Intravenous medication safety practices of registered nurses in neonatal and paediatric critical care areas

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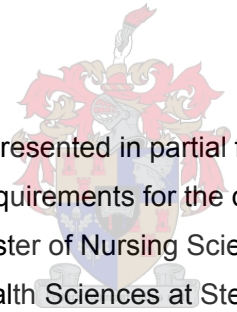

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DECLARATION

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ABSTRACT

A literature study showed that the topics of medication safety and medication error prevention have been studied in depth. Findings from the literature revealed that medication errors are reported to be common in neonatal and paediatric ICUs, that more than half of these errors are preventable and that risk reduction measures protect patients against untoward outcomes or adverse events (Clifton-Koeppel, 2008:72). If and when there is a failure in the process of safe medication administration, it results in a medication error, which is defined as a breach of one or more of the five rights of medication administration (Institute for Safe Medication Practices Alert, 2007:1).

Medication administration, which is predominantly a nursing task, is of high risk and high volume in the intensive care unit (ICU). The accuracy of intravenous medication administration is critical for a neonatal and paediatric ICU patient since it can potentially heighten the patient's vulnerability if further harm is caused. In view of the complexity of medication administration for neonatal and paediatric ICU patients, researchers confirm the diverse role of the registered nurse in safe medication administration practices.

The purpose of the study was to describe the perceptions of registered nurses (RNs) regarding the factors that influence IV medication safety practice in the neonatal intensive care unit (NICU); paediatric intensive care unit (PICU); and paediatric cardiac intensive care unit (CSICU) in Saudi Arabia. The study objectives were set to describe the actual factors that have an influence on IV medication safety practices of RNs working in these ICUs; to determine the knowledge of registered nurses in the selected ICUs with regard to safe intravenous medication administration practices and to describe nursing medication administration strategies that are focused on medication error prevention.

A quantitative research approach was selected for this study which had a descriptive, survey design. An 85% non-probability purposive sampling method was used to draw a sample (n=103) of the target population of NICU-, PICU- and CSICU-registered nurses (N=121) who were responsible for administering intravenous medication at King Faisal Specialist Hospital and Research Centre in Jeddah (KFSHRC-J).

A self-administered questionnaire with closed-ended Likert and open-ended question was designed to describe the objectives under study. A pilot study was conducted to pre-test the questionnaire. A quantitative method was used to analyse the study data. MS Excel was used to capture the quantitative data after which it was analysed using descriptive statistics by means of STATISTICA 9 software. The open–ended questions (indicating "other" and Question 70) were also interpreted quantitatively after exploring the main aspects in the responses. The main findings were that multiple perceived factors influence the intravenous medication safety practices of RN's working with neonatal and paediatric ICU patients in a particular Saudi Arabian tertiary hospital. It was found that these nurses' had knowledge regarding safe medication administration practice that constitutes that all five medication rights have to be checked through nursing 'double-checks' in the steps of medication administration, as the method of checking as per hospital policy. However, from the findings, it is reflected that RNs perceptions of completely and correctly checking medication rights through complete and independent nursing 'double-checks', do not match the steps required by policy and that their knowledge is inadequate. It is evident from the perceptions of RNs that they are aware of the multiple factors influencing IV medication safety practice in this vulnerable patient setting. As perceived by RNs, it is possible to implement more safety strategies. Key recommendations on conclusion of the study include that there are more nursing medication administration strategies that could still be implemented for medication error prevention. These strategies relate to medication safety awareness, the role of the nurse and nursing managers, mandatory staff education, and review of knowledge and skills.

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OPSOMMING

Gebaseer op 'n literatuurstudie blyk dit dat medikasieveiligheid en voorkoming van medikasiefoute reeds in diepte bestudeer are. Bevindings dui daarop dat medikasiefoute algemeen voorkom in neonatale en pediatriese intensiewesorgeenhede, dat meer as die helfte daarvan voorkombaar is, en dat maatreëls om risiko te vermindering pasiënte teen voorkombare uitkomste beskerm (Clifton-Koeppel, 2008:72). Indien en wanneer die proses vir veilige medikasietoediening faal, kom 'n medikasiefout voor, wat gedefinieer word as die verbreking van een of meer van die vyf medikasieregte (Institute for Safe Medication Practices Alert, 2007:1).

Medikasietoediening is hoofsaaklik 'n verpleegtaak, wat 'n hoërisiko- en hoëvolume-taak behels. Die akkuraatheid van intraveneuse medikasietoediening is kritiek vir neonatale en pediatriese intensiewesorgpasiënte, aangesien hul weerloosheid verhoog word indien verdere skade veroorsaak word. Omrede medikasietoediening vir neonatale en pediatriese intensiewesorgpasiënte kompleks is, bevestig navorsers dat geregistreerde verpleegkundiges se rol ten opsigte van veilige medikasietoediening veelsoortig is.

Die doel van die studie was om die persepsies van geregistreerde verpleegkundiges aangaande die faktore wat medikasieveiligheid in die neonatale en paediatriese intensiewe eenhede in Saoedi-Arabië beinvloed, te beskryf. Studiedoelwitte is gestel om die spesifieke faktore te beskryf wat aanleiding gee tot medikasietoedieningsfoute in die genoemde intensiewesorgeenhede; om geregistreerde verpleegkundiges in die geselekteerde intensiewesorgeenhede se kennis van veilige medikasietoediening te bepaal; en die medikasietoedieningstrategieë wat op die voorkoming van medikasietoedieningsfoute fokus, te beskryf.

'n Kwantitatiewe navorsingsbenadering is geselekteer vir die studie wat 'n beskrywende navorsingsontwerp gehad het. 'n 85% nie-waarskynlike gerieflikheidsteekproef is gebruik om 'n steekproef (n=103) te selekteer vanuit die teikenpopulasie geregistreerde verpleegkundiges (N=121) wat verantwoordelik was vir medikasietoediening in die geselekteerde intensiewesorgeenhede by King Faisal Specialist Hospital and Research Centre, Jeddah (KFSHRC-J).

'n Self-geadministreerde vraelys met geslote Likert- en oop-eindevrae is opgestel om die gestelde studiedoelwitte te ondersoek. 'n Vooraf-toetsing van die vraelys is tydens die loodsstudie uitgevoer. 'n Kombinasie van kwantitatiewe en kwalitatiewe metodes is gebruik vir die ontleding van die studie-data. Die kwantitatiewe data is op MS Excel ingevoer, waarna beskrywende statistiek deur middel van Statistica 9-sagteware gebruik is om dit te ontleed. Die studie het hoofsaaklik bevind dat veelvuldige faktore die veiligheidspraktyk ten opsigte van intraveneuse medikasie van geregistreerde verpleegkundiges wat met neonatal en pediatriese intensiewesorgpasiënte in 'n spesifieke tersiêre hospitaal in Saoedi-Arabië werk, beïnvloed. Dit blyk dat hierdie verpleegkundiges se kennis voldoende is aangaande 'n veilige medikasie toedieningspraktyk wat bestaan uit die kontrolering van al vyf medikasieregte deur verpleegkundige dubbel-kontrolering, soos beskryf is in die hospitaalbeleid. Volgens die bevindinge blyk dit egter dat die verpleegkundiges se persepsie van volledige and korrekte verpleegkundige dubbel-kontrolering, nie met die stappe volgens die hospitaalbeleid ooreenstem nie en dat hulle kennis onvoldoende is. Dit is duidelik dat die verpleegkundiges bewus is van die veelvuldige faktore wat intraveneuse medikasieveiligheidpraktyk vir weerlose pasiënte beïnvloed. Die verpleegkundiges se persepsie is dat daar meer verpleegkundige medikasietoedieningstrategieë is wat geïmplementeer kan word om medikasiefoute te voorkom, insluitende veiligheidsbewustheid ten opsigte van medikasie, die rol van verpleegkundiges en verpleegbestuurders, verpligte personeelopleiding, en hersiening van kennis en vaardighede.

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LIST OF TERMINOLOGY, ABBREVIATIONS AND ACRONYMS

Terminology, abbreviations and acronyms that are frequently mentioned in this thesis and that are not commonly known to the average reader are hereby explained:

- *BSN:* Bachelor of Science in Nursing
- *CSICU:* cardiac surgery intensive care unit
- *Cardiac surgery patient:* babies and children receiving pre- and post-operative cardiac surgery care)
- *CPOE:* computerised physician order entry
- *Double-checks:* routine safety checks of the five medication rights and performed by two registered nurses during the IV medication administration process to prevent medication errors by reducing the risk; also known as 12- and 24- hour checks, as per policy (KFSHRC-J, 2008a:2).
- *HREC:* Human Research Ethical Committee
- *ICU:* intensive care unit
- *IHI:* International Health Initiative
- *IOM:* Institute of Medicine
- *IRB:* Institutional Review Board which evaluates the ethical aspects of research studies before they are conducted
- *IV:* intravenous
- *JCAHO:* Joint Commission on Accreditation of Healthcare Organizations
- *KFSHRC-J:* King Faisal Specialist Hospital and Research Centre in Jeddah
- *MAR:* medication administration record
- *Medication administration:* the actual process of administering medication to the patient according to the five rights, namely that the right patient receives the right medication, the right dose, through the right route at the correct time; also referred to as *nursing medication administration practice.*
- *Medication error:* any failure of medication administration or incorrect action that may result in patient harm when the medication is administered by the nurse or physician. It occurs at any time from the ordering time to the time that the patient receives it. As per research hospital policy for medication administration, an error can be intercepted by RNs if the five medication rights are completely checked prior to medication

administration (KFSHRC-J, 2008a:2). According to ISMP (2007:1) a breach of one or more of the five mentioned rights may result in a medication error'.

- *NICU:* neonatal intensive care unit
- *Neonatal patient:* a newborn infant born at/after 37 weeks of gestational age up to one month of age from the date of birth
- *Paediatric patient:* an infant born at/after 37 weeks of gestational age up to 13 years and 11 months.
- *Perceptions:* refers to an insight, awareness, view, opinion or experience. Within the context of this study perceptions refer to the insights, views and opinions of the ICU RNs regarding IV medication safety.
- *Policy and procedure:* entails a rule, guidelines or course of action that is documented. In the context of this research study, it entails the documented set standards that RNs have to follow regarding medication administration.
- *PICU:* paediatric intensive care unit that accommodates acutely ill babies and children up to 13 years and 11 months.
- *RN:* Registered nurse – a person who has either a four-year degree in Nursing Science, or a four-year diploma in Nursing Science and is approved by the Human Resources Recruitment Department and Nursing Affairs Department to perform specific, comprehensive nursing care duties, including medication administration. At the time of the study these nurses at King Faisal Specialist Hospital (KFSH) were referred to as staff nurses and were the equivalent of nurses considered to be registered nurses in South Africa. A charge nurse employed at KFSH was defined as a staff nurse and assumed the function of shift leader, coordinated activities for patients and liaised with the head nurse regarding all clinical and operational matters. Since primary care was the model of care used at KFSH at the time of the study, all registered nurses were also called primary assigned nurses.
- *WIs:* work interruptions

CHAPTER 1: SCIENTIFIC FOUNDATION OF THE STUDY

1.1 INTRODUCTION

In this section of Chapter 1, the background to the study is briefly discussed. This is followed by a review of the literature on medication errors, and the problem statement, aim, and objectives of the study.

1.1.1 Background and preliminary review of literature

Medication errors are common in the neonatal and paediatric critical care areas and it is estimated that more than half of these errors are preventable (Clifton-Koeppel, 2008:72). Due to the complexity of medication administration for neonatal and paediatric critical care patients, the role of the nurse is to implement, monitor and maintain safe medication practices (Camire, Moyen & Stelfox, 2009:936; Clifton-Koeppel, 2008:72; Lefrak, 2002:78; Swanson, 2006:230). Furthermore, a uniform research setting is selected for this study within which intravenous (IV) medication administration is routinely done by registered nurses (RNs) in the neonatal intensive care unit (NICU), paediatric intensive care unit (PICU) and paediatric cardiac surgery intensive care unit (CSICU) for all IV fluids through 'smart pumps' and IV pumps. The units' similarity will be discussed further in paragraph 1.2.3 and 3.2.3.

As depicted in the researcher's conceptual framework, safe medication administration practice is seen within the context of the 'five rights of medication administration', which is meant to ensure that the right patient receives the right drug (and form of drug), the right dose (strength and rate of the infusion), via the right route, and at the right time (Shane, 2009:546). According to the Institute for Safe Medication Practices Alert (ISMP, 2007:1), a medication error is seen as a breach of one or more of the five above-mentioned rights. For the purpose of this research, a medication error is 'any preventable event that occurs during any stage of the medication administration process that may result in a medication error' (Clifton-Koeppel, 2008:72). The 'five rights' principles also form the basis of the medication administration policies, that set standards in the research hospital that the medication rights should be checked prior to medication administration in the research setting. Safe medication administration practice is *secondly* also seen within the context of the research hospital's policy regarding medication administration, in terms of how these medication rights should be 'double-checked'. The method, as guided by this policy, in which these five medication rights should be double-checked, ensures safety in medication administration if the RN completes nursing 'double-

checks' that are focused on checking all of the medication rights with a witnessing RN (KFSHRC-J, 2008a:2).

Though safety is of concern for all patients, Lenclen (2007:71) argues that neonates are more at risk for medication errors than adults and children for reasons that are discussed in paragraph 2.3 and 2.4. The intensive care unit (ICU) accommodates patients that are acutely ill or hospitalised for a long term. As a result, paediatric ICU patients are even more vulnerable to the negative outcomes of IV medication errors (Clifton-Koeppel, 2008:72; Shane, 2009:546). It is evident that the setting and patient types seem to make it likely for medication errors to occur. This is due to the patients' extensive exposure to medications in the ICU, that there are different dosages for different patients in the ICU and that medication dosage principles are based on either gestational age, or weight of the child (Clifton-Koeppel, 2008:72; Lefrak, 2002:78; Lucas, 2004:33).

In a study done by Kaushal, Bates, Landrigan and Adams (2001:2114), the highest number of potential or preventable medication errors was found to occur in the NICUs, namely 2.8 per 100 orders, in comparison with 1.3 per 100 orders in the PICUs and 0.78 per 100 orders in medical wards. Furthermore, the accuracy of IV medication administration in children is considered critical (Parshurram, To & Seto, 2008:42; Shane, 2009:546; Simpson, Lynch & Grant, 2004:480; Swanson, 2006:235).

In order to have a clear understanding of safe medication administration practice, there is a need to determine what safe nursing practice entails. Wanzer (2005:471) states that the way towards safe medication administration practices is to create an environment or process that makes it difficult for medication errors to occur. The occurrence of medication errors is affected by the various factors, including the lack of neonate-specific commercial medicinal products authorised for neonatal use, the adaption of adult dosages for neonatal and paediatric use, and the narrow therapeutic index of medication when administered to sick children (Buck, Hofer & McCarthy, 2008:14; Lenclen, 2007:71). Simpson et al. (2004:480) and Suresh et al. (2004:1609) describe the significance of misidentification as a cause of medication errors in the NICU to be between 11% and 25%. In Suresh et al.'s (2004) findings NICU and PICU patients were found to be at risk during all aspects of their care. Distractions in the neonatal clinical environment contribute to 46% of medication errors (Hohenhaus & Powell, 2008:108; Suresh et al. 2004:1609). It has been found that the type of medication errors in the NICU and PICU varies, but it is reported that administration errors are the most common type of medication error (Chuo,

Lambert & Hicks, 2007:104; Ligi, Arnoud & Jouve, 2008:404; Suresh et al., 2004:1609). Medications may require further dilution prior to administration, depending on whether a peripheral or central line is in place (Lucas, 2004:33). These findings suggest that practitioners must become conscious of safety measures to reduce risk for this vulnerable patient population. Cohen and Shastay (2008:38) report on a survey conducted in the USA to review the attitudes and practices of nurses to maintain safe medication administration. Their findings have raised the question whether the critical care RNs education preparation, practice perceptions and experiences have an impact on medication errors.

Many strategies have been implemented in health care facilities to reduce the risk of medication errors by increasing medication administration safety (Benjamin, 2003:768; Hennessy, 2007:28; Hohenhaus & Powell, 2008:108; l Lefrak, 2002:76; Suresh et al., 2004:1609; Trossman, 2005:75). These strategies include the implementation of safer systems; computerised order entry; standard medication labelling; and safety checks in the medication administration process, including double checking (Clifton-Koeppel, 2008:72; Hennessy, 2007:28; Lefrak, 2002:76; Suresh et al., 2004:1609; Swanson, 2006:230; Walsh, Landrigen & Adams, 2008:423; Wanzer, 2005:82).

Armutlu, Foley, Surette, Belzile and McCusker (2008:64) acknowledge the problem of applying effective strategies for the particular practice environment by arguing that more research is needed on the impact of the unit safety culture on medication safety practices in the adult ICU population. That leaves the question as to what the impact of unit safety culture is in the NICU and PICUs. It also leaves the question as to what the impact of unit safety culture is on the medication safety perceptions of RNs in the NICU and PICUs. In studying the incidence of medication errors, Ghaleb and Wong (2005:20) affirmed that the risk of medication errors among paediatric patients is not well studied. Cohen and Shastay (2008:47) made a further compelling argument in recommending the importance of evaluating nursing practice. They also emphasised that nurses continuously need to strive towards making changes that help keep patients safe. Finally, in view of the literature, the researcher is compelled to describe which factors have an influence on IV medication safety as perceived by RNs working in the NICU, PICU and paediatric CSICU.

1.1.2 Problem statement

Despite the implementation of strategies to reduce multiple medication errors in health care, the prevention of medication errors in the ICU remains a challenge and IV medication errors still

occur in the NICUs and PICUs (Clifton-Koeppel, 2008:80; Shane, 2009:545). Buck et al. (2008:14) found that infants in ICUs are at greater medication error risk due to more frequent use of IV medication and drugs. The neonatal, paediatric and paediatric cardiac surgery patients in the ICU are all vulnerable and susceptible to untoward outcomes, if and when there is a failure in the process of safe medication administration. In the research hospital, medication error prevention is also a challenge since medication errors indeed occur in the research setting. Therefore, a uniform research setting is selected for this study within which IV medication administration is routinely done by RNs in the NICU, PICU and paediatric CSICU for all IV fluids through 'smart pumps' and IV pumps. The units' similarity is discussed in paragraph 1.2.3 and 3.2.3.

Medication errors occur in these units, but unfortunately the researcher was not allowed to display medication error rates of the NICU, PICU and paediatric CSICU, since this is regarded as sensitive information of the particular setting. However, the researcher, a member of the management team of King Faisal Specialist Hospital and Research Centre in Jeddah was concerned about medication errors in the particular setting and became interested in continued efforts to prevent medication errors. As no specific study had been conducted in Saudi Arabia regarding medication error prevention in the NICU, PICU or CSICU, the researcher identified a need to describe the perceptions of RNs regarding the factors that influence IV medication safety practices of RNs in the NICU, PICU and paediatric CSICU in a Saudi Arabian tertiary hospital. The IV medications being administered and considered in this study were continuous IV medications, intermittent IV medication administration (administered at a specific frequency per 24 hours), and stat IV doses.

1.1.3 Aim of the research study

This research project aimed to describe the perceptions of RNs regarding the factors that influence IV medication safety practices in the NICU, PICU and paediatric CSICU in a particular Saudi Arabian tertiary hospital.

1.1.4 Objectives

Specific objectives formulated for this study were to:

- describe the actual factors that have an influence on IV medication safety practice of RNs working in NICU, PICU and paediatric CSICU;
- determine the knowledge of the registered nurses in the NICUs, PICUs and paediatric CSICUs related to safe IV medication administration practices; and

- describe nursing medication administration strategies to prevent medication errors.

1.2 RESEARCH METHODOLOGY

1.2.1 Research approach and design

A quantitative research approach was selected. A descriptive design was used to describe the factors that affect IV medication safety practices of registered nurses working in NICUs, PICUs and paediatric CSICUs. Descriptive or survey designs are described by De Vos, Strydom, Fouché and Delport (2005:137) to be quantitative in character, because they require a questionnaire as a data collection method.

Bless and Higson-Smith (1995, cited in De Vos et al., 2005:104) define the unit of analysis as the individual(s) or object(s) from which the researcher gathers information. In this study all the registered nurses working in the NICUs, PICUs and paediatric CSICUs were the primary unit of analysis.

1.2.2 Research question

The terms 'research question' and 'hypothesis' are used in referring to a specific aspect of the overall research topic, namely to inform the reader of the purpose of the research and thus answer the question why the particular study should be undertaken (De Vos, 2001:99). The primary research question in this study was formulated as follows:

> What are the perceptions of RNs regarding IV medication safety practices in the NICU, PICU and paediatric CSICU in a particular Saudi Arabian tertiary hospital?

1.2.3 Population and sampling

The *actual practice setting* included the NICU, PICU and paediatric CSICU, which represent the practice environment within which the RN practices and administers IV medication. A uniform research setting is selected for this study within which IV medication administration is routinely done by RNs for all IV fluids through 'smart pumps' and IV pumps. The units are similar in terms of patients admitted pre- and post-operatively, but for different types of surgery. Neonates are admitted in any of these units, but depending on their illness and whether they are admitted from home or other facilities or being born in the hospital.

De Vos et al. (2005:294) describe a *target population* as 'the total amount of those components related to the research problem under investigation'. The population targeted for data collection in this study included the RNs working in the NICU, PICUs and paediatric CSICU as they were prominent and the focus of this study (N=121). King Faisal Specialist Hospital and Research Centre in Jeddah has an NICU that provides critical care to neonates of 25 to 42 weeks of gestational age, a PICU that accommodates paediatric patients who need medical-surgical intensive care, as well as a CSICU that accommodates paediatric patients who undergo cardiac surgery. The target population was calculated according to the particular hospital's manpower statistics between 1 March 2011 and 31 March 2011.

Kerlinger (1986, cited in De Vos et al., 2005:193) describes *sampling* as 'taking any portion of a population or universe as representative of that population or universe'. The researcher chose an 85% non-probability purposive *sample* of NICU, PICU and CSICU RNs (n=103) who were employed at the selected hospital and were responsible for administering IV medication. This is due to the fact that at any given time, 15% of the staff is on annual leave, as per nursing staffing planning. Some staff may also be on sick leave. The reason for choosing a non-probability purposive sample was to include purposively 'elements which contain the most characteristic or representative or typical attributes of the population' in the study to ensure that respondents who had experience with and knowledge of the phenomena under investigation were included (De Vos et al., 2005:202).

The researcher was not allowed by her authorities to display any sensitive information of the particular research setting (hospital and the three ICUs) and had to change the focus of the study from an observation by means of a check list, to a questionnaire that rather explored and described the RNs perceptions and opinions related to medication safety practices.

1.2.4 Inclusion criteria

All RNs who passed their competency examination during their nursing orientation at the institution were included in this study. The examination covered dosage calculation, pharmacology and IV medication. These nurses were working either day or night duty in any of the three selected ICUs. The RNs, who were in their period of unit orientation, or probationary period, were also included in the study.

1.2.5 Data collection instrument

The data collection instrument proposed for the data collection in this study was a self-administered questionnaire to describe the perceptions of RNs regarding the *factors* that influence IV medication safety in the practice environment; to determine the *knowledge* of RNs related to safe the IV medication safety practices; describe nursing medication administration *strategies* for medication error prevention, as recommended by RNs who administered IV medication routinely in the NICU, PICU and paediatric CSICU thereby achieving the objectives for this study. The questionnaire items were developed and refined by incorporating specific local institutional policies and procedures. Items related to 'factors' influencing medication safety practice, 'knowledge' and 'strategies' in the questionnaire were also based on a literature review and based on study outcomes. Any aspect of the different steps during medication administration was considered as a medication administration procedure and tested in the questionnaire.

Closed-ended and open-ended questions were included in the questionnaire. A larger portion of closed-ended questions and Likert-type questions were included in the questionnaire to provide the researcher with mainly quantitative data, while the smaller portion of open-ended questions provided the researcher with more detailed information that the RNs identified as appropriate and related to IV medication safety aspects.

1.2.6 Pilot study

De Vos et al. (2005:206) emphasise the importance of a conducting a pilot study before one embarks on the main investigation. A pilot study is similar to the planned study, albeit on a smaller scale. Brink (2006:166) recommends a pilot study to 'test the practical aspects and … feasibility of a research study' in order 'to detect possible flaws in the data collection instrument … as well as [to determine] whether the variables defined by operational definitions are … measurable'. A pre-test of the questionnaire was done for a period of three weeks from 22 June 2011 until 15 July 2011. It was conducted prior to starting the actual data gathering and the aim was to assess the suitability of the questionnaire, and to identify any problems that may influence the outcome of the study.

Twelve RNs (n=12), which is 10% of the target population, who were working in either the NICU, PICU and/or paediatric CSICU, were asked to complete the concept questionnaire in order to determine whether the questions were clear and understandable and to make any suggestions to improve the questionnaire, if needed. De Vos et al. (2005: 171) emphasises the

essence of pilot-testing a newly compiled questionnaire, so that errors could be corrected before the main data collection. According to the authors, ambiguous questions lead to non-comparable responses, leading questions lead to biased responses and vague questions lead to vague answers, no matter the effectiveness of sampling or data analysis. The questionnaire was also submitted to research experts at the university and the quality management department at the particular hospital. Return of the questionnaire indicated that voluntary consent was given. Once feedback had been obtained, the questionnaire was modified and finalised for use in the main research study.

The same sampling and execution methods employed in the pilot study were used for the main investigation. However, the particular RNs and data obtained during the pilot study were excluded from the final data collection.

1.2.7 Validity and reliability

De Vos et al. (2005:160) argue that the researcher must ensure 'acceptable levels of reliability and validity' of the measurement instruments and measurement procedures that are used in a study, before the study starts. In order to ensure reliability and validity the compiled questionnaire was submitted to experts in nursing quality management and research methodology, as well as to RNs in the neonatal intensive care unit, paediatric intensive care unit and cardiac surgery intensive care unit. Furthermore, the pilot study was utilised in order to add concepts that added value to the questionnaire in the description of RNs' perceptions regarding the actual factors that influence IV medication safety in the specific practice environment.

Bostwick and Kyte (1981, cited in De Vos et al., 2005:163) define reliability as the 'extent to which independent administration of the same instrument (or similar instruments) consistently yields the same (or similar) results under comparable conditions'. The questionnaire ensured that the same questions were asked to all participants in a consistent way.

According to De Vos et al. (2005:160), there are two important aspects to validity, namely 'that the instrument actually measures the concept in question, and that the concept is measured accurately'. The questions were designed specifically for this environment's policies and computerised physician order entry (CPOE). Validity was categorised according to content, face and criterion validity (De Vos et al., 2005:160). For the purpose of this study content validity and face validity were applicable as discussed in paragraph 3.2.7.2.

1.2.8 Data collection

The data was collected over a period of two months (between July 2011 and September 2011). If necessary, it was decided to extend the data collection period until at least 80% of the questionnaires had been returned.

The questionnaire was completed by the registered nurses of the NICU, PICU and paediatric CSICU during the data collection phase. The researcher mailed the questionnaire to the RNs working in the selected ICUs for the pilot study, as well as the main study. Completed questionnaires were sent by soft copy mail through the researcher's hospital e-mail or as by hard copy mail through the internal mail. As part of the mailed questionnaire, a cover memo, – hard and/or soft copy – provided specific information as to what was required from the study participants. Return of the questionnaire indicated that consent was voluntarily given.

1.2.9 Data analysis and interpretation

Microsoft Excel was used to capture the quantitative data and STATISTICA 9 software was used to analyse the data. The quantitative data analysis was conducted in consultation with a statistician of Stellenbosch University (question 1 to 69). Inferential statistics were not required. Since a descriptive design was chosen for this study, descriptive statistics were used in analysing the data. Distributions of variables were presented with histograms and/or frequency tables.

1.2.10 Ethical considerations

After formal approval was obtained from the Human Research Ethical Committee (HREC) at Stellenbosch University, official permission to conduct the study in the hospital was sought from the Institutional Review Board (IRB) of KFSHRC-J. This research study was approved by the Human Research Ethics Committee, Republic of South Africa (reference no: N11/04/126) as well as by the KFSHRC-J Institutional Review Board (IRB), reference no. IRB 2011-16 (RC-J 159-32).

The Declaration of Helsinki was the ethical model that applied to this study. In this study, there were no implications for the neonate or child as no changes in practice took place and/or treatment was changed (Stommel & Wills, 2004:377). Rather, perceptions of RNs were described, regarding the actual factors that influence IV medication safety in the practice

environment. This way the results and implied recommendations might benefit future patients, and not necessarily the children during this study.

The principles of informed consent and maintaining participants' confidentiality and anonymity are vital ethical considerations. Providing information in a questionnaire might have been perceived as threatening. Participants were informed during the information sessions and the cover letter that their participation is entirely voluntary and free to decline to participate at any time before or during the study. If a respondent would withdraw from the study, it would not affect the respondent negatively in any way. The researcher was obliged to respect the privacy of the nurses who were involved. Potential participants were assured that no information that could possibly identify a particular individual would be revealed. Therefore, assurance was given in the cover letter which accompanied the questionnaire that privacy and confidentiality would be maintained by the researcher. It was also achieved by having the provided study data accessed only by the researcher, the administrative assistant and research experts from the university. According to De Vos et al. (2005: 59), there are multiple ways to ensure informed consent is done appropriately, which were described in this section. For both the pilot study and the main study, there was no signed consent requested from the participants. However, during the information sessions, information was provided to participants that is appropriate in order to obtain informed consent, as recommended by De Vos et al. (2005: 59). As recommended by the authors, this includes all information regarding the goal of the study, the procedures to be followed, the advantages, disadvantages that participants would be exposed to, as well as the credibility of the researcher. The method of returning the questionnaires was discussed. In order to ensure anonymity, the participants were showed the designated, sealed box which was provided in all three ICU's. The respondents were reassured that if they chose to drop the questionnaires into the sealed box provided, the person who would collect questionnaires by opening and re-sealing the sealed box, would be the researcher (for the PICU and paediatric CSICU). For the NICU, the person who is managing their information sessions (a hospital assistant and trained field worker) who is not working in any of the units of study would be the only person allowed to collect questionnaires, by opening and re-sealing the sealed box. This was a further measure to maintain participants' anonymity. During the information sessions, the participants were informed that data entry was to be done by the trained, designated hospital assistant for the NICU participants. The data entry for the PICU and CSICU participants was done by the researcher because the respondents are not known by the researcher and therefore, there was no risk to recognize the handwriting on any questionnaire. No identifying

information was made known and no names were used, but codes only. There was no financial benefit to the participants for completing the questionnaire.

1.3 OUTLINE OF RESEARCH REPORT

The outline of this research report is as follows:

Chapter 1: Scientific foundation of the study

A general overview of the research was given in this chapter. The overview included an introduction to the research topic, background and preliminary review of the literature, the problem statement and rationale of the research study, as well as the aim and objectives. The methodology of the study was briefly explained and the ethical considerations were also discussed.

Chapter 2: Literature review

In this chapter, the factors that influence IV medication safety in the practice environment, safe medication administration practice and medication errors are defined in the framework of neonatal and paediatric patients' vulnerability in the ICU setting, specifically for IV fluid and medication. The various causes of medication errors are discussed, with specific attention being given to human, environmental and system factors and the factors that have an influence on IV medication safety perceptions of ICU RNs. The concepts of potential or actual harm to patients as a result of medication errors, as well as several error prevention strategies in creating a safe environment, are also discussed. In addition, previous relevant research studies are reviewed and discussed.

Chapter 3: Research methodology

The research approach and design, selection of subjects for the sample, the data collection method and process, as well as the data management are explained in this chapter.

Chapter 4: Data analysis, interpretation and discussion

The analysis and interpretation of the findings are discussed in this chapter.

Chapter 5: Synthesis, conclusions and recommendations

This chapter contains the synthesis, conclusions and recommendations of the study.

1.4 SUMMARY

Medication administration is an intervention that every nurse faces in the clinical setting. In today's situation of staff shortage, increased productivity and modern technology, the

challenges for nurses are manifold. Therefore the implementation of safety measures and the development of safety awareness are central to patient care and to the study objectives. Medication safety in paediatric critical care units remains a matter that requires constant attention, given the vulnerability of the particular patient population.

A preliminary literature review on the research topic was included in this chapter. The problem statement; research question; aim and objectives had been formulated to guide the study. In the discussion of the proposed methodology, the study approach and design were described; and the target population, sample size and sampling methods were identified. A self-administered questionnaire was selected as data collection instrument and briefly discussed.

An extensive literature review on IV medication errors is provided in detail in Chapter 2.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

A literature review serves as a valuable strategy for a researcher to learn from other's methods and findings as well as from the problems they experienced in conducting the research (Burns & Grove, 2007:135). The search for relevant information and research studies relevant to the topic of this study was undertaken using *EBSCO, Cinahl, Ovid, Medscape, Pubmed* and *Proquest Library* electronic databases. Core words used in identifying applicable studies were 'medication errors', 'safe nursing practice', 'safe practice', 'medication safety',' safe medication administration',' neonatal', 'paediatric', and 'neonatal and paediatric intensive care unit'.

The focus of the literature review was to locate local, national and international studies conducted on medication errors in neonatal and paediatric critical care areas. Since medication administration is predominantly a nursing task, the researcher conducted the literature review in order to determine what nurses could do to ensure medication safety. The literature review was instrumental in describing the influencing factors of medication errors and the knowledge that an RN has to acquire in order to ensure safe medication administration within this specific practice setting. The review gave the researcher the opportunity to describe the findings from other researcher in context of the set standards of the local policy and procedure. It also enabled the researcher to test concepts from the literature findings through specifically compiled questions in the questionnaire to describe safety influencing factors, as perceived by RNs. The articles searched and reviewed had a nine-year span from 2002 to date in order to review current studies because of the fast changing health care within the context of changing technology.

