplete prescriptions	☐1	☐2	☐3	☐4
9. Cultural or language barriers between health care professionals	☐1	☐2	☐3	☐4
10. Other (Please specify): _____	☐1	☐2	☐3	☐4

D2. Please indicate how much of a risk the following human factors pose in causing medication administration errors in your unit:	**No risk**	**Small risk**	**Moderate risk**	**Significant risk**
1. Knowledge, educational or training deficit	☐1	☐2	☐3	☐4
2. Procedures or policy not followed (e.g. not checking the five rights of medication administration)	☐1	☐2	☐3	☐4
3. Inexperience	☐1	☐2	☐3	☐4
4. Slips or memory lapses	☐1	☐2	☐3	☐4
5. Psychological factors (e.g. being stressed or emotionally exhausted)	☐1	☐2	☐3	☐4
6. Physical factors (e.g. being too tired or hungry)	☐1	☐2	☐3	☐4
7. Miscalculations of dosages	☐1	☐2	☐3	☐4
8. Incorrect preparation of medications	☐1	☐2	☐3	☐4
9. Incorrect labeling of medications	☐1	☐2	☐3	☐4
10. Not documenting medication administration directly after administration	☐1	☐2	☐3	☐4
11. Other (Please specify): _____	☐1	☐2	☐3	☐4

D3. Please indicate how much of a risk the following environmental factors pose in causing medication administration errors in your unit:	**No risk**	**Small risk**	**Moderate risk**	**Significant risk**
1. Having to administer a large number of medications at peak times	☐1	☐2	☐3	☐4
2. Interruptions or distractions	☐1	☐2	☐3	☐4
3. Work overload	☐1	☐2	☐3	☐4
4. High patient to nurse ratio	☐1	☐2	☐3	☐4
5. High acuity level of patients (very ill patients)	☐1	☐2	☐3	☐4

	No risk	Small risk	Moderate risk	Significant risk
6. Inadequate staffing	☐1	☐2	☐3	☐4
7. High staff turnover (new staff)	☐1	☐2	☐3	☐4
8. Lack of supervision	☐1	☐2	☐3	☐4
9. Non-optimal learning climate	☐1	☐2	☐3	☐4
10. Working more than 40 hours per week	☐1	☐2	☐3	☐4
11. Lack of patient information	☐1	☐2	☐3	☐4
12. Uncooperative or violent patients	☐1	☐2	☐3	☐4
13. Technology failures (e.g. infusion pump problems)	☐1	☐2	☐3	☐4
14. Other (Please specify): _____	☐1	☐2	☐3	☐4

D4. Please indicate how much of a risk the following medication-related factors pose in causing medication administration errors in your unit:

	No risk	Small risk	Moderate risk	Significant risk
1. Look-alike medication labels or packaging	☐1	☐2	☐3	☐4
2. Look-alike or sound-alike medication names	☐1	☐2	☐3	☐4
3. Wrong medication provided by the pharmacy	☐1	☐2	☐3	☐4
4. Stock distribution problems – certain medications are not available at your institution	☐1	☐2	☐3	☐4
5. There is a large variety of drugs in the medicine cabinet or the medication trolleys are overstocked	☐1	☐2	☐3	☐4
6. Labels of medications are of poor quality or damaged	☐1	☐2	☐3	☐4
7. Insufficient resources such as medication glasses, etc.	☐1	☐2	☐3	☐4
8. The same medication is prescribed in different dosages	☐1	☐2	☐3	☐4
9. Generic substitution of medications (Different names for one medication)	☐1	☐2	☐3	☐4
10. Other (Please specify): _____	☐1	☐2	☐3	☐4

E. In your unit, when the following medication administration errors occur, *how often are they reported?*

	Never	Rarely	Some-times	Most of the time	Always
1. When an error is made, but is *caught and corrected before affecting the patient*, how often is this reported?	☐1	☐2	☐3	☐4	☐5
2. When an error is made, but has *no potential to harm the patient*, how often is this reported?	☐1	☐2	☐3	☐4	☐5
3. When an error is made that *could harm the patient*, but does not, how often is this reported?	☐1	☐2	☐3	☐4	☐5
4. When an error is made that *harms the patient*, how often is this reported?	☐1	☐2	☐3	☐4	☐5

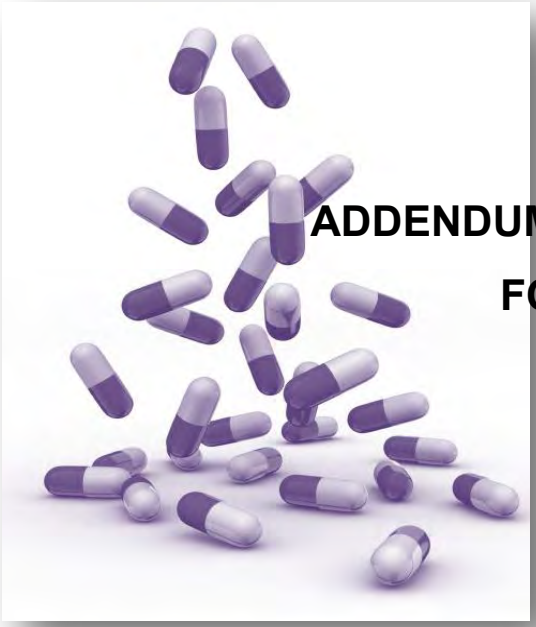
F. Reasons why medication administration errors are not reported in your unit.

Please indicate the number that best reflects the extent to which you agree that the following reasons contribute to why errors are not reported in your unit.	Strongly Disagree	Moderately disagree	Slightly disagree	Slightly agree	Moderately Agree	Strongly Agree
1. Nurses do not agree with the hospital"s definition of a medication error	☐1	☐2	☐3	☐4	☐5	☐6
2. Nurses do not recognize an error occurred	☐1	☐2	☐3	☐4	☐5	☐6
3. Filling out an incident for a medication error takes too much time	☐1	☐2	☐3	☐4	☐5	☐6
4. Contacting the physician about a medication error takes too much time	☐1	☐2	☐3	☐4	☐5	☐6
5. Medication error is not clearly defined	☐1	☐2	☐3	☐4	☐5	☐6
6. Nurses may not think that the error is important enough to be reported	☐1	☐2	☐3	☐4	☐5	☐6
7. Nurses feel that other nurses will think they are incompetent if they make medication errors	☐1	☐2	☐3	☐4	☐5	☐6
8. The patient or family might develop a negative attitude toward the nurse, or may sue the nurse if a medication error is reported	☐1	☐2	☐3	☐4	☐5	☐6
9. The expectation that medications be given exactly as ordered is unrealistic	☐1	☐2	☐3	☐4	☐5	☐6
10. Nurses are afraid the physician will reprimand them for the medication error	☐1	☐2	☐3	☐4	☐5	☐6
11. Nurses fear adverse consequences from reporting medication errors	☐1	☐2	☐3	☐4	☐5	☐6
12. The response by nursing administration does not match the severity of the error	☐1	☐2	☐3	☐4	☐5	☐6
13. Nurses could be blamed if something happens to the patient as a result of the medication error	☐1	☐2	☐3	☐4	☐5	☐6
14. No positive feedback is given for passing medications correctly	☐1	☐2	☐3	☐4	☐5	☐6
15. Too much emphasis is placed on medication errors as a measure of the quality of nursing care provided	☐1	☐2	☐3	☐4	☐5	☐6
16. When medication errors occur, nursing administration focuses on the individual rather than looking at the systems as a potential cause of the error	☐1	☐2	☐3	☐4	☐5	☐6

G. About yourself

1. Please indicate your gender ☐Male ☐Female
2. Are you working in this hospital full-time? ☐Yes ☐No
3. How old are you? ☐☐ years
4. How many years" experience do you have in administrating medication? ☐☐ years
5. How many years have you been administrating medication in this hospital? ☐☐ years
6. Please indicate your rank ☐Registered Nurse ☐Staff Nurse ☐Student Nurse ☐Other:_____
7. What is your highest level of education? ☐Master"s degree or higher ☐Degree ☐Diploma ☐Certificate ☐Grade 12