2.2 SAFE MEDICATION ADMINISTRATION PRACTICE

Medication errors are common in neonatal and paediatric critical care areas and it is estimated that more than half of these errors are preventable (Clifton-Koeppel, 2008:72). Other researchers seem to agree that medication errors are preventable (Jain, Basu & Parmar, 2009:150; Lenclen, 2007:76). From a quality perspective, Hall, Moore and Barnsteiner (2008:422) asked the question as to what role nurses play in medication administration practice with expectation for quality-driven patient care and found that the role of the nurse is complex.

In order to have a clear understanding of which factors influence safe medication administration practice, there is a need to determine what these causing factors are. Wanzer (2005:471)

claims that the way towards safe medication administration practices is to create an environment or process that prevents or eliminates medication errors. A safe practice environment is seen as an optimal physical environment that is needed to promote accurate medication use and how anyone involved in the process can establish a safer workplace, according to the ISMP Alert, 'Safe practice environment' (ISMP, 2008:1).

As depicted in the researcher's compiled conceptual framework, safe medication administration practice is seen within the context of the 'five rights of medication administration', which is meant to ensure that the right patient receives the right drug (and form of drug), the right dose (strength and rate of the infusion), via the right route, and at the right time (Shane, 2009:546). According to the Institute for Safe Medication Practices Alert (ISMP, 2007:1), a medication error is seen as a breach of one or more of the five above-mentioned rights. For the purpose of this research, a medication error is 'any preventable event that occurs during any stage of the medication administration process that may result in a medication error' (Clifton-Koeppel, 2008:72). The 'five rights' principles also form the basis of the medication administration policies, that set standards in the research hospital that the medication rights should be checked prior to medication administration in the research setting. Safe medication administration practice is *secondly* also seen within the context of the research hospital's policy regarding medication administration, in terms of how these medication rights should be 'double-checked'. The method, as guided by this policy, in which these five medication rights should be double-checked, ensures safety in medication administration if the RN completes nursing 'double-checks' that are focused on checking all of the medication rights with a witnessing RN (KFSHRC-J, 2008a:2).

A medication error is seen as a breach of one or more of the five above-mentioned rights, according to the Institute for Safe Medication Practices Alert as published as 'Another heparin error: Learning from mistakes so we don't repeat them' (ISMP, 2007:1). A medication error, by definition, is also seen as a breach of one or more of the above-mentioned five rights, in the medication administration policy of the research hospital and depicted in the researcher's conceptual framework (paragraph 2.7). Medication administration takes place within the practice environment. In this research study, a medication error is 'any preventable event that occurs during any stage of the medication administration process' (Clifton-Koeppel, 2008:72). Therefore, in essence, this study is aimed at describing factors that cause medication errors, so that, by elimination or reduction of these causing factors, the researcher could describe

strategies for prevention. Therefore, RNs who are working in this practice setting were asked what are the factors, as they perceived, that influence medication safety practice.

However, in view of published findings on the causes of medication errors, a gap still exists between practice and patient safety due to the impact of multiple human and system factors on patient care delivery within the practice environment (George et al., 2010:1763). It is reported that more research is required to evaluate new strategies and technologies to support safe medication administration. Issues affecting safe IV practice have to be addressed, whether they are organisational, technical, human or related to the need to transform the nurse's practice environment (Cousins, Sabatier, Begue, Schmitt & Hoppe-Tichy, 2005:190; George et al., 2010:1763; Kane-Gill & Weber, 2006:273). Therefore, RNs who are working in this practice setting were asked what they perceive are the strategies to ensure medication safety. Medication administration is mainly a nursing responsibility and IV therapy should be regarded as a high risk activity by all those responsible for this activity (Cousins et al., 2005:190). In setting the standard for safe practice, it is stated that nurses are responsible for ensuring safe, quality patient care at all times (Elliott & Liu, 2010:300). According to Raja, Boo, Rohana and Cheah (2009:70), nurses' non-compliance with the standard practice of medication administration can be improved by standardising IV medication administration. This statement supports the view held by Bates, Vanderveen, Seger, Yamaga and Rothschild (2005:203).

Therefore, if medication errors are reported in the literature to be preventable, it indicates that RNs, who are working with these vulnerable patients, can optimize their medication administration practice to be safe. It also sparked the researcher's interest to seek information from RNs in this specific practice environment that could give an understanding of the perceptions of RNs regarding the factors that influence IV medication safety in the practice environment, through the specifically compiled data collection instrument.

2.3 VULNERABILITY OF NEONATAL AND PAEDIATRIC PATIENTS WITHIN THE PRACTICE ENVIRONMENT

In describing the practice environment, the ICU accommodates patients that are acutely ill or hospitalised long term. As a result, ICU patients are more vulnerable to the negative outcomes of IV medication errors, and infants and children more so than adults (Buck et al., 2008:14; Clifton-Koeppel, 2008:72; Lenclen, 2007:71; Shane, 2009:546).The risk for medication errors seems to be precipitated by two aspects, namely the ICU setting and patient types (Kane-Gill & Weber, 2006:273). The setting is significant because patients are extensively exposed to

medications in the ICU and different dosages exist for different patients in the ICU (Chedoe et al., 2007:503; Clifton-Koeppel, 2008:72; Forni, Chu & Fanikos, 2010:13; Lefrak, 2002:78).

The patient type is also significant, since several factors affect the patient's vulnerability. Firstly, medication dosage principles and dosage calculation for neonates and/or paediatric patients are based on either gestational age, or weight of the child (Clifton-Koeppel, 2008:72). Therefore, if the wrong dose is given it is likely to affect the patient because fluid sensitivity is a common problem among premature and cardiac patients. Careful monitoring of fluid intake, as well as of intake and output balances, is done to prevent fluid overload, resulting in specific care plans. For example, since multiple infusions are delivered, the continuous IV infusions may have to be concentrated more to accommodate all IV medication and fluids. These patients may also have hypoglycaemia or hyperglycaemia, which requires that the fluid bases for medication delivery may have to be altered so as to counteract the hypoglycaemia or hyperglycaemia (Hennessy, 2007:28). In the practice environment, this means that the nurse may change IV fluids and alter IV pump settings an unpredictable number of times during the shift. Secondly, minor hemodynamic changes in the neonatal and paediatric patient influence the pharmaco-dynamics of medication used and it is thus imperative to ensure that the dosage and frequency are changed accordingly (Buckley, Erstad, Kopp, Theodorou & Priestley, 2007:150; Clifton-Koeppel, 2008:72;). Thirdly, Ghaleb and Wong (2005:21) describe the importance of the various stages of development and maturation in children as another medication error risk that poses complications in the clinical setting. The levels of some liver enzymes that metabolise medication are only present at birth; some are only induced the week after birth, while others delay their appearance until one to three months of age (Ghaleb & Wong, 2005:21). Franke, Woods and Holl (2009:85) mention a fourth factor, namely that children in the ICU may have multi-organ system dysfunctions which alter medication delivery and clearance.

Due to the vulnerability of these patients, the nurse's responsibility is mainly to minimise patient risk in IV practice (Cousins et al., 2005:190). Therefore the setting at the research hospital was selected for the small, safety-margin patients in the NICU, PICU and CSICU in order to investigate the specific objectives under study.

Based on the literature review, the setting and patient type in the practice environment pose certain risks for patients. With reference to the researcher's conceptual framework (figure 2.1), the causing factors, as identified in the literature, in combination with latent factors, could lead to a medication error if medication administration practice is not safe, for example, when either

knowledge-based, rule-based, action-based and/or memory-based errors are made, according to Aronson's classification (discussed in paragraph 2.6).

2.4 INFUSION OF IV FLUIDS AND MEDICATION WITHIN THE PRACTICE ENVIRONMENT

IV medications are vital during ICU patient management because this is the main route of medication administration (Anderson & Townsend, 2010:24). It is reported that medication administration errors as a result of IV infusion pumps can cause harm for critically ill patients because IV administered medication acts faster than orally administered medication (Rothschild et al., 2005:535). This compelled the researcher to describe the perceptions of RNs regarding the factors that influence IV medication safety in the research setting. The IV medication that were being administered and considered in this study, were continuous IV medications, intermittent IV medication administration (administered at a specific frequency per 24-hours) and stat IV doses, as tested in the questionnaire.

According to the literature, IV therapy poses certain challenges for patients in this unique setting, which is intensified when a medication error occurs. According to Anderson and Townsend (2010:24), 20% of ICU medication errors are potentially life-threatening, and 42% of these errors require extra life-sustaining treatments (Kane-Gill & Weber, 2006:273). It also seemed to be important to review practice related to IV fluids and medication in this research setting. Medications may require further dilution prior to administration, depending on whether a peripheral or central line is in place (Lucas, 2004:33). This was tested in the questionnaire. Intravenous medication administration for neonatal and paediatric patients is critical because of poor venous access for these patients and the low infusion rate that these small patients receive, especially when they have to receive multiple infusions. Inadequate information on the physico-chemical compatibility of drugs makes caring for these patients risk-prone (De Giorgi, Guignard, Fonzo-Christe & Bonnabry, 2010:522).

Within these risk-prone situations, nurses' role is complex, in that they have to perform multiple IV calculations during their daily practice. Larsen, Parker, Cash, Connell and Grant (2005:21) reported that the correct weight-adjusted dose (at an acceptable rate, concentration and volume) have to include multi-variable calculation every time that a dose is changed. It was found that standard drug concentrations, IV pumps (also known as 'smart pumps') and redesigned labels decreased medication errors by 73% for an absolute risk reduction of 3.1 to 0.8 per 1000 doses (Larsen et al., 2005:23). The results were due to the following reasons:

nurses were able to make fewer calculations when an IV dose had to be changed, IV pump pre-programmed safety nets alerted the nurse when a dose exceeded set limits, and infusions could not be administered unless the settings were overridden by the nurse. From the literature findings, it seems that nurses in the study could also accurately account for infusion volume that had been infused and they could use information on standardised labels to perform double-checks prior to the initial start of the continuous infusion (Larsen et al., 2005:24). This aspect was tested in the questionnaire. Since this is also a specific requirement in the institution's policy and procedure, it was tested in order to gain information of the RNs perceptions regarding factors that influence IV medication safety. The literature review, provided the researcher with more information regarding the factors that could cause medication errors, and as a result enrich the research setting with risk-prone situations, as mapped by the conceptual framework (figure 2.1).

2.5 PREVALENCE OF MEDICATION ERRORS

Prevention of medication errors in the ICU, however, remains a challenge and IV medication errors still occur in the neonatal and paediatric ICU (Clifton-Koeppel, 2008:80; Shane, 2009:545). ICU patients are reported to be more vulnerable to medication errors when there is a failure in the process of safe medication administration (Anderson & Townsend, 2010:24; Clifton-Koeppel, 2008:72; Franke et al., 2009:85). As tested in the questionnaire, information was sought from the RNs in this study, as to whether they exhibit knowledge that patients could be harmed when medication administration process fails.

The accuracy of IV medication administration in children is considered to be critical (Parshurram et al., 2008:42; Shane, 2009:546; Simpson et al., 2004:480; Swanson, 2006:235). As confirmed by 79% of nurses in a study which included 775 nursing study participants, medication errors are found to occur when nurses do not follow the five rights of medication administration (Cohen, Robinson & Mandrack, 2003:37). This finding was supported in a follow-up study five years later, where it was found that 89% of nurses among 1296 nursing study participants believed that medication errors occur as a result of a breach of the medication rights (Cohen et al., 2003:37).

Fahimi, Sistanizad, Abrishami and Baniasadi (2007:145) found that incorrect dose (70%), labelling error (20%) and unauthorised medication (10%) of medication doses administered through infusion pumps occurred in their study. In another study, actual ADEs (3.6) and

potential ADEs (9.8) were reported per 100 orders (Buckley et al., 2007:145). According to Buck et al. (2008:14), 31% of medication errors occur during drug administration, 25% during dispensing, and 16% during ordering. In another study, it was reported that nurses did not carry out at least one of the ten standard medication administration steps. The researchers were asking the question whether nurses are aware of the value of having another nurse to witness drug administration. The most commonly omitted step was having another nurse to witness drug administration (95%). Following implementation of remedial measures by these researchers in terms of education of RNs, a medication safety awareness was established that made these RNs aware of medication error causing factors by reporting medication error causes in this study, in 94% of doses administered, the nurses still did not get a witness to countercheck calculations of drug dosages before administration (Raja et al., 2009:70). In the research hospital, the 'double-checking' of all medication by two RNs, is a mandated practice standard by the research hospital policy and procedure. Therefore, the researcher tested these aspects in detail in the questionnaire, as perceived by the RNs. The researcher is also familiar with the research hospital's policies and procedures as well as annual mandatory medication safety training. The annual training is conducted by pharmacists, during which staff awareness is increased regarding the exponential risk of missing one of the medication rights. The challenge in this particular practice environment, is that the witnessing of double-checks that requires time and undivided attention, because the omission of the nursing 'double-checks', can result in an omitted check of one of the medication rights, for example, checking the right dose for patients, implies that the RN verified the medication order in the medication formulary (with the patient's age and weight). It also implies that the medication label, when the medication is dispensed, is double-checked with another RN as witness, to verify with the set rate on the medication label as well as the set rate on the IV pump. If these vital steps in 'double-checking' are not witnessed by another RN, a medication error could be caused, as illustrated by the conceptual framework (figure 2.1).

In summary, these literature findings seem to indicate that nurses must become conscious of safety measures to reduce risk for this vulnerable patient population. Therefore, in this study, the factors that have an influence on IV medication safety perceptions of RNs working in NICU, PICU and paediatric CSICU, are tested and the knowledge of registered nurses in these ICUs was determined. Nursing medication administration strategies to prevent medication errors are described and multiple empirical findings are reviewed.

2.6 CLASSIFICATION OF MEDICATION ERRORS

Aronson (2009:602) claims that an effective way to understand how medication errors happen and thus how to prevent them is by classifying medication errors. This researcher claims that there is a disadvantage to focusing on human rather than system errors, but argues that a focus on human and system errors is more effective than focusing on only human errors. Medication errors can be classified, invoking psychological theory, upon which it can inform preventive strategies (Aronson, 2009: 603). For this reason, human factors that contribute to medication errors were described in this research study, and tested in the questionnaire. This also inspired the researcher's interest to investigate all perceived factors influencing the registered nurses safe medication administration practice (as discussed in 3.2.5).

Aronson's classification of medication errors provides an organisation of underlying causes. Four broad types of medication errors are revealed, namely knowledge-based, rule-based, action-based and memory-based errors (Aronson, 2009:602). Knowledge-based errors stem from ignorance of expert knowledge, while rule-based errors are seen as the misapplication or failure to apply a 'good rule', or the application of a 'bad rule'. An action-based error is seen as the non-intentional performance of an action. A technical error is action-based, for instance when an outcome fails or the wrong outcome results because an action was not correct. Memory-based errors occur when the nurse forgets something. This author's classification method seems to be valuable for application by nursing managers and nursing staff who are responsible for medication error analysis.

This classification was utilised by other researchers a year later. The findings of Johnson and Young's (2011:131) behavioural study revealed that, of a total study population (n=104), action-based errors (either resulting in patient harm or no harm) are the highest-ranking cause of errors (70.2%), after which knowledge-based (14.4%), memory-based(8.6%) and rule-based errors (6.7%) are ranked.

This literature review reflects that the classification of medication errors seems to assist RNs to analyze the occurrence and cause of a medication error. This information may be helpful in applying specific action plans to accurately work on the identified cause, for example the suitability of RN education and training for knowledge-based medication errors.

2.7 CAUSES OF MEDICATION ERRORS AND CONCEPTUAL FRAMEWORK

Errors relate to various aspects in the medication administration process (Lucas, 2004:33). Based on findings reported in the literature and since the occurrence of medication errors is also an identified problem in the research hospital, the researcher identified the need to describe the perceptions of RNs regarding the factors that influence IV medication safety in the NICU, PICU and paediatric CSICU in a Saudi Arabian tertiary hospital.

In view of the multiple causes of medication errors, as identified by the literature (paragraph 2.7.1 to 2.7.12), it necessitates a discussion of the conceptual framework used for this study. The conceptual model of Van der Schaaf (1992) contends that technical or human operator failure and/or organisational failure causes a dangerous situation (interpreted by the researcher as a medication error) if there are inadequate system defences (interpreted by the researcher as designed safety checks or processes) to prevent the medication error from happening. If the human (interpreted by the researcher to be the RN) recovers the situation (interpreted by the researcher as the act of intercepting the medication error), a near-miss is caused if the medication has not yet been administered to the patient. However, if it has been administered to the patient, it leads to a medication error.

Van der Schaaf (1992) explained that the causal factors include technical, human operator and organisational failures. The researcher's own conceptual framework was compiled based on the literature review of comprehensive research done over the last decade with the focus on which factors cause safe versus unsafe medication administration practice. This conceptual framework depicts safe and unsafe medication administration practice within the context of checking the medication rights through nursing 'double-checks' by two RNs. Safe medication administration practice is based on whether all the medication rights are completely and correctly checked through nursing 'double-checks that are performed independently and completely by two RNs. Unsafe medication administration practice is achieved, if one or more of these medication rights are partially checked or incorrectly checked through nursing 'double-checks that are performed incorrectly by one RN and/or incompletely done by two RNs.

However, multiple factors may be present in the practice environment, including environmental, human, system factors. Multiple examples of medication error causes are grouped under these broad categories. Based on the literature review, it is demonstrated how these factors, in combination with latent factors, provide the risk for a medication error to take place within the practice environment. Environmental factors may include interruptions, noise, work pressure,

patient condition that is unstable or multiple nursing tasks to be performed in a limited time. Human factors may include knowledge-based, rule-based, action-based and memory-based errors, as discussed in paragraph 2.6 for Aronson's classification of medication error causes from a psychological approach (Aronson, 2009:602). System factors may include inadequate, complex technology, training, or processes).

In view of the local policy and procedure, nursing 'double-checks' and complete checks of the medication rights are set as a standard for medication safety. Nursing 'double checks' is defined as checks that are performed with a witnessing RN, regarding the five medication rights, as per order and matched with the medication label, patient's infusion lines and the patient's infusion pumps. If there are no nursing 'double-checks' or checking is not 'independent' (as described in more detail in paragraph 2.10.6), if unlimited distractions occur and if there are only partial checks of medication rights within the practice environment and therefore is an omission of one or more mandated steps in the medication administration process. The potential for a medication error to take place within the practice environment always exists. The researcher's discussion of medication error causes (paragraph 2.7.1 to 2.7.12) is focused on latent, human, system or environmental factors that influence safe medication administration practice. Safe medication administration practice relates to medication that is administered safely to the patient, while unsafe medication administration practice relates to a medication error that may or may not cause harm to patients (paragraph 2.8). When a medication error has occurred, an analysis should be done upon which action plans have to be set for prevention of medication errors in future.

In order to gain a better understanding of how a near-miss or medication error can potentially take place within a particular practice environment, the researcher's conceptual framework is represented in Figure 2.1 and subsequently discussed. The absence or presence of factors influencing safe medication practice, as per the literature review, encouraged the researcher to seek information (as provided by RNs in the particular research setting) to describe their perceptions regarding the factors that influence IV medication safety since standards are set within the policies of the research hospital. However, medication errors still occur.

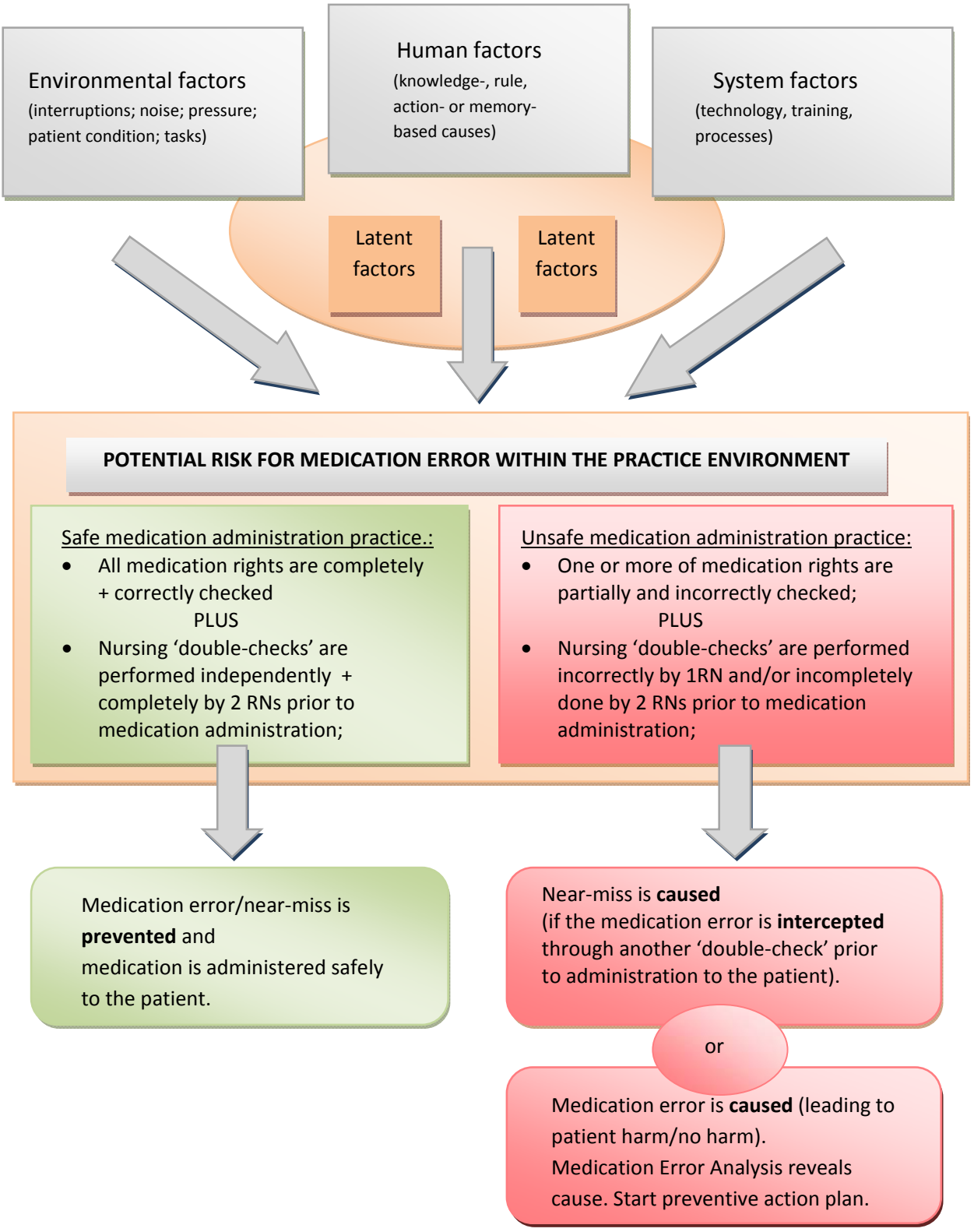

Figure 2.1: Researcher's conceptual framework for medication safety practice

2.7.1 Incorrect dose, quantity or time

Anselmi, Peduzzi and Dos Santos (2007:1847) reported that medication dose omission and wrong dose were the most frequent causes of medication error in three hospitals of their cross-sectional study. Johnson and Young (2011:129) confirm that incorrect dose, wrong time and dose omission are causes of medication error. Tang, Sheu, Yu, Wei and Chen (2007:449) also reported 'wrong dose' errors (26.4%), while Ozkan, Kocaman, Ozturk and Seren (2011:139) found that 36.5% medication errors occurred in the paediatric setting, of which 40.3% were due to the wrong time and 34.6% to the wrong dose given. These findings demonstrate that a significant problem exists for patients (Anderson & Townsend, 2010:23). As a result, the RNs who participated in this study were also asked to identify whether medication errors are caused by incorrect dose, quantity or time due to literature reports that describe medication errors to be under-reported (discussed in paragraph 2.10.5).

The increased risk for medication errors with the use of IV pumps was described, since nursing staff are prone to make dosing errors while setting the infusion devices (Chuo et al., 2007:104). It is further claimed that it happens during times of high workload; especially ‘the evening hours around shift change’ are found to be the most vulnerable time (Chuo et al., 2007:104). In this modern day of health care, technology improves care delivery but brings other unique challenges, as reported in the literature. Infusion pump medication errors seem to occur mostly due to a lack of knowledge or precision during preparation and/or administration procedures (Fahimi et al., 2007:297).

In summary, the problem of medication errors is well-studied, as described in the literature review. Medication errors of incorrect dose, quantity or time potentially may be caused by human or system factors, if it is not intercepted by humans (RNs) who need to act as adequate system defences. The researcher’s conceptual framework (figure 2.1) showcases that the medication error can still be prevented from reaching the patient, if this error is intercepted through adequate system defences (adhering to adequate medication administration process), as found in this literature review. However, in order to determine how medication errors can be prevented in this research setting, the researcher sought information from the study participants (RNs who know the challenges of this research setting) which factors they perceived to influence IV medication safety in the NICU, PICU and paediatric CSICU.

2.7.2 Wrong drug

About 1230 reports from 54 hospitals in the Vermont Oxford Network revealed near-misses to be 47% for wrong medication, dose, schedule, or infusion rate including nutritional agents and blood products (Suresh et al., 2004:1609).

In their two-year review in paediatric hospitals, Buck et al. (2008:14) found that 14% of documented errors related to the use of an unauthorised or wrong drug in paediatric areas. The drug classes most often involved were analgesics and antibiotics and the errors mostly occurred during the ordering process (Buck et al., 2008:14). This supports Tang et al.'s (2007:449) finding that antibiotics (38.9%) are commonly involved in medication errors. Fahimi et al. (2007:116) observed that Amikacin® was involved in the highest rate of error (11%) among all the selected medications.

Items were included in the questionnaire to determine which drug class is often involved in medication errors in this research setting.

2.7.3 Calculations

As mentioned previously, multiple medication errors in neonatal and paediatric ICUs are caused by the need to carry out a sequence of calculations to determine the medication dose and dilution (Lucas, 2004:33). Hennesy (2007:28) as well as Hicks, Becker and Chuo (2007:300) also recognised the diverse needs of ICU patients. The infusions used require an infusion pump that operates on minimum rates with which medications can safely and accurately be infused. Calculations for continuous infusions through infusion pumps are complex and error-prone, even more than the calculations required for intermittent medication administration (Fahimi et al., 2007:295). The need for calculations can be decreased through 'minimum infusion rates' when 'standardised medication concentrations' are developed to ensure that the selected concentrations will provide 'reliable infusion rates' (Hennesy, 2007:28). Another common error is the 'inadvertent interchange of milligrams for micrograms for neonatal and paediatric patients, as reported by Swanson (2006:230).

Cologna, Pederzini, Capretta, Malossi and Barelli (2005:12) agree that the calculation of medication dilutions and dosages to be administered is one of the main causing factors for medication errors. It will suffice to report that different opinions are found in the literature regarding calculation skills being a cause of medication errors. Fahimi et al. (2007:298) found that it is necessary to improve nurses' training in calculating dosage to avoid risks associated

with medication preparation. Various researchers (e.g. Fry & Dacey, 2007:680; Johnson & Young, 2011:134) recommend regular review sessions on mathematical calculations.

Wright (2009:548) disagrees with other researchers and claims that there is little evidence to demonstrate that nurses are poor at solving drug calculation in practice. It is reported that learning must take place predominantly in the unit. Wright (2007:831) declares that written numeracy assessment tools are not valid instruments to use in testing the numeracy skills nurses would require for clinical practice and that nurse education needs to focus on researching and examining how best to support, assess and develop nurses' numeracy skills to ensure that they are fit for practice. Two years later, Wright (2009:548) reported that the drug calculation skill of nurses was still a national concern in the USA. The continued concern led to the introduction of mandatory drug calculation skills tests which a student must pass in order to be registered as a nurse in the USA. Wright (2010:85) subsequently conducted a literature review through the databases Medline, CINAHL, the British Nursing Index (BNI), the Journal of American Medical Association (JAMA) and Archives, as well as Cochrane reviews in the search for research findings or systematic reviews which report on the incidence or causes of drug errors in clinical practice. Still no literature was found relating to medication errors in practice that are caused by nurses' poor calculation skills, neither were there studies that examined nurses' drug calculation errors in practice. However, other aspects of nurses' preparation and administration of medications, which contribute to medication errors in practice, are more pressing (Wright, 2010:97). Those aspects include nurses' numeracy, literacy and mathematical skills. In the United Kingdom these skills are formally tested according to the Nursing and Midwifery Council's Essential Skills Clusters that stipulates the agreed standards before student nurses are deemed competent to be registered nurses (Wright, 2010:86).

Based on the literature, the researcher deemed it necessary to test in the questionnaire whether calculations and calculation checks are perceived to be a causing factor of medication errors in this research setting.

2.7.4 Lack of neonate-specific medicinal products

According to Buck et al. (2008:14) the lack of neonate-specific commercial medicinal products authorised for neonatal use and the adaption of adult dosages for neonatal and paediatric use have an impact on the occurrence of medication errors. This supports Lenclen's earlier view (2007:71). As reported by the Institute of Medicine (IOM), 50% to 75% of prescribed medications had not been tested in neonatal and paediatric patients (IOM, 2008:1).

Ghaleb and Wong (2005:20) state that dosing errors could occur because 'very few drugs are available in ready-to-administer unit dosages that are appropriate for children'. Clifton-Koeppel (2008:72) agrees that medication used in the NICU is 'often off-label', indicating that it is prescribed outside the scope of the Federal Drug Agency's approved label. In their observational study, Fahimi et al. (2007:296) also found that 10% of doses administered through infusion pump were unauthorised medication. Clifton-Koeppel (2008:72) found that medication errors were common due to the lack of dosing information. Errors were also found to occur because the dosing information varied and medication was ordered per kilogram of weight for infants and children. Anderson and Townsend (2010:24) declare that nurses must have access to accurate information on medication currently in use and that this information should be obtained from, among others, protocols, order sets, computerised drug information systems and medication administration records. Both these aspects were tested in the questionnaire to determine whether the RNs perceived it to be a factor influencing IV medication safety.

2.7.5 Misidentification

Simpson et al. (2004:480) found misidentification as one of the causes of medication errors in the NICU to be 25%. They found that neonatal and paediatric ICU patients were at risk during all aspects of their care. Of 1 230 anonymously reported medication error reports from 54 hospitals in the Vermont Oxford Network, 11% showed that near-misses and adverse events were related to patient misidentification and 10% were due to labelling error (Suresh et al., 2004:1609).

According to Anderson and Townsend (2010:23), the 'right patient' is the first of the 'five rights' in medication administration and that it ensures prevention of administration errors. These authors state that the required patient information includes name, age, birth date, weight, allergies, diagnosis, current laboratory results, and vital signs. 'Flawed or absent patient identification processes' are also reported as 'wrong patient' medication errors, for example where there are infants in the ICU with the same first name and similar hospital identification numbers. In the ISMP Alert (2011a:1) titled 'Oops, sorry, wrong patient! A patient verification process is needed everywhere, not just at the bedside', it is reported that the wrong medication administration record (MAR) was used and the wrong medication was administered to an infant.

In order to address the problem of medication errors caused by misidentification, some researchers advocate the use of barcode scanning of the patient's identification band to confirm identity (Anderson & Townsend, 2010:23). However, as reported, this technology has the

disadvantage that the bar code is not fail-proof, as the patient's armband may be missing, or the scanner may fail to scan due to a battery failure (Anderson & Townsend, 2010:23).

Misidentification, a causing factor as identified in the literature, was tested in the questionnaire to determine whether the RNs in this study perceived it to be a factor influencing IV medication safety. The steps of patient identification (right patient) and medication identification (right medication) are included in the institution's policy and procedure, as an RN responsibility.

2.7.6 Human factor

Reason (2008:303) comments that making errors is one of the sub-dimensions of human behaviour and he recommends that the system should rather be altered since human nature cannot be changed. However, Lucas (2004:33) described the importance of having 'a system designed … to eliminate human error and if human error still occurs, that the system should allow for its correction'. The way in which the system should allow for its correction is through a standardised medication process, which is in line with the researcher's conceptual framework.

It has been found that human errors are the main cause of medication errors (George et al., 2010:1763; Kane-Gill & Weber, 2006:273). Brady, Malone and Fleming (2009:690) report the same findings, but they add that multiple contributing factors are identified, such as deviation from procedures, distractions during administration, excessive workloads, and nurses' lack of knowledge of medications. It was also found that nurses' problem-solving mode may have an impact on the risk for medication errors when a 'medication is not used often' and/or is 'not well understood by the practitioner' (Lefrak, 2002:75; Tucker, Parry, McCabe, Nicolson & Tarnow-Mordi, 2002:99).

Lefrak (2002:76) reports that medication errors are prone to happen when the 'five rights' are not checked as per standard and that familiarity with the process may lead to the omission of standard checks. Hicks, Becker and Chuo (2007:300) found that nearly a quarter of NICU medication errors occurred due to device miss-programming. These researchers state that nurses' misinterpretation of the modes on the pump, namely time, volume and rate, contribute to device miss-programming.

Hicks, Becker and Chuo (2007:300), who also identified many other factors, point out that errors occur disproportionately between 18:00 and 24:00. In contrast, Fahimi et al. (2007:297) reported that the IV rounds conducted at 09:00 had the highest rate of error (19.8%). Johnson and Young (2011:138) found that medication errors occurred between 08:00 and 11:00 as well as from

20:00 to 23:00. These findings may correlate with findings on other nursing tasks during these reported high-risk times. Nurses may benefit by being aware of these research findings in order to improve medication administration safety practice during these hours.

Fatigue and sleep deprivation seem to be factors that influence safe practice. It is evident from the literature that these two factors lead to limitations in vigilance, memory, information processing, reaction time and decision making. An exhausted nurse may not notice a near-miss, which could result in a medication error (Anderson &Townsend, 2010:25). In the same vein, Buckley et al. (2007:147) found memory lapses (23.8%) to be the most frequent cause of error (46.7%).

All of the above human factors, as found in the literature, were tested in the questionnaire to determine whether the RNs perceived any of these to be factors that influence IV medication safety.

2.7.7 Environmental distractions and interruptions

Nurses have to care for patients in a practice environment that seems to be risk-prone. Conrad, Fields, McNamara, Cone and Atkins (2010:143) state that the nurse works in a stressful environment because interruptions and distractions are regularly encountered. Clifton-Koeppel (2008:76) defines distractions as ‘events that draw a nurse’s attention somewhere else’ while interruptions ‘stop the person’s current action’. Gurses and Carayon (2007:185) define interruptions as performance obstacles that hinder ICU nurses’ capacity to perform their jobs in their immediate work environment. This definition is reiterated by Petrova (2010:47) who emphasises that distractions and interruptions disrupt the nurse’s focus, which could lead to serious mistakes and jeopardise patients’ safety.

Regarding the impact of distractions and interruptions, the literature findings are very specific as to the types that occur in the practice environment. In a study by Fry and Dacey (2007:679), nurses reported that the most important factors contributing to medication incidents were interruptions by patients and relatives or visitors and telephone calls during the medication administration process. Suresh et al. (2004:1609) found that distractions in the neonatal clinical environment contributed to 12% of medication errors such as a noisy environment (46%), distractions from families (42%), hectic workday (40%), and crowded workspace (37%). Clifton-Koeppel (2008:76) claims that the frequency, type of distractions and how to reduce them have not been well studied. However, Gurses and Caravon (2007:185) found that the following types

of distractions in their multi-site, cross-sectional study included the delay in getting medications from the pharmacy (36%), spending a considerable amount of time teaching families (34%), equipment not being available as someone else is using it (32%), patients' rooms not being well-stocked (32%), insufficient work space for completing paperwork (26%), searching for supplies (24%) or patients' charts (23%), receiving many phone calls from families (23%), delay in seeing new medical orders (21%), and misplaced equipment (20%).

MEDMARX data reflects that distractions are a causative factor in about 45% of medication errors. For example, the most frequent source of interruptions has been found to be co-workers asking for assistance. These findings are reported according to the ISMP Alert, 'Safe practice environment' (ISMP, 2008:1).Another group of researchers agree that the primary source of interruption was members of the health care team (Hall et al., 2010:1046). In a study by Biron, Lavoie-Tremblay and Loiselle (2009:335), characteristics of nurses' work interruptions (WIs) were documented during medication administration through a direct observation method. They reported 6.3 WI/hour during the medication preparation and administration phases. During the preparation phase, nurse colleagues (29.3%), followed by system failures such as missing medication or equipment (22.8%), were the most frequent sources of WIs. Nurses were interrupted during the preparation phase mostly to solve system failures (26.8%) or for care coordination (24.4%). During the administration phase, the most frequent sources of WIs were self-initiation (16.9%) and patients (16.0%). The most frequent secondary task undertaken during the administration phase was direct patient care (43.9%). WIs lasted 1 minute 32 seconds on average, and were mostly handled immediately (98.3%). It seems from this study that the medication administration process is not protected against WIs, which place patients at risk.

Interruptions lead to patient safety issues such as treatment delays and the nurse's loss of concentration (Hall et al., 2010:1046). It is also reported that absence of nurses from the patient's bedside directly affects patient care (Anderson & Townsend, 2010:25; Petrova, 2010:47). An optimal, safe practice environment is required to promote accurate medication administration (ISMP, 2008:1). However, the nature of the ICU environments meets the criteria of a high-risk environment. They can be very loud and cluttered and circumstances can be chaotic (Clifton-Koeppel, 2008:76). According to the ISMP (2008:2), high-risk areas deserve special attention for medication error prevention. In such a high-risk environment multiple interactions occur with diagnostic or treatment technology; many different types of equipment are utilised; multiple individuals are involved in patient care; the ambient atmosphere is prone to

distractions or interruptions; the need exists for rapid care management decisions; nurses experience time pressures; there is an unpredictable patient flow; diagnostic interventions take place with a narrow margin of safety, like high-risk medications; and nurses experience communication barriers with patients and/or co-workers. The concern for the practice environment is also supported by Anderson and Townsend (2010:25) who report other environmental factors, namely inadequate lighting, increased patient acuity and distractions during drug preparation or administration.

Medication errors caused by these factors can be prevented if nurses consciously reduce the distractions and interruptions they experience in the practice environment (Conrad et al., 2010:143; Johnson & Young, 2010:134).

The type of environmental factors was tested in the questionnaire to determine whether the participants in this study perceived environmental factors, and if so, which factors, to influence IV medication safety in this research setting.

2.7.8 Administration error

It is evident that the types of medication errors in the NICU and PICU vary, but it has been reported that administration errors are the most common type of medication error (Chuo et al., 2007:104; Ligi et al., 2008:404; Suresh et al., 2004:1609). Fahimi et al. (2007:116) observed a total of 524 preparations and administrations in ICU and reported that 9.4% errors were identified. Of those, 33.6% were related to the preparation process and 66.4% to the administration process. The most common type of error (43.4%) found was the injection of bolus doses faster than the recommended rate. According to the findings of Buck et al. (2008:1), as reviewed in MEDMARX (a USA adverse drug event database) data for paediatric hospitals over two years of data collection, half of all medication errors are administration errors. Anderson and Townsend (2010:23) reported that administration errors account for 26% to 32% of total medication errors. In a recent study, Jones and Treiber (2010:240) found that 78% of nurses confirmed that they made a medication error.

Although many errors arise at the prescribing stage, some are intercepted by pharmacists, nurses, or other staff (Anderson & Townsend, 2010:23). Many nursing tasks are risk prone, and medication administration carries the greatest risk because of potential patient harm (Elliott & Liu, 2010:300). Therefore, Lenclen (2007:76) reported that medication safety issues regarding the medication administration process should be identified in the practice environment.

RNs, who are working in this practice environment, are responsible for medication administration too, with specific responsibilities founded by policy and procedure. Specific perceptions regarding IV medication administration safety were therefore tested in the questionnaire.

2.7.9 Registered nurses' education, practice perceptions and experiences

Cohen and Shastay (2008:39) reported that nurses' attitudes and practice perceptions are found to attribute to medication errors. Although this survey was conducted in the adult ICU, there is value in determining whether these factors also have an impact on registered nurses who are working in the NICU, PICU and CSICU setting. In another study, evidence was indeed found that the promotion of a unit safety culture (unit-specific culture of medication safety) change can effectively diminish medication errors in neonates and children (Otero, Leyton, Mariani & Ceriani, 2008:740). These researchers conducted both a pre-intervention and a post-intervention cross-sectional study in the NICU, PICU and general paediatric settings. Several interventions, including incorporating positive, non-punitive unit safety culture and specific prescribing and drug-administration recommendations were implemented between the two phases of the study. Otero et al. (2008) found that the medication error rate in the second phase was 7.3% against 11.4% in the first phase. A unit safety culture, which is described as 'the way we do things around here', produces the organisation's social concepts regarding what is considered 'dangerous, risky, safe or appropriate' (ISMP, 2011c:1).

Recruitment and training for all staff focusing on the patient, maintenance of staff competence and a unit safety culture were recommended by the Institute of Medicine. These recommendations, which focused on patient safety, were entitled 'Achieving a new standard for care' (IOM, 2003:1). It was also recommended that nurses' knowledge and skills need to guide safe practice. Thomka (2007:24) found that senior nurses may take risks as a result of their comfort or familiarity with the medication process, and junior nurses (newly orientated staff) may feel pressured to emulate the practices of senior nurses, thereby quickly fitting into the unit safety culture. Armutlu et al. (2008:58) found that no relationship existed between perceived sources of error and years of experience. However, a need for ongoing education programmes on medication safety for all nurses, regardless of years of experience, was identified (Armutlu et al., 2008:62). Therefore, it seems pivotal to maintain continuous education for newly employed and current nursing staff.

It also seems imperative to review nurses' perceptions regarding medication errors as Mayo and Duncan's study (2004:215) revealed that there are differences in nurses' perceptions about causes of medication errors and error reporting, for example illegible handwriting of physicians, and exhausted nurses. However, Fry and Dacey (2007:676) reported a lack of empirical research on nurses' views of the medication factors that cause errors. As a result of these study findings, the researcher was compelled to study and describe the perceptions of RNs related to medication error causes in the NICU, PICU and paediatric CSICU.

Sulosaari, Suhonen and Leino-Kilpi (2011:465) discuss nurses' involvement in a patient's medication process and the fact that nurses need adequate competence to fulfil their role. They identified 11 competency areas for nurses' medication competence as part of patient safety. These areas are anatomy and physiology, pharmacology, communication, interdisciplinary collaboration, information seeking, mathematical and medication calculation, medication administration, medication education, assessment and evaluation, documentation, and promoting medication safety. In their analysis these researchers also identified three major categories of these nursing competency areas, namely decision-making competence, theoretical competence and practical competence. Therefore, medication competence requires nurses to have a 'solid knowledge base', the ability to apply that knowledge in complex and dynamic patient medication processes, and demonstrate decision making competence (Sulosaari et al., 2011:476). Decision-making competence is regarded as an essential part of a nurse's theoretical and practical competence and potentially a topic for further research (Sulosaari et al., 2011:476).

Dilles, Vander Stichele, Van Rompaey, Van Bortel and Elseviers (2010:1078) declare that nurses have considerable pharmaco-therapeutic responsibilities and that nursing practice patterns are determined by the health care setting and the nurse's educational level. Despite standardised educational preparation for registered nurses, medication errors still occur. In view of the fact that registered nurses from different educational backgrounds are employed in this working environment, the researcher identified the need to determine the knowledge of registered nurses in the NICU, PICU and CSICU related to safe IV medication administration practices.

In summary, the factors of unit safety culture (unit-specific culture of medication safety), practice perceptions, knowledge, skills, and educational preparation were tested in the questionnaire to determine whether the RNs perceived it to influencing IV medication safety at all.

2.7.10 Latent error and 'near-miss'

Rosen (2004:466) defines a latent error as 'an accident waiting to happen' as a result of either human error or equipment failure. This is supported by Ozkan et al. (2011:137) who state that 'a latent error may lie dormant for a long time and only become evident when it is aggravated by contributing factors that will breach the system's defences'. Latent factors such as fatigue, illness, inexperience, understaffing and inadequate equipment can influence the person or system's functioning. These factors are prevalent in paediatric medical care (Fernandez & Gills-Ring, 2003:158). As reflected in the researcher's conceptual framework (figure 2.1), latent factors are depicted, as described in the above literature findings. Based on Van der Schaaf's model (1992) as discussed in paragraph 2.7, a 'dangerous situation' is depicted to be caused by certain factors. It is therefore interpreted by the researcher that the 'dangerous situation' reflects a medication error that can potentially cause patient harm and the factors to be any of the wide range of factors, as discussed in this chapter.

A 'near-miss' is defined as 'an event that did not cause harm to the patient but had the potential to, and may be intercepted at any point during the medication administration process' (Lefrak, 2002:80). A near-miss is therefore 'an act of commission or omission that could have led to patient harm, but did not happen' (IOM, 2003:1). According to the IOM Alert called 'Patient Safety: Achieving a new standard for care', near-miss events are 7 to 100 times more common than medication errors, but no data is available because no reporting systems for near-misses are available. In the same IOM Alert, it is recommended that near-miss data for health care should be analysed more extensively than is currently the case (IOM, 2003:1).

Based on the literature findings, nurses' fatigue or exhaustion' was classified as a human factor in the questionnaire that participants could potentially perceive as an influence of medication safety. The researcher also aimed to determine whether the RNs perceived the analysis of medication errors with the unit staff to be a safety strategy to ensure IV medication safety.

2.7.11 Ordering and dispensing

According to Buck et al. (2008:14), it seems that 79% of medication errors occur during the ordering process because infants receive drugs with a narrow dosing range. According to Cologna et al. (2005:12), the main areas in which medication errors occur are the prescription of medications, transcription on the medication sheet, and the calculation of drug dilutions and dosages. It is interesting to note that medication errors also occur due to the 'fragmentation of

tasks', reflecting that different health care workers order, prepare and administer medications for the same patient.

A total of 821 prescriptions were analysed and 9.6% errors were detected by Rothschild et al. (2005:1697), who reported that every tenth prescription had a medication error in ordering or dispensing while every sixth prescription in an emergency department and nineteenth prescription in NICU contained a medication error.

Various systems for the ordering of medications exist in institutions. In some institutions medications are ordered electronically (Walsh, Landrigan & Adams 2008:421). It has been reported that computerised physician order entry (CPOE) improves the efficiency and quality of care during medication ordering because it improves the completeness and legibility of orders; it alerts physicians to medication allergies and drug interactions and provides 'a means for standardization of practice' (Forni et al., 2010:13). In the research hospital that is included in this study, prescription changed from handwritten prescriptions to the entering in the above-mentioned electronic system, during the latter part of 2007. An extensive system was implemented for checking physician orders as measures to prevent, identify, report and review medication errors, as guided by the institution's policies and procedures. This system is directly linked to the pharmacy that is responsible for the dispensing of the medication.

In order to understand the potential influence that the CPOE system has in the clinical setting, it is vital to describe the nurse's responsibilities related to reviewing the electronic MAR and documenting medication that is administered (KFSHRC-J, 2008b:1). This policy is called, Medication System: Nursing responsibilities. If an RN is employed from another institution that does not use a similar system, the RN has to assimilate these responsibilities, as subscribed by policy and procedure in the research hospital. Training and orientation to this system are mandated. Furthermore, the RN has to be able to recognize challenges with the system in terms of the time it takes to access the system and review or document in the electronic MAR. Due to the set standard that pharmacy has set to maintain current medications for patients, the medication has to be renewed at a specific time interval. If not renewed at this time interval, the medication will revert to the inactive medication list in the electronic MAR, for example eight days for regular medication and antibiotics, and two days for narcotics. The RN has to review the listed medication at a twelve hourly interval and request that the physician renews the order. Because of a total patient care (case) nursing care approach used in this practice environment, one RN assumes total responsibility of providing complete care for one or more patients while

on duty (total patient care). If the RN is looking after this patient for the first time, he/she might or might not notice on time that the medication is not appearing on the electronic MAR anymore. As a result, the patient is not dispensed with the medication by the pharmacy and therefore, it is considered as a medication error of omission.

Based on the researcher's knowledge of these aspects, it was included as one of the potential system factors in the questionnaire. It was also tested from the angle whether it is a potential factor influencing IV medication safety and/or a form of technology that prevents medication errors the most as a medication safety strategy, as perceived by RNs.

2.7.12 Other causing factors

In view of what has been discussed thus far, the causing factors are commonly encountered in nursing practice. Fahimi et al. (2007:297) reported more factors that could cause errors. They mention performance level failures such as inadequate knowledge, or a lack of precision in medication preparation. Furthermore, Ozkan et al. (2011:137) reported violations of protocols, high workload, insufficient protocols regarding work environment conditions, late arrival of medications from the pharmacy; and misinterpreting of medication preparation protocols. In their study, Suresh et al. (2004:1609) found that 47% of medication errors were due to a failure to follow policy or protocol.

Look-alike or sound-alike medications have been identified as a cause of medication errors. Anderson and Townsend (2010:24) reviewed the Medication Errors Reporting Program (operated jointly by the US Pharmacopeia and ISMP) and MEDMARX and found 25 530 such errors. Suresh et al. (2004:1609) found that medication errors were also caused by inattention (27%), communication problems (22%), errors in charting or documentation (13%), inexperience (10%) and poor teamwork (9%). Medication errors resulting from miscommunication among physicians, pharmacists and nurses have been reported by Anderson and Townsend (2010:24).

Tang et al. (2007:449) found multiple contributing factors to medication errors as reported by nurses. These factors include 'personal neglect' (86.1%) and 'new staff' (37.5%) in three of the eight categories. The top three factors were reported as the 'need for RNs to solve other problems while administering drugs', 'advanced drug preparation without rechecking', and 'new graduate'.

The aspects that were included in the questionnaire were knowledge, the recommended action if an RNs calculation does not correspond with the witness RN (the method of 'double-checking'

with witness RN); high workload (environmental factor); when policy is not followed as error prone situation (environmental factor); whether new staff receive sufficient unit-specific training related to medication administration. The researcher needed to determine whether RNs perceived these factors to influence IV medication safety in this research setting.

In summary, there are multiple factors described thoroughly in the literature that cause medication errors. This include incorrect medication dose, quantity or time of medication administration; wrong drug; multiple calculations under stressful conditions; lack of neonate-specific medicinal products; misidentification; human factor; environmental distractions and interruptions; administration error; registered nurses' perceptions and experiences; latent error and 'near-miss'; ordering and dispensing; and other causing factors. It is feasible to categorize all these causes as human, system or environmental factors, which are described under the researcher's conceptual framework. As depicted in studies over the last decade, these causes pose specific risk to patients, as medication errors may potentially or actually cause patients harm.

2.8 POTENTIAL OR ACTUAL HARM AS A RESULT OF MEDICATION ERRORS

Hicks and Becker (2006:27) state that medication errors can be harmful, especially if they involve the IV route of administration. This finding echoes that of Bates et al. (2005:203), namely that a significant and unnecessary variation in IV medication practice is associated with increased risk of patient harm. While patients are harmed or injured by medication errors, some suffer permanent disability, and for others the errors are fatal (Brady et al., 2009:679; Elliott & Liu, 2010:300; Hicks, Becker, Windle & Krenzischeck, 2007:419).

In their study, Rothschild et al. (2005:1698) found that the rates per 1 000 patient-days for all medication errors, preventable medication errors, and serious medication errors in the ICUs were 80.5, 36.2, and 149.7 respectively. Among medication errors, 13% were life-threatening or fatal, and among serious errors, 11% were potentially life-threatening. Most were found to occur during the ordering of medication or the treatment implementation (61%). Since nurses are responsible for IV therapy, these findings implicate nursing practice and patient safety.

In summary, the information reveals the concerning problem of variation in IV medication practice that result in medication errors, and as a result causing harm to patients. Therefore, the aspects tested in the questionnaire were aimed at determining the knowledge of RNs related to safe medication administration. Nursing quality experts, to whom the questionnaire was

submitted for review, confirmed that the questions were based on policies and procedure of the research hospital.

2.9 SPECIFIC LOCAL INSTITUTIONAL POLICY AND PROCEDURE

Two specific policies guide practice at the research hospital, including 'Medication Administration' and 'Medication System: Nursing responsibilities' (KFSHRC-J, 2008a:1; KFSHRC-J, 2008b:1). A discussion will follow that describe the standard practice, as guided by each of these policies.

In policy description of the requirements for safe medication administration practice, the nurse's responsibility, according to the first mentioned policy, is to ensure that administered medication and IV fluids are checked for the right medication, right dose, right patient, right time, right route, expiration date and correct documentation (KFSHRC-J, 2008a:2). All paediatric medications must be checked and signed by two nurses. The policy also stipulates specific infusions that need to be checked by both registered nurses before being administered. As part of this complete check, both registered nurses must check the patient's identification band and the rate setting of the infusion pump (KFSHRC-J, 2008a:3). Furthermore, two registered nurses must sign when the medications for paediatric patients are ordered, renewed or discontinued. As per policy, registered nurses RNs have to sign for each medication those patients receive, including the rate of the infusions (KFSHRC-J, 2008a:4). Standard nursing practice, as per policy and monitored in the medication administration audits includes the completion of policy prescribed standards, called safety checks on day duty as well as on night duty, to be documented at certain time frames. This has been designed as a safety check to intercept changes in medication prescription.

Medication administration times are standardised at the research hospital, meaning all medications are uniformly administered at the same time in all the nursing units. For example, every eight hours means medication is administered at 06:00, 14:00 and 22:00. This applies for all the different medication administration times for ordered medication (KFSHRC-J, 2008a:3). When medication is not available by the time that the medication is due, registered nurses have to send 'missing dose' communication slips to pharmacy. This is also documented in the CPOE system. According to policy, when a dose is missing, registered nurses are expected to follow up prior to the standard administration time of a dose, and take action to ensure that it is dispensed by pharmacy.

All registered nurses who have successfully completed the examinations during general nursing orientation may administer medication and IV fluids (KFSHRC-J, 2008a:2). When a medication error has occurred in the research hospital, registered nurses have to report the incident through the online incident reporting system. Such reports are included in the annual mandatory training of all hospital staff in the research hospital (KFSHRC-J, 2008a:2).

Previously, medication was ordered at the research hospital through a CPOE system and once ordered, the medication was transcribed by registered nurses, as covered by policy (KFSHRC-J, 2008a:2). In October 2010, the pharmacy module was implemented at the research hospital. Much more of this module has since been computerised, including the electronic MAR and documentation of IV infusions on the system. The registered nurse now electronically signs in the same system's electronic MAR that the medication was administered. Each RN has their own individual log-in access, upon which the electronic MAR is signed when the nurse documents that the 'right' medication and dose are administered, at the 'right' time through the 'right' route.

In policy description of the requirements for safe medication administration practice, the nurse's responsibility, according to the second mentioned policy, is to ensure that RNs have knowledge related to the responsibility of documenting in the electronic MAR, reviewing orders and doing the checks in the CPOE. Previously, before the electronic module for MAR was implemented in the same CPOE system, registered nurses manually transcribed medication. Therefore, transcription errors may have been related to handwriting, wrong transcription on the MAR when the medication was initiated and missing one or more of the five medication rights. According to the Medication Safety Committee and Pharmacy, this CPOE system has a variety of benefits related to workflow and access to patient information, elimination of handwriting errors. Due to errors that could be caused during ordering, dispensing and administration, the CPOE system has benefits for RNs, physicians and pharmacists. It allows the physician to review orders made for error in duplication or incorrect doses. It allows the pharmacy to view whether medication is dispensed to the practice environment, to view when the RN reviewed and administered medication, and when the physician has renewed the medication (KFSHRC-J, 2010).

A responsibility for RNs, as outlined by both these research hospital policies, is correct patient identification. This matches the described literature, regarding the accuracy of patient identification which is vital when providing care or treatment. Both the Institute of Safe Medicine Practices Alert (ISMP Alert) (ISMP, 2011b:1) and the Joint Commission National Patient Safety

Goal exclude the use of the patient's room number or location. The two acceptable patient identifiers to be used in the practice environment before medication administration are the patient's full name and the medical record number. As mentioned, this requirement is embedded in the medication administration policies of the research hospital, which is Joint Commission accredited. The Joint Commission stipulates that all patients should be weighed at admission in order for prescribed medications to be accurately prepared to allow for dose checking by the care-giving team. The mandate is that no medication should be dispensed by the system if no weight has been provided, even for emergency medications. This aspect is strictly enforced in the research hospital by pharmacists who do not dispense any medication, even to ICU patients requiring emergency care, if the patient's weight is not entered in the CPOE (KFSHRC-J, 2008b:1).

In summary, the responsibilities of RNs are multiple, as based on organisational policy and procedure. The aim is to provide safety measures in nursing practice in creating a safer environment for patients.

2.10 STRATEGIES IN CREATING A SAFE ENVIRONMENT

Over the years various studies have been done on medication errors and the different safety measures that are implemented for medication error prevention (Balguer, Fernandez & Escribano, 2001:55; Poe, 2005:198). Medication error prevention strategies relate to the previously described concepts (paragraph 2.2 to 2.9), because strategies are based on previous empirical findings and study outcomes in order to create a safer practice environment. It is evident that medication error reduction is directly linked to increased strategies for medication administration safety, as confirmed by the literature (Benjamin, 2003:768; Hennessy, 2007:28; Hohenhaus & Powell, 2008:108; Lefrak, 2002:76; Suresh et al., 2004:1609; Trossman, 2005:75). These strategies include the implementation of safer systems, CPOE, standard medication labelling, standard concentrations of infusions, and safety checks in the medication administration process, including double-checking (Clifton-Koeppel, 2008:72; Hennessy, 2007:28; Lefrak, 2002:76; Suresh et al., 2004:1609; Swanson, 2006:230; Walsh, Landrigan & Adams, 2008:423; Wanzer, 2005:82). Buckley et al. (2007:145) also recommended that direct observation and voluntary incident reporting can be effective in the detection of medication errors.

2.10.1 Safer systems and processes of communication

Benjamin (2003:768) and Trossman (2005:75) contend that the implementation of safer practices requires the development of safer systems. While Benjamin recommends safer systems, he recommends analysis of system errors and the application of failure mode effect analysis (FMEA) is presented to determine the part of the 'safety net' that failed. Because the 'what should be done' is generally known as 'the five rights': the right drug, right dose, right route, right time, and right patient, he described how one can make an error of omission (failure to act correctly) or an error of commission (acted incorrectly) through the analysis of each case to provide insight into how the medication error could have been prevented. Trossman described how technology should be easy to use. Fahimi et al. (2007:1609) reiterate this view by emphasising that systems should be developed that guarantee safe medication administration as an outcome. These researchers conducted an observational study to observe medication errors as a result from IV pumps in the ICU, because there was no detailed hospital based incident reporting system available that could detect errors and consequently no action plans were implemented to work on error prevention.

Campino, Lopez-Herrera, Lopez-de-Herdia & Valls-I-Soler (2008:330) argue that medication errors due to system errors should not be considered to be human errors and that staff should therefore not be held accountable in such cases. Medication errors in medication dispensing and medication administration is achieved by safe systems that include electronic surveillance, reminders and alerts identifying patients who are susceptible to an adverse event, communication of critical changes in a patient's condition, facilitation of timely and appropriate treatment, bar code technology, IV infusion safety systems and electronic medication administration records (Forni et al., 2010:17). According to Forni et al. (2010:17), compliance in the successful use of health information technology is crucial to the achievement of safe medication use processes. Since many researchers have reported that medication administration is a major medication error category, nurses should be involved in the process of ensuring a safe practice environment.

Furthermore, organisations need to focus on open communication as it relates to the formulation of systems for identification and reporting of errors as well as feedback related to medication error rates. Leadership should clearly articulate expectations to staff regarding patient safety through publicised organisational goals and should be transparent about patient injury results. It is recommended by the ISMP (2003:1) that health care organisations be held accountable for designing and implementing safe processes and communicate analyses to

nurses which would enable nurses to deliver safe care (ISMP, 2003:1). It is clear that systems for the reporting of medication errors should be able to detect whether such errors have occurred and communicate the results to nursing staff. This view is supported by the IOM Alert, called 'Patient Safety: Achieving a new standard for care', which describes how such analysis provides opportunities for learning about both weaknesses in the health care delivery system and ways in which the system is able to recover from dangerous or risky situations (IOM, 2003:1). Medication errors are analysed at the research hospital by nursing quality department in collaboration with the quality management department through the use of a system, called Safety Reporting System (SRS), which is an electronic database and enables RNs, physicians and pharmacists to anonymously report incidents via this reporting system. The reporting of medication errors is communicated with nursing manager on unit-level, who is required to complete a follow-up section in this database, which pertains to the corrective action plan taken (discussed in conceptual framework in paragraph 2.7). Aronson's classification system provides an approach to understand how medication errors occur in order to plan a preventive approach (2009:601). Hicks et al. (2007:419) propose that institutions should be aware of occurrences of medication error to ensure vigilance regarding medication error prevention. At the research hospital, quality data is reported to the unit manager, of which medication errors form part of this report. However, the results may be deemed as sensitive and therefore not quoted in this report. The study recommendations are in line with what is practiced at the research hospital. However, medication errors are not prevented in the research setting, despite the current presence of systems and communication of results. Furthermore, the ISMP (2003:1) states that there is no use for data collection if it does not lead to change that result in safer patient care. Therefore, the researcher identified the need to describe factors that influence IV medication safety perceptions, knowledge related to safe IV medication administration practices and describe nursing medication administration strategies, as reported by registered nurses working in the PICU, paediatric CSICU and NICU.

2.10.2 Computerised physician order entry (CPOE) system

A computerized physician order entry system is defined as an electronic computerized database in which the ordering, dispensing and administration are documented by physicians, pharmacists and nurses for patients in the research hospital (KFSHRC-J, 2010).

According to Cologna et al. (2005:12), computerised calculation medication dosages should be infused for critically ill infants to minimise the risk for medication errors in neonatal and paediatric ICUs. CPOE is recommended because it is evident from the literature that it reduces

errors by alerting physicians to patient allergies or drug interactions; eliminates poorly handwritten prescriptions; and allows standardised dosing plans (Anderson & Townsend, 2010:26; Lucas, 2004:33). Walsh, Landrigan, Adams, Vinci et al. (2008:421) agreed because their findings reflected that medication errors were reduced by improving standards of prescriptions. A standard CPOE system has recently been utilised at the research hospital, with comprehensive policies that mandate the checking of all physician orders, the reviewing of medication dispensing information as well as the documentation of administered medication, namely IV medication and infusions.

It is evident that the medication process is structured by technology in order to ensure patient safety. As reported in the literature, it is important to realise that when technological innovations are being introduced in health care, the impact of technology on nursing work should be considered. It is evident from the literature that technological innovations change practice, often in unintended or unknown ways. Nurses are therefore encouraged to critically evaluate the ways their work has been transformed (Folkmann & Rankin, 2010:3218). At the research hospital, nurses in the nursing informatics team are responsible for training newly recruited nursing staff to become familiar with the CPOE. This team is also responsible for alerting nursing staff regarding updates in the system and communicating the changes to unit managers who are responsible for further training staff on unit-level.

2.10.3 Standard medication labelling

Wanzer (2005:471) suggests that standard medication labelling and identification of high-alert medications be implemented. The Joint Commission International requires health care institutions to identify look-alike and sound-alike drugs each year and to implement a process to prevent medication errors (Anderson & Townsend, 2010:24). This happens at the research hospital through monthly electronic newsletters sent to all hospital staff with a picture of the look-alike and sound-alike medication.

Fahimi et al. (2007:296) reported 20% labelling errors in their observational study of medication doses administered through infusion pumps. Neoh, Hassali, Shafie, Awaisu and Tambyappa (2009:199) claim that good medicine labelling practice is vital to ensure safe medicine use and that non-compliance to labelling standards is a potential source of medication errors. A standard labelling system is used at the research hospital which is computer generated and reflects the name and MRN of the patient, the name, dose and route of the medication, the concentration and volume, expiry date and the pharmacist who constituted the medication.

2.10.4 Standard infusion concentrations and infusion pumps

Literature findings related to smart pumps are described in the context of addressing variable IV administration practice and how these pumps can enhance IV administration practice. It is recommended that infusion devices be programmed with individual hospitals' 'best practice' rules for IV medication administration. Alerts can be programmed if medication dosages fall outside pre-established limits (Bates et al., 2005:203). The injectable drug process reviewed in a NICU and PICU found that a clinical pharmacy and ready-to-use syringes appear to be the most promising safety tools (De Giorgi et al., 2010:176).

The standardisation of IV medication concentrations are deemed vital by Hennessy (2007:28) This view supports the Joint Commission on Accreditation of Healthcare Organizations' (JCAHO) mandate to standardise concentrations of infusions. Infusion practice within the ICU has a wide variation in concentrations of drug infusions and ICU nurses spend much time in the preparation and administration of IV infusions (Keeling, Scales, Keeling & Borthwick, 2010:33). However, as per policy, IV medication or infusions are not prepared by registered nurses in the research hospital, except in emergency situations. Preparation is done by the hospital's internal pharmacy.

It is apparent that IV medication errors could be detected using smart pumps (Rothschild et al., 2005:535). However, these researchers confirm that technological and nursing behavioural factors must also be addressed if these pumps are to improve medication safety. It was found by Trbovich, Pinkney, Cafazzo and Easty, that in assessing the impact of infusion pump technology on nurses' ability to administer IV medication safely, changeable limits in smart infusion pumps had no significant effect in preventing dosing errors, because the smart pumps are programmed with changeable limits (2010:432). The role of smart pumps is therefore reported to be limited (Trbovich, et al., 2010:432). In the practice setting, smart pumps have to be programmed because infusions require titration, depending on the patient's condition. In the practice environment, dosing errors are still possible, not because RNs change the limits, but may be due to the wrong rate, when the smart pump is set, delivering a medication dose over a short time, especially if caution is not used when the rate is set to run over the specific ordered time. For example, an inotrope (Dopamine) infusion may be set to run over one hour, instead of over 24 hrs, and as a result deliver the wrong dose (due to wrong infusion rate) because of the wrong programming due to human error. For this reason, it is a requirement by the hospital policy for an RN to utilize a witness RN to review ('double-check') all the medication rights from order in the CPOE, to the medication label to the setting of the smart pump (KFSHRC-J,

2008a:2). The risk for a potential medication error is generated when safe medication practice, as reflected in the research hospital policy standard for two RNs to check the five medication rights, is not followed (paragraph 2.7). Therefore, non-compliance with the hospital policy makes a measurable impact on the medication error rate at the research hospital, through technological and human behaviour factors that can improve medication safety or decrease safety, if there is non-compliance with the standards, as set in the policy.

The standardization of IV medication concentrations and the use of 'smart' pumps were tested in the questionnaire, to determine whether the RNs perceived it to be a factor influencing IV medication safety.