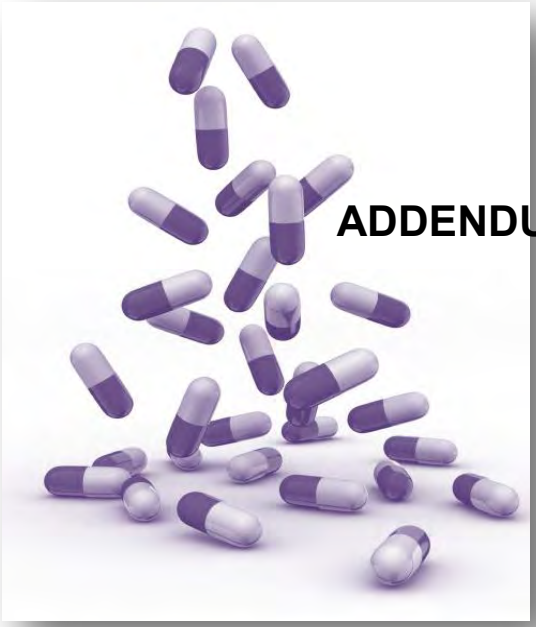
THANK YOU FOR COMPLETING THIS SURVEY.



ADDENDUM XIV: INTERVIEW SCHEDULE USED FOR SEMI-STRUCTURED INTERVIEWS

Interview schedule

7. In your opinion, what would you say causes medication errors in your unit?
8. How would you say that we can limit this risk?
9. The medication administrators also gave me a few causes of medication errors. These were high workload, stock distribution problems and illegible prescriptions. What can we do to lessen our staff‟s workload?
10. What can we do to limit the stock distribution problems?
11. What would you say we can do about the illegible prescriptions?
12. Is there anything else you would like to add that we can do to improve medication administration safety?



ADDENDUM XV: EXAMPLE OF AN INTERVIEW TRANSCRIPTION

Interview 9	
Interviewer:	So sister, thank you so much again for your time, I only have a few questions for you. In your opinion, what would you say can easily cause medication errors?
Participant:	Medication error can be caused by not reading the prescription clearly to understand what you should do before you give, and then also not identifying patients clearly, and then again the giving of expired medication to a patient, not checking, using your five right methods, before you can give your patient‟s treatment.
Interviewer:	And how would you say that we can limit this risk?
Participant:	The risk… It‟s just to adhere to the five rules of giving medication. Like you check first the expiries, you check the name of the patient, you check the prescription, whether the doctor has written right route, the right medication, the right time, and then the right patient. Mm.
Interviewer:	And how will you ensure that your staff adhere to this protocol?
Participant:	To adhere is by giving in-service training at least once a month so that you know that your staff is doing the correct thing and then especially to the newly employed again, and other in-service should be given and also to student who are coming. May have to continuously supervise them so that the errors does not happen.
Interviewer:	Thank you for that. The medication administrators also gave me a few causes of medication errors. These were high workload, stock distribution problems and illegible prescriptions. Is there something we can do to lessen our staff‟s workload?
Participant:	The staff in the ward, the other thing, this week I have been having students, second year students teaching them how to give medication. They wanted to know and then I was giving them everything, even though I haven‟t done everything, everything, but I did highlight some of the things that will danger to the patient. I did start first with mixing. How to mix medication, how it should be given. How to prevent the infections. I was giving the IV, not the oral, ne, so

	the checking of the line, putting the cap, and from the short-drip, everything. The other thing, if we can have this, the time for stuff not to be overloaded. I was telling them about a certain device that has been used especially in private hospital. I used it once in a public hospital. It is a device you put in from the vial and to the bag. That thing saves time, because with the syringe, remember you have to put it in, take it out, put it again. If the public hospital could afford, I would really go for it. Because it saves too much time for the patient. Because you find that the ward is full, you start from the other side, those patients in the other side they will be waiting. I remember last week there was one that said, „I have been waiting", but we started the other side, there is no way, there is only one person giving, so we started nearly half-an-hour before, but it is many patients. So also that will save time.
Interviewer:	Are you talking about a recon device?
Participant:	Yes. It"s quicker. We had a rep here, but the management would not go for it. I love it, but if it is only me, we won"t get it. If all of agree, then maybe… And the other thing, the oral medication ne, I could see the crushing of the tablets, it"s a problem. I see the staff-nurses having to crush the tablets, we don"t have devices to crush those tablets for patients who are not able to swallow a pill like it is. I don"t know what we should get to crush, but I remember one of the TB wards, we used to have these things to help us to crush (indicating the use of a mortar and pestle). I don"t know if this is a good thing or if you get some sort of machine to crush those medication.
Interviewer:	Thank you. Is there anything you can think of that we can do to limit the stock distribution problems?
Participant:	Eish, also that one is a really big challenge which I don"t know how to do it, because really I find that we are waiting for ward-stock which will come late in the afternoon. The rest we don"t have. Then when we phone the pharmacy again it will be a thing of no, send one of your

	staff and we are short staffed. I don‟t know how they do this. To me, I used to work in hospital X*. We used to have pharmacy assistants who delivered the medication to the floor. So it limited our time cueing at pharmacy, calling again, because to pick up a phone, and to go, it‟s a waste of time. So if you can just get more assistance to do these things. And even in the wards, we don‟t have a messenger, we, the cleaners and the staff in the ward we rotate, whoever goes down go via pharmacy and check if 1,2,3. So everyone has to leave their work to go. So messengers again, if they can do that for us, it will limit everything. Because with the pharmacy thing again, pharmacy is a lot of things. I don‟t say they don‟t do anything, but you will find the cue for the patients who need TTO, there are pharmacists who are busy with the TTOs, pharmacists who are busy with the ward-stock things, because though we have different dates of ordering, it‟s a lot. Because it depends on the load of work to them. So that‟s it. So the other day in the meeting I even asked can‟t we have two pharmacists to work with the TTO, because the patient would be discharged in the morning, then casualties will phone for a bed, but the patient is still there. He is discharged, but the medication will only come at three. At that time there is an admission, this one again is delaying, some of them will ask if they can go home, someone will come and get them, but the medication is not there. Now she will skip having medication that day. She will only take the medication the other day. So maybe if they can get someone just to do TTO‟s. Because there are many TTO‟s.
Interviewer:	Thank you for that suggestion. What are we going to do about the doctor‟s handwriting?
Participant:	Eish! That one a big, big challenge of which I don‟t know. Maybe it‟s their way of doing their training. In their training they are taught to do that. They don‟t train them well, they were busy from the first year up to the seventh year that they should write medication like this. I don‟t

	know. Because with us nurses, they teach us to write like this and like that. But to them, it is as if they don‟t touch that. And it is a big challenge. They don‟t write the dates, many papers, I can bring. Some come without a name. And then when they come to the prescription itself. It‟s written date, dosage, frequency, duration, but they won‟t fill it like it‟s written there, it‟s conducting you, but they will only choose to write ampicillin one gram eh… 8 hourly. They won‟t write five days, they won‟t write eh… the duration, whether per os, per syrups, injection, it‟s a really big challenge. But I only see during their training, they are not given that this is very very important. Because, as I remembered, when I was training of that five rule, the importance of checking before, during and after, but with the doctors, I don‟t know if they do go to that, because really, every doctor is like from the same mother, they do like that. There is no one that comes with the prescription with written everything. Worst of all, you know mos their signatures. They will just quickly and then not even read. But now it is better, I don‟t know with other hospitals, but here they have eh… done stamps for them, you can at least see the name. And then the other thing, the doctor prescribes in casualty, the patient comes to the ward. By the time the patient comes to the ward, he does not have a doctor that is going to rectify that. Then waste of time again, you have to send a nurse, go down, say to the doctor please rectify 1, 2, 3. And by then the one who wrote is gone. It‟s another doctor, who again it will be a challenge for her because it‟s full in casualty he has to come up to rectify. It is really a challenge. Will they be able to correct it? I don‟t‟ know. But we are trying, telling them, but yoo, they don‟t adhere. Maybe one should send somebody to do the research to follow up at their training so we can see there‟s the problem. Serious.
Interviewer:	Thank you for that. Is there anything else you would like to add that we can do to improve medication administration safety?
Participant:	Um, eish, safety. It is just those in-service trainings now and again