2.10.5 Voluntary incident reporting

Voluntary incident reporting is described as a method in which RNs, physicians and pharmacists can report medication errors when it has occurred (Lefrak, 2002:80). It is recommended that it should not be the only error detection method used but ideal to use as a complementary approach to other methods (retrospective chart reviews) to detect medication errors (Buckley et al., 2007:149). It has also been found that by other researchers that voluntary incident reporting provides an opportunity to improve patient care and to understand the nature of IV-related medication errors through error analysis (Hicks & Becker, 2006:20). This indicates that voluntary incident reporting could provide information from the reporter as to the causing factors of the error. Standards for nursing staff related to their responsibility of medication errors reporting and documentation of the standards should be provided, such as the immediate reporting of medication errors to the attending physician and the 'on-shift nursing manager' (Lefrak, 2002:80). This indicates to the researcher that the documentation of the standards should be provided to staff in the form of policy and procedure, which is in place at the research hospital. The voluntary incident reporting system is totally anonymous and classifies the error as medication safety. It seems that a voluntary, non-punitive incident reporting method is effective, as supported by Snijders, Van Lingen, Klip, Fetter, Van der Schaaf and Molendijk (2009:14).

However, other researchers report that voluntary reporting does not provide reliable medication error data (Carlton & Blegen, 2006:38; Kagan & Barnoy, 2008:360; Lefrak, 2002:80).

The underreporting of medication errors is a challenge to medication safety improvement (Chiang, Lin, Hsu & Ma, 2010:17; Kagan & Barnoy, 2008:360). They found that 47% participating nurses had failed to report their own or co-workers' medication administration

errors. While such results may be a cause for concern with regard to vulnerable neonatal and paediatric patients in the ICU setting, Cohen et al. (2003:38) found that only 5% of medication errors are reported in a setting that is reliant on voluntary reporting, and only if it results in harm to the patient. According to other researchers, most administration errors are not even intercepted or reported (Anderson & Townsend, 2010:23; ISMP, 2003:1). It was found that due to organisational barriers the medication error reporting rate to nurse managers was 42.1% (Pflege, 2010:525). These organisational barriers relate to the climate of voluntary reporting of errors, which indicates to the researcher that this may have a potential effect on the perceptions of RNs regarding the factors that influence medication administration. This correlates with the findings from another study in which only 45.6% of the 983 nurses believed that all medication errors are reported, and reasons for not reporting include fear of the manager and peer reactions (Mayo & Duncan, 2004:215). For this reason, this item was included in the questionnaire.

Policies related to high-risk nursing tasks should reflect a 'just culture'; in other words an element of safe culture which means that employees should willingly report adverse events and near-misses without threat of retribution (Reason & Hobbs, 2003:165). However, it is not acceptable to have a totally blame-free environment; a balance should be maintained between the need to learn from mistakes and the need to take disciplinary action (ISMP, 2003:1). Reason and Hobbs (2003:156) believe it is vital to report unsafe acts and to learn from them. They also describe a unit safety culture as a just culture, a reporting culture and a learning culture. These authors also claim that it is necessary to make a collective agreement in the practice environment as to where the line should be drawn between acceptable and unacceptable (Reason & Hobbs, 2003:157). It can be concluded that the factor of unit-specific culture of safety may potentially influence the perceptions of RNs related to voluntary incident reporting. The researcher therefore felt compelled to include the aspects related to a unit safety culture in the questionnaire in order to determine whether RNs view the research hospital's implemented safety strategies as a factor influencing IV medication safety and to determine the knowledge of the RNs related to safe IV medication administration.

2.10.6 Practice monitors and safety checks ('double-checks')

Safe nursing practice can be achieved by creating an environment for nurses in which errors are prevented (Wanzer, 2005:471). In the literature, several instances are mentioned where nurses can minimise the risk to patients and improve patient safety (Benjamin, 2003:768; Matthew, 2007:45). The aspect of nursing 'double-checks' was defined as routine safety checks of the five

medication rights and performed by two registered nurses independently during the IV medication administration process to prevent medication errors by risk of making a mistake (KFSHRC-J, 2008a:2). This was also discussed under safe medication practice in paragraph 2.2 and tested in the questionnaire to describe the knowledge of the registered nurses in the particular ICUs related to safe IV medication administration practices.

Double-checks, which are performed by nurses, fail at times because of confirmation bias, namely 'seeing only what one expects to see and overlooking disconfirming evidence'. Unintentional 'blindness' can lead to medication errors by misreading drug labels, which makes double-checking with another nursing colleague imperative. The term 'unintentional blindness' is explained as a failure by the brain to distinguish recognisable information and, potentially a comprehensive picture is built based on incomplete information. In other words, the nurse sees what he or she expected to see (Clifton-Koeppel, 2008:78). In the ISMP Alert, 'The virtues of independent double checks – they really are worth your time' (ISMP, 2003:1) it is stated that although independent double-checks fail at times, one should never doubt their value. Because of the impact of human factors, double-checks are more effective if they are performed independently by staff because this would enable the nurse to intercept a mistake. In double-checking, the person checking the medication should perform all calculations independently, without knowledge or cues of any prior calculations (ISMP, 2003:1; ISMP, 2009:1). If the nurse shares prior calculations or performs a double-check together with the person who originally completed the calculation, it is possible that a mistake may not be intercepted (ISMP, 2003:1). Medication double-checking is fundamentally a 'human factors approach, with the necessary built-in redundancies', especially for vulnerable patients (Clifton-Koeppel, 2008:77). It seems essential therefore that double-checking be done in the ICU setting where neonatal and paediatric patients are cared for.

Obstacles for double-checks include the perceived time it requires to perform, workload challenges and staff shortage. Clifton-Koeppel (2008:78) describes double-checking practices to be 'inconsistent and often performed casually'. The minimum requirement is to check the five rights (patient, drug, dose, time, and route) with another nurse. Additional rights are recommended by this researcher, namely the 'reason, medication expiration, checking the medication levels, and documentation'.

As already mentioned, safe medication administration is mainly the responsibility of the nurse. Double-checking medication with another nurse prevents medication errors from happening.

However, according to Clifton-Koeppel (2008:77), this issue has not been thoroughly studied. This researcher agrees that it is important to perform double-checks correctly, but recommends that they be 'performed completely' (using the five rights), 'performed independently' (two nurses check independently without verbal prompting), and 'performed uniformly' (the five rights are checked in the same order each time). This recommendation agrees with Campbell and Facchinetti's (2000:948) argument that double-checks will intercept approximately 95% of medication errors and that the double-checking helps to enhance 'patient safety; improve reliability; and define formal procedures and expected behaviour in the work place'.

The importance of independent double-checking is confirmed in the ISMP Alert that double-checks work best when they are conducted independently (ISMP, 2009:1). It is stated that the person checking – in this context the nurse – has to form an independent judgement without receiving clues from the person doing the initial work. If it is done in this way, double-checking is seen to be effective: two people should calculate a dose separately and then compare their answers, rather than perform the calculation together, or to have one share his or her answer with the other before double-checking occurs. Through double-checking, a mistake or near-miss can be intercepted, if the medication does not correspond with the order in the CPOE and checked completely and independently prior to administration of the medication. Since the standards related to nursing 'double-checks' are set in the research hospital as well as the literature, this item was therefore tested in the questionnaire to determine whether the RNs perceived it to be a factor influencing IV medication safety and whether RNs have adequate perceived knowledge related to how nursing 'double-checks' should be done to ensure safe medication administration, as outlined in the researcher's conceptual framework (figure 2.1).

2.10.7 Medication safety awareness

A well-established system of accountability exists in a practice environment that has a unit safety culture (Clifton-Koeppel, 2008:79). On the other hand, it is also emphasised that a non-punitive approach to medication errors does not advocate that there should be 'a lack of accountability for breach of safety standards' (Clifton-Koeppel, 2008:79). The same researcher recommends that nurses are 'accountable to providing safe nursing care using policies that guide practice'. Another researcher confirms that knowledge regarding medication errors is important in designing safe nursing practice (Cohen & Shastay, 2008:47). Therefore, it is included as one of the objectives under study.

According to the literature, safe medication administration practice is linked with medication safety awareness (Armutlu et al., 2008:64; Kunac & Reith, 2005:251). Kunak and Reith (2005) found safety vulnerabilities in the entire medication process. The development of a staff education programme focused on the promotion of a cultural change in medication safety approach can effectively diminish medication errors in neonates and children (Armutlu et al., 2008:64). Furthermore, the ISMP (2003:1) emphasises that health care professionals should be prepared both mentally and physically so that they are able to carry out their responsibilities. They need to have an awareness of the practice environment, they should be vigilant in identifying hazardous situations and they must be able to respond to these situations when they occur. In support of this view, Stievano, Jurado, Rocco and Sasso (2009:397) declare that high standards of nursing education and competence should be sought.

As described in the literature, several items were included in the questionnaire to test perceived medication safety awareness and knowledge. This was one of the objectives under study in order to determine whether RNs in the particular ICUs perceive this as a factor influencing their IV medication safety practice.

2.10.8 The role of the nurse in medication error prevention

It is evident from the literature reviewed up to this point that medication errors affect patient safety. Equally, the nurse's role in safe medication management is recognised. Within this context, the nursing profession has been identified as being essential to the promotion of patient safety (Choo, Hutchinson & Bucknall, 2010:853).

The role of the ICU nurse is to implement, monitor and maintain safe medication practices for neonatal and paediatric critical care patients (Camire et al., 2009:936; Clifton-Koeppel, 2008:72; Lefrak, 2002:78; Swanson, 2006:230). As stated in the IOM Alert 'Patient Safety: Achieving a new standard for care' (IOM, 2003:1), the nurse is the only barrier between an adverse event and quality patient care. The nurse has to 'continually detect, arrest, and deflect potential adverse events for patients, even subconsciously' (IOM, 2003:1). Montalvo (2007:12) concurs that 'nursing has a responsibility to measure, evaluate and improve practice'.

By improving the medication administration process, patient safety and the efficiency of nurses are enhanced (Conrad et al., 2010:143). They found that medication errors could be reduced by improving the physical design and organisational layout of the medication room and creating a

standard medication process. This successful change has led to enhanced nursing satisfaction within this context.

According to Hall et al. (2008:417), the National Patient Safety Goals can only succeed if there is ongoing involvement and leadership of nurses. Although these patient safety goals originated in the USA, they are also applicable in the research hospital, which is American-based. Hall et al. (2008:419) mention that the nurse minimises the risk of error through 'clarification of orders; appropriate labelling of medications; and accurate patient identification'. Various authors have pointed out that the contribution of knowledgeable and skilled nurses is valued in high quality, safe and patient-centred care (Batalden & Davidoff, 2007:2; Hall et al., 2008:417; Toth, 2007:342).

Essentially, the role of RNs, as perceived by them, was tested in the questionnaire. This RN role subscribes the goal of patient safety through the prevention of medication errors.

2.10.9 The role of nursing managers in medication error prevention

The essence and diversity of the unit manager's role in the prevention of medication errors has been reported in several studies (Brady et al., 2009:679; Kagan & Barnoy, 2008:360; Poe, 2005:198). Nursing managers have to be role models by 'setting the tone; encouraging staff; coaching; and taking an active role in education and systems improvement' (Kagan & Barnoy, 2008:360). Nursing leaders therefore have to 'declare error reduction as a goal; replace complacency; remove barriers; challenge punishment; and move toward an environment that views patient care as a top priority' (Kagan & Barnoy, 2008:360). This statement echoes Poe's (2005:198) emphasis on the importance of instilling patient safety principles in the hearts and minds of staff, as it was found that the success of patient safety programmes is enhanced in this way. Lefrak (2002:79) contends that unit managers' are responsible for establishing or improving unit safety culture by aiming to reduce the fear of staff to report medication errors. Moreover, they should reward nurses for reporting medication errors (Lefrak, 2002:79). However, the strongest reward for nurses may be in seeing that their reports have led to real changes to ensure a safer practice environment (Lefrak, 2002:79).

Nursing managers must encourage staff to change the mindset to 'what went wrong instead of who did it' (Lefrak, 2002:83). This can be achieved by creating a unit-specific culture of safety, in which the nurse manager analyzes medication errors on the unit objectively with unit staff. Aronson's classification is useful for such an objective application in the practice environment

(Aronson, 2009:602). Communication is therefore seen as a key factor in creating a positive culture (Kerfoot, 2005:36). There should also be organisational commitment for detection of patient injuries and near-misses, for example in tracking and rigorously analysing injury-related events (ISMP, 2003:1). The researcher concluded that an analysis ('what went wrong') could be achieved through Aronson's classification of medication errors (as discussed in paragraph 2.6). Therefore medication error analysis was included in the questionnaire. From the literature, it can be concluded that knowledge-based, rule-based, action- based or memory based causing factors could be identified as latent factors that are depicted by the researcher's conceptual framework (figure 2.1).

In the particular research hospital, case reviews are done when a medication error occurs, with the aim of creating valuable opportunities for learning from what contributed to the medication error and how to prevent it from happening again. This means that the medication error is analyzed in depth as to what has occurred with the staff involved, discussion of proposed corrective action and implementation of the plan. The process of case review is a formal process in the research setting. Since this is a formal process at the hospital, the researcher included this item in the questionnaire in order to describe the perceptions of RNs related to this factor that may be perceived as a medication error prevention strategy or not. Policy review is done with the unit staff, if and when non-compliance with hospital policies has been identified. Brady et al. (2009:679) agree that managers should evaluate and audit IV practice. Staff should be educated about medication error prevention and what constitutes a medication error (Brady et al., 2009:679; Kovner, Brewer, Yingrengreung & Fairchild, 2010:29).

Hall et al. (2010:1046) recommend that nurse leaders should examine ways to reduce interruptions. In a study done by Petrova (2010:46), it was shown that distraction from patients and co-workers during medication administration should be avoided. The unit manager should support staff to minimise distractions in creating a safe practice environment. Based on the literature findings, the researcher concluded that interruptions could be potentially identified as a latent factor by participants of this study, and it was therefore included in the questionnaire.

2.10.10 Mandatory staff education and review of knowledge and skills

The practice environment, in which nurses have to administer medication, is described as fast-paced, complex and unpredictable (Jones & Treiber, 2010:240). Medication administration is seen as a complex task that requires extensive knowledge and skills to perform correctly. Authors Toth (2007:342) and Cohen and Shastay (2008:47) argue that the nursing profession

has a responsibility to define and monitor nursing knowledge, as well as to determine what the basic required knowledge is to ensure safe practice in the ICU.

Specific recommendations are made in the literature for nursing education programmes. Error reporting mechanisms should be easy and simple and staff should be given clear instructions on how to use them. Managers are advised to teach staff to report 'near-misses' and 'latent errors' (Lefrak, 2002:80). The importance of voluntary reporting should also be addressed in staff training programmes to prevent the fear of punishment. Nurses need to be taught the concept of anonymous reporting systems because it may seem helpful for staff to realise that the 'guilt and blame cycle' has been stopped (Lefrak, 2002:83). This view is supported by Chiang et al. (2010:17) who recommend that nurses should be educated about the goals of incident reporting systems and using medication administration error data to enhance the unit safety culture.

There is also value in teaching staff to report 'near-misses' and 'latent errors' and the difference between them, because unreported errors are likely to re-occur (Lefrak, 2002:80). Carlton and Blegen (2006:19) state that since nurses are primarily involved in and responsible for medication administration, it is important for them to understand factors that contribute to medication administration errors. It is evident that an understanding of the causing factors enables nurses to direct action plans towards preventing medication errors within the challenging practice environment of the ICU setting. Fahimi et al. (2007:298) found that improved training of nurses in calculating dosage is necessary to avoid risks associated with medication preparation. Regular review sessions on mathematical calculations are recommended by various researchers (Fry & Dacey, 2007:680; Johnson & Young, 2011:134).

When staff education programmes are planned, an important step to improve safety is to identify the nursing staff attitudes toward medication errors (Clifton-Koeppel, 2008:79). The researcher mentioned that 'nurses may believe that error prevention during medication administration is not possible and efforts to reduce errors are inevitable' (Clifton-Koeppel, 2008:79). However, a contrasting argument was found in a study done by Fry and Dacey (2007:680) where nurses reported that medication errors are problematic and that simple practice changes could help to reduce medication errors, such as 'protected' medicine rounds, and that patient simulation can be used to teach nurses the principles of medication administration in a 'safe' setting that closely resembles the practice environment (George et al., 2010:1763).

Several other factors which need to be included in staff education programmes are reported in studies. One of these is the way in which RNs can learn how to control their exposure to disturbances. This is done through minimising 'the potential for distractions in critical medication use areas' or through teaching workers 'to avoid interrupting co-workers for non-urgent reasons while they are performing medication-related tasks' (ISMP, 2008:1). Preventive techniques may include visual cues, such as nurses wearing an orange safety vest when administering medication, and checklists to focus and refocus attention when administering medication. The importance of developing methods to reduce distractions and interruptions is supported by Hohenhaus and Powell (2008:108). These researchers' focus is adopted from the 'sterile cockpit rule' from the aviation industry, during which 'crew members are prohibited to perform non-essential duties or activities while the aircraft is involved in "high-threat" times such as take-off, landing and other flight operations' Hohenhaus and Powell (2008:108). These authors also recommend that prohibitions should such as not allowing social commentary and being assertive when colleague interruptions take place during medication administration be implemented. Johnson and Young (2011:134) recommend that continued reinforcements be given for the five rights and assessment of drug calculation skills during orientation programmes of new staff. A standardised curriculum is proposed, with components for teamwork, communication techniques, respectful assertion and situation awareness, among other things (Hohenhaus & Powell, 2008:108).

Staff education, as a medication safety strategy, was tested in the questionnaire, so as to describe whether RNs perceive it to be an effective strategy to prevent medication errors or whether improvement is needed on unit-specific level, as reported by the study participants.

In summary, these identified medication safety strategies are created to ensure patients are cared for in a safe environment, because medication administration practice is described to be safer when these are implemented. However, despite the strategies that are in place to prevent medication errors, medication administration remains a challenge in the ICU environment in the particular research setting. As per the study outcomes, multiple factors cause medication safety concerns in the research setting. Prevalence data of the research hospital, is seen as sensitive information, and may not be released by the researcher. As per the researcher's conceptual framework (figure 2.1), multiple medication error causes (latent, human, system, and environmental factors) may present itself in the practice environment, providing the risk for a medication error to take place if the medication process is inadequate, for example if one of these identified medication error prevention strategies is not followed or adhered to. The

potential for a medication error to take place within the practice environment always exists. However, if the medication process is adequate, a medication error or near-miss is prevented and medication is administered safely to the patient. Therefore the researcher was compelled to ask the study respondents what they perceived as factors influencing IV medication safety.

2.11 SUMMARY

In this chapter causing factors of medication errors were reviewed. Based on the literature review, findings revealed that medication errors are caused by a variety of human-, system- and/or environmentally oriented factors. As per the researcher's conceptual framework, these causing factors, together with latent factors present in the practice environment provide the risk for a medication error to take place if the medication process is inadequate. The potential for a medication error always exists. However, if the medication process is adequate, a medication error or near-miss is prevented and medication is administered safely to the patient. The vulnerability of neonatal and paediatric patients was discussed within the context of the risk that exists for infants in ICUs due to more frequent use of IV medication, the ICU setting and patient types. The importance of registered nurses' education, practice perceptions and experiences within the context of medication errors was also discussed. The process of safe medication administration was reviewed within the framework of the five rights of medication administration and health care strategies in creating a safe environment for medication error prevention, for example the diversity of the nursing role in safe IV medication administration practice, the role of managers in medication error prevention, and mandatory staff education. Johnson and Young (2011:134) confirm that medication administration, which is error prone and affects patients, is a complex process. However, nurses have the ability to reduce medication errors to a great extent.

The methodology for studying the factors influencing IV medication safety practices of RNs, knowledge of RNs related to safe IV medication administration practice and medication safety strategies at a particular tertiary hospital in Saudi Arabia is discussed in detail in Chapter 3.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methodology that was applied in the study that described the perceptions of RNs regarding the factors that have an influence on the IV medication safety practices of registered nurses working with neonatal and paediatric ICU patients is discussed in this chapter. Research methodology is defined by De Vos et al. (2005:105) as the scientific endeavour to explore, to describe or to explain. It is furthermore described as the process to follow in order to solve a problem (De Vos et al., 2005:71).

3.2 METHODOLOGY

3.2.1 Research approach and design

A quantitative research approach with a descriptive survey design was selected to describe the perceptions of RNs regarding the factors that influence IV medication safety in NICUs, PICUs, and paediatric CSICUs, to determine the knowledge of the RNs related to safe IV medication administration practices and to describe nursing medication administration strategies to prevent medication errors. De Vos et al. reports that the quantitative-descriptive design, also known as a survey design, require questionnaires as a data collection method (2005:137). According to Burns and Grove (2007:24), quantitative research is a formal, rigorous and systematic process for generating information. De Vos et al. (2005:137) explain that descriptive or survey designs are quantitative in character as they require a questionnaire as a data collection method. The open-ended question (Question 70) was added to this questionnaire that was intended to supplement the quantitative data regarding the prevention of medication errors.

Bless and Higson-Smith (1995, cited in De Vos et al., 2005:104) define the unit of analysis as the individual(s) or object(s) from which the researcher gathers information. In this study all the RNs working in the NICU, PICU and paediatric CSICU of a particular hospital in Saudi Arabia were the primary unit of analysis.

3.2.2 Research question

Both a research question and a hypothesis refer to a specific aspect of the overall research topic, namely to inform the reader of the purpose of the research and thus answer the question

why the particular study should be undertaken (De Vos, 2001:99). From the background provided above the primary research question in this study was formulated as follows:

> What are the perceptions of RNs regarding IV medication safety practices in the NICU, PICU and paediatric CSICU in a particular Saudi Arabian tertiary hospital?

3.2.3 Population and sampling

The *actual practice setting* included the NICU, PICU and paediatric CSICU, representing the practice environment within which the RN practices and administers IV medication. The description thereof is made in terms of patient condition and pre- and post-operative surgery in all three ICUs; ICU lay-out (a number of patients per room in NICU, one patient per cubicle in PICU and paediatric CSCIU); RN to patient ratio; supporting services (porter may be unavailable to pick-up medication from pharmacy); tasks (RNs responsible for multiple tasks due to comprehensive patient care delivery); equipment used (IV medication administered through IV pumps or 'smart pumps'; hardware (computers); software (CPOE); location of pharmacy; environment (noisy, multiple interruptions); pharmacy dispensing system (provision of IV medication a day prior to due time); medication (ready-to-administer, prepared by pharmacy); medication labels (RN responsible for checking); multiple infusions per patient (requiring extensive checking of all pumps); medication administered according to standardised timing throughout the research hospital; routine time of changing IV infusions (night time between 20h00 and 22h00); delivery of IV infusions to the unit (18h00 to 20h00); handover time between shifts (between 7h00 to 7h30 and 19h00 to19h30); nursing-doctor's rounds (7h30 to 8h00). The research hospital has three neonatal and paediatric ICU's, which includes a NICU that provides critical care to neonates of 25 to 42 weeks of gestational age, a PICU that accommodates paediatric patients who need medical-surgical intensive care and a paediatric CSICU that accommodates paediatric patients who undergo cardiac surgery.

A *target population* is defined by McBurney (2001, cited in De Vos et al., 2005:194) as 'the totality of persons, events, organisation units, case records or other sampling units with which the research problem is concerned'. The population targeted for data collection in this study included the registered nurses working in the NICU, PICU and paediatric CSICU as they were prominent and constituted the focus of this study (N=121), as indicated in Table 3.1.

Table 3.1: Population of registered nurses in the ICUs

Population	Population size (N)
Registered nurses in NICU (neonatal)	40
Registered nurses in PICU (medical-surgical)	38
Registered nurses in CSICU (paediatric cardiac surgery)	43
	Total=121

Sampling method: Seaberg (1988, cited in De Vos et al., 2005:194) describes sampling as 'taking a small portion of the total set of objects, events or persons which together comprise the subject of study'. As referenced in Chapter 1, Kerlinger (1986, cited in De Vos et al., 2005:193) adds that sampling should be '…any portion of a population or universe as representative of that population or universe'. The researcher chose an 85% non-probability purposive sampling of NICU, PICU and paediatric CSICU critical care registered nurses (n=103) who were employed at the selected hospital and responsible for administering IV medication. At any given time, up to 15% of the target population is on either annual leave or sick leave, as per budgetary staffing planning. Therefore an 85% sampling was chosen (n=121) in the study. The reason for choosing a non-probability purposive sampling was to include purposively 'elements which contain the most characteristic or representative or typical attributes of the population' in the study to ensure respondents who had experience with and knowledge of the phenomena under investigation were included (De Vos et al., 2005:202). Information regarding safe medication practice was sought from the target population under study.

Sample analysis: A sample of RNs (n=103) was selected to participate in the study and 10% of the target population (n=12) was utilized for the pilot study. The sample portion (n=103) is representative of the target population (N=121) who possess 'specific characteristics …or measurements of interest to the researcher', as described by De Vos (2005: 204).

3.2.4 Inclusion criteria

All registered nurses who had passed their competency examination during their nursing orientation, namely dosage calculation, pharmacology and IV medication, were included in this study. These nurses were working either day or night duty in any of the three selected ICUs.

The registered nurses who were in their period of unit orientation or probationary period were also included in the study.

3.2.5 Data collection instrument

The data collection instrument proposed for the data collection in this study was a self-administered questionnaire to describe the perceptions of RNs regarding the *factors* that influence IV medication safety in the practice environment; to determine the *knowledge* of RNs related to safe the IV medication safety practices; describe nursing medication administration *strategies* for medication error prevention, as recommended by RNs who administered IV medication routinely in the NICU, PICU and paediatric CSICU, thereby achieving the objectives for this study as set out in paragraph 1.1.4.

The questionnaire items were developed and refined by incorporating specific local institutional policies and procedures. Items related to 'factors' influencing medication safety practice, 'knowledge' and 'strategies' in the questionnaire were also based on a literature review and based on study outcomes. Any aspect of the different steps during medication administration was considered as a medication administration procedure and tested in the questionnaire. Any aspect of the different phases during medication administration was considered to be a medication administration procedure and tested in the questionnaire in terms of medication rights being checked through nursing 'double-checks' performed by two RNs. The questionnaire was developed and refined to incorporate four sections. Questions that would generate information regarding the background information of the participants, factors influencing IV medication errors in the ICUs, IV medication administration practices of registered nurses, and medication error prevention processes and strategies were included.

Since medication administration is predominantly a nursing task, the researcher conducted the literature review in order to utilize the literature findings and study outcomes to determine which factors caused medication errors in other research settings. The literature review was instrumental in describing the influencing factors of medication errors and the knowledge that an RN has to acquire in order to ensure safe medication administration within a specific practice setting. The review gave the researcher the opportunity to link questionnaire items with previous research outcomes as well as the policies and procedures that guide safe medication administration practice, at the research hospital (KFSHRC-J, 2008a:2). This enabled the researcher to specifically compile items in the questionnaire to gather data in terms of medication safety influencing factors, as perceived by RNs.

Guided by De Vos et al. (2005: 171), specific recommendations were followed for the compilation of questions for the questionnaire, which included: sentences should be brief and clear; question and response alternatives should be clear; questions should contain only one thought; questions should be relevant to the purpose of the questionnaire; abstract questions should be avoided; general, non-threatening questions should be asked first and more sensitive questions later; and consideration should be given to the length of questions and that response categories should offer a real range of alternatives. Closed-ended Likert-type questions were included in the questionnaire to provide the researcher with mainly quantitative data, while an open-ended question provided information given by the RNs and related to the IV medication safety aspects under investigation.

3.2.6 Pilot study

De Vos et al. (2005:206) emphasise the importance of conducting a pilot study before the main investigation is undertaken. A pilot study is similar to the planned study, but it is done on a smaller scale. Brink (2006:166) recommends a pilot study to 'test the practical aspects and … feasibility of a research study' in order 'to detect possible flaws in the data collection instrument … as well as whether the variables defined by operational definitions are … measurable'. A pre-test of the data collection instrument was done for a period of three weeks from 22 June 2011 to 15 July 2011. It was conducted prior to starting the actual data gathering in order to assess the suitability of the questionnaire and to identify any problems that might influence the outcome of the main study.

Twelve registered nurses (n=12), which is 10% of the target population, who were working in either the NICU, PICU and/or CSICU, were instructed to complete the concept questionnaire in order to determine whether the questions were clear and understandable and to make any suggestions to improve the questionnaire, if needed. Since the twelve RNs who participated in the pilot study, also meet the inclusion criteria of the target population as they have experience and knowledge in administering IV medication in the research setting. They were therefore seen as able to identify if there are factors present in the practice environment, which may affect medication safety practice, according to their perceptions.

The questionnaire was also submitted to nursing quality experts, to review whether the questions are representative of standards set in policy.

The questionnaires were sent out by hospital intranet to the pilot study participants. A reminder invitation to participate was also sent to them through the hospital intranet. The overall response rate for the pilot study was 42% (n=5) of the intended pilot study participants. The pilot study time frame was extended to a third week in order to achieve a higher response rate. It was also submitted to research experts at the university and quality management department at the hospital. Return of the questionnaire indicated that voluntary consent was given. Once feedback had been obtained, the questionnaire was modified and finalised for use in the main research study.

Corrections that were done after the pilot study included the addition of ‘not applicable’ as another option to question 7, since some staff were not only in either their probation or unit orientation period. Unit orientation is two weeks or 84 hours, as per hospital policy, which may also be recommended to be extended by the unit Head Nurse if the registered nurse needs more orientation. The probation period is a period of the first three months of employment, as set by hospital policy. Most study participants were past their unit orientation and/or probation period and were employed for a period of more than three months up to several years. Another addition suggested was to include ‘select one’ to questions 9 and 10, since it was mentioned in question 8. One of the respondents asked the researcher for clarification regarding question 13, which asked the respondent about two aspects, namely IV medication errors that happen in the ICU because of ‘patients requiring multiple IV medications and need emergency therapy’ because it tested two constructs and would lead to ambiguity of the question. The researcher decided to test only the latter, namely that ‘patients require multiple IV medications’, in this particular question. A minor change was also made to question 14 because ‘occur’ and ‘happen’ were appearing in the same sentence. The researcher decided to use only the word ‘occur’. In question 28 an addition was made: the word 'independently' was added, so that the relevant part of the sentence would read as follows: ‘... performing the calculations independently without ...'

Changes were therefore only made to some unclear terms that were either deleted or changed to more understandable terms. An additional option to some answers was also included in the questionnaire based on the respondents’ recommendation. Unfortunately not all of the respondents commented on how long it took them to complete the questionnaire, but one commented that it took twenty minutes to complete. Once feedback from all the respondents included in the pilot study had been obtained, the questionnaire was modified and finalised for use in the main research study.

The same sampling and execution methods were employed in the pilot study as for the main investigation, except that the researcher decided to distribute the questionnaires in two ways during the main study. Due to the low response rate of 42% during the pilot study, a combination approach was used for the main study. The particular registered nurses who participated in the pilot study and the data obtained during the pilot study were excluded from the final data collection process.

3.2.7 Validity and reliability

De Vos et al. (2005:160) argue that before commencement of the main study the researcher must ensure 'acceptable levels of reliability and validity' of the measurement instruments and measurement procedures that are used in a study.

3.2.7.1 Reliability

Reliability is defined by Bostwick and Kyte (1981, cited in De Vos et al., 2005:163) as the 'extent to which independent administration of the same instrument (or similar instruments) consistently yields the same (or similar) results under comparable conditions'. The data collection tool or measurement tool (questionnaire) needs to produce similar results, when the same variables are measured under the same conditions. In a similar setting, the questionnaire will test the same variables under study if the RNs are also responsible for the same medication administration tasks than they are responsible for as in this research setting. The questionnaire ensured that questions were asked to all participants in a consistent way.

Reliability is achieved in four ways, as described by De Vos et al (2005: 163), which includes conceptualizing constructs in the questionnaire; increasing the level of measurement; using multiple indicators of a variable; and using a pre-test or pilot study. In order to determine whether 'constructs are clearly conceptualized', the questionnaire was exposed to RNs (n=12) during the pilot study and questions that were not clear, were corrected and clarified. The questionnaire was also given to experts in research at the university and the statistician to determine whether the questions were clear. In order to increase the level of measurement, the research experts and statistician provided input as to whether the questionnaire measured what it is supposed to measure and to enable data analysis. Corrections were made as to the accurate numbering of the different variables that were tested. Multiple indicators of a variable were used to increase the reliability of each measured variable through the repeat of a question in a negative to see whether the participants provide the same information or through the repeat question in a different way. As discussed in detail in Chapter 4, the measurement of a variable

in different ways was adequately achieved. Therefore, increased reliability of the information gained, was achieved.

3.2.7.2 Validity

According to De Vos et al. (2005:160), validity has two important aspects to it, namely 'that the instrument actually measures the concept in question, and that the concept is measured accurately'. Validity is categorised according to content, face, construct and criterion validity (De Vos et al., 2005:160). For the purpose of this study, content validity and face validity were applicable and are discussed as follows:

- In order to ensure content validity, items and concepts in the questionnaire were based on an extensive literature review, as well as on the objectives set for the study. The questions were designed specifically to test the perceptions of RNs regarding the factors that influence IV medication safety in the practice environment. The factors, as described in detail in the literature review and the research setting's policies (policy related to medication administration and policy related to nursing responsibilities regarding the medication system, which is known in the literature as CPOE) were linked and tested as items in the questionnaire. Safe medication administration practice is defined in chapter 2 to be the complete and correct check of all the medication rights through 'double-check of medication rights' by 2 RNs. As per the researcher's conceptual framework (paragraph 2.7), these factors are categorized as environmental, human, system and latent oriented, which was utilized from previous study outcomes to be the cause of medication errors. A statistician, experts in research methodology and nursing quality management, as well as registered nurses in the NICU, PICU and CSICU reviewed the questionnaire. The research methodology, data collection, results and interpretation of results were also reviewed by an expert in research methodology. In addition, a pre-test of the questionnaire enabled the researcher to determine whether there was any ambiguity or inaccuracies with the data collection instrument.
- Face validity is the least scientific definition of validity and relates to the superficial appearance (face value) of a measurement procedure or technique (De Vos et al., 2005: 161). In order to ensure face validity, experts in nursing quality management reviewed the questionnaire to ascertain that the instrument measured the variables it was supposed to measure. Experts in nursing quality management at the research hospital confirmed that the questionnaire was adequately testing RNs knowledge based on institutional policies. RNs who participated in the study had reviewed the questionnaire,

to determine whether it appeared relevant to those participants who would complete it, as described by De Vos et al. (2005:161). The researcher had also compiled the questionnaire, based on a thorough literature review in order to ensure that the data collection tool accurately measured the attributes under consideration, as described in De Vos et al. (2005:161).

During the review of literature phase of this study, the researcher compiled a list of all factors that influence IV medication safety and result in medication errors. These items were organized under the sections of medication error influencing factors, creating a set of items that were based on study outcomes. The questions were compiled specifically, based on these items to test the perceptions of RNs regarding the factors that influence IV medication safety in the practice environment. The factors were based on study outcomes from the literature review, the research setting's policies (as discussed) and the researcher's conceptual framework (paragraph 2.6). The described factors were categorized as environmental, human, system and latent oriented, which is utilized from previous study outcomes to be the cause of medication errors.

3.2.8 Data collection

The data collection took place over a period of two months between July 2011 and September 2011. It was decided that if necessary, the data collection period would be extended until 80% or more of the questionnaires had been returned and data saturation had been reached.

The questionnaire was completed by the NICU, PICU and paediatric CSICU critical care registered nurses during the data collection phase. A cover memo, as part of the mailed questionnaire in hard and/or soft copy, provided specific information as to what was required from the study participants. Return of the completed questionnaire indicated that consent was voluntarily given to take part in the main study. During the main study, the researcher sent the questionnaires out to the respondents (n=121) by hospital intranet as per the study's inclusion criteria. In the week thereafter, the researcher distributed hard copy questionnaires, each placed in an envelope, to the respondents working on day and night duty. To ensure convenient return of questionnaires, the researcher provided a sealed, identified box in each ICU. These boxes had an opening through which participants could deposit the questionnaires. During the distribution of the questionnaires, the researcher briefly introduced herself to the ICU registered nurses, explained the aim of the research study and the methods by which the questionnaires could be returned and offered an opportunity for any questions and answers, if needed.

In answering the questionnaire questions, the respondents were required to select the most appropriate option to each question. Most of the questions had the following keys to guide the respondents: 5=strongly agree; 4=agree; 3=unsure; 2=disagree; and 1=strongly disagree. The other key used in the questionnaire was to select the most appropriate answer from a variety of options listed, including the option for the respondent to provide other information. A smaller number of questions had the following key to use: Y=Yes and N=No. An open-ended question (Question 70) was also included with the purpose of collecting data regarding suggestions from the participants to the prevent medication errors in their units.

Return of the questionnaire during the main data collection indicated that consent for participation was voluntarily given. This study was completely anonymous and confidential and to ensure this, the method of return of the questionnaires was also identified at the time when the questionnaires were handed out. The respondents were reassured that if they chose to drop the questionnaires into the sealed box provided, the person who would collect and open the sealed box, would be the researcher (for the PICU and paediatric CSICU). The data entry for these two units was done by the researcher. However, an added measure was taken to ensure anonymity and confidentiality for the respondents of the NICU: since researcher was working in the NICU, the data collection for the NICU was done by a trained administrative assistant who was not employed in any of the areas involved in the research. She managed the information sessions, and collected the returned questionnaires from the NICU that were placed in a sealed box provided. The administrative assistant, who was trained prior to the start of the data collection phase, was the only person who was allowed to open the sealed box. The administrative assistant also captured the data from NICU respondents onto a Microsoft Excel spreadsheet to ensure that the researcher could not recognise the handwriting of any of the NICU registered nurses on the submitted questionnaires.

After the data capturing was done by the administrative assistant, the questionnaires were locked away for a period of five years until the time the researcher gives consent for the questionnaire to be shredded and destroyed. In this way the researcher ensured that her role was kept neutral and did not influence the data collection process. This also ensured that no unauthorised persons would be able to use the data.

3.2.9 Data analysis and interpretation

Microsoft Excel was used to capture the quantitative data, and STATISTICA Version 9 software was used to analyse the data. The quantitative data analysis was conducted in consultation with

a statistician of Stellenbosch University (Q1 to Q69). Inferential statistics were not required and no inferential statistics testes were requested from the statistician to determine the correlation between variables, as adequate cross-referencing and cross-interpretation of data were done (see Chapter 4). This was done by referencing the data with the literature and by interpreting the outcomes from a question to another that was testing the same item. Given that a descriptive design was chosen for this study, descriptive statistics were used in analysing the data. Distributions of variables were presented with histograms and/or frequency tables.

The data generated by the open-ended question (Q70) was intended to supplement the quantitative data, and was not analysed qualitatively . The several responses were classified and the frequencies of such responses were recorded in order to determine a trend of recommendations regarding the prevention medication errors.

As discussed in chapter 5, core themes that emerged, were the following: ‘five medication rights’, ‘double-checks’, ‘delay in pharmacy delivering the medication’, ‘more in-service training’, ‘nurse to patient ratio’, ‘share results and feedback with staff’.

3.3 SUMMARY

In this chapter, the methodology that was implemented was described in detail regarding the perceptions of RNs on the factors that influence IV medication safety practices of RNs working with neonatal and paediatric ICU patients, as well as the knowledge of the RNs related to safe IV medication administration practices and nursing medication administration strategies to prevent medication errors. The research approach and design of the present study were discussed, as well as the target population and sampling thereof, and the data collection and analysis techniques.

In Chapter 4 the results of the study are provided, discussed and contextualised.

CHAPTER 4: DATA ANALYSIS AND RESULTS

4.1 INTRODUCTION

According to De Vos et al. (2005:218), the purpose of data analysis is to reduce data into an intelligible and interpretable form so that the relations of research problems can be studied and tested and conclusions drawn. In order to reflect on why the particular study was undertaken, the research question in this study was formulated as follows:

> What are the perceptions of RNs regarding IV medication safety practices in the NICU, PICU and paediatric CSICU in a particular Saudi Arabian tertiary hospital?

Burns and Grove (2007:41) state that a data analysis is conducted to reduce, organise and give meaning to the data.

4.2 THE METHOD OF DATA ANALYSIS

This study was quantitative by nature (Question 1 to 69) with an open-ended question (Question 70). Since this was a quantitative study with a descriptive survey design, descriptive statistics were requested from a statistician. The results of each item were displayed in either *f*-tables or histograms in this chapter. After each section a conclusive summary was made.

In the open-ended question (Q70) the respondents were asked to make recommendations regarding safety strategies. The frequencies of such responses were recorded in order to support the findings regarding the prevention medication errors. As discussed in paragraph 3.2.5, the data collection instrument used was a self-administered questionnaire to describe the perceptions of RNs regarding factors that influence IV medication safety practices in neonatal and paediatric ICUs. The data was analysed as discussed in paragraph 3.2.9.

The data collection through questionnaires achieved a response rate of 80.5% (n=83). Unfortunately few respondents gave more than one answer per question in the main study while they were clearly asked to ‘select the most important reason’. The instruction to select one was repeated in brackets after each question in the questionnaire. The particular questions involved were Q8, Q9, Q10, Q17, Q18, Q19, Q47, Q48, Q49 and Q68. However, this was not revealed as a problem during the pilot study as the respondents selected one answer per question. The readings were therefore considered as spoilt, as the provision of more than one answer per question compromised the data analysis.

Unless requested to do otherwise, all the respondents answered the various questions under each question. The percentages in the text were rounded off to the closest integer to simplify the discussion.

4.2.1 Section A: Background information

Question 1: What is your nursing position in the hospital?

One respondent did not answer this question. As indicated in Table 4.1, the majority (more than half) of respondents who answered the questionnaire were registered nurses working in the NICU, PICU and CSICU (n=75 or 91.4%). The nursing positions grouped under 'Other' (n=4 or 4.8%) included nursing positions of registered nurses who were directly involved in the review of practice standards in the research setting, which included either the programme director, the quality analyst or the computer applications nurse.

Table 4.1: Nursing position

Category	Frequency (*f*)	Percentage (%)
RN=registered nurse	75	91.4
CHC=clinical nurse coordinator	2	2.4
HN=head nurse/assistant head nurse	1	1.4
0=other	4	4.8
Total	**n=82**	**100.0**

Question 2: Please indicate the exact number of years that you have worked at KFSHRC-J in your current position. (n=83)

Two respondents did not answer this question. Table 4.2 indicates the number of years that the registered nurses had been employed at the research hospital. The number of respondents (n=21 or 25.9%) who had been employed for two years, while a number of respondents (n=14 or 17.2%) had been employed for three years. There were also a number of respondents (n=11 or 13.5%) who had been employed for four years at the research hospital. The mean number of years that the respondents had worked at KFSHRC-J in their current position was 4.4 years (X=4.4). According to De Vos (2001:216), the mean is 'the sum of the measurements divided by the amount of measurements', whereas the mode was 2 years (Mo=2). De Vos (2001:215) defines the mode as 'the value which occurs most frequently in a distribution'.

Table 4.2: Years at KFSHRC-J

Category	Frequency (*f*)	Percentage (%)
<1 year	2	2.4
1 year	2	2.4
2 years	21	25.9
3 years	14	17.2
4 years	11	13.5
5 years	5	6.1
6 years	6	7.4
7 years	9	11.7
8 years	2	2.4
9years	4	4.9
10 years	2	2.4
>11 years	3	3.7
Total	**n=81**	**100.0**

Question 3: Please indicate the number of years that you have worked in your unit (in your current position). (n=83)

Five respondents did not answer this question. Table 4.3 indicates the number of years that the registered nurses had been employed in either of the NICU, PICU or CSICU in the research hospital. The number of the respondents (n=22 or 28.2%) had been working in either one of the ICUs for two years, while a number of respondents (n=12 or 15.3%) had been working in one of the three ICUs for three years. The mean number of years that the respondents had worked in the particular unit was 4.5 years (X=4.5), whereas the mode was 2 years (Mo=2).

Table 4.3: Years in unit

Category	Frequency (*f*)	Percentage (%)
<1 year	1	1.2
1 year	4	5.1
2 years	22	28.2
3 years	12	15.3
4 years	8	10.2
5 years	5	6.4
6 years	6	7.6
7 years	9	11.5
8 years	1	1.9
9 years	5	6.4
10years	1	1.2
11 years	3	3.8
12 years	0	0.0
13 years	0	0.0
14 years	0	0.0
>15 years	1	1.2
Total	**n=78**	**100.0**

It seemed that in question 3 (number of years worked in unit) some of the respondents indicated a higher number of years than the number of years in question 2 (number of years worked at KFSHRC-J). It is possible that these respondents misunderstood the question and filled in the total years of experience in that particular unit, as the years of work in the particular ICU cannot exceed the years of work at the research hospital. It could also be interpreted by the respondents that the number of years of experience could be in the same unit that they are currently working in.

Question 4: Please indicate your highest nursing qualification: (SELECT ONLY ONE OPTION.) (n=83)

Figure 4.1 indicates that as many as 67.0% (n=56) of the ICU registered nurses who took part in this study held a Bachelor of Science in Nursing (BSN) degree, whereas 27.0% (n=22) were registered nurses. Only 5.0% (n=4) of the ICU registered nurses had master's degrees, while

1.0% (n=1) had a post-graduate qualification. None of the respondents mentioned that they had either a doctoral or other nursing qualification as listed in the questionnaire.

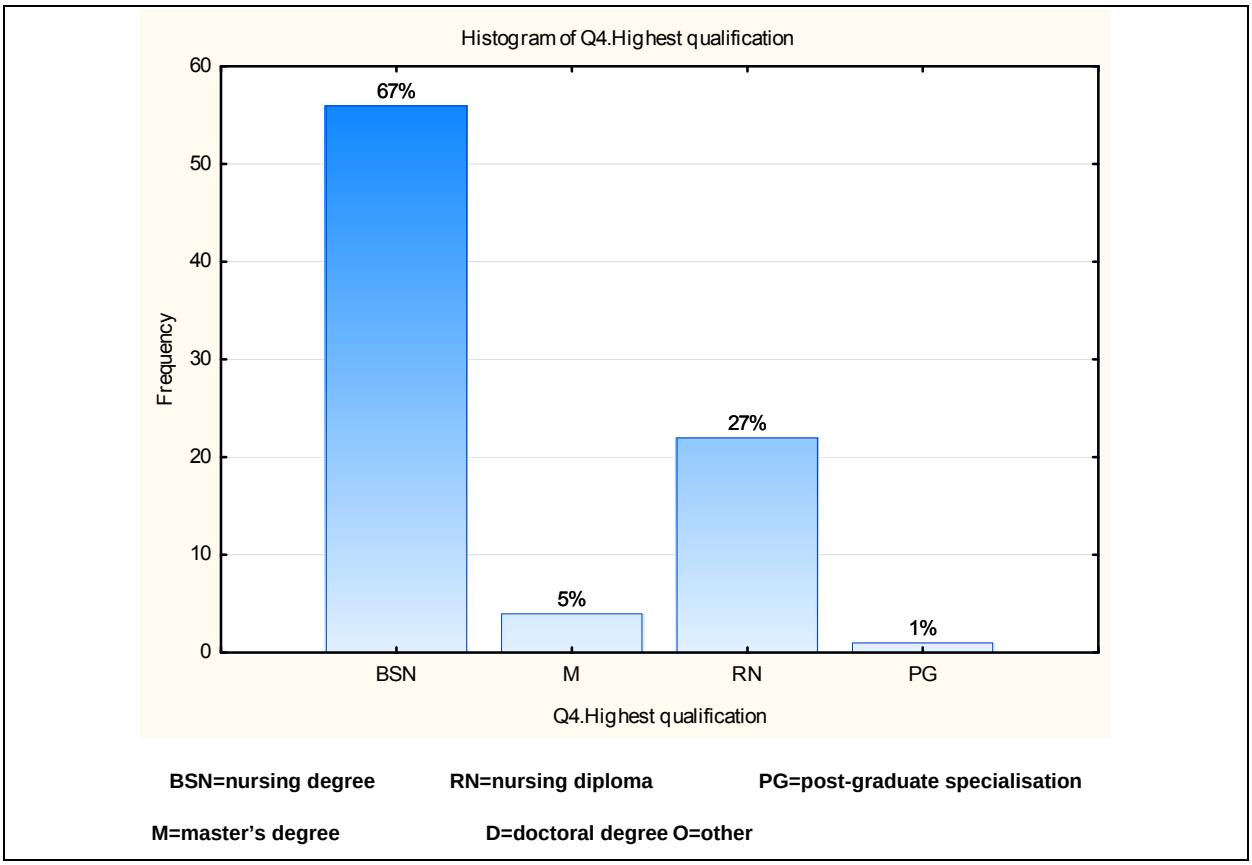

Figure 4.1: Highest nursing qualification

Question 5: Have you completed your check-off exams related to dosage calculation, pharmacology and IV medication administration? (n=83)

Five respondents did not answer this particular question. The majority of the respondents (n=77 or 98.7%) mentioned that they had written the check-off examinations during general nursing orientation. One respondent (n=1 or 1.3%) mentioned that he or she did not write the check-off examinations. However, it is not feasible for any registered nurse to omit writing these mandatory examinations during the general nursing orientation period, since newly employed nursing staff are monitored by the nursing education department with feedback to nursing affairs. All registered nurses working at the research hospital are performance evaluated close to the end of the probation period (first three months of employment). Their performance is documented and monitored through the nursing affairs department and salary benefits are continued if the probation is successfully passed. Therefore it is not feasible that a registered

nurse will continue working in any nursing unit of the research hospital if these examinations are not passed. From these findings it seems as if the particular respondent may have either misinterpreted the question or may not have known what the examinations are called.

Question 6: Please indicate whether you are working in the unit that corresponds with your area of specialty. (n=83)

One respondent did not answer this particular question. A total of 95.2% respondents (n=78) mentioned that they were working in the ICU that corresponds with their area of specialty (based on experience and/or training); whereas three respondents (3.6%) reported that they were not working in their area of specialty. One respondent (1.2%) selected the option 'Other' which indicates 'student'. If only one has a post-graduate qualification, this is maybe interpreted by the respondents as not an easy question to answer. Or it could mean that some RNs are not working in their original area of specialty. The researcher is familiar with an educational programme at the research hospital, during which RNs are trained to work in the ICUs, if an RN wishes to apply for a transfer. Unfortunately, this data is not available to the researcher to draw comparison with due to the confidentiality of the research hospital's data.

Question 7: Please indicate whether you are currently in your unit orientation period or probation period. (n=83)

Two respondents did not answer this particular question. None of the respondents were in their unit orientation period at the time of data collection, whereas only 3.7% (n=3) ICU registered nurses were in their probation period. The majority of neonatal and paediatric ICU registered nurses who completed the questionnaires (n=78 or 96.3%) were employed on an annual contractual basis.

4.2.2 Section B: Factors influencing IV medication errors in the ICUs

In view of the multiple causes of medication errors, as identified by the literature review in chapter 2 (2.7.1 to 2.7.12), the data findings presented in this section provide information regarding the RNs perceived factors that influence medication safety, as per the conceptual model used for this study.

Question 8: Human factors may contribute to the incidence of medication errors. Please select THE MOST IMPORTANT REASON for medication errors by providing your answer with a tick (✓) in the appropriate box. (SELECT ONE.)

A number of respondents (n=83) had answered this question originally. However, a number of respondents (n=24) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However, the data was re-analyzed, and presented in the table. As indicated in Table 4.4, the number of respondents (n=23 or 39%), who participated in this study, perceived that medication errors are caused by missing one or more of the medication rights, namely the right patient, right drug, right dose, right route, right frequency, and right administration time, as the first-ranking human factor. As a second-ranking factor, 13.5% (n=8) of respondents indicated that medication errors are caused if the registered nurse did not perform double-checks or did incomplete double-checks. The respondents identified the third-ranking factor, as perceived, that medication errors are caused by high patient to nurse ratio (n=5 or 8.5%). The identified factors are routine ICU nursing tasks, as outlined in the research hospital's policies and procedures and were therefore tested in the questionnaire.

Table 4.4: Human factors contributing to medication errors

Category	Frequency (*f*)	Percentage (%)
a=nurse's fatigue/exhaustion	2	3.4
b=missing one/more of the 5 rights	23	39
c=work pressure	4	6.8
d=error-prone situations	3	5.1
e=hesitance to request clarification	0	0
f=unfamiliarity with the medication	0	0
g=distractions/interruptions	2	3.4
h=incorrect dilution calculations	0	0.0
i=incorrect dosage calculations	4	6.8
j=incorrect rate calculations	1	1.7
k=nurse's lack of concentration	4	6.7
l=misplaced decimal points	0	0
m=high patient-nurse ratio	5	8.5
n=only one RN checking with colleague	0	0
o=advanced drug preparation	0	0
p=dilution errors	0	0
q=failed communication	1	1.7
r=administration of wrong IV medication	1	1.7

s=misidentification	0	0.0
t=not performing or incomplete double-checks	8	13.5
u= missing one/more of the 5 rights	0	0
v=other	1	1.7
Total	**n=59**	**100.0**

Question 9: System factors may contribute to the incidence of medication errors. Please select THE MOST IMPORTANT REASON for medication error by providing your answer with a tick (✓) in the appropriate box. (SELECT ONE.)

Three respondents who participated in the study did not answer this question. As shown in Table 4.5, the majority of the respondents (n=19 or 29.6%) who participated in this study indicated that medication errors are caused when a great deal of medication is scheduled at peak times in the ICU. Peak times, is considered those times where other nursing tasks are due. This implies that the respondents perceived time when medication errors occur, is reported to happen when the medication is administered at the same time when other nursing tasks are due. Medication doses are scheduled according to peak times, as per hospital policy ((KFSHRC-J, 2008b:3).

QOD (alternate days) - 09h00

Daily (daily) - 09h00

BID/q12h (twice daily)-09h00 and 21h00

TID (three times daily)- 09h00, 15h00 and 21h00

Q8h (every 8 hours) - 06h00, 14h00 and 22h00

QID (four times daily) - 09h00, 13h00, 17h00 and 21h00

Q6h (every 6 hours) - 06h00, 12h00, 18h00 and 24h00

This was indicated as the first-ranking system factor. As the second-ranking factor, 17.8% (n=11) of the respondents indicated that medication errors in the ICU are caused if drugs look alike and/or their names sound alike.

The identified factors (medication errors happen at peak times, drugs that look-alike, sound-alike) were also identified in the literature review, and therefore tested in the questionnaire. As per the inclusion criteria of this study, the IV medication considered were continuous IV infusions, intermittent medication (for example antibiotics, boluses, electrolytes and diuretics)

and stat IV medication. Routinely, all newly issued IV infusions are hooked between 21:00 and 23:00. From these findings, it could be possible to deduce that the due times of routinely scheduled IV medications coincided with the times that IV infusions were hooked because IV medication that is ordered q8h or BID, will have a scheduled administration due time during the peak time when all of the infusions are hooked and patient care is due.

A number of respondents (n=16) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However, the data was re-analyzed, and presented in the table. However, the data was re-analyzed, and presented in the table.

Table 4.5: System factors contributing to medication errors

Category	Frequency (*f*)	Percentage (%)
a=complicated/incomplete prescriptions	10	15.5
b=smart pump difficult to operate	1	1.5
c=insufficient unit-specific training	2	3.1
d=narrow therapeutic index	3	4.6
e=medications scheduled at peak times	19	29.6
f=standard medication labelling	5	7.8
g=lack of neonate-specific medicinal products	1	1.5
h=computerised physician order entry(CPOE)	10	15.5
i=look-alike, sound-alike drugs	11	17.8
j=other	2	3.1
Total	**n=64**	**100.0**

Question 10: Environmental factors may contribute to the incidence of medication errors. Please select THE MOST IMPORTANT REASON for medication errors by providing your answer with a tick (✓) in the appropriate box. (SELECT ONE.)

Four respondents who participated in this study did not answer this question. A number of respondents (n=79) have answered this question originally. However, a number of respondents (n=15) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However,

the data was re-analyzed, and presented in the table. However, the data was re-analyzed, and presented in the table. As shown in Table 4.6, the majority of the respondents (n=16 or 25%) who participated in this study mentioned that medication errors are caused by the patient's critical condition, being the first-ranking environmental factor. A patient's critical condition may increase the number of nursing tasks due, as identified by the second ranking factor. As a second-ranking environmental factor, 20.3% (n=13) of the respondents indicated that medication errors in the ICU are caused if multiple nursing tasks are done in limited available time. This factor seems to repeat. This is in line with what was reported in question 10, namely that a great deal of medication is scheduled at peak times. A third-ranking environmental factor, namely that medication errors are caused by a high patient-nurse ratio, was identified by 15.6% (n=10) of respondents.

Table 4.6: Environmental factors contributing to medication errors

Category	Frequency (*f*)	Percentage (%)
a=work pressure	3	4.7
b=error-prone situations	9	14.0
c=patient types	6	9.4
d=critical condition of patient	16	25
e=high patient-nurse ratio	10	15.6
f=multiple nursing tasks in limited time	13	20.3
g=increased workload	6	9.4
h=English not the first language of staff	0	0
i=other	1	1.6
Total	**n=64**	**100.0**

In questions 11 to 16 the respondents were requested to provide an answer with a tick (✓) in the appropriate box. The respondents had to select either '1=strongly disagree'; '2=disagree'; '3=agree'; or '4=strongly agree'.

Question 11: I feel that I have control over environmental influences, e.g. noise level in the ICU that affects my concentration.

One respondent did not answer this particular question. As indicated in Table 4.7, the majority of respondents indicated that they had control over environmental influences by ticking off either 'agree' (n=46 or 56.0%) or 'strongly agree' (n=14 or 17.0%).

Table 4.7: Control over environmental influences

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	3	3.6
2=disagree	19	23.4
3=agree	46	56.0
4=strongly agree	14	17.0
Total	**n=82**	**100.0**

Question 12: IV medication errors are happening in our ICU because of a combination of human, system and environmental factors.

Two respondents did not answer this particular question. As indicated in Table 4.8, the majority of respondents indicated that IV medication errors were happening because of a combination of causing factors by ticking off either 'agree' (n=42 or 51.8%) or 'strongly agree' (n=27 or 33.3%).

Table 4.8: Combination of human, system and environmental factors

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	3	3.8
2=disagree	9	11.1
3=agree	42	51.8
4=strongly agree	27	33.3
Total	**n=81**	**100.0**

Question 13: IV medication errors are happening in our ICU because patients require emergency therapy.

Three respondents did not answer this particular question. As indicated in Table 4.9, by ticking off either 'agree' (n=41 or 51.2%) or 'strongly agree' (n=10 or 12.5%) the majority of respondents indicated that IV medication errors occur when patients receive emergency therapy. The positive responses may show that medication errors happen during times when patients in the ICU receive emergency therapy in the form of medication administered during a code. This would leave the patients vulnerable when they receive emergency therapy. However, a significant number of respondents disagreed (n=22 or 27.5%) to the above statement.

Table 4.9: Patients require emergency therapy

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	7	8.8
2=disagree	22	27.5
3=agree	41	51.2
4=strongly agree	10	12.5
Total	**n=80**	**100.0**

Question 14: IV medication errors occur because of device miss-programming, e.g. setting an infusion to run over one (1) hour instead of over six (6) hours.

Two respondents did not answer this particular question. As indicated in Table 4.10, by ticking off 'disagree' (n=36 or 44.4%), the majority of respondents indicated that IV medication errors occur because of IV devices that are miss-programmed. However, an almost equal number of respondents agreed (n=35 or 43.2%) to the above-mentioned statement. As shown by the responses, there was an almost equal response rate in the respondents' positive and negative perception of the question. Patients in this particular research setting receive multiple infusions. Agreement by the majority respondents that the cause of medication errors is because IV devices that are miss-programmed may be the reason why there are different reports from registered nurses in the research setting, as the various respondents may have had different experiences with the root cause of a medication error that occurred in the practice environment..

Table 4.10: Device miss-programming

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	7	8.6
2=disagree	36	44.4
3=agree	35	43.2
4=strongly agree	3	3.8
Total	**n=81**	**100.0**

Question 15: IV medication errors occur because of IV infusion rates that are accidentally switched.

Two respondents did not answer this particular question. As indicated in Table 4.11, by ticking off 'agree' (n=40 or 49.4%), the majority of respondents indicated that IV medication errors occur because of IV infusions that are accidentally switched. A significant number of respondents disagreed (n=28 or 34.6%) with this statement. This question links with the data related to the leading human factor cause as identified by the respondents in this study (see question 8), namely by missing one or more of the medication rights. There also seemed to be different reports from the respondents who worked in the NICU, PICU and CSICU.

Table 4.11: IV infusion rates accidentally switched

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	7	8.6
2=disagree	28	34.6
3=agree	40	49.4
4=strongly agree	6	7.4
Total	**n=81**	**100.0**

Question 16: Misidentification is a reason why a medication error can happen in my unit, e.g. patient misidentification or medication misidentification.

Two respondents did not answer this particular question. As indicated in Table 4.12, by ticking off either 'disagree' (n=32 or 39.5%) or 'strongly disagree' (n=26 or 32.1%), the majority of respondents (n=46 or 56.8%) indicated that IV medication errors were NOT happening because of patient misidentification. As shown by the responses, the respondents' positive and negative perceptions of misidentification as a reason for a medication error are almost equally balanced.

Table 4.12: Misidentification

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	14	17.3
2=disagree	32	39.5
3=agree	26	32.1
4=strongly agree	9	11.1
Total	**n=81**	**100.0**

Question 17: In my opinion, the drug class most often involved in medication errors is: (Please tick ONE.)

Two respondents who participated in the study did not answer this question. However, a number of respondents (n=6) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was considered as spoilt. However, the data was re-analyzed, and presented in the table.

Continuous IV medications include Furosemide infusions, narcotic infusions. Intermittent IV medication includes any IV medication that is administered BID, q8h, q6h. Maintenance infusions include dextrose based infusions. As shown in Table 4.13, the majority of the respondents (n=20 or 26.7%) indicated that inotropes, which are used in the treatment of critically ill patients, are most often involved in IV medication errors. Stat IV medication, as the second-ranked drug class involved in medication errors, were identified by 21.3% (n=16) of the respondents. Intermittent IV medication was identified as the third-ranked drug class by 16.0% (n=12) of the respondents, while 14.7% (n=11) of respondents identified antibiotics as the fourth-ranked drug class involved in medication errors. Due to inotrope infusions, as identified by the respondents, it could be concluded that IV medication errors occur at times when patients are very unstable, requiring inotrope infusions to increase cardiac output, and when these patients are mechanically ventilated.

Since the identified drug classes were identified in the literature review, they were tested in the questionnaire. The information gained from this question links with question 13 in the sense that the drug classes most often involved in medication errors are indicative of emergency treatment being given to the neonatal and paediatric ICU patient population, as identified by the respondents.

Table 4.13: Drug class most often involved

Category	Frequency (*f*)	Percentage (%)
a=TPN/IL	3	4.0
b=Antibiotics	11	14.7
c=Inotropes	20	26.7
d=Stat IV medications	16	21.3
e=Continuous IV medications	7	9.3
f=Intermittent IV medication	12	16
g=Maintenance infusion	2	2.7
h=Other	4	5.3
Total	**n=75**	**100.0**

Question 18: In my opinion, medication errors occur mostly during the following times: (Please tick ONE.)

A number of respondents (n=83) have answered this question originally. However, a number of respondents (n=4) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However, the data was re-analyzed, and presented in the table. However, the data was re-analyzed, and presented in the table. As shown in Table 4.14, the vast majority of the respondents (n=53 or 67.1%) indicated that IV medication errors occur at any time during the 24 hours. However, question 9 revealed that 29.6% (n=19) of respondents indicated that medication errors occur when medications are scheduled at peak times. As discussed in question 9, the schedule for intermittent and the 24-hourly change of continuous IV medication coincide with other tasks related to IV medication administration practices at specific high-peak times. According to the literature, medication errors have been found to happen when medication administration coincides with high peak times. For this reason, this aspect was tested in the questionnaire. New information has been gained in the sense that respondents indicated that IV medication errors happen at any time during the 24 hours.

Table 4.14: Medication error times

Category	Frequency (*f*)	Percentage (%)
a=on day duty	2	2.5
b=on night duty	9	11.4
c=during shift change	5	6.3
d=I don't know	4	5.1
e=when 12-hour checks are not done	1	1.3
f=when 24-hour checks are not done	3	3.8
g=any time during 24 hours	53	67.1
h=other	2	2.5
Total	**n=79**	**100.0**

Question 19: In my opinion, medication errors occur mostly because the following was missed: (Please tick ONE.)

Two respondents who participated in the study did not answer this question. However, a number of respondents (n=4) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However, the data was re-analyzed, and presented in the table. However, the data was re-analyzed, and presented in the table. As shown in Table 4.15, the majority of the respondents (n=27 or 35%) indicated that that IV medication errors mostly occur because the right dose, as one of the medication rights, was missed. The wrong dose for IV medication potentially has serious consequences for patients, by either not receiving a lower dose and therefore not the correct treatment or a higher dose than what was ordered. They may be consequently harmed. As revealed in the literature review, the right dose for an IV infusion also indicates the right concentration. If the correct dose is NOT administered for IV infusions and medications, it also indicates that the right dose was not administered, as shown by the responses in Table 4.15.

Table 4.15: Medication rights missed

Category	Frequency (*f*)	Percentage (%)
a=right medication	7	9.1
b=right dose	27	35.0
c=right route	2	2.6
d=right frequency	11	14.3
e=right time	15	19.5
f=other	15	19.5
Total	**n=77**	**100.0**

4.2.3 Section C: IV medication administration practices of registered nurses

Questions 20 to 29 requested that the respondents provide their opinion with a tick (✓) in the appropriate box. The respondents had to select either '1=strongly disagree', '2=disagree', '3=agree', or '4=strongly agree'.

In view of the study's objective to describe the perceptions of RNs regarding the factors that influence medication administration practice, as identified by the literature review in chapter 2 (2.9 and 2.10.6), the data findings presented in this section provide information regarding the RNs perceived factors (knowledge) that would influence medication administration practice. Medication administration practice is tested in the context of the five medication rights and

performing nursing 'double-checks', since aspects are forming the basis of the research hospital's policy and procedure for medication administration.

Question 20: Routine nursing double-checks by two RNs can reduce the risk of IV medication administration errors for neonatal/paediatric ICU patients.

As indicated in Table 4.16, by ticking off either 'agree' (n=28 or 33.7%) or 'strongly agree' (n=54 or 65.0%), the majority of respondents indicated that routine double-checks can reduce the risk of IV medication administration errors.

Table 4.16: Routine nursing double-checks reduce risk

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.3
2=disagree	0	0.0
3=agree	28	33.7
4=strongly agree	54	65.0
Total	**n=83**	**100.0**

Question 21: Routine nursing double-checks by two RNs are conducted during handover at shift change, e.g. double-check infusion rates and physician orders.

As indicated in Table 4.17, by ticking off either 'agree' (n=25 or 30.1%) or 'strongly agree' (n=53 or 63.8%), the majority of respondents indicated that routine double-checks are conducted during handover at shift change.

Table 4.17: Routine nursing double-checks during handover

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.3
2=disagree	4	4.8
3=agree	25	30.1
4=strongly agree	53	63.8
Total	**n=83**	**100.0**

Question 22: The current standard of nurses' practice in the ICU is adequate in preventing medication errors.