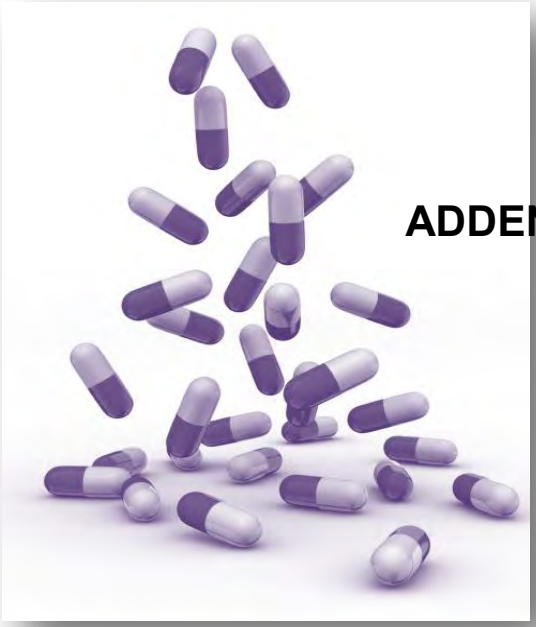
	and during their trainings they should emphasize again that this can take you far. Read and understand the side-effect things. The thing that is making the medication working correctly. When you administer IV, then you can see that your line has bubbles. So just telling, getting more information what will those air do in the patient later. It might not be now, but later if that patient is time and again a hospital patient it will come up with something. And then supervision. Supervision in the hospitals is not like the old-old. Because now they are running short of their tutors to come here and follow up. Because with us again, we are over-laboured, we don"t do thorough supervision to them doing one, two, three. Maybe because they are saying they are bringing back those tutors to come and supervise. Let the colleges to re-open to get more tutors to come and supervise the students because the ward sisters they are there, but they are overloaded. We don"t get time for these little ones to teach them properly. Maybe this will minimise this medication error. Even every error will be minimized if there is someone following them.
Interviewer:	Thank you so much, I really appreciation your time.
Participant:	All right.

*Pseudonyms

ADDENDUM XVI: AUKUH ACUITY AND DEPENDENCY TOOL

AUKUH Adult Acuity/Dependency Tool ©

Levels of Care	Inclusion Criteria	Guidance on Care Required
Level 0 Patient requires hospitalisation. Needs met through normal ward care.	Elective Medical or Surgical Admission, Routine Post Diagnostic/Surgical Procedure care, May have underlying medical condition requiring on-going treatment, Patient awaiting discharge.	Routine post-op/ post procedure care (Incl ½ hry obs until stable), Regular observations 2 - 4 hourly, ECG monitoring to establish stability, Fluid management, PCA, Oxygen therapy 24 – 40% (Specialist Surgical Areas ONLY – single chest drain). Requires routine nursing assistance
Level 1 Appropriately managed on in-patient ward but requires more than baseline resources. **Level 1a** Acutely ill patient requiring intervention or those who are **UNSTABLE** with a **GREATER POTENTIAL** to deteriorate.	Observation & Therapeutic Intervention - "Step Down" from Level 2 care, Post-Op care following Emergency or Complex Surgery, or following peri-operative event. Emergency Admission requiring immediate therapeutic intervention. Deteriorating Condition or Fluctuating vital signs.	Instability requiring continual observation/ invasive monitoring, Support of Outreach Team but **NOT** higher level of care. Oxygen Therapy greater than 40% +/- Chest Physiotherapy 2 – 6 hourly. Arterial Blood Gas analysis – intermittent. 24 - 48 hours following Tracheostomy, insertion Central lines/ Epidurals/ Chest drains.
Level 1b Patients who are in a **STABLE** condition but have an increased dependence on nursing support.	Severe Infection, Sepsis, Complex wound management. Compromised Immune system. Psychological Support/Preparation. Requires Continual Supervision. Spinal Instability / Mobility Difficulties.	Complex Drug regimes, Patient and/or carers require continued support owing to poor disease prognosis or clinical outcome. Completely dependent on nursing assistance for all activities of daily living. Constant observation due to risk of harm.
Level 2 Patients who are unstable and at risk of deteriorating and should **NOT** be cared for in areas currently resourced as general wards. (May be managed within clearly identified, designated beds, resourced with the required expertise and staffing level OR may require transfer to a dedicated Level 2 facility/unit).	Deteriorating /Compromised Single Organ System, Post-op Mgt following Major Surgery, Post operative optimisation/ extended post-op care. "Step Down" from Level 3 Care. Uncorrected Major Physiological Abnormalities.	Patients requiring Non-invasive ventilation/ resp support. Routine short-term post-operative ventilation. First 24 hrs following Tracheostomy insertion. Requires a range of therapeutic interventions including; Greater than 60% oxygen, Continuous ECG & invasive pressure monitoring, Vasoactive drug infusions (amiodarone, potassium, inotropes, GTN, magnesium), Haemodynamic instability. Pain Management ; IV analgesic infusions, CNS depression of airway & protective reflexes, Neuro monitoring.
Level 3 Patients needing advanced respiratory support and therapeutic support of mulitple organs.	Monitoring and Supportive Therapy for Compromise or Collapse of two or more Organ Systems.	Respiratory or CNS depression/ compromise requires Mechanical/ Invasive ventilation, Invasive monitoring, vasoactive drugs, treatment of hypovolaemia/haemorrhage/ sepsis or neuro protection.



ADDENDUM XVII: DEMOGRAPHICS SHEET

Hospital demographics

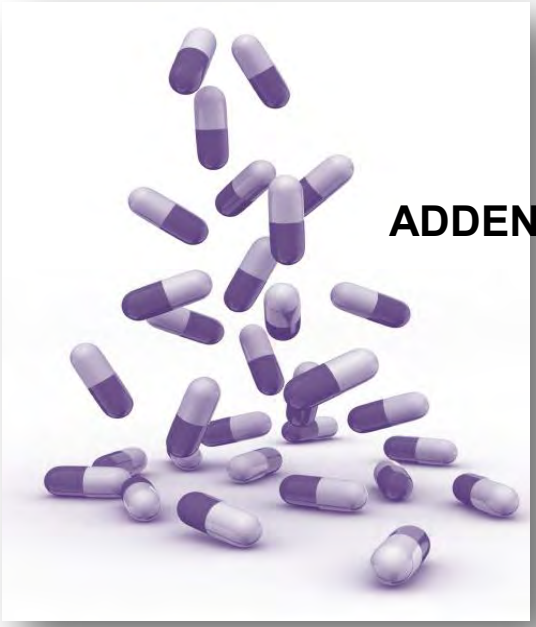
Number of wards	
Number of beds	

Ward demographics (A)

Number of beds	
Occupancy on day of observation	
Average acuity (AUKUH) on day of observation	
Number of level 0 patients	
Number of level 1a patients	
Number of level 1b patients	
Number of level 2 patients	
Number of level 3 patients	
Number of staff on day of observation	
Full time staff	
Part-time staff	
Students	
Staff required according to AUKUH	

Ward demographics (B)

Number of beds	
Occupancy on day of observation	
Average acuity (AUKUH) on day of observation	
Number of level 0 patients	
Number of level 1a patients	
Number of level 1b patients	
Number of level 2 patients	
Number of level 3 patients	
Number of staff on day of observation	
Full time staff	
Part-time staff	
Students	
Staff required according to AUKUH	



ADDENDUM XVIII: SPECIFICATION SHEETS OF EXAMPLE HARDWARE

Honeywell

Wearable Solution

For Dolphin 70e Mobile Computer

There are lots of opportunities throughout the enterprise to increase efficiency and reduce labor costs using a hands free computing solution: small parts picking, large package handling, sortation, truck loading... any time two hands are required. Up until now, that has required the use of a dedicated wearable device and a redesign of the application and the process to utilize the limited user interface. Using the rugged enterprise class Dolphin 70e with purpose-built wearable accessories provides a new approach to enabling hands free operations. The large display, flexible touchscreen keypads, and WEH 6.5 architecture allow existing applications to be deployed hands free. Without reengineering!