One respondent who participated in the study did not answer this question. As indicated in Table 4.18, by ticking off either 'agree' (n=51 or 62.2%) or 'strongly agree' (n=20 or 24.4%), the vast majority of respondents indicated that the current standard of nurses' practice in the ICU was adequate. The vast majority of respondents perceived their IV medication administration practice to be up to standard. In agreement with the literature, researchers reported that medication errors are prevented if medication administration is safely executed. It appears that if the IV medication administration practice were up to standard, IV medication errors would not occur in the practice environment under study, which is happening in the practice environment under study. Unfortunately, the researcher was not allowed by her authorities to disclose such confidential information.

Table 4.18: Current standard of nurses' practice

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	2	2.5
2=disagree	9	10.9
3=agree	51	62.2
4=strongly agree	20	24.4
Total	**n=82**	**100.0**

Question 23: The implementation and maintenance of standard IV medication concentrations help to provide reliable infusion rates.

As indicated in Table 4.19, by ticking off either 'agree' (n=51 or 61.4%) or 'strongly agree' (n=27 or 32.5%), the majority of respondents indicated that standard IV medication concentrations help to provide reliable infusion rates. In the ICU practice environments of the research hospital, standard IV medication concentration is routine practice and embedded in the nursing and pharmacy policies. Since this aspect matches with what was brought to light through the literature review, it was tested in the questionnaire.

Table 4.19: Standard IV medication concentrations

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.3
2=disagree	4	4.8
3=agree	51	61.4
4=strongly agree	27	32.5
Total	**n=83**	**100.0**

Question 24: Each patient must have a dosage calculation sheet that includes emergency IV medications' dosages and volumes based on the patient's weight.

As indicated in Table 4.20, by ticking off either 'agree' (n=32 or 38.6%) or 'strongly agree' (n=47 or 56.6%), the majority of respondents indicated that each patient must have a dosage calculation sheet based on his or her weight. It was the respondents' perception that their IV medication administration practice was up to standard.

Table 4.20: Dosage calculation sheet based on the patient's weight

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.2
2=disagree	3	3.6
3=agree	32	38.6
4=strongly agree	47	56.6
Total	**n=83**	**100.0**

Question 25: IV medications require further dilution prior to administration, dependent on whether a peripheral IV or CVC line is in place.

One respondent who participated in the study did not answer this question. As indicated in Table 4.21, by ticking off either 'agree' (n=34 or 41.4%) or 'strongly agree' (n=39 or 47.6%), the vast majority of respondents indicated that IV medications require further dilution prior to administration. It seems evident from this information that the respondents had adequate knowledge regarding IV medication safety. As per the scope of service for the practice environment under study, central lines are the method of choice for IV access in the ICUs. However, patients also have peripheral IVs in place when their condition improves. Due to the

typical, complex IV therapy that ICU patients receive in this research setting, it is a vital part of the nurse's tasks to know whether the patient has a central or peripheral IV in place .

Table 4.21: Further dilution prior to administration

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	3	3.7
2=disagree	6	7.3
3=agree	34	41.4
4=strongly agree	39	47.6
Total	**n=82**	**100.0**

Question 26: Titrations for IV medication (e.g. Heparin protocol, inotropes) are done by two RNs.

As indicated in Table 4.22, by ticking off either 'agree' (n=29 or 34.9%) or 'strongly agree' (n=49 or 59.0%), the majority of respondents indicated that IV titrations are done by two registered nurses. Inotropes and heparin are titrated during critical patient care, based on whether the patient's condition improves or deteriorates. It is measured in this item whether titrations are done by two RNs. These infusions are infused when patients in this practice environment under study, are very unstable. It can be concluded that when patients receive emergency therapy, medication checking is NOT done by two registered nurses. This is in contrast with what is set as standard in the research hospital's policy related to medication administration, which mandates that all IV infusions are to be checked by two RNs by checking all five medication rights (KFSHRC-J, 2008a:2). During emergency therapy in the ICU, staff work together to get the patient stabilised. Nurses' attention is potentially focused on other nursing tasks of importance, and not entirely on checking medication. It poses a risk for patient safety if medications (or infusions) are not checked by two registered nurses before they are titrated. It is concluded, that this item may be a perceived factor in influencing medication safety.

Table 4.22: Titrations done by two registered nurses

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	2	2.5
2=disagree	3	3.6
3=agree	29	34.9
4=strongly agree	49	59.0
Total	**n=83**	**100.0**

Question 27: Routine checks include whether there is incompatibility with other medication or with the diluting liquid, with each IV medication that I administer.

One respondent who participated in the study did not answer this question. As indicated in Table 4.23, by ticking off either 'agree' (n=28 or 34.1%) or 'strongly agree' (n=48 or 58.5%), the majority of respondents indicated that routine checks include checking the compatibility with other medication or with the diluting fluid. As per hospital policy, it is a requirement to check fluid compatibility (KFSHRC-J, 2008a:2). It does not seem evident from this information that the respondents are all practicing this standard, as based on the opinion of these respondents nor that they have adequate knowledge regarding IV medication safety awareness. Due to the typical, complex IV therapy that ICU patients receive in this research setting, it is a vital part of the nurse's tasks to check for medications' compatibility before the continuous infusion is set to run through the infusion device. It is also vital for an ICU nurse to use the specialised nursing knowledge to care safely for patients during routine and emergency care. For example, during a patient's resuscitation, sodium bicarbonate can only be diluted with sterile water and not with normal saline solution.

Table 4.23: Routine check for incompatibility

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.2
2=disagree	5	6.2
3=agree	28	34.1
4=strongly agree	48	58.5
Total	**n=82**	**100.0**

Question 28: The patient's assigned nurse and a second RN must check the five medication rights together by both performing the calculations independently without relying on each other's calculations.

One respondent who participated in the study did not answer this question. As indicated in Table 4.24, by ticking off either 'agree' (n=27 or 33.0%) or 'strongly agree' (n=51 or 62.2%), the majority of respondents indicated that the patient's assigned nurse as well as a second registered nurse must check the five medication rights together and that the calculations must be checked independently. It seems evident from this information that the respondents have adequate knowledge regarding medication safety awareness. However, compared with question 8 (medication errors caused by missing one or more of the medication rights and the registered nurse does not perform a double-check), it seems evident that registered nurses know that the five medication rights have to be checked by two registered nurses, but that there is non-compliance with this safety precaution, as perceived by the findings. This aspect matches with the reviewed literature and was therefore tested in the questionnaire.

Table 4.24: Checking of the five medication rights

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	2	2.4
2=disagree	2	2.4
3=agree	27	33.0
4=strongly agree	51	62.2
Total	**n=82**	**100.0**

Question 29: It is important to question my colleague RN's calculation if it does not correspond with my calculation.

Two respondents did not answer this particular question. As indicated in Table 4.25, by ticking off either 'agree' (n=21 or 25.9%) or 'strongly agree' (n=59 or 72.8%), the vast majority of respondents indicated that ICU registered nurses must question each other's calculations if their calculations do not correspond. It is not acceptable to accept that the other's calculation is the correct calculation. However, in order to have an effective double-check, both registered nurses' critical thinking and critical decision-making skills are required to judge when they need help to consult another resource person, if they are in doubt about a calculation.

Table 4.25: Query colleague's calculation

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.3
2=disagree	0	0.0
3=agree	21	25.9
4=strongly agree	59	72.8
Total	**n=81**	**100.0**

From the above discussion as reflected in Tables 4.16 to 4.25, it seems evident that the respondents either had inadequate knowledge regarding medication safety awareness or do not practice or comply with the set standards, as guided by the research hospital's policies. Therefore, it can be concluded as a potential factor influencing medication safety.

In the questions on how double-checks should be performed, the respondents replied as follows (Questions 30 to 33):

Question 30: I check with another RN: the patient's identification number and IV medication label against the patient's electronic Medication Administration Record (MAR).
As indicated in Figure 4.2, by ticking off either 'agree' (n=29 or 35.0%) or 'strongly agree' (n=52 or 63.0%), the vast majority of respondents indicated that a double-check must include checking the patient's identification number and IV medication label against the electronic MAR. This question seems to correlate with the findings from question 43 (appropriate to check to patient identifiers before medication administration) presented later in this chapter, since the results are the same.

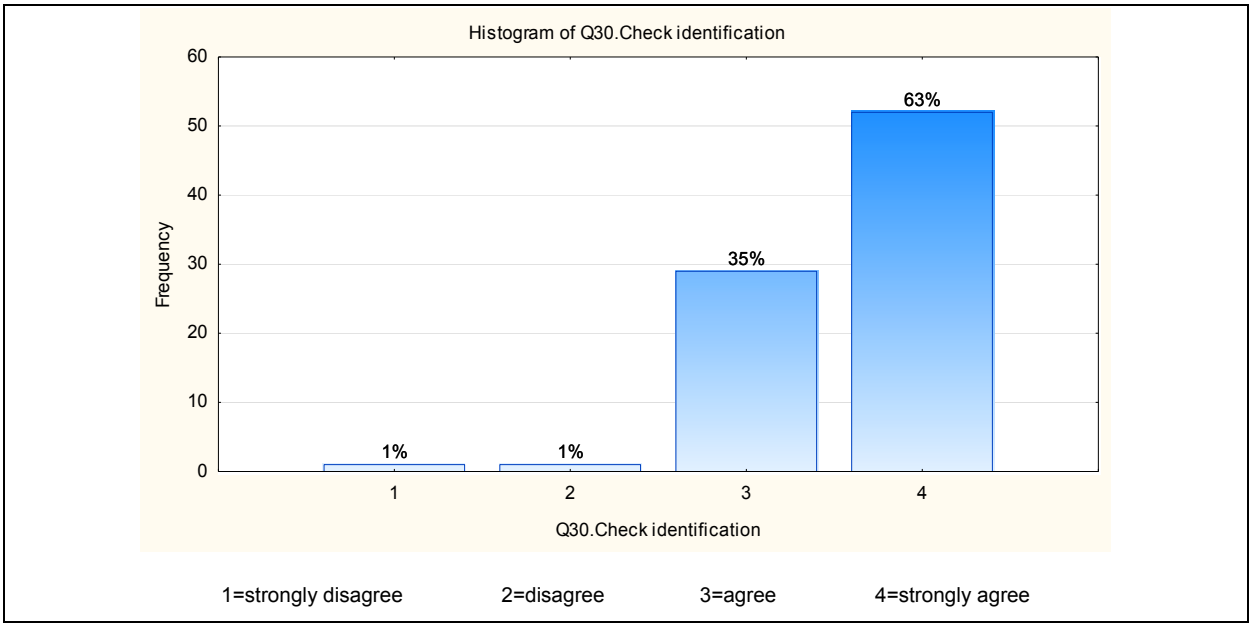

Figure 4.2: Double-check identification

Question 31: I check with another RN: all pump settings and trace the IV tubing to the site of injection before the infusions are started.

As indicated in Figure 4.3, by ticking off either 'agree' (n=27 or 33.0%) or 'strongly agree' (n=45 or 54.0%) the vast majority of respondents indicated that a double-check includes checking the pump settings with another registered nurse and tracing the IV tubings to the injection site before the infusions are started. A significant number of respondents (n=11 or 13.0%) indicated that the pump settings are NOT checked with another registered nurse, despite this aspect being a policy requirement and therefore tested in the questionnaire. This is a concern for patient safety in this research setting, since the potential is created for latent errors to exist in the practice environment. The question arises: if the majority of respondents indicate that checks are performed by two registered nurses, how do medication errors still occur? When this information is linked with question 15 (IVs are accidentally switched) and question 19 (errors that are happening, are due to wrong dose), it is evident that double-checks do NOT seem to be effectively performed.

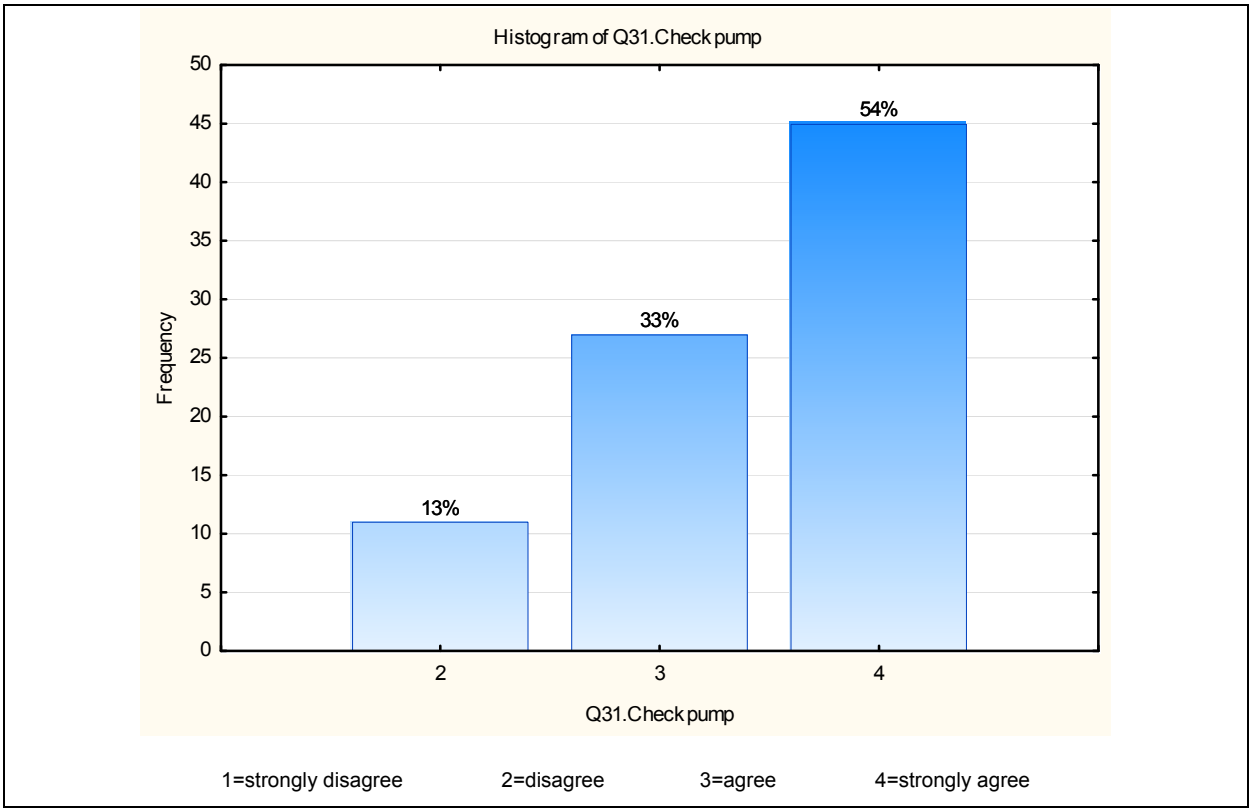

Figure 4.3: Double-check pump settings and IV tubings

Question 32: When I double-check with another RN, one of us performs the medication dose and concentration calculation at the time of checking the IV medication.

Two respondents who participated in the study did not answer this question. As shown in Figure 4.4, the majority of respondents indicated by ticking off either 'agree' (n=27 or 33.0%) or 'strongly agree' (n=21 or 26.0%) that when a double-check is performed, one registered nurse should check the dose and concentration calculation of the medication. However, by ticking off either 'disagree' (n=18 or 22.0%) or 'strongly disagree' (n=15 or 19.0%), a significant number of respondents also indicated that when a double-check is performed, it should NOT be done by one registered nurse checking the dose and concentration calculation of the medication. This question was formulated to test the opposite, namely only ONE registered nurse performs the calculation, versus the patient's nurse AND a second registered nurse should check, as tested in question 28. Therefore, the majority of respondents who agreed and strongly agreed to this question either did not read the question well, or it is confirmed that registered nurses do not follow the guidelines for safety precautions that two registered nurses must check the medication dose and calculation prior to the administration of IV medication. This policy

requirement is matched with what is stated in the literature, namely that double-checks must be performed completely. Therefore it was tested in the questionnaire.

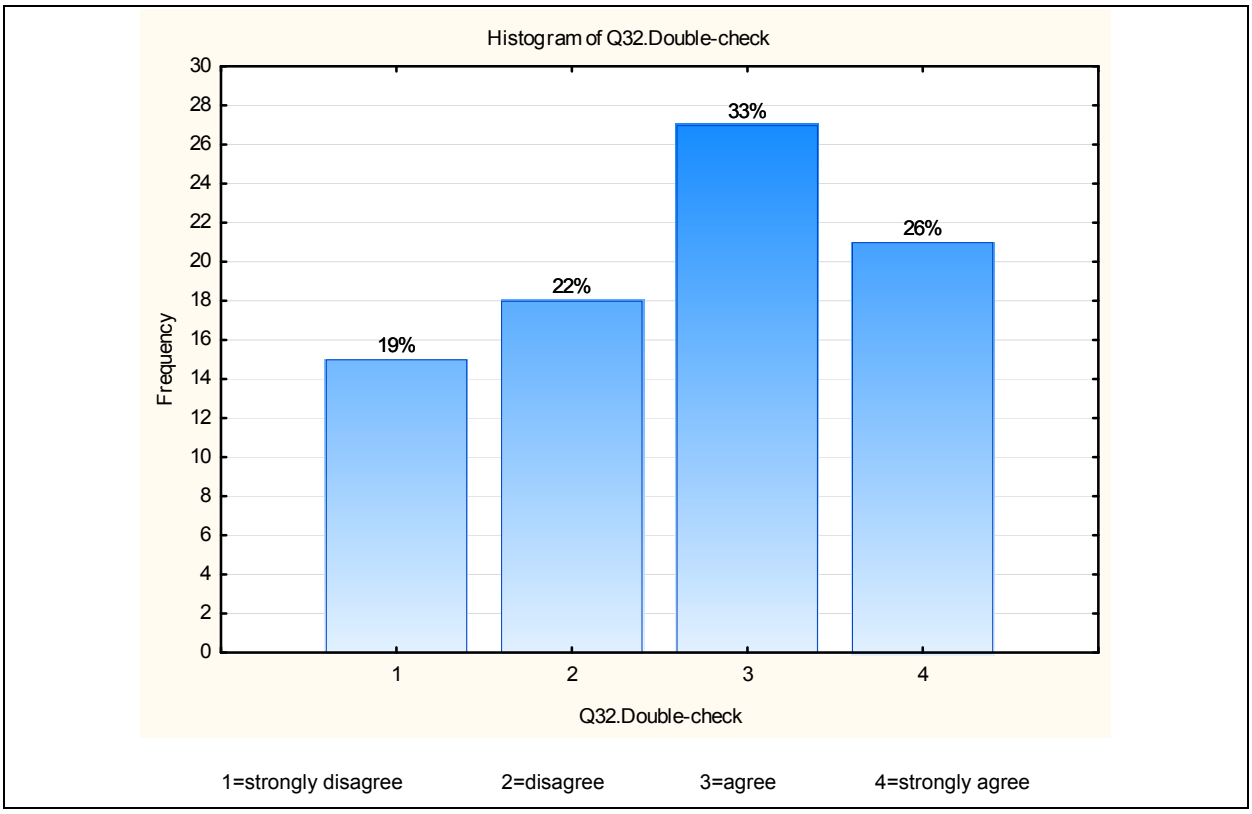

Figure 4.4: Double-check calculation

Question 33: I independently perform my medication calculation checks and ask another RN to perform his/her calculations for the correct dose and concentration when he/she has finished his/her tasks.

As indicated in Figure 4.5, by ticking off either 'agree' (n=31 or 37.0%) or 'strongly agree' (n=32 or 39.0%), the vast majority of respondents indicated that a double-check is performed by asking another registered nurse to check the calculations when he/she has finished his/her tasks. However, by ticking off either 'disagree' (n=9 or 11.0%) or 'strongly disagree' (n=11 or 13.0%), a small number of respondents also indicated that when performing a double-check, the registered nurse should NOT ask another registered nurse to check the calculations for correct dose and concentration of the medication. This question was formulated specifically to determine whether registered nurses perform double-checks prior to medication administration or whether they perform the double-checks at different times when the other registered nurse is free. Both medication administration and the checking of medication are high-risk nursing tasks.

Therefore, full concentration by two registered nurses is needed in performing an effective double-check together and directly prior to medication administration. The double-check should not be performed separately by two registered nurses at different times before medication administration, because the value of a critical and therefore effective double-check is lost and the margin for risk is increased.

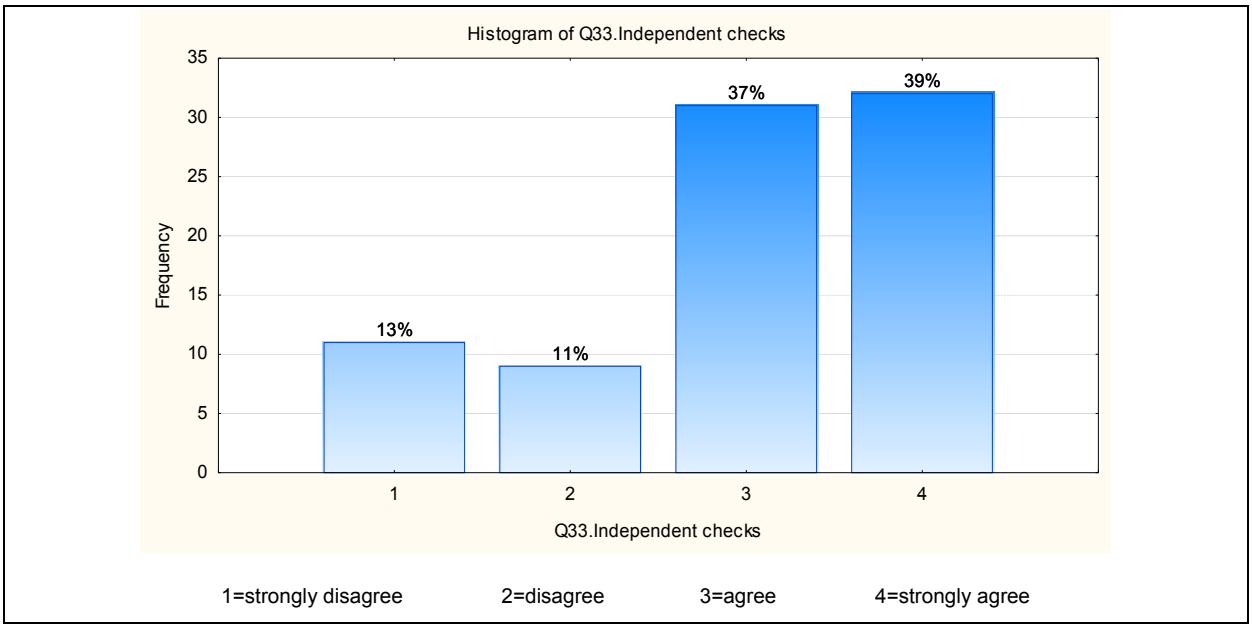

Figure 4.5: Independent checks

From the above discussion as displayed in Figures 4.2 to 4.5 it seems evident that the respondents had adequate knowledge regarding medication safety awareness.

The respondents were requested to indicate their agreement or disagreement by ticking off either ‘yes’ or ‘no’ on Q34 to Q36.

Question 34: Have you intercepted a medication error before?

One respondent who participated in the study did not answer this question. The majority of respondents indicated that they had intercepted a medication error before by ticking off ‘yes’ (n=53 or 64.6%). The rest of the respondents answered ‘no’ (n=29 or 35.4%) to this question. It is globally seen as the nurse’s role to intercept any adverse outcome for a patient. As shown in the literature, medication errors can occur at any step of the high-risk process of medication administration (question 58).

Question 35: Lack of concentration during IV medication administration places my patient at risk.

The respondents indicated their responses by ticking off either 'yes' (n=73 or 87.9%) or 'no' (n=10 or 12.1%). The vast majority of respondents had the shared perception that a lack of concentration during a high-risk activity such as IV medication administration places the patient at risk. If and when a medication error takes place, this risk is increased when a neonate or paediatric patient is cared for, because of their vulnerability.

Question 36: When I am in doubt regarding a prescription/calculation, I do not administer the IV medication.

By ticking off 'yes' (n=76 or 91.6%), the vast majority of respondents agreed that it is appropriate not to administer the IV medication if there is any doubt regarding the prescription/calculation. The rest of the respondents answered 'no' (n=7 or 8.4%) to this question. The nurse is responsible for administering the medication. Therefore, part of the nurse's role and responsibility is to deliver safe and ethical patient care through carrying out nursing tasks that contribute to positive patient outcomes. This question was based on the literature review and therefore it was tested in the questionnaire.

In view of defined IV medication administration practice related to the five medication rights and performing nursing 'double-checks', these aspects are forming the basis of the research hospital's policy and procedure for medication administration. As per the study's inclusion criteria, all RNs undergo the mandatory education related to medication administration and write the mandatory medication exams, prior to administering any medication in the research hospital. As mandated by policy and procedure, RNs have to undergo the mandatory training for the electronic data base system. The data findings presented in this section provide information regarding the RNs perceptions related to knowledge regarding factors that influence medication administration practice. As per the conceptual framework used for this study, 'knowledge' is categorized under human factors.

4.2.4 Section D: Medication error-prevention processes and strategies

Questions 37 to 46 requested the respondents to provide their opinion with a tick (✓) in the appropriate box. The respondents had to select either '1=strongly disagree', '2=disagree', '3=agree', or '4=strongly agree'.

In view of the study's objective to describe medication error prevention strategies, as identified by the literature review in chapter 2 (2.10.1 to 2.7.10), the data findings presented in this section provide information regarding the RNs perceived factors that would positively influence medication safety.

Question 37: The way toward safe IV medication administration practices is to create a process that prevents medication errors.

As indicated in Table 4.26, by ticking off either 'agree' (n=39 or 46.9%) or 'strongly agree' (n=44 or 53.1%), the vast majority of respondents indicated that the way toward safe IV medication administration practices is a focus on medication error prevention. As shown in the data, safe IV medication administration practice indicates a prevention of medication errors. The registered nurse's role is to keep the patient safe at all times by preventing medication errors. This applies especially to vulnerable patients.

Table 4.26: Create process

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	0	0.0
3=agree	39	46.9
4=strongly agree	44	53.1
Total	**n=83**	**100.0**

Question 38: IV pumps enable nurses to work safely and efficiently.

As indicated in Table 4.27, by ticking off either 'agree' (n=56 or 67.5%) or 'strongly agree' (n=21 or 25.3%), the majority of respondents indicated that IV pumps enable nurses to work safely and efficiently. The response rates matched those revealed in the literature review.

Table 4.27: IV pumps

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	2	2.4
2=disagree	4	4.8
3=agree	56	67.5
4=strongly agree	21	25.3
Total	**n=83**	**100.0**

Question 39: The reporting of medication errors is part of my responsibility as an RN.

As indicated in Table 4.28, by ticking off either 'agree' (n=33 or 39.8%) or 'strongly agree' (n=50 or 60.2%), the majority of respondents indicated that the reporting of medication errors is part of a nurse's responsibility. The data reveals a firm belief in the core values of the nursing profession, which includes identifying and reporting a specific patient need in order to ensure that the appropriate treatment plan is executed for the patient. This perception of the registered nurse's role is vital in medication error prevention.

Table 4.28: Reporting of medication errors

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	0	0.0
3=agree	33	39.8
4=strongly agree	50	60.2
Total	**n=83**	**100.0**

Question 40: It is valuable for the unit manager to analyse IV medication errors with the unit staff.

One respondent who participated in the study did not answer this question. As indicated in Table 4.29, by ticking off either 'agree' (n=39 or 47.6%) or 'strongly agree' (n=43 or 52.4%), the majority of respondents identified that it is valuable for the unit manager to analyse IV medication errors with the unit staff. Through the analysis of medication errors, staff could identify what went wrong in the practice environment, as reflected in the literature.

Table 4.29 Analyse medication errors with unit staff

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	0	0.0
3=agree	39	47.6
4=strongly agree	43	52.4
Total	**n=82**	**100.0**

Question 41: Neonatal and paediatric patients require additional safeguards compared to adult patients.

As indicated in Table 4.30, by ticking off either 'agree' (n=34 or 40.9%) or 'strongly agree' (n=43 or 51.8%), the majority of respondents indicated that neonatal and paediatric patients require additional safeguards as compared to adult patients. Nursing safety checks need to be adequate and complete, because of the risk that unsafe safety checks (inadequate and incomplete practice) pose in the practice environment.

Table 4.30: Additional safeguards

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	6	7.3
3=agree	34	40.9
4=strongly agree	43	51.8
Total	**n=83**	**100.0**

Question 42: Nursing double-checks function like safety nets to prevent a medication error from happening.

As indicated in Table 4.31, by ticking off either 'agree' (n=46 or 55.4%) or 'strongly agree' (n=37 or 44.6%), the majority of respondents identified that nursing double-checks function like 'safety nets'. The data indicates nurses' perception regarding double-checks. If nurses view a double-check as a safety net that will intercept a medication error when it has occurred, they would be likely to comply with these double-checks, also known as safety nets.

Table 4.31: Safety nets

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	0	0.0
3=agree	46	55.4
4=strongly agree	37	44.6
Total	**n=83**	**100.0**

Question 43: I believe it is appropriate to check the patient's name and MRN (two identifiers) before administering any medication.

As indicated in Table 4.32, by ticking off either 'agree' (n=29 or 34.9%) or 'strongly agree' (n=53 or 63.9%), the majority of respondents indicated that it is appropriate to check the patient's name and medical record number before medication administration. The data depicted in Table 4.32 yielded the same results as the data obtained from question 30 (check patient identification number and IV label against patient's electronic MAR).

Table 4.32: Check identifiers

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	1	1.2
3=agree	29	34.9
4=strongly agree	53	63.9
Total	**n=83**	**100.0**

Question 44: There should be a paediatric pharmacist available at all times for critical care patients.

One respondent who participated in the study did not answer this question. As indicated in Table 4.33, by ticking off either 'agree' (n=32 or 39.0%) or 'strongly agree' (n=39 or 47.6%), the majority of respondents indicated that there should be a paediatric pharmacist available for critical care patients at all times. The data depicted indicates that nurses perceive a pharmacist to be a resource in the practice environment. As found in the literature review, a paediatric pharmacist is recommended.

Table 4.33: Pharmacist available at all times

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	11	13.4
3=agree	32	39.0
4=strongly agree	39	47.6
Total	**n=82**	**100.0**

Question 45: A near miss that did not cause harm to the patient is not a medication error.

Two respondents who participated in the study did not answer this question which was tested in the negative in order to test the correct perception. As indicated in Table 4.34, by ticking off either 'disagree' (n=33 or 40.7%) or 'strongly disagree' (n=24 or 29.6%), the majority of respondents indicated that they did not regard a near miss that did not cause harm to the patient as a medication error. As revealed in the literature review, a near miss remains a medication error, whether it caused harm or not.

Table 4.34: Near miss

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	24	29.6
2=disagree	33	40.7
3=agree	18	22.2
4=strongly agree	6	7.5
Total	**n=81**	**100.0**

Question 46: I think that technology prevents IV medication errors on my unit.

As indicated in Table 4.35, by ticking off 'agree' (n=37 or 44.6%), the majority of respondents indicated that technology prevents IV medication errors on the unit. However, an almost similar number disagreed (n=34 or 41.0%) on this statement. Both a positive and an almost equal negative response were thus obtained from the respondents working in the practice environment. If the data obtained from this question is compared with that in question 38 (IV pumps enable registered nurses to work safely), the question arises as to what the respondents' disagreement indicates. It either indicates that they believe there is not enough technology that

could prevent medication errors or that technology does not make a difference as a strategy to prevent or reduce medication errors within their practice environment.

Table 4.35: Technology

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	6	7.2
2=disagree	34	41.0
3=agree	37	44.6
4=strongly agree	6	7.2
Total	**n=83**	**100.0**

From the above discussion as shown in Tables 4.26 to 4.35 it seems evident that the respondents had adequate knowledge regarding medication safety processes and strategies that are focused on medication error prevention.

Question 47: Examples of technology that prevents medication errors THE MOST, are as follows: (Please tick ONE)

Five respondents who participated in the study did not answer this question. However, a number of respondents (n=10) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However, the data was re-analyzed, and presented in the table.

As shown in Table 4.36, the majority of the respondents (n=28 or 41.2%) who participated in the study identified the CPOE system as the most effective medication error prevention strategy. Since the CPOE system has been used in the research hospital for a number of years, registered nurses have become used to the technology. The one CPOE system has changed to another so that the electronic MAR is now incorporated in the same CPOE. Since the previous process required that nurses transcribe from the CPOE to the manual MAR, the change in CPOE may potentially have been viewed as an improvement by respondents. This matches what was noted in the literature review regarding CPOE. Because transcription is not done at the research hospital any longer, the researcher did not regard it as essential to capture this aspect in the literature review. However, there is literature available on transcription errors. Five respondents (7.4%) mentioned ‘other’ examples of technology to prevent medication errors,

namely ‘syringe pump libraries with high and low lock out for medications using standard drug concentrations for example Dopamine’, and ‘technology only ever assist to help prevent mistakes’. Three of these five respondents ticked ‘other’, but did not provide any further information.

Table 4.36: Examples of technology

Category	Frequency (*f*)	Percentage (%)
a=CPOE	28	41.2
b=internet	2	2.9
c=syringe drivers	21	30.9
d=volumetric pumps	12	17.6
e=other	5	7.4
Total	**n=68**	**100.0**

Question 48: Which method do you consider to be the BEST STRATEGY to prevent medication errors? (Please tick ONE.)

A number of respondents (n=83) had answered this question originally. However, a number of respondents (n=7) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However, the data was re-analyzed, and presented in the table. As shown in Table 4.37, a number of the respondents (n=23 or 30.2%) who participated in the study indicated that frequent reminders and discussion with staff are considered to be the best strategy to prevent medication errors. In view of the belief that discussions about practice and frequent reminders will prevent medication errors, it seems evident that the respondents regard medication error prevention as something nurses have control over. Five respondents (6.6%) ticked off ‘other’, which included answers like ‘the 5 medication rights’; ‘free staff for help’; ‘close [the] loop medication administration’; and ‘don’t know [it is] much more complex than this’.