The lightweight wearable accessories provide increased comfort and improved hygiene over conventional wearables. The rubber watchband style armbands stretch slightly as the arm moves, and therefore remain tight to prevent sliding down or spinning around the arm. The rubber materials do not absorb perspiration and are easily cleaned between shifts. All components are breakaway for safety and easily swappable for left hand or right hand operation. The system supports corded or BT-connected ring scanners and provides a rugged audio interface to Honeywell's line of headsets. All standard D70e accessories, such as charging cradles and 4 bay battery chargers, are available.

Several software enhancements have been incorporated to make use as a wearable device even more user friendly. Pairing the BT ring scanners is now as easy as scanning a single barcode. APIs are available that allow voice applications to optimize voice recognition performance and the user's audio experience. An integrated keyboard designer is included that allows creation of popup keypads that are appropriate for the operation at hand. The appropriate keypad can be invoked by the user using hot keys, by a local application using an API, or by a Telnet host using special commands to the terminal emulation SW. This provides for a context-sensitive keypad: the users see only the keys they need when they need them.

A new approach to hands free computing – get the benefits without the cost and hassle of reengineering your process or applications

Features

- **Hands Free without Reengineering:** Run your existing applications as a wearable solution- without rewriting.
- **General Purpose Device:** Don't get stuck with a dedicated device that only serves one purpose. Share the D70e on different tasks between shifts, or standardize on one general purpose device across multiple enterprise applications, including hands free.
- **Large Clear Display:** The 4.3" display with capacitive touch screen and outstanding readability provides plenty of space for data and keypads. Clearly superior to conventional wearable displays.
- **Light Weight:** The total weight of the Honeywell Wearable Solution is less than conventional wearable computers.
- **Flexible Keypad:** The use of touchscreen-based keypads and the integrated keyboard designer allow you to deploy just the keys that the user needs, only when needed. Can be controlled by a local application, hot keys, or a Telnet Host application.
- **Watchband Style Armband:** Improves comfort and eliminates hygiene concerns. The rubber watchband straps are comfortable, reduce sliding or rotating on the arm, and don't absorb perspiration. Easily cleaned.

Honeywell Wearable Solution Technical Specifications

Mechanical		
Dimensions (LxWxH)	D70e with Standard Battery:	134 mm x 73 mm x 18 mm (5.3" x 2.9" x 0.7")
	D70e with Extended Battery:	134 mm x 73 mm x 23.9 mm (5.3" x 2.9" x 0.9")
	Arm Mounted Sled:	141mm x 83mm x 38mm (5.6" X 3.3" x 1.5")
	Corded Laser Ring Scanner:	48mm x 28mm x 28mm (1.9" x 1.1" x 1.1")
	Corded Imager Ring Scanner:	48mm x 28mm x 33mm (1.9" x 1.1" x 1.3")
Weight	D70e Standard Battery:	204 g (7.2 oz)
	D70e Extended Battery:	244 g (8.6 oz)
	Corded Laser Ring Scanner:	65 g (2.3 oz)
	Corded Imager Ring Scanner:	79 g (2.5 oz)
	Sled and Armband:	163 g (5.7 oz)
Environmental		
Operating Temperature	-20° to 50°C (-4°F to 122°F)	
Storage Temperature	-25° to 70°C (-13° to 158°F)	
Humidity	Humidity 0 to 95% relative humidity (non-condensing)	
Drop	Withstands multiple 4' (1.2m) drops to concrete, all axis, and across operating temperature range (standard and extended batteries)	
Tumble	Exceeds 1,000 (0.5m) tumbles per IEC 60068-2-32 specification (standard battery) (not while in sled) Exceeds 300 (0.5m) tumbles per IEC 60068-2-32 specification (extended battery) (not while in sled)	
ESD	± 15KV Air and ± 8KV Contact	
Environmental Sealing	Independently certified to meet IP54 standards for moisture and particle intrusion (IP67 outside of sled)	
System Architecture		
Processor	1GHZ single core TI OMAP	
Operating System	Microsoft® Windows® Embedded Handheld 6.5	
Memory	512MB RAM X 1GB FLASH	
Display	4.3" WVGA (480 x 800), super bright, sunlight viewable	
Touch Panel	2 finger capacitive touch, optically bonded for extra durability and better sunlight viewability	
Keypad	Dedicated scan key, 4 programmable keys, volume up and down keys, side scan key, Honeywell Virtual Keypad™ and Keypad Creator™	
Audio	Speaker, dual array digital microphones with echo and noise cancellation	
I/O Ports	Micro USB, 3.5 mm headphone (not accessible while in sled) Combo mic/headphone jack with supporting shroud and overmold	
Camera	5.0 megapixel camera with autofocus and flash (Not accessible while in sled)	
Sensors	Accelerometer, vibration, ambient light and proximity	
Storage Expansion	User accessible microSD slot (SDHC compatible). Please check with your Honeywell representative for available qualified card options.	
Battery	Standard: Li-ion 3.7 V, 1670 mAh; Extended: Li-ion 3.7 V, 3340 mAh	
Hours of Operation	Laser, Standard battery: 6 hrs, Extended battery: 12 hrs (scanning and sending data over WLAN every 10 secs) 2D Imager, Standard battery: 4 hrs, Extended battery: 8 hrs (scanning and sending data over WLAN every 10 secs)	
Integrated Decode Capabilities	Dedicated imager capable of decoding standard 1D and 2D bar code symbologies (Not accessible while in sled)	
Corded Ring Scanners	Standard range laser, standard range 2D imager with enhanced white LED illumination	
Development Environment	Honeywell SDK for Microsoft® Windows® Embedded Handheld 6.5	
HSM Application Software	Honeywell Powertools™ and Demos, Remote MasterMind™ for Mobility remote device management RFTerm and ETE Terminal emulations Keypad development tool suite Context Sensitive Keypad Deployment tools	
Warranty	1 year factory warranty	
Wireless Connectivity		
WLAN	IEEE 802.11 a/b/g/n; Wi-Fi™ certified	
WLAN Security	WEP, 802.1x, LEAP, TKIP, MD5, EAP-TLS, WPA-PSK, WPA v2.0, PEAP, CCXv4	
WPAN	2.4 GHz (ISM Band) Adaptive "frequency hopping" Bluetooth® v4.0; Class I.5, 10m (33') line of site	

For a complete listing of all compliance approvals and certifications, please visit www.honeywellaidc.com/compliance

For a complete listing of all supported bar code symbologies, please visit www.honeywellaidc.com/symbologies

Honeywell Scanning & Mobility
9680 Old Bailes Road
Fort Mill, SC 29707
800.582.4263
www.honeywellaidc.com

D70e (HWS)-DS Rev A 09/14

Panasonic recommends Windows.

Panasonic

TOUGHBOOK 19

- 10.1" Convertible Tablet with Touch or Multi Touch + Digitizer Display
- Sunlight-viewable up to 6000 Nit in Direct Sunlight
- Full Magnesium Alloy Case with Hand Strap
- Shock-mounted Flex-connect Hard Drive with Quick-release
- Optional 4G LTE Multi Carrier Mobile Broadband with Satellite GPS

IP65

6-FOOT DROP RATING

MIL-STD 810G

The first MIL-STD-810G certified tablet PC[1]

RUGGED, LIGHTWEIGHT, WIRELESS AND CONVERTIBLE.