Table 4.37: Best strategy

Category	Frequency (*f*)	Percentage (%)
a=CPOE	10	13.2
b=telling a friend	0	0.0
c=volumetric pumps	0	0
d=reporting of the medication error	11	14.5
e=root cause analysis	8	10.5
f=pharmacy dispensing process	19	25
g=frequent reminders and discussion	23	30.2
h=other	5	6.6
Total	**n=76**	**100.0**

Question 49: How can medication safety awareness be IMPROVED in your unit? (Please tick ONE.)

Three respondents who participated in the study did not answer this question. However, a number of respondents (n=8) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However, the data was re-analyzed, and presented in the table. As shown in Table 4.38, the majority of the respondents (n=23 or 31.9% who participated in the study indicated that an analysis through case reviews would improve medication safety awareness in their respective units.

Table 4.38: Safety awareness

Category	Frequency (*f*)	Percentage (%)
a=analysis through case reviews	23	31.9
b=monitoring of practice	20	27.8
c=regular reviews of policy	16	22.2
d=review of standards during orientation	9	12.5
e=education	1	1.4
f=mathematical skills review	3	4.2
Total	**n=72**	**100.0**

In questions 50 to 56 the respondents were requested to provide their opinion with a tick (✓) in the appropriate box. The respondents had to select either '1=strongly disagree', '2=disagree', '3=agree', or '4=strongly agree'.

Question 50: Experience, training and skills play a role in safe IV medication administration.
As indicated in Table 4.39, by ticking off either 'agree' (n=35 or 42.2%) or 'strongly agree' (n=43 or 51.8%), the majority of respondents indicated that experience, training and skill play a role in safe IV medication administration. Specialised nursing knowledge is required to work in area of specialty. The findings from this question correlate with the literature review.

Table 4.39: Training and skills

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	5	6.0
3=agree	35	42.2
4=strongly agree	43	51.8
Total	n=83	100.0

Question 51: Serum medication levels are done at the correct interval, for Phenobarbital and nephrotoxic or oto-toxic antibiotics
Two respondents who participated in this study did not answer this question. As indicated in Table 4.40, by ticking off either 'agree' (n=50 or 61.7%) or 'strongly agree' (n=24 or 29.6%), the majority of respondents indicated that serum medication levels are done at the correct interval. Specialty nursing knowledge enables nurses to focus on appropriate nursing care plans in the critical care practice environment. A vital component of safe medication administration is that patients require medication levels as routine part of their treatment plans. The findings do not reflect a satisfactory safety perception of the respondents and satisfactory specialised nursing knowledge that are in line with medication safety processes and strategies for patient care.

Table 4.40: Correct interval

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	2	2.5
2=disagree	5	6.2
3=agree	50	61.7
4=strongly agree	24	29.6
Total	**n=81**	**100.0**

Question 52: It is not important to report a medication error if no harm was caused to the patient.

Four respondents who participated in the study did not answer this question. As indicated in Table 4.41, by ticking off either 'disagree' (n=32 or 40.5%) or 'strongly disagree' (n=41 or 51.9%), a number of respondents did not agree with the above statement. These findings seem to correlate with question 39 (medication error reporting is part of my responsibility as a nurse). Nurse managers have an ongoing role and opportunity to provide education for unit staff, to foster a positive unit culture of medication safety, and to be alert to the medication safety mind-set of staff in the high-risk practice environment.

Table 4.41: Report a medication error

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	41	51.9
2=disagree	32	40.5
3=agree	5	6.3
4=strongly agree	1	1.3
Total	**n=79**	**100.0**

Question 53: The medication administration procedure in my hospital is time-consuming.

One respondent who participated in the study did not answer this question. As indicated in Table 4.42, by ticking off either 'disagree' (n=40 or 48.8%) or 'strongly disagree' (n=11 or 13.4%), the majority of respondents indicated that they did not agree with the above statement. As shown by the responses, there were, however, a significant number of respondents who

indicated that the medication administration process IS time-consuming. However it was not the perception of the majority of respondents to the above question.

Table 4.42: Time-consuming

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	11	13.4
2=disagree	40	48.8
3=agree	26	31.7
4=strongly agree	5	6.1
Total	**n=82**	**100.0**

Question 54: New staff receives sufficient unit-specific training related to safe medication administration.

One respondent who participated in the study did not answer this question. As indicated in Table 4.43, by ticking off either 'agree' (n=58 or 70.7%) or 'strongly agree' (n=15 or 18.3%), the majority of respondents indicated that new staff receive sufficient unit training related to safe medication administration. From the findings it is evident that the respondents perceive the processes and strategies to be effective for medication error prevention.

Table 4.43: New staff

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	2	2.5
2=disagree	7	8.5
3=agree	58	70.7
4=strongly agree	15	18.3
Total	**n=82**	**100.0**

Question 55: Experienced staff receives sufficient ongoing reviews of safe medication administration.

Two respondents who participated in the study did not answer this question. As indicated in Table 4.44, by ticking off either 'agree' (n=52 or 64.2%) or 'strongly agree' (n=15 or 18.5%), the majority of respondents indicated that experienced staff receive sufficient ongoing reviews of safe medication administration. Since formal case reviews are considered a form of 'ongoing

reviews' provided to staff, the findings from this question correlate with question 40 (valuable to analyse IV medication error with unit staff). Therefore it indicates that it is the staff's perception that nursing managers should continue to use this approach to educate staff related to the factors influencing medication safety, based on each case review when a medication error has occurred in the practice environment. This is in line with the policy requirements set for unit managers to conduct a case review with the nursing staff, in collaboration with pharmacy and nursing quality experts. Considering the response rate, it may be perceived by RNs that they need more ongoing reviews related to safe medication administration. If a unit culture of medication safety is fostered in the practice environment, staff may wish to receive alerts that could function as a learning opportunity and benefit for the larger group after a medication error has taken place.

Table 4.44: Experienced staff

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	5	6.2
2=disagree	9	11.1
3=agree	52	64.2
4=strongly agree	15	18.5
Total	**n=81**	**100.0**

Question 56: We have access to a formulary/reference specific to neonatal and paediatric patients.

One respondent who participated in the study did not answer this question. As indicated in Table 4.45, by ticking off either 'agree' (n=43 or 52.4%) or 'strongly agree' (n=32 or 39.0%), the majority of respondents indicated that they had access to a formulary specific to neonatal and paediatric patients. The data indicated that a medication formulary, as safety strategy, is available in the high-risk practice environment. The relevant question is based on the literature and asked in the questionnaire.

Table 4.45: Access to a medication formulary

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.3
2=disagree	6	7.3
3=agree	43	52.4
4=strongly agree	32	39.0
Total	**n=82**	**100.0**

Based on the above discussion and shown in Tables 4.39 to 4.45 it seems evident that the respondents had adequate knowledge regarding medication safety processes and strategies that are focused on medication error prevention, as displayed in the findings of questions 50 to 56.

Question 57: If a medication error occurs on my unit, it immediately gets reported to: (Please tick ONE.)

Two respondents who participated in the study did not answer this question. As indicated in Figure 4.6, the majority of respondents (n=35 or 43.0%) who participated in the study indicated that if an IV medication errors occurs, it is immediately reported to the shift charge nurse. None of the respondents chose the option 'nobody'. In the research hospital, a charge nurse is a registered nurse who coordinates patient activities on a 12-hour shift (day and night duty) and functions as a shift leader. As per set standard in the research hospital's policy related to medication administration (KFSHRC-J, 2008a:3), all registered nurses working in the practice environment routinely have to report the occurrence of a medication error to the charge nurse. Medication errors can happen at any time and the majority response rate potentially indicates that respondents have integrated their role, as described and therefore report to the charge nurse during office hours as well as after hours (night duty and weekends) when a medication error has occurred. Due to this aspect that medication errors can happen at any time of the day or night, why do 43.0% of respondents indicate that medication errors get reported to the charge nurse? Since it is a set standard to inform the physician when a medication error has occurred, why do 21.0% of respondents indicate that they reported a medication error to the physician? The reason for this set standard is that the physician, in collaboration with the nurse, has to decide on whether there is a level of harm done to the patient, as a result of the medication

error. It can be concluded that the perceived knowledge of RNs is not at the level of policy compliance.

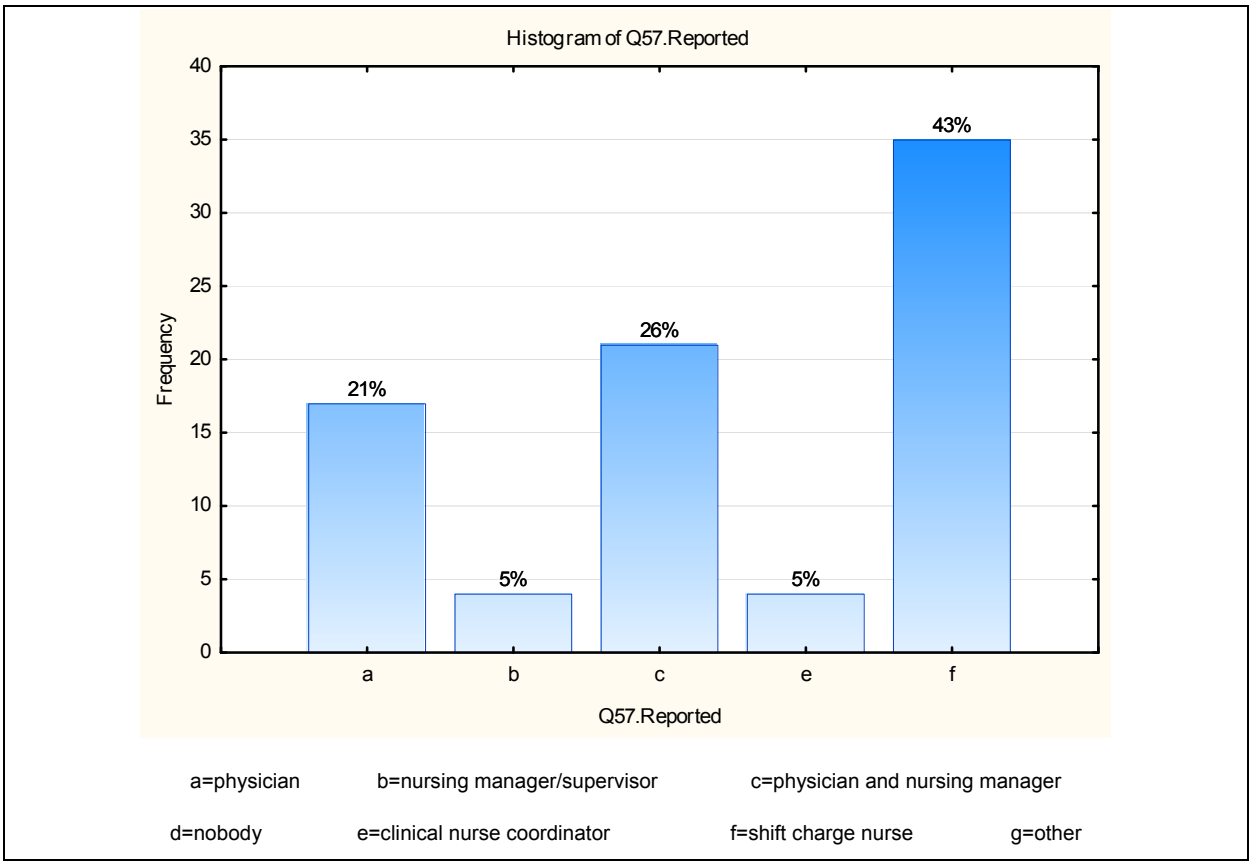

Figure 4.6: Reporting of medication errors

Questions 58 to 65 requested that the respondents indicate their opinion with a tick (✓) in the appropriate box. The respondents had to select either '1=strongly disagree', '2=disagree', '3=agree', or '4=strongly agree'.

Question 58: IV medication errors may happen at every step of the medication administration process.

One respondent who participated in the study did not answer this question. As indicated in Table 4.46, the majority of respondents agreed with the above statement, by ticking off either 'agree' (n=42 or 51.4%) or 'strongly agree' (n=35 or 42.6%). The data indicated that the respondents realised the risk and potential for medication errors to happen from ordering and dispensing to medication administration.

Table 4.46: Every step of medication administration process

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.2
2=disagree	4	4.8
3=agree	42	51.4
4=strongly agree	35	42.6
Total	**n=82**	**100.0**

Question 59: It is important to create a unit-specific culture of IV medication safety.

One respondent who participated in the study did not answer this question. As indicated in Table 4.47, the majority of respondents agreed with the above statement by ticking off either 'agree' (n=49 or 59.7%) or 'strongly agree' (n=30 or 36.5%). It is evident that the majority of respondents perceived a unit-specific culture of IV medication safety to be an important strategy for medication error prevention.

Table 4.47: Unit-specific culture of IV medication safety

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	1	1.4
2=disagree	2	2.4
3=agree	49	59.7
4=strongly agree	30	36.5
Total	**n=82**	**100.0**

Question 60: Safe IV medication administration practice ensures the delivery of quality nursing care.

Three respondents who participated in the study did not answer this question. As indicated in Table 4.48, the majority of respondents agreed with the above statement by ticking off either 'agree' (n=36 or 45.0%) or 'strongly agree' (n=44 or 55.0%). None of the respondents indicated a negative response to this question at all. The data indicated that the respondents from the practice environment under study perceived safe IV medication administration practice to link with the delivery of quality nursing care.

Table 4.48: Safe IV medication administration practice

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	0	0.0
3=agree	36	45.0
4=strongly agree	44	55.0
Total	**n=80**	**100.0**

Question 61: Medication error reporting supports ethical nursing conduct because the patient's rights, health and safety are promoted, advocated for and protected.

One respondent who participated in the study did not answer this question. As indicated in Table 4.49, the majority of respondents agreed with the above statement by ticking off either 'agree' (n=40 or 48.8%) or 'strongly agree' (n=42 or 51.2%). The data indicated that respondents perceived medication error reporting to be ethical in a patient safety approach focused on promoting, advocating for and protecting the patient's rights, health and safety. The data obtained from this question correlates with question 39 (the reporting of medication errors is part of my responsibility as an RN). The role of the nurse in medication error reporting is based on the research setting's set policy for medication administration in that a medication error has to be reported (KFSHRC-J, 2008a:2).

Table 4.49: Ethical nursing conduct

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	0	0.0
3=agree	40	48.8
4=strongly agree	42	51.2
Total	**n=82**	**100.0**

Question 62: Rules should be built into the computer physician order entry system to alert the prescriber and pharmacist that an entered dose falls outside the acceptable dosage range based on the patient's weight.

One respondent who participated in the study did not answer this question. As indicated in Table 4.50, the majority of respondents showed that they agreed with the above statement by ticking off either 'agree' (n=38 or 46.3%) or 'strongly agree' (n=44 or 53.7%). No respondent gave a negative response. A 'rule' is representative of 'programmed alerts' that should be functioning as a reminder once the physician orders the medication and the dose is higher than the acceptable dosage range based on the patient's weight. The data indicated that rules should be built into the CPOE system that functions to alert both the prescriber and the pharmacist. The findings indicate that more safety measures could be implemented that could improve the CPOE system for patient safety. When the information obtained from this question is compared with question 47 (examples of technology that prevents medication errors the most), respondents indicated that the CPOE is seen as the most effective form of technology to prevent medication errors in the practice environment. It seems, however, from the findings depicted in Table 4.50 that there is still room for improvement or that the respondents' perceptions for the difference between 'agree' and 'strongly agree' is more a variation of the nurse's conviction.

Table 4.50: Rules built into the CPOE system

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	0	0.0
3=agree	38	46.3
4=strongly agree	44	53.7
Total	**n=82**	**100.0**

Question 63: The fear of punishment prevents me from reporting a medication error.

One respondent who participated in the study did not answer this question. As indicated in Table 4.51, the majority of respondents showed that they disagreed with the above statement by ticking off either 'disagree' (n=33 or 40.2%) or 'strongly disagree' (n=13 or 15.9%). Interestingly, however, by ticking off either 'agree' (n=26 or 31.7%) or 'strongly agree' (n=10 or 12.2%), a significant number of respondents indicated that they agreed with the above

statement. The cumulative number of respondents who disagreed with the above statement is considered a majority (n=46 or 56.1%), but the cumulative number of respondents (n=36 or 43.9%) who agreed with the statement is not far lower than half of the response rate. Although respondents agreed in question 60 (safe IV medication administration practice ensures quality nursing care) and in question 61 (medication error reporting is ethical), the number of respondents who agreed with this statement would pose an interesting opportunity for nurse managers to address in the practice environment under study. For the safety of this high-risk patient population, nursing managers' role in exploring what can be done to address this perception of staff becomes significant. Since the findings indicate that medication errors are not always reported, as shown in Table 4.51, this is a problem. The staff perception of fear to report medication errors is addressed in the literature.

Table 4.51: Fear of punishment

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	13	15.9
2=disagree	33	40.2
3=agree	26	31.7
4=strongly agree	10	12.2
Total	**n=82**	**100.0**

Question 64: Most medication errors occur when one, some or all five rights of medication administration are omitted.

Two respondents who participated in the study did not answer this question. As indicated in Table 4.52, the majority of respondents indicated that they agreed with the above statement, by ticking off either 'agree' (n=48 or 59.2%) or 'strongly agree' (n=31 or 38.3%). The data indicated the perception of respondents regarding medication rights being the reason for most medication errors occurring. Omission of the medication rights can have a potentially detrimental effect on patient safety, because the patient can be harmed as a result of the medication error. An inotrope infusion (see the findings of question 17) and a dose error (see the findings from question 19) could significantly affect a critically ill patient. The role of nursing is to prevent the potential for patient harm caused by a medication error, and nursing safety checks should be enhanced in the practice environment in order to ensure patient safety. As shown in the literature, the majority of medication errors are preventable.

Table 4.52: Rights of medication administration omitted

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	2	2.5
3=agree	48	59.2
4=strongly agree	31	38.3
Total	**n=81**	**100.0**

Question 65: It is important to have no interruptions during the IV medication administration process.

Two respondents who participated in the study did not answer this question. As indicated in Table 4.53, the majority of respondents indicated that they agreed with the above statement by ticking off either 'agree' (n=43 or 53.1%) or 'strongly agree' (n=35 or 43.2%). The data indicated that the cumulative number of respondents (n=78 or 96.3%) agreed that there should be no interruptions during the IV medication administration process. This includes the interruptions caused by colleagues, as seen in the literature review. The question that arises is whether registered nurses working in the practice environment experience interruptions, and if so, what type of interruptions these would entail, as this was not reflected in the responses in the open-ended question. However, the vast majority response rate gives an indication that registered nurses face interruptions during the IV medication administration process.

Table 4.53: Interruptions during medication administration process

Category	Frequency (*f*)	Percentage (%)
1=strongly disagree	0	0.0
2=disagree	3	3.7
3=agree	43	53.1
4=strongly agree	35	43.2
Total	**n=81**	**100.0**

From the above discussion, as shown in Tables 4.46 to 4.53, it seems evident that the respondents had adequate knowledge regarding medication safety processes and strategies

that are focused on medication error prevention, as displayed in the findings of questions 58 to 65.

Questions 66 and 67 requested the respondents to indicate whether they agreed or disagreed with the following statements by selecting either 'yes' or 'no'.

Question 66: I always think about the patient's well-being and safety.
Two respondents who participated in the study did not answer this question. All the respondents indicated that they agreed with this statement by ticking off 'yes' (n=81 or 100.0%). The data reflects that nurses act in line with the core ethical norms and values of the profession.

Question 67: Staff perceptions of medication safety can affect nursing practice.
Five respondents who participated in the study did not answer this question. The majority of respondents indicated that they agreed that staff perceptions of medication safety can affect nursing practice, by ticking off 'yes' (n=72 or 92.3%). Six of the respondents (7.7%) answered 'no' to this question. As per the literature, nursing practice is affected by multiple factors and therefore tested in the questionnaire.

Question 68: What do you think is the main reason for medication error reporting? (Please tick ONE.)
Two respondents who participated in the study did not answer this question. However, a number of respondents (n=2) had indicated more than one answer in this particular question, therefore these responses were excluded from the data analysis as it is not statistically feasible to analyze more than one variable per question as the data was therefore considered as spoilt. However, the data was re-analyzed, reflecting the following data, as discussed. The vast majority of respondents (n=76 or 93.8%) who participated in the study indicated that the main reason for medication error reporting is to gain an understanding of why the medication error has occurred through an analysis of the incident. A minority of respondents (n=2 or 2.4%) indicated '[have] to write an incident report'. One respondent (n=1 or 1.3%) indicated 'don't know', while no respondents (n=0 or 0%) indicated 'other'. From the findings in this question, one could say that an analysis of the medication error incident was recognised by staff as a strategy for medication error prevention, and that this is in line with the objectives of this research study, which were covered in the questionnaire.

Question 69: Is it possible to implement more safety strategies in your unit in order to prevent IV medication errors from happening?

Nine respondents who participated in the study did not answer this question. The fact that such a relatively high number of respondents did not answer the question is interesting if compared with the responses in the rest of the questionnaire. By ticking off 'yes', (n=41 or 55.4%) the majority of respondents indicated that it was possible to implement more safety strategies in their respective units. The rest of the respondents answered 'no' (n=33 or 44.6%) to this question. The information obtained from this question correlates with the information obtained from question 59 (it is important to create a unit-specific culture of medication safety). Nurses who are well-oriented to the unit (see question 7) and who have been employed for at least two years at the hospital and in their respective unit (see questions 2 and 3) would know their practice environments and therefore would be able to understand which factors affect practice standards. The respondents would be able to know whether it is possible to implement more safety strategies within the practice environment. The number of negative responses (which is also significant) could potentially, indicate that there are already sufficient processes and strategies in place for medication error reduction in the respondents' practice environment, which is covered by the institution's policies and procedures. However, this was not the opinion of the majority of the respondents.

Question 70 was formulated as an open-ended question where the respondents were asked to comment on what more can be done in the particular unit in order to prevent IV medication errors from happening. The data generated by the open-ended question (Q70) was intended to supplement the quantitative data. Several responses were identified and the frequencies of such responses were analyzed to support the findings regarding the prevention medication errors. For example participants' responses (in the open-question) regarding nursing 'double-checks' were grouped in the category for nursing 'double checks'. The researcher was able to identify that some participants were following the policies and some participants were not, as discussed in chapter 5. As discussed in paragraph 3.2.9, core themes that emerged, were the following: 'five medication rights', 'double-checks', 'delay in pharmacy delivering the medication', 'more in-service training', 'nurse to patient ratio', 'share results and feedback with staff'.

Question 70: If you have indicated 'yes', what more could be done?

Of the majority respondents (n=41 or 55.4%) who answered 'yes' in the previous question to whether it is possible to implement more safety strategies to prevent medication errors, a smaller number of respondents (n=25) answered this question, by providing information on what could be done specifically. Some respondents made more than one recommendation. The core themes are indicated in italics in the text. The most appropriate quote has been selected to

support the core theme through grouping the same items together in one group of items. Numbers are indicated in brackets to show the tendency of opinions by the respondents. Most of the respondents demonstrated an understanding of IV medication errors, the factors that caused the errors, and how safety could be improved in their individual unit.

The respondents (n=7) identified nursing *double-checks* as a safety strategy to prevent medication errors. Responses included the following: '… double checks during titration of the inotropes is [being followed]'; 'The clinical nurse can perform spot-on checks to see or assess nurses compliance with established safety nets'; '… frequent review of patients medication if you are the primary nurse'; '… with the routine double-checking with another registered nurse checking to ensure [the] patient [is] still receiving correct medication [and] comparing it with the ID badge [medical record number]'; and 'In our unit we are trying to prevent medication errors by checking with another nurse before administering medication.'

Some respondents (n=6) mentioned that *medication rights* need to be adhered to, with a description of how the rights should be checked, in order to prevent medication errors. Responses included the following: 'Two RNs should check for all five right(s) every time'; 'Don't rely on each other'; 'Other rights/not just the 5 must be recognised as equally important and be taught'; 'Strictly follow the 5 rights before the medicine administration'; 'Do the dosage calculation, especially as multi-dose bottle (vial) and check the expiry date also'; and '... 2 nurses [should check] the medication separate from each other, not one read the information and the other just listening ...'

The respondents (n=6) further identified *a delay in medication delivery* as a factor in delayed medication administration, and also as a factor that causes nurses to spend a great deal of time in following up to ensure that the patient receives the medication at the right time. Responses included the following: 'Delayed medication administration is happening due to delayed delivery of meds from pharmacy'; '… to improve pharmacist services, like to deliver IV meds [medication] especially the intermittent doses completely for 24 hours to avoid delays'; '… better pharmacy communication'; '… pharmacy to dispense IV medication infusions (especially at night) at the right time'; 'Delay delivery of meds can cause delayed administration of antibiotic and stat medication'; and 'Delays in unit dose deliveries at times put staff in situations where they want to prepare for and administer medications that can be prepared and delivered within 30 min. e.g. stat medications.'

The respondents (n=5) indicated that more *reviews/discussion during routine reviews or meetings* are needed. Responses included the following: '… more in-services and review of policies'; '… reviews on the safe dose for common medications/infusions administered in the unit'; '… frequent teaching; illustrations for reminder to staff'; '… include in monthly meeting the medication safety'; and '… intermittent or continuous unit based refresher session'.

A smaller group of respondents (n=2) indicated that the *institutional policies* can ensure a prevention of medication errors, as illustrated in the following responses: 'If the staff could follow the policies well [it] can prevent medication errors'; and 'All of us has a responsibility to deliver safe/correct medication, just follow the IPP regarding medication administration to avoid medication error'.

Other recommendations for medication safety improvement in the particular practice environments included the following: '… regular review of medication errors'; 'Implement further policy on IV medications'; '… regular training in medication calculation'; '… smart pump libraries with high and low dose limits'; '… IV compatibility charts'; 'A nurse must not be under pressure so [that] she could do and administer medications with a full concentration'; '… strict calculations of infusions during the handover process with two RNs doing it together'; '… by improving reporting'; '… incentives to those nurses who have performed exceptional in preventing and intercepting errors'; 'Medication errors could be avoided when a nurse administering has a full knowledge of her patient and the medication her patient is taking'; 'Change the attitude of blaming a nurse who committed a medication error [as] there are so many factors that can predispose the nurse to commit errors at work'; and 'Ready-to-administer doses must be dispensed from the pharmacy.'

The respondents' responses were grouped, resulting in the identification of six core responses. The respondents' perceptions of what could contribute to medication safety in their respective practice environment were summarised as follows:

- 'double-checking of medication and orders' (n=7);
- 'adherence to check the five medication rights and other medication rights' (n=6);
- 'medication delivery by pharmacy' (n=6);
- 'reviews/discussion during in-service/meetings' (n=5);
- 'institutional policies' (n=2); and
- 'improved technology and administration procedures' (n=12).

It is evident from the respondents' feedback that institutional policies could be adhered to more meticulously (checking of medication rights, double-checks) in order to prevent medication errors, or that system and process factors have been identified (delayed delivery of medication by pharmacy) by the respondents.

4.3 SUMMARY

In this chapter, the data generated by both the open-ended and the closed-ended questions was analysed in order to describe the perceptions of RNs regarding the factors that influence IV medication safety practices of registered nurses working with neonatal and paediatric ICU patients. The main findings were that multiple perceived factors influence the intravenous medication safety practices of registered nurses working with neonatal, paediatric and cardiac ICU patients in a particular Saudi Arabian tertiary hospital. It was found that these nurses' had knowledge regarding safe medication administration practice that constitutes that all five medication rights have to be checked, through nursing 'double-checks' of the steps in medication administration, as the method of checking is described, as per hospital policy (KFSHRC-J, 2008a:2). However, from the findings, it is reflected that RNs perceptions of completely and correctly checking medication rights through complete and independent nursing 'double-checks', do not match the steps required by policy and that their knowledge is inadequate. It is evident from the perceptions of RNs that they are aware of the multiple factors influencing IV medication safety practice in this vulnerable patient setting. As perceived by RNs, it is possible to implement more safety strategies. When matched with the researcher's conceptual framework (paragraph 2.7), these findings confirm that safe medication administration practice (as per set standards in the medication administration policy) will ensure medication safety through elimination of the factors that cause medication errors. These findings also confirm that unsafe medication administration practice (through non-compliance with the set standards in the medication administration policy) will result in a near-miss or medication error.

In Chapter 5 the conclusions and recommendations of the study are discussed and contextualised.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

The research project reported in this thesis was aimed at describing the perceptions of RNs regarding the factors that influence IV medication safety in the NICU, PICU and paediatric CSICU in a particular tertiary hospital in Saudi Arabia (see paragraph 1.1.3). In order to reflect on why the particular study was undertaken, the research question in this study was formulated as follows:

> What are the perceptions of RNs regarding IV medication safety practices in the NICU, PICU and paediatric CSICU in a particular Saudi Arabian tertiary hospital?

The study findings were described and discussed according to the objectives set for the study, namely to describe the factors that have an influence on IV medication safety in the NICU, PICU and paediatric CSICU; to describe the knowledge of RNs in the above-mentioned ICUs related to safe IV medication administration practices; and to describe nursing medication administration strategies to prevent these medication errors as recommended by the RNs (paragraph 1.1.4).

The purpose of this chapter is to discuss the conclusions based on the main findings of this study, as well as the limitations of the study, and to present the main recommendations that emerged from the literature review and empirical findings in order to prevent IV medication errors. The conclusions were formulated, through a synthesis of findings from the literature review and empirical results by means of cross referencing throughout this chapter.

5.2 MAIN CONCLUSIONS

The background information of the respondents who participated in the study are described in terms of the following aspects: nursing position; the number of years employed at the hospital; the number of years worked in their respective units; their highest nursing qualification; completion of the check-off examination during nursing orientation; whether they were working in the area of their specialty; and whether the respondents were either in unit orientation, probation period or already permanently employed.

Regarding their nursing position, the majority of respondents working in the NICU, PICU and CSICU at the time the data was collected were registered nurses (91.4%), while the nursing

positions grouped under 'other' (4.8%) comprised registered nurses who were directly involved in the review of practice standards in the research setting. The majority of the respondents (25.9%) had been employed at the research hospital for two years. Interestingly, the majority of the respondents (28.2%) had been working in either one of the ICUs for two years only, which could be considered as a short period of experience in this particular practice environment.

In view of the highest nursing qualification, the majority of ICU registered nurses (67.0%) who participated in the study were Bachelor of Science degree in Nursing (BSN) holders, while 27.0% were registered nurses with a diploma in nursing and 5.0% had a master's degree. The majority of the respondents (98.7%) mentioned that they had written the mandatory check-off examinations during general nursing orientation. A number of 95.2% respondents mentioned that they were working in the ICU that did correspond with their area of specialty (based on experience and/or training). The majority of respondents had passed their probation period at the time of the main data collection and were employed on an annual contractual basis (96.3%). Passing of the probationary period, implicates that all of the required nursing medication administration exams are passed, with a minimum passing level of 85%. The implication for the institution is that the majority of RNs working in the research setting have tertiary nursing qualifications, working in their area of specialty and have undergone the required certifications upon hire. These findings indicate that skilled RNs are working with vulnerable patients in this practice environment, within the context of medication safety.

Only the main conclusions based on the empirical findings of this study and supported by the literature review where applicable, are discussed in the sections that follow.

5.2.1 Factors influencing IV medication safety perceptions of RNs working in the NICU, PICU and paediatric CSICU

Human-, system- and environment-related factors, that may be a latent factor of a medication error (as depicted by the conceptual framework in paragraph 2.7) and may influence medication errors were identified in the literature (paragraphs 2.7.1 to 2.7.12) and tested in this study. In this study, by ticking off either 'agree' (51.8%) or 'strongly agree' (33.3%), the majority of respondents indicated that IV medication errors were occurring because of a combination of human, system and environmental factors (question 12, Table 4.8).

The findings related to these three factors are presented in the sub-sections below.

5.2.1.1 The human factor

The main findings regarding human factors that have an impact on IV medication errors, as gathered from the empirical findings from this study as well as from the literature review, are discussed in this section.

In the literature, Lucas (2004:33) reported that it is important to have 'a system designed … to eliminate human error and if human error still occurs, that the system should allow for its correction'. Other researchers (George et al., 2010:1763; Kane-Gill & Weber, 2006:273) reported that medication errors are mainly caused by human factors that are impacted by system factors, despite a focus on longstanding safety principles, such as the 'five rights' as mechanism to promote patient safety. Brady et al. (2009:690) reported the same findings, but also included multiple contributing factors, such as deviation from procedures, distractions during administration, excessive workloads, and the nurse's knowledge of medications, to name a few (paragraph 2.7.6). Kane-Gill and Weber suggest safe practices to improve medication safety in the ICU (2006:273)

i) Omission of medication rights

The majority of the respondents (39%) indicated medication errors mainly caused by missing one or more of the medication rights (the right patient, right drug, right dose and frequency, right route, and right administration time) as the first-ranking human factor (question 8, Table 4.4)., This corresponds with the findings of Cohen et al. (2003:37) who reported that medication errors are found to occur when nurses do not follow the five rights of medication administration (paragraph 2.5).

ii) Misidentification versus 'right patient'

Misidentification was found to be almost equally balanced in the respondents' positive and negative perceptions reflected in question 16, but with a slight majority of the respondents (56.8%) who indicated that IV medication errors were NOT happening because of patient misidentification (Table 4.12). According to Anderson and Townsend (2010:23), the 'right patient' is the first of the 'five rights' in medication administration. They emphasise that adherence to this principle ensures that administration errors are prevented. In their study, Suresh et al. (2004:1609) found that 11% of near-misses and adverse events are related to patient misidentification (paragraph 2.7.5).

iii) Critical IV medication versus 'right drug'

A number of respondents (26.7%) indicated that inotropes are most often involved in IV medication errors, which is used in the treatment of critically ill patients (question 17, Table 4.13). Stat IV medication was ranked second in medication errors by 21.3% of the respondents, while intermittent IV medication was ranked third by 12% of respondents. The administration of antibiotics was ranked fourth in medication errors by 14.7% of respondents. A significant finding, as depicted in Table 4.9 (question 13), was that the majority of respondents indicated, by ticking off either 'agree' (51.2%) or 'strongly agree' (12.5%), that IV medication errors occur when patients receive emergency therapy. The respondents indicated that medication errors happen during times when patients in the NICU, PICU and CSICU receive emergency therapy and are therefore very vulnerable.