If you want a fully rugged, lightweight, wireless laptop that converts from a powerful notebook PC to a convenient tablet PC with one quick swivel, then the Toughbook® 19 is for you. The first tablet PC to be certified[1] for MIL-STD-810G and IP65, it features a full magnesium alloy case capable of withstanding a 6-foot drop[1]—ideal for working in challenging environments and mission-critical situations. At only five pounds, it's good on the go with a hand strap, Wi-Fi, a brilliant LED screen capable of up to 6000 nit in direct sunlight, and optional embedded 4G LTE multi carrier mobile broadband with satellite GPS. Additionally, the Toughbook 19 is available with two display options, both allowing you to touch the screen with or without gloves.

1.800.662.3537
us.panasonic.com/toughbook/19

TOUGHBOOK®

Panasonic recommends Windows.

SOFTWARE
- Windows® 8.1 Pro 64-bit (available Windows® 7 Professional downgrade option)
- Panasonic Utilities, Panasonic Dashboard, Recovery Partition

DURABILITY
- MIL-STD-810G certified (6' drop, shock, vibration, rain, dust, sand, altitude, freeze/thaw, high/low temperature, temperature shock, humidity, explosive atmosphere)[1]
- MIL-STD-461F certified[1]
- IP65 certified sealed all-weather design[1]
- Optional class I division 2, groups ABCD certified model
- Hard drive heater
- Full magnesium alloy case with hand strap
- Shock-mounted flex-connect hard drive with quick-release
- Pre-installed replaceable screen film for LCD protection

CPU[2]
- Intel® Core™ i5-3610ME vPro™ Processor
  - 2.7GHz with Turbo Boost up to 3.3GHz
  - 3MB cache

STORAGE & MEMORY
- 4GB-16GB SDRAM (DDR3L-1333MHz)[3,4]
- Shock-mounted flex-connect hard drive with quick-release
  - 500GB 7200rpm hard drive with heater[5]
  - Optional 128GB and 256GB solid state drives (SSD) with heaters[5]

DISPLAY
- 10.1" XGA sunlight-viewable LED 1024 x 768
  - Resistive touchscreen
  - 5-point resistive multi touch + digitizer
- TransflectivePlus and Panasonic CircuLumin™ technology
- 1-6000 nit (depending on lighting conditions and settings)[6]
- AR, AG and circular polarizer
- Ambient light sensor
- Intel® QM77 video controller; max. 1545MB shared VRAM with 32-bit[3]
- External video support up to 1280 x 1024 at 16.7 million colors
- Concealed mode (configurable)

AUDIO
- Intel® high-definition audio compliant
- Integrated speaker
- Keyboard volume and mute controls

KEYBOARD & INPUT
- Touchscreen or multi touch + digitizer
- Integrated stylus holder
- 82-key with dedicated Windows® key
- Pressure-sensitive touchpad with vertical scrolling support

EXPANSION SLOTS
- PC card type II
- SD card (SDXC)
- ExpressCard/54

INTERFACE

Docking connector	Dedicated 100-pin
VGA	D-sub 15-pin
Headphones/speaker	Mini-jack stereo
Microphone/line in	Mini-jack stereo
Serial	D-sub 9-pin
Ext. antenna conn. (x 2)	50 ohm coaxial
USB 3.0 (x 1), USB 2.0 (x 1)	4-pin
IEEE 1394a (FireWire)	4-pin
10/100/1000 Ethernet	RJ-45

WIRELESS
- Optional integrated 4G LTE multi carrier mobile broadband with satellite GPS
- Optional GPS (u-blox NEO-M8N)
- Intel® Centrino® Advanced-N 6235 802.11a/b/g/n
- Bluetooth® v4.0 + EDR (Class 1)
- Security
  - Authentication: LEAP, WPA, 802.1x, EAP-TLS, EAP-FAST, PEAP
  - Encryption: CKIP, TKIP, 128-bit and 64-bit WEP, Hardware AES
- Dual high-gain antenna pass-through
- Slide on/off switch

POWER SUPPLY
- Lithium ion battery pack (10.65V, typical 5700mAh, minimum 5400mAh)
- Battery operation: 10 hours (touchscreen), 9.5 hours (multi touch + digitizer)[8]
- Battery charging time: 3.5 hours[8]
- AC Adapter: AC 100V-240V 50/60Hz, auto sensing/switching worldwide power supply

POWER MANAGEMENT
- Suspend/Resume Function, Hibernation, Standby, ACPI BIOS

SECURITY FEATURES
- Password Security: Supervisor, User, Hard Disk Lock
- Kensington cable lock slot
- Trusted platform module (TPM) security chip v.1.2
- Computrace® theft protection agent in BIOS[9]
- Intel® Anti-Theft Technology
- Optional fingerprint reader
- Optional insertable SmartCard reader

WARRANTY
- 3-year limited warranty, parts and labor

DIMENSIONS & WEIGHT
- 8.5"(L) x 10.7"(W) x 1.9"(H)
- 5.1 lbs.

INTEGRATED OPTIONS[10]
- 4G LTE multi carrier mobile broadband with satellite GPS
- GPS (u-blox NEO-M8N)
- 5MP camera with auto focus and dual LED light[11]
- Backlit keyboard—sealed rubber or plastic emissive
- Insertable SmartCard reader
- Fingerprint reader
- HDD and battery lock
- 128GB and 256GB solid state drives (SSD) with heaters

SELECT ACCESSORIES[10]

AC Adapter (3-prong)	CF-AA6503A2M
Battery Pack	CF-VZSU48U
Battery Charger	CF-VCBTBZW
LIND Car Adapter 120W	CF-LNDDC120
LIND Car/AC Adapter 90W (with USB port)	CF-LNDACDC90
LIND Car Adapter 90W MIL-STD	CF-LNDMLDC90
ToughMate ComUniversal Jr. Carrying Case	TBCCOMUJR-P
ToughMate Always-on 19 Case	TBC19AOC5-P
ToughMate 19 "X" Hand Strap	TBC19XSTP-P
Memory Card 4GB DDR3	CF-WMBA1304G
Memory Card 8GB DDR3	CF-WMBA1308G
Desktop Dock	CF-VEB191AU
Vehicle Docks (no pass-through)	
– Gamber-Johnson with LIND power supply	7160-0264-03-P
– Havis with LIND power supply	CF-H-PAN-212-P
Vehicle Docks (dual pass-through)	
– Panasonic	CF-WEB194AC
– Gamber-Johnson with LIND power supply	7160-0264-04-P
– Havis with LIND power supply	CF-H-PAN-212-2-P
Zebra 4" Bluetooth® Printer	PZ420BT
Zebra 4" Bluetooth® Printer with MagStripe Reader	PZ420BTMC
PDRC Backlit Keyboard	CF-VKBL03AM
Dual Touch Replacement Stylus (for Digitizer)	CF-VNP012U
Touchscreen Replacement Stylus	CF-VNP003U
Tether	CF-VNT002U
LCD Protector Film	CF-VPF11U

Please consult your reseller or Panasonic representative before purchasing.
[1]Tested by national independent third party lab following MIL-STD-810G Method 516.6 Procedure IV for transit drop test and IEC 60529 Sections 13.4, 13.6.3, 14.2.5 and 14.3 for IP65.
[2]An Intel Core i7 processor is also available.
[3]Total usable memory will be less depending upon actual system configuration. Maximum of 4GB of memory when equipped with camera. Windows 7 64-bit max. VRAM is 1696MB.
[4]1GB = 1,000,000,000 bytes.
[5]500 nit without ambient light assistance. Up to 6000 nit in clear, sunny conditions under direct sunlight.
[6]Battery performance features such as charge time and life span can vary according to the conditions under which the computer and battery are used. Battery operation and recharge times will vary based on many factors, including screen brightness, applications, features, power management, battery conditioning and other customer preferences. Battery testing results from MobileMark 2007.
[8]Requires software and activation to enable theft protection.
[10]Accessories and Integrated Options may vary depending on your notebook configuration. Visit Panasonic website for more accessories and details.
[11]Camera replaces the second memory slot located on the bottom of the PC.

1.800.662.3537
us.panasonic.com/toughbook/19

TOUGHBOOK®

Panasonic recommends Windows 8.

intel inside CORE i5 vPro

TOUGHPAD FZ-M1

- MIL-STD-810G, 5' Drop and All-weather IP65 Dust and Water-resistant Design
- User-replaceable Battery, Bridge Battery and Optional Long Life Battery
- USB 3.0, Optional NFC, Ethernet, Serial, SmartCard, Magnetic Stripe and Barcode Reader[1]
- Wi-Fi, Bluetooth® and Optional Dedicated GPS or 4G LTE Multi Carrier Mobile Broadband
- 3-year Warranty with Business Class Support

7" Windows® 8 tablet with a choice of two Intel® processors.

The Panasonic Toughpad® FZ-M1 is the world's thinnest and lightest fully-rugged 7" Windows® tablet, built to enable mission-critical mobile worker productivity without compromise. Powered by Windows® 8.1 Pro and a choice of two Intel® processors, the Toughpad FZ-M1 features a long life, user-replaceable battery and a daylight-readable, high-sensitivity multi touchscreen for use with heavy gloves. With the broadest range of configuration options available in its class, the highly customizable Toughpad FZ-M1 is the ideal tool for today's mobile workforce.

5-FOOT DROP RATING

IP65

MIL-STD-810G

1.800.662.3537
panasonic.com/toughpad/M1

SOLUTIONS FOR BUSINESS

TOUGHPAD

Panasonic

Panasonic recommends Windows 8.

DURABILITY
- MIL-STD-810G design (5' drop, shock, vibration, rain, dust, sand, altitude, freeze/thaw, high/low temperature, temperature shock, humidity, explosive atmosphere)
- IP65 certified sealed all-weather fanless design
- Solid state drive heater
- Magnesium alloy chassis encased with ABS and elastomer corner guards
- Optional hand strap or rotating hand strap
- Port covers
- Raised bezel for LCD impact protection
- Pre-installed replaceable screen film for LCD protection

SOFTWARE
- Windows® 8.1 Pro 64-bit (with Windows® 7 downgrade option) (Intel® Core™ i5 model)
- Windows® 8.1 with Bing 64-bit (Windows 7 not available) (Intel® Celeron® model)
- Panasonic Utilities (including Dashboard), Recovery Partition

CPU
- Intel® Core™ i5-4302Y vPro™ Processor
  - 1.6GHz with Intel® Turbo Boost up to 2.3GHz
  - 3MB cache
- Intel® Celeron® N2807 Processor
  - Up to 2.16 GHz
  - 1MB cache

STORAGE & MEMORY
- Intel® Core™ i5 model:
  - 8GB SDRAM (DDR3L-1333MHz)[2,3]
  - Up to 64GB additional with optional microSDXC card
  - 128GB and 256GB solid state drives (SSD) with heaters[2]
- Intel® Celeron® model:
  - 4GB SDRAM (DDR3L-1333MHz)[2,3]
  - Up to 64GB additional with optional microSDXC card
  - 64GB eMMC (standard)
  - 128GB and 256GB solid state drives (SSD) with heaters[2]

DISPLAY
- 7" WXGA 1280 x 800 with LED backlighting
- 10-point capacitive multi touch daylight-readable screen
  - 500 nit
  - IPS display with direct bonding
  - Anti-reflective screen treatment
  - Ambient light sensor, digital compass, gyro and acceleration sensors
  - Automatic screen rotation
  - Intel® HD graphics 4200 video controller, max. 1664MB shared VRAM with Win 8 64-bit[4]
- Concealed mode (configurable)

AUDIO
- Integrated microphone
- Realtek high-definition audio
- Integrated speaker
- On-screen and button volume and mute controls

KEYBOARD & INPUT
- 10-point multi touch
  - Supports gloved touch and gestures and capacitive stylus pen
- 6 tablet buttons (2 user-definable)
- Stylus pen with integrated holder in rotating hand strap
- On-screen QWERTY keyboard

CAMERAS
- 720p webcam with mic
- 5-8MP rear camera with auto focus and LED light

EXPANSION
- MicroSDXC

INTERFACE

Docking connector	24-pin
Headphone/speaker	Mini-jack stereo
USB 3.0 (x 1)	4-pin

WIRELESS
- Optional integrated 4G LTE multi carrier mobile broadband with satellite GPS
- Optional dedicated GPS (Ublox Neo M8 series)
- Intel® Dual Band Wireless AC7260 Wi-Fi 802.11a/b/g/n/ac
- Bluetooth® v4.0 (Class 1) + EDR
- Security
  - Authentication: LEAP, WPA, 802.1x, EAP-TLS, EAP-FAST, PEAP
  - Encryption: CKIP, TKIP, 128-bit and 64-bit WEP, Hardware AES
- Optional dual high-gain antenna pass-through

POWER SUPPLY
- Li-Ion battery pack:
  - Standard battery: 7.2V, typical 3220mAh, minimum 3120mAh
  - Long life battery: 7.2V, typical 7100mAh, minimum 6800mAh
- Battery operation[5]:
  - Standard battery: 8 hours
  - Optional long life battery: 16 hours
  - Bridge battery: 30 seconds
- Battery charging time[5]:
  - Standard battery: 2.5 hours off, 3 hours on
  - Optional long life battery: 4.5 hours off, 5 hours on

POWER MANAGEMENT
- Suspend/Resume Function, Hibernation, Standby

SECURITY FEATURES
- Password Security: Supervisor, User, Hard Disk Lock
- Kensington cable lock slot
- Trusted platform module (TPM) security chip v.1.2
- Computrace® theft protection agent in BIOS[6]
- Intel® Anti-Theft Technology
- Optional insertable SmartCard reader[1]
- Optional contactless RFID and SmartCard reader[1]

WARRANTY
- 3-year limited warranty, parts and labor

DIMENSIONS & WEIGHT[7]
- 7.98"(L) x 5.20"(W) x 0.71"(H)
- 1.2 lbs.

INTEGRATED OPTIONS[8]
- 4G LTE multi carrier mobile broadband with satellite GPS
- Available upgrade packages[1]:
  - Bridge battery only and 1D/2D barcode reader (EA30) or LAN or serial
  - SmartCard reader (half-insertable) and bridge battery, 1D/2D barcode reader (EA30), LAN, serial or 2nd USB
  - Magnetic stripe reader and bridge battery, 1D/2D barcode reader (EA30), LAN, serial or 2nd USB
  - HF/RFID 13.56MHz reader (ISO 15693 and 14443 A/B compliant and bridge battery, 1D/2D barcode reader, LAN, serial or 2nd USB
  - UHF/RFID 900MHz EPC Gen2 reader

ACCESSORIES[8]

AC Adapter (3-prong)	CF-AA6373AM
Standard Battery Pack	FZ-VZSU94W
Long Life Battery Pack	FZ-VZSU95W
Multi-battery Charger	FZ-VCBM11U
Standard Hand Strap with Stylus Holder and Tether	FZ-VSTM11AU
Rotating Hand Strap with Stylus Holder and Tether	FZ-VSTM12AU
Capacitive Replacement Stylus	FZ-VNPM11U
Desktop Cradle	FZ-VEBM12AU
Lite-function Cradle	FZ-VEBM11AU
Replacement Protection Film	FZ-VPFM11U

Please consult your reseller or Panasonic representative before purchasing.
Caution: Do not expose bare skin to this product when handling this unit in extreme hot or cold environments.
[1]Mutually exclusive option.
[2]1GB = 1,000,000,000 bytes.
[3]Total usable memory will be less depending upon actual system configuration.
[4]The size of the VRAM cannot be set by the user and varies by operating system as well as size of RAM. Windows 7 max. VRAM is 1344MB.
[5]Approximate time. Battery performance features such as charge time and life span can vary according to the conditions under which the computer and battery are used. Battery operation and recharge times will vary based on many factors, including screen brightness, applications, features, power management, battery conditioning and other customer preferences. Battery testing results from MobileMark 2007.
[6]Requires software and activation to enable theft protection.
[7]Length measurements do not include protrusions or configurable options.
[8]Accessories and Integrated Options may vary depending on your configuration. Visit Panasonic website for more accessories and details.