Since nursing tasks are performed in a high-risk environment such as the NICU, PICU and CSICU, nurses may benefit by being aware of these research findings in order to improve medication administration safety practice when caring for these vulnerable patients. Considering that all IV infusions are administered through infusion devices, the RNs are responsible for several tasks in the practice environment. This include IV insertion and maintenance, checking the medication rights with another RN, programming the infusion devices (set the rate, time to be delivered and the volume to be delivered) and medication administration during stabilization and care of the critically ill patient. However, nursing tasks have to be performed fast and efficiently during emergency treatment. When assistance is needed from another RN, it may not be possible to immediately obtain the assistance of the witnessing RN because he/she may be occupied with his/her patient.

iv) Dose error versus 'right dose'

One of the main findings in this study, as shown in Table 4.15 (question 19), the majority of the respondents (34.6%) indicated that IV medication errors mostly occur because the right dose, as one of the medication rights, was missed. These findings match what was found in the literature review (paragraph 2.7.8), which revealed that administration errors are reported. Administration errors include wrong dose and wrong infusion rate within this context. Administration errors are to be the most common medication error in several research studies (Chuo et al., 2007:104; Ligi et al., 2008:404; Suresh et al., 2004:1609). The increased risk for medication errors with the use of IV pumps was described in paragraph 2.7.1. Nursing staff appear to be prone to make dosing errors while setting the infusion devices (Chuo et al., 2007:104; Fahimi et al., 2007:297). As indicated in Table 4.10 (question 14), the majority of

respondents also indicated that IV medication errors occur because of IV devices that are being miss-programmed (43.2%). Han, Coombes and Green (2005:181) reported that 18.0% of medication errors were related to wrong administration rate of continuous IV infusions, while Suresh et al. (2004:1609) found 14% were related to medication administration errors. Fahimi et al. (2007) found that the commonest type of error (43.4%) was the injection of bolus doses at a faster rate than the recommended one (paragraph 2.7.8).

Hicks, Becker & Chuo (2007:300) found that nurses may misinterpret the modes on the pump (namely the time, volume and rate) and that this could contribute to device miss-programming. In this study, by ticking off 'agree', almost half of the respondents (49.4%) (question 15, Table 4.11) indicated that IV medication errors occur because of IV infusions that are accidentally switched. It is also evident that there are different reports from the respondents who worked in the NICU, PICU or CSICU. It was reported that double-checks were not performed or incompletely performed (12.0%); dosages were incorrectly calculated (8.4%) and nurses demonstrated a lack of concentration (8.4%). These findings indicate how vital the human factor is in correctly and safely administering the right medication at the right dose, and in approaching double-checks ('safety checks') with safety as aim. By ticking off either 'agree' (38.6%) or 'strongly agree' (56.6%) (question 24, Table 4.20), the majority of respondents indicated that each patient must have a dosage calculation sheet based on the patient's weight.

v) Administration errors of medication versus 'right route'

A very small number of respondents (2.5%) indicated that medication errors occur because of the right medication route being missed (Table 4.15). It appears as if the respondents who participated in the study did NOT encounter this medication right as a causing factor of medication error. The reason for this could be that all IV medication and infusions are dispensed in transparent syringes and the oral medication is dispensed in brown non-transparent syringes, a practice standard that the pharmacy services implemented in the research setting several years ago. Hicks and Becker (2006:27) state that medication errors can be harmful to patients, especially if they involve the IV route of administration (paragraph 2.8). The respondents perceived their IV medication administration practice to be up to standard. Despite majority positive responses in these findings, the respondents (21.3%) indicated in question 17 that medication errors occur in STAT medication in the practice environment under study.

vi) IV medication error times versus 'right time'

The majority of the respondents (29.6%) indicated that IV medication errors occur because a great deal of medication is scheduled at peak times in the ICU (question 9, Table 4.5). As per the inclusion criteria of this study, the IV medication considered are continuous IV infusions, intermittent infusions (such as antibiotics, boluses, electrolytes and diuretics) and stat IV medication. Routinely, all newly issued IV infusions are hooked between 21:00 and 23:00. It could be possible to deduce from these findings that the due times of routinely scheduled IV medications coincide with the times that IV infusions are hooked. Ozkan et al. (2011:139) found that 40.3% of medication errors that occur in the paediatric setting are due to the wrong time. This factor poses a significant problem for patients. For example, if an IV antibiotic is prescribed for a neonatal or paediatric patient and it is given more frequently that what is ordered, it could be harmful to the patient, especially if it is oto-toxic or nephro-toxic. If, for example, an antibiotic is administered less frequently than what was ordered, it has once again implications for the patient, because the patient does not receive the intended treatment, as planned.

vii) Omission of double-checks

It is indicated by 13.5% of respondents (Table 4.4) who identified that, secondary to the main IV medication error cause, IV medication errors are caused if the RN did not perform double-checks or incomplete double-checks were done (question 8). This correlates with the findings of Raja et al. (2009:70) who reported that the most commonly omitted step was having another nurse to witness drug administration (95%) (paragraph 2.5). In paragraph 2.7.6 human errors are reported by Lefrak (2002:76) to be prone to happen when the 'five rights' are not checked as per standard and that familiarity with the process may lead to the omission of standard checks.

From the above discussion it is clear that human factors impact the occurrence of IV medication errors due to the omission of medication rights and double-checks; and that critical IV medication is involved, specifically through dose errors that occur during medication administration at specific IV medication error times in the ICU.

5.2.1.2 System factors

The following were the main findings regarding the system factors impacting IV medication errors as gathered from the empirical findings from this study as well as from the literature review. According to Campino et al. (2008:330) it is imperative not to consider medication errors due to system errors, as human errors can be caused by system failures.

i) Medication labelling

Only 7.8% of respondents identified that standard medication labelling is the cause of medication errors (question 9, Table 4.5). When compared with the literature, it seems that the prevalence of reported errors correlates with literature findings for labelling error. According to Suresh et al. (2004:1609) it was reported that 10% of near-misses and adverse events are related to labelling error. From the findings in this research setting, it seems that there may have been only single medication errors incidents caused by this factor. Medication labelling at the research hospital is standardised, which include the medication name; dose; patient's name and medication administration record; time due; administration route; the expiry date of the medication; and the signature of the pharmacist who prepared the medication. Medication preparation is done by the pharmacy in the research hospital, except for medication that is administered during emergencies (for example codes). Based on the findings from this question, it seems possible that medication errors due to labelling could happen during emergencies in the ICUs. It is also possible that nurses performed the checks and intercepted a medication from pharmacy due to the findings from question 34, that the majority of respondents had intercepted a medication error before, by ticking off 'yes' (64.6%). The question is, however, not specifically designed to ask whether the respondent has intercepted an error made by pharmacy, a physician or a fellow colleague. The researcher aimed to test the standard of nursing practice, since interception of an error will indicate that nurses indeed perform checks, otherwise will not be able to intercept an error if the medication was not checked in the first place.

ii) Computerised physician order entry (CPOE)

A number of respondents (15.5%) identified the computerised physician order entry (CPOE) system as a contributing factor to medication errors, which was identified as the third medication error causing factor amongst system factors (question 9, Table 4.5). However the majority of the respondents (41.2%) who participated in the study indicated the CPOE system as the most effective medication error prevention strategy (question 47, Table 4.36). Since CPOE system has been used in the research hospital for years, registered nurses have come accustomed to the use of technology. During the latter part of 2007, the medication ordering system in the research hospital has changed to another medication ordering system which could accommodate an electronic MAR in order to ensure that nurses could indicate infusion rates and administration of medications and infusions in the electronic MAR. It is possible that nurses recognise this particular CPOE as an example that prevents medication errors the most (as

depicted by the findings in question 47) because the previous CPOE system required that nurses transcribe from the CPOE to the manual MAR. The change in CPOE may potentially be viewed as an improvement by respondents. The findings from this study match the literature review regarding CPOE. It is reported by Forni et al. (2010:13) that CPOE improves the efficiency and quality of care during medication ordering because it improves the completeness and legibility of orders; it alerts physicians to medication allergies and drug interactions and provides 'a means for standardization of practice' (paragraph 2.7.11).

iii) Ordering and dispensing

As reported by Rothschild et al. (2005:1697) every tenth prescription had a medication error in ordering or dispensing while every sixth prescription in an emergency department and nineteenth prescription in NICU had a medication error. Buck et al. (2008:14) referred to the results of retrospective reviews, which were conducted in twelve children hospitals. It seems that 79% of medication errors mostly occurred during the ordering process due to the fact that infants receive drugs with a narrow dosing range (paragraph 2.7.11).

In this study, a number of respondents (15.5%) indicated that complicated and/or incomplete prescriptions may contribute to medication errors (question 9, Table 4.5). As discussed in the information of Question 70, a delay of medication delivery was identified as a factor in delayed medication administration, as reported by 7.2% respondents. This is displayed by specific comments, which includes 'pharmacy [has] to dispense IV medication infusions (especially at night) at the right time'. This is a factor that potentially leads to a lot of time spent by nurses to follow up in ensuring that the patient receives the medication at the right time. In comparison with question 19 (Table 4.15), 19.8% of respondents reported that IV medication errors mostly occur because the right time, as one of the medication rights, was missed. It is possible that registered nurses either miss to administer IV medications at the right time because of a delay in dispensing (questions 70 and 19), or because of a human oversight, as confirmed by responses in this study that medication errors are happening mostly because one or more of the medication rights are missed, as discussed in question 8 (paragraph 5.2.1.1.1).

iv) Specific institutional policy and procedure versus violation thereof

The role of the nurse is specific, and focused on IV medication safety (paragraph 2.9). It includes the checking and administration of IV medication and IV fluids, according to the medication rights (KFSHRC-J, 2008a:2). This includes the responsibility that all paediatric medications must be checked and signed by two RNs and the responsibility that both RNs must

check the patient's identification band and the rate setting of the infusion pump, as part of this complete check. When a medication error has occurred in the research hospital, RNs have to report the incident through the online incident reporting system. It is included in the annual mandatory training of all hospital staff in the research hospital (KFSHRC-J, 2008a:2).

It is perceived by the majority of respondents that neonatal and paediatric patients require additional safeguards versus adult patients, by ticking off either 'agree' (40.9%) or 'strongly agree' (51.8%) (question 41, Table 4.30). Nursing safety checks need to be adequate and complete, because of the risk that unsafe safety checks (inadequate and incomplete practice) pose in the practice environment. A significant concern rose. Despite the fact that RNs in this practice environment seem to possess adequate perceptions regarding medication safety, as covered by the institutional policies, medication errors still occur because of a failure to complete double-checks (questions 8) and not reported (question 63).

Unfortunately, the findings from this study show in question 8 that the majority respondents (39%) reported that medication errors are caused by missing one or more of the medication rights (discussed in paragraph 5.2.1.1). These findings are also reflected in the literature, as reported by Ozkan et al. (2011:137) regarding violations of protocols; high workload; insufficient protocols regarding work environment conditions; late arrival of medications from pharmacy; inexperience; and miss-interpreting of medication preparation protocols. It is confirmed by Suresh et al. (2004:1609) that 47% of medical errors were also due to a failure to follow policy or protocol (paragraph 2.7.12). The question arises that how RNs working in the NICU, PICU and paediatric CSICU perceive that the current standard of nursing practice is adequate to prevent medication errors, if IV medication administration policies are not followed. This was not asked specifically, but rather as an open-ended question as to whether RNs have any perceived factors to identify in order to improve medication safety in the unit.

Registered nurses are also expected to administer medication according to the standard medication administration times as per protocol, for example every eight (8) hours means medication is administered at 06h00, 14h00 and 22h00 (KFSHRC-J, 2008a:3). As discussed in question 9, IV medication errors are caused by a lot of medication that are scheduled at peak times in the ICU (paragraph 5.2.1.1.6). Routinely, all newly issued IV infusions are hooked between 21h00 and 23h00. Although 24% respondents reported that medication errors occur because of the critical condition of the patient, the vast majority of the respondents (67.8%) identified that IV medication errors occur anytime during the 24 hours (Table 4.14).

From the above discussion it is clear that system factors impact the occurrence of IV medication errors due to a variation in standards of nursing practice; registered nurses' education, practice perceptions and experiences; ordering and dispensing; and when specific safety precautions in the institutional policies are not adhered to.

5.2.1.3 Environmental factors

The following were the main findings regarding the environmental factors impacting IV medication errors as gathered from the empirical findings from this study as well as from the literature review.

i) The patient's critical condition

The majority of the respondents (25.0%) who participated in this study mentioned that medication errors are caused by the patient's critical condition which contributes to an increased workload of registered nurses (question 10, Table 4.6). This was identified as the main environmental factor that contributed to medication errors in the NICU, PICU and CSICU. The secondary, third and fourth reported causing factors, included that multiple nursing tasks are done in a limited time available (20.3%); a high patient to nurse ratio (15.6%); and error prone situations, for example when policy or protocol is not followed (14.0%). This reveals that registered nurses do recognise when a policy is not followed by themselves or a colleague. These findings seem to match with the literature regarding the practice environment and that nurses have to care for patients in a practice environment that seems to be risk-prone.

ii) Interruptions and distractions

The nurse works in a stressful environment because interruptions and distractions are regularly encountered (Conrad et al., 2010:143). Both Clifton-Koeppel (2008:76) and Gurses and Caravon (2007:185) found distractions and interruptions to be an important cause of medication errors (paragraph 2.7.7). The findings from question 10 as discussed, and the findings of the open-ended question (Q70) seem to be in line with recommendations by the Institute of Safe Medicine Practices (ISMP, 2008:2). According to the ISMP, high-risk areas should get special attention for medication error prevention because of the criteria that make such an environment risk-prone (paragraph 2.7.7). A few of these criteria are an atmosphere prone to distractions or interruptions, the need for rapid care management decisions, nurses being time pressured, and unpredictable patient flow.

Both Johnson and Young (2010:134) and Conrad et al. (2010:143) claim that medication errors can be prevented if nurses consciously reduce the distractions and interruptions they experience in the practice environment. In the current study, the cumulative number of respondents (96.3%) agreed, by ticking off either 'agree' (53.1%) or 'strongly agree' (43.2%) (question 65, Table 4.53), that there should be no interruptions during the IV medication administration process. MEDMARX data reflects that distractions – for example co-workers asking for assistance as the most frequent source of interruptions – are a causative factor in about 45% of medication errors. These findings are reported in the ISMP Alert, 'Safe practice environment' (ISMP, 2008). The question that arises is whether the registered nurses working in the practice environment of the research hospital where the investigation was done were indeed encountering interruptions. If so, what types of interruptions would be involved, since this was not reflected in the open-ended question component of this study. However, the vast majority response rate does give an indication that registered nurses claim that medication errors can be prevented if nurses consciously reduce the distractions and interruptions they experience in the practice environment.

Despite the findings of question 10 (medication errors are caused by the patient's critical condition which contributes to an increased workload for registered nurses), by ticking off either 'agree' (56.0%) or 'strongly agree' (17.0%) (question 11, Table 4.7), more than half of the study respondents revealed that they had control over environmental influences that affected their concentration. Question 11 does not negate question 10, but was intentionally asked in order to determine whether they feel in control of environmental factors in terms of informing the colleagues if the noise level affects his/her concentration, for example. Interestingly, 23.4% of the respondents believed that that they did NOT have control over environmental influences that affected their concentration. Despite the positive response from the majority of respondents under study, they indicated that the environment did indeed have an influence on the occurrence of medication errors and that it related to a combination of factors (paragraph 5.2.1). These aspects need to encourage registered nurses to address those factors over which they have control. It is not surprising that there will be multiple factors in the practice environment that affects RNs in different ways. But it is surprising that almost a quarter of the respondents perceived it that they do not have control over the environment that affected their concentration.

From the above discussion it is clear that environmental factors can cause error-prone situations during medication administration because of the patient's critical condition and environmental distractions and interruptions.

5.2.1.4 Other IV medication error-causing factors

The other main finding regarding factors that have an impact on IV medication errors as gathered from the empirical findings from this study as well as from the literature review is the variations in medication administration practice.

Variations in medication administration practice will be inevitable if all staff working in the practice environment do not consistently adhere to the safety precautions for medication administration. Bates et al. (2005:203) contend that a significant and unnecessary variation in IV medication practice is associated with increased risk of patient harm. Thomka (2007:24) argues that senior nurses may take risks as a result of their comfort or familiarity with the medication process, and junior nurses (newly oriented staff) may feel pressured to emulate the practices of senior nurses, thereby quickly fitting into the unit safety culture (paragraph 2.7.9).

As discussed in question 20 (Table 4.16), the majority of respondents indicated, by ticking off either 'agree' (33.7%) or 'strongly agree' (65.0%), that routine double-checks can reduce the risk of IV medication administration errors. This finding reveals that the respondents were adequately aware of medication safety and medication error prevention. Question 28 (Table 4.24) revealed that the patient's assigned nurse as well as a second registered nurse must be involved in checking the five medication rights together by BOTH registered nurses performing the calculations independently. The respondents indicated this viewpoint by ticking off either 'agree' (33.0%) or 'strongly agree' (62.2%). Once again, it seems evident that the respondents were adequately aware of medication safety and medication error prevention. However, compared with the findings from question 8 (medication errors caused by missing one or more of the medication rights and the RN does not perform a double-check), it seems evident that there is non-compliance with this safety precaution.

Question 32 was formulated to test the opposite, namely that ONE registered nurse performs the calculation, as opposed to the stipulation that the patient's nurse AND a second registered nurse should check, as tested previously in question 28. As tested in question 32 (Figure 4.4), the concern is that a majority of respondents indicated, by ticking off either 'agree' (33.0%) or 'strongly agree' (26.0%), that a double-check is performed by one registered nurse checking the dose and concentration calculation of the medication. However, a significant number of respondents also indicated, by ticking off either 'disagree' (22.0%) or 'strongly disagree' (19.0%), that a double-check should NOT be carried out by one registered nurse checking the dose and concentration calculation of the medication. It is possible that the respondents who

agreed and strongly agreed to this question, did not read the question well, or that the registered nurses were not following safety precautions that stipulate that two registered nurses should check the medication dose and calculation prior to the administration of IV medication. It is also possible that registered nurses do not properly understand how to check medications independently with another registered nurse. These findings seem to be in line with the recommendation from Johnson and Young (2011:134) that checking of the five rights prior to medication administration should be emphasised during orientation programmes.

According to the findings from question 8 (Table 4.4), registered nurses did not believe calculation skills to relate to medication errors. This finding is determined because a small number of respondents indicated that medication errors are caused by incorrect dosage calculations (6.8%) and the nurse's lack of concentration (6.7%). Dosage calculation is a routine ICU nursing task, and this nursing skill is tested through mandatory nursing examinations that are written by all newly recruited nursing staff in their nursing orientation period. According to Bates et al. (2005:203), a significant and unnecessary variation in IV medication practice is associated with increased risk of patient harm. Hicks and Becker (2006:20) found that the leading underlying cause of error omission involved clinician performance deficit, like calculation errors (paragraph 2.8). Interestingly, the findings in this study (Table 4.15) identified dose errors and not calculation errors per se as a leading cause of IV medication errors (paragraph 5.2.1.1).

Another practice variation which could affect the occurrence of a medication error was noted. As discussed in question 31 (Figure 4.3), the vast majority of respondents indicated, by ticking off either 'agree' (33.0%) or 'strongly agree' (54.0%), that a double-check includes checking the pump settings with another registered nurse and tracing the IV tubing to the injection site before the infusions are started. However, a significant number of respondents (13.0%) indicated that the pump settings are NOT checked with another registered nurse, despite this aspect being a policy requirement and therefore tested in the questionnaire. It is possible that the potential could be created for latent errors to exist in the practice environment if this safety precaution is not followed. The question arises: if the majority of respondents indicated that checks were performed by two registered nurses, why did medication errors still occur? When this information is linked with question 15 (IVs are accidentally switched) and question 19 (errors that occur are due to wrong dose), it seems evident that double-checks were NOT effectively performed.

From the above discussion it is clear that variations in medication administration practice cause medication errors. The analysis of this study's findings provided an understanding of the factors that nurses encounter as a cause of medication errors. Since it takes one medication error to cause harm to a patient, nurses need to take pro-active action to reduce or eliminate the potential for medication errors in the practice environment.

5.2.2 Knowledge of registered nurses related to safe IV medication administration practices

The main findings regarding registered nurses' knowledge influencing medication errors in the practice environment under study, as gathered from the empirical findings from this study and from the literature review, are discussed in the sections that follow. Knowledge of RNs may be a latent factor, as cause of a medication error (as depicted by the conceptual framework in paragraph 2.7) since knowledge is also considered as a human factor. This knowledge is tested in the questionnaire items in terms of RN's knowledge of the research hospital's policy to check that the right patient receives the right drug (and form of drug), the right dose (strength and rate of the infusion), via the right route, and at the right time (Shane, 2009:546). Their knowledge is also tested in terms of whether 'double-checking' these medication rights are performed with a witnessing nurse, as depicted by the institution policy and conceptual framework (KFSHRC-J, 2008a:2).

5.2.2.1 Knowledge of standardisation of IV medication concentrations

According to Hennessy (2007:28), the mandate of the Joint Commission on Accreditation of Health Care Organization (JCAHO) to standardise concentrations of infusions is vital (paragraph 2.10.4). As discussed in question 23 (Table 4.19), the majority of respondents indicated, by ticking off either 'agree' (61.4%) or 'strongly agree' (32.5%), that standard IV medication concentrations help to provide reliable infusion rates. Since the research hospital is accredited by the Joint Commission International, IV medications are standardised by pharmacy. This situation seems to assist in error prevention. From the findings (see question 19) it also seems possible that a lack of IV medication concentration standardisation is not a cause of dose errors in the NICU, PICU and CSICU.

5.2.2.2 Checking IV medication compatibility

According to De Giorgi et al. (2010:522), the physico-chemical compatibility of drugs makes caring for neonatal and paediatric patients risk-prone (paragraph 2.4). As discussed in question 27 (Table 4.23), the majority of respondents indicated, by ticking off either 'agree' (34.1%) or

'strongly agree' (58.5%), that routine checks include checking the compatibility with other medication or with the diluting fluid. Based on these findings, it seems possible that the respondents perform this vital nursing double-check before infusions are set to run. It also seems possible that this is also not a cause of dose errors, as discussed in the findings of question 19.

5.2.2.3 Checking identification

By ticking off either 'agree' (35.0%) or 'strongly agree' (63.0%) (question 30, Figure 4.2), the vast majority of respondents indicated that a double-check must include checking the patient's identification number and IV medication label against the electronic MAR. . According to Anderson and Townsend (2010:23), the 'right patient' ensures prevention of administration errors. Raja et al. (2009:70) also reported that the visual inspection (71%) of a patient's identification tag is a contributing factor to medication errors (paragraph 2.7.5). However, it seems that the respondents in this research setting have adequate knowledge for medication error prevention.

5.2.2.4 Knowledge of an effective double-check method

The vast majority of respondents indicated, by ticking off either 'agree' (37.0%) or 'strongly agree' (39.0%) (question 33, figure 4.5), that a double-check is performed by asking another registered nurse to check the calculations when he or she is finished with his or her tasks. However, a small number of respondents also indicated, by ticking off either 'disagree' (11.0%) or 'strongly disagree' (13.0%), that a 'double-check' should NOT be carried out in this manner. There is value in a critical, and effective double-check that decreases the margin for risk. Clifton-Koeppel (2008:77) states that medication double-checking is fundamentally a 'human factors approach'. According to the ISMP Alert, 'The virtues of independent double checks' (ISMP, 2003:1), nursing double-checks fail at times because of confirmation bias, namely 'seeing only what one expects to see and overlooking disconfirming evidence'.

5.2.2.5 Unit-specific training

As per question 9 (Table 4.5) to determine whether insufficient unit-specific training could contribute to medication errors, only 3.1% of respondents indicated that unit-specific training was insufficient. The findings from this question seem to correlate with questions 54 and 55. In question 54 (Table 4.43) the majority of respondents indicated, by ticking off either 'agree' (70.7%) or 'strongly agree' (18.3%), that new staff receive sufficient unit training related to safe medication administration. As shown in question 55 (Table 4.44), the majority of respondents

indicated, by ticking off either 'agree' (64.2%) or 'strongly agree' (18.5%), that experienced staff receive sufficient ongoing reviews of safe medication administration. From the findings it is evident that the respondents believed that the educational processes and strategies for medication error prevention are effective. The findings from this study match the recommendations of Sulosaari et al. (2011:465), who reported that nurses need adequate competence to fulfil their role.

5.2.2.6 Standard of nursing practice

By ticking off either 'agree' (62.2%) or 'strongly agree' (24.4%) (question 22, Table 4.18), the vast majority of respondents indicated that the existing standard of nurses' practice related to IV medication administration in the ICU was adequate. As also shown in the literature review, they commented that medication errors are prevented if medication administration is safely executed. Safe medication administration practice is seen within the context of the 'five rights of medication administration' which aims to ensure that the right patient receives the right drug (and form of drug), the right dose (strength and rate of the infusion) via the right route and at the right time (Benjamin, 2003:768; Elganzouri et al., 2009:424; Elliott & Liu, 2010:300; Shane, 2009:546). According to George et al. (2010:1763), it is essential to evaluate strategies and to address organisational, technical or human issues in attempting to transform the nurse's practice environment (paragraph 2.2).

5.2.2.7 Registered nurses' education, practice perceptions and experiences

As discussed in paragraph 5.2, the majority of the respondents (28.2%) had been working in either one of the ICUs only for two years. As discussed in question 50 (Table 4.39), the majority of respondents indicated, by ticking off either 'agree' (42.2%) or 'strongly agree' (51.8%), that training, experience and skills play a role in safe IV medication administration. Specialised nursing knowledge is required to work in an area of specialty. However Armutlu et al. (2008:58) found that there was no relationship between medication practices or perceived sources of error by years of experience (paragraph 2.7.9), but they mention that there is a need for ongoing education programmes on medication safety for all nurses, regardless of years of experience.

It also seems imperative to review nurses' perceptions regarding medication errors. Mayo and Duncan's study (2004:215) found that there are differences in nurses' perceptions about causes of medication errors and the reporting thereof (paragraph 2.7.9). The majority of respondents who participated in this current study agreed that staff perceptions of medication safety can affect nursing practice (92.3%) (question 67).

A disturbing practice perception is the significant number of respondents who agreed that the fear of punishment prevented them from reporting a medication error. They indicated this information by ticking off either 'agree' (31.7%) or 'strongly agree' (12.2%), which added up to a cumulative number of 43.9% respondents (question 63, Table 4.51). The same trend was found in the literature regarding the voluntary reporting of medication errors. This implies that reliable medication error data is not provided because fear of the manager as well as peer reactions cause barriers to reporting. The situation is often exacerbated by nurses' perceptions that they are incapable of providing quality nursing care if a medication error has occurred (Carlton & Blegen, 2006:38; Kagan & Barnoy, 2008:360; Lefrak, 2002:80).

Furthermore, the majority of respondents agreed, by ticking off either 'agree' (45.0%) or 'strongly agree' (55.0%), that safe IV medication administration practice ensures the delivery of quality nursing care. None of the respondents indicated a negative response to this question at all (question 60, Table 4.48). The data indicated that the respondents from the practice environment under study perceived safe IV medication administration practice to link with the delivery of quality nursing care. This finding links with that of Otero et al. (2008:740), namely that the promotion of a unit safety culture (unit-specific culture of medication safety) change can effectively diminish medication errors in neonates and children.

From the above discussion it is clear that registered nurses' knowledge regarding medication safety influences medication errors because error prevention is ensured through standardised IV concentrations and an effective double-check method.

5.2.3 Nursing medication administration strategies to prevent medication errors

As discussed in question 69, the majority of respondents indicated, by ticking off 'yes' (55.4%), that it is possible to implement more safety strategies in their respective units. The rest of the respondents answered 'no' (44.6%) to this question. Nurses who are well-oriented to the unit (question 7) and who have been employed for at least two years at the hospital and in their respective units (questions 2 and 3), would be able understand which factors affect practice standards and whether it is possible to implement more safety strategies within the practice environment. The number of negative responses (which is also significant) could possibly indicate that there are already sufficient processes and strategies in place for medication error reduction in the respondents' practice environment. These processes and medication safety strategies (checking of the medication rights and performing these checks by two RNs) are

thoroughly covered by the institution's policies and procedures, which include two specific policies that guide medication safety practice at the research hospital, including 'Medication Administration' and 'Medication System: Nursing responsibilities' (KFSHRC-J, 2008a:1; KFSHRC-J, 2008b:1). However, the finding described, was not the majority finding from the responses that it is not possible to implement more safety strategies, as initially discussed in this paragraph.

Various nursing medication administration strategies to prevent medication errors were identified in the literature and also tested in this study. These strategies are safer systems, CPOE, standard medication labelling, standard infusion concentrations and infusion pumps, voluntary reporting, practice monitors and safety checks (double-checks), medication safety awareness, the role of the nurse in medication error prevention, the role of nursing managers in medication error prevention, and mandatory staff education and review of their knowledge and skills. Some of these strategies, namely safe systems, CPOE, standard medication labelling, standard infusion concentrations and infusion pumps, voluntary reporting, and practice monitors and safety checks (double-checks) are already in place in the research setting (the research hospital).

Based on the literature review and empirical findings of this study, only the main conclusions that could potentially reduce or eliminate medication errors in the research hospital are discussed in this section. These include medication safety awareness, the role of the nurse and the nursing manager, and mandatory staff education and review of knowledge and skills.

5.2.3.1 Medication safety awareness

According to Kunac and Reith (2005:251) as well as Armutlu et al. (2008:64), safe medication administration practice is linked with medication safety awareness. Evidence was found from a study by Otero et al. (2008:740) that the promotion of a unit safety culture (unit-specific culture of medication safety) change can effectively diminish medication errors in neonates and children.

The findings from Question 70 revealed that a number of respondents identified the need for 'more reviews or discussion during in-services and/or meetings'. As confirmed by the findings of question 49 (Table 4.38) the majority of the respondents (31.9%) indicated that an analysis through case reviews would improve medication safety awareness in their respective units. Therefore it appears as if the respondents are interested in gaining current, up-to-date

knowledge of medication safety through reviews or discussions. From the rest of the findings in this chapter, it also seems as if the majority of respondents have an adequate knowledge of causing factors that cause medication errors as well as of medication safety. It would therefore be ideal to build further on these foundations in order to establish a unit-specific culture of medication safety related to all nursing medication tasks.

Medication safety awareness enables nurses to be conscious of nursing practice and the practice environment. Reason and Hobbs (2003:156) argue that it is vital to learn from unsafe acts related to medication safety. They also contend that a unit safety culture has 'a number of interlocking parts', including a just culture, a reporting culture and a learning culture. These researchers also maintain that it is necessary to make a collective agreement in the practice environment as to where the line should be drawn between what is acceptable and what is unacceptable.

5.2.3.2 The role of the nurse in medication error prevention

According to Choo et al. (2010:853), the nursing profession is essential to the promotion of patient safety. Furthermore, Reason and Hobbs (2003:156) emphasise that it is important for nurses to report unsafe acts. A major part of the ICU nurse's role is to implement, monitor and maintain safe medication practices for neonatal and paediatric critical care patients (Camire et al., 2009:936; Clifton-Koeppel, 2008:72; Lefrak, 2002:78; Swanson, 2006:230). The nurse has to 'continually detect, arrest, and deflect potential medication errors for patients, even subconsciously' (IOM, 2003:228). The link between nurses and nursing managers should be strengthened through a partnership in patient safety. This can be achieved through regular discussions and by making staff aware of the importance of medication safety. Carlton and Blegen (2006:19) point out that since nurses are primarily involved in and responsible for medication administration, it is important for them to understand factors that contribute to medication administration errors. These authors found that an understanding of the causing factors enables nurses to direct action plans towards preventing medication errors within the challenging practice environment of the ICU setting.

5.2.3.3 The role of nursing managers in medication error prevention

The open ended question (Q70) revealed that a number of respondents identified the need for nursing managers to 'provide feedback to staff about medication errors incurred in the practice environment' (Question 70). It seems as if the respondents have an interest in receiving current, up-to-date feedback regarding medication errors or issues that may arise in the practice

environment. Organisations need to focus on open communication, especially on how leadership (the nurse manager) sets clear expectations to staff regarding patient safety through publicised organisational goals, including being transparent about patient injury results (ISMP, 2003:1).

Aronson (2009:601) states that the best approach to understanding how medication errors occur is to use a classification system in order to plan a preventive approach. As discussed in paragraph 2.6, Aronson's classification of underlying medication error causes, ensure specific, retrospective analysis of a medication error because the occurrence and cause of a medication error are analyzed (Aronson, 2009:602). Another researcher confirms that an error analysis with nursing staff is crucial after a medication error has occurred in order to understand the nature of IV medication errors (Clifton-Koeppel, 2008:79). Therefore, based on the recommendations of these authors it seems that one of the roles of nursing managers could include reviewing a medication error incident with staff through classifying the causing factors