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panasonic.com/toughpad/M1

ADDENDUM XIX: EPPI-REVIEWER SOFTWARE FEATURES

Features

EPPI-Reviewer 4: software for research synthesis

EPPI-Reviewer 4 is the EPPI-Centre's comprehensive online software tool for research synthesis. It is a web-based software program for managing and analysing data in literature review and has been developed for all types of systematic review such as meta-analysis, framework synthesis and thematic synthesis.

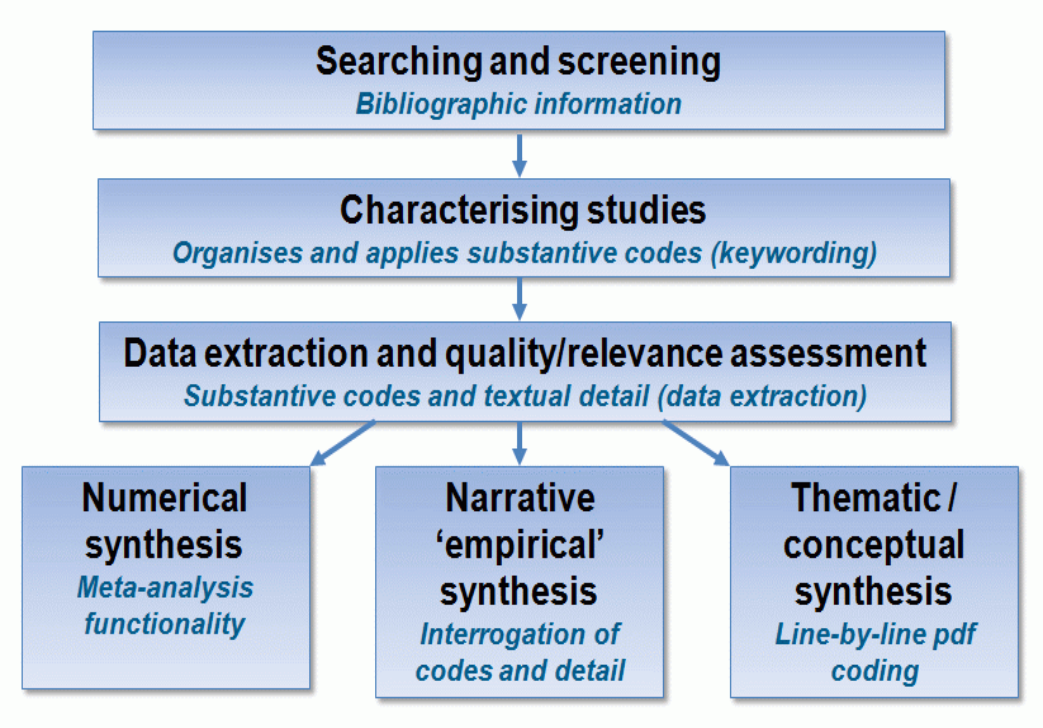
Systematic review

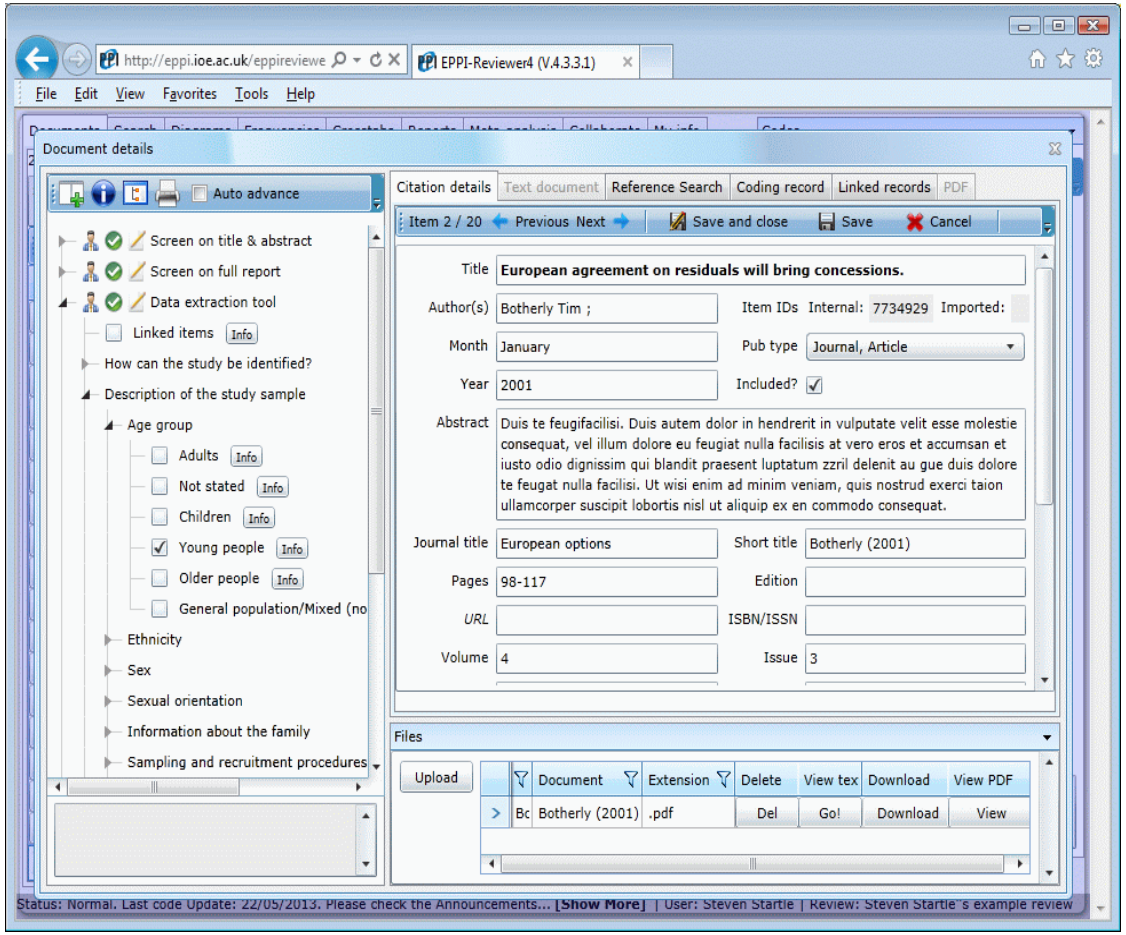
EPPI-Reviewer 4 has the functionality to help manage your systematic review through all stages of the process from bibliographic management, screening, coding and right through to synthesis.

It manages references, stores PDF files, facilitates qualitative and quantitative analyses and allows easy export of review data to enable use with other software programmes.

The software allows multiple concurrent users to access the system and being web-based allows members of a review group to be located in different geographic locations.

EPPI-Reviewer 4 supports many different analytic functions for synthesis including meta-analysis, empirical synthesis and qualitative thematic synthesis. It allows you to present your data in summary diagrams and customisable reports.

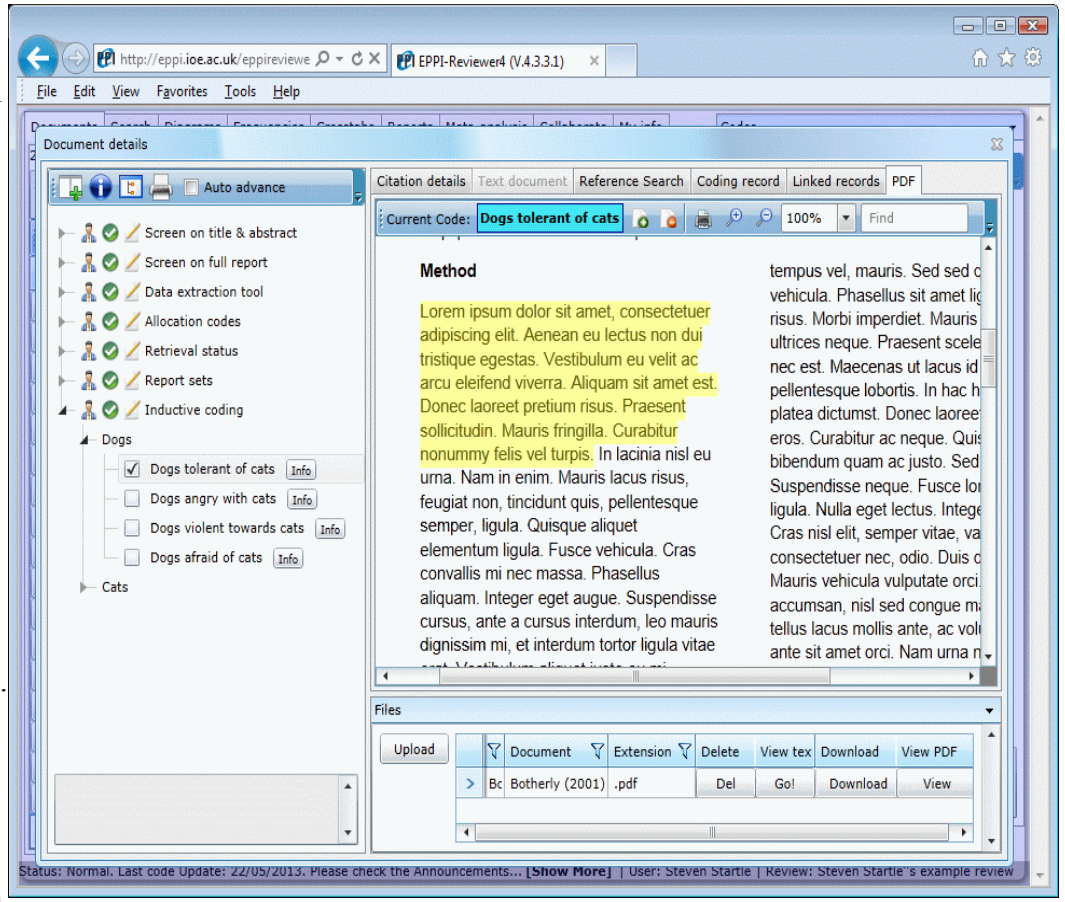




Study classification and data extraction

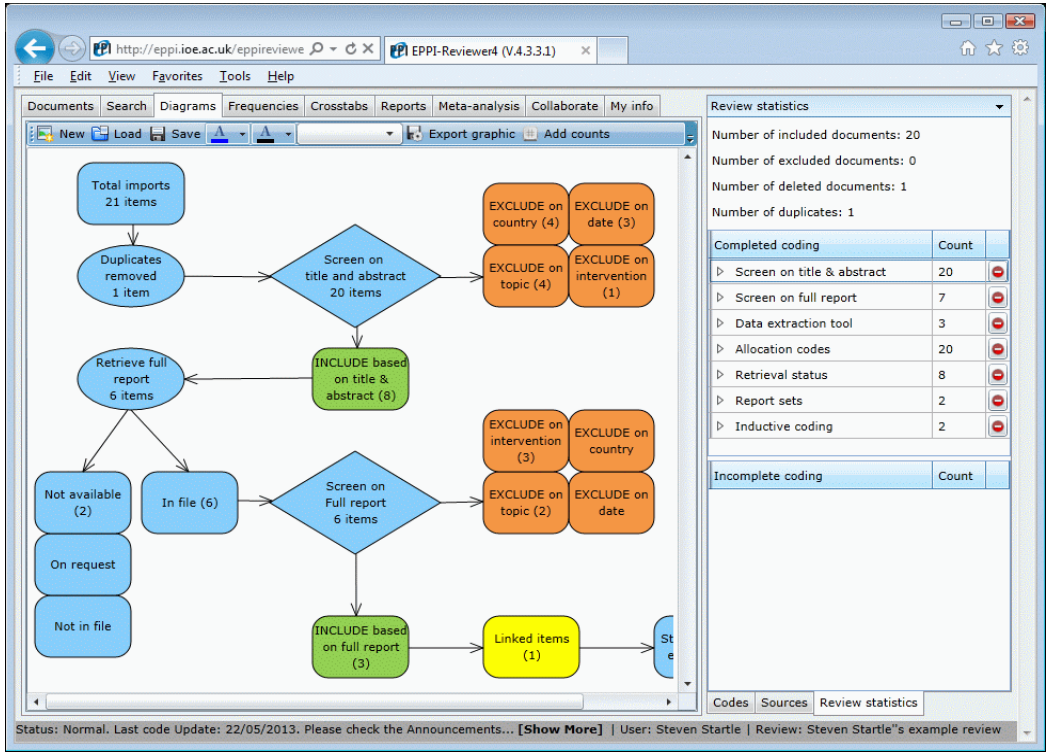
- Flexible coding schemas for classifying studies:
  - Inclusion / exclusion / eligibility criteria;
  - Codes for descriptive 'mapping' of research activity.
  - Codes to capture detailed information about a study.
- Concurrent multi-user classification: multiple users can classify studies independently and then compare their results; EPPI-Reviewer 4 works throughout this process, producing summary discrepancy reports and an interface to facilitate the process of agreeing final decisions.
- Bulk application / removal of codes to selected studies
- Calculation of common measures of effect (odds ratios, risk ratios, risk differences, standardized mean differences, mean differences) from a variety of statistics (2 x 2 tables, means, standard deviations, confidence intervals, p, t and r values).
- Text mining: automatic term recognition and document clustering.

Synthesis



- Running meta-analyses (fixed and random effects models); calculating I-squared and supporting sub-group analyses using analog to the anova
- A powerful search engine enabling users to search by categories and text and combine searches using Boolean terms
- Producing reports of categorical, numeric and textual data in a wide variety of formats from frequency reports, crosstabs and full-text reports, to tabular summary reports and summary statistics of numeric data
- Text mining functionality. Automatic document clustering, using text mining, is one way of describing the range of studies you have identified at the click of a button. Text mining can assist with searching by identifying significant terms in the documents you have already included.
- Inductive coding functionality. This allows line by line coding of textual data and organising and structuring these codes graphically into 'conceptual relationship diagrams to display analytic and descriptive themes found through inductive coding.

- Fulltext reference searching using the uploaded pdfs.
- Diagrams to summarise e.g. qualitative syntheses and theories of change for interventions.



Review Management

- The ability to create an unlimited number of non-shareable reviews.
- Allocation of classification tasks (e.g. screening / data extraction) to individual users.
- Work progress reporting.
- Individual reviewer permissions (forthcoming)
- Review flow charts which update automatically (e.g. with counts of how many studies have been included / excluded according to which criterion in order to generate PRISMA flow-diagrams).
- Easy export of review data to enable use with other software programmes and to enable long term independent storage of data.

Under development

We have been developing ways of using emerging text mining technologies in systematic reviews. Currently used during the searching and screening stages of a review, you can read a paper which outlines their potential published in Research Synthesis Methods*. We have also written up our early findings in the NCRM Newsletter and in a poster presented at the 2011 Cochrane Colloquium. Methods to use these technologies are still in their infancy and require significant further evaluation. While automatic term recognition and document clustering are available for all users, document classification often requires significant server processing time and support; therefore this technology is not yet generally available in EPPI-Reviewer. However, if you would like to use a classifier in your review, please contact us to discuss your particular requirements.

*Thomas J, McNaught J, Ananiadou S (2011) Applications of text mining within systematic reviews. Research Synthesis Methods 2: 1-14.

ADDENDUM XX: LANGUAGE EDITING CERTIFICATE

Declaration

This is to declare that I, Annette L Combrink, accredited language editor and translator of the South African Translators' Institute, have language-edited the thesis by

Alwiena Johanna Blignaut (20213654)

with the title

Medication administration safety in medical and surgical units of the Gauteng Province

Prof Annette L Combrink
Accredited translator and language editor
South African Translators' Institute
Membership No. 1000356
Date: 4 November 2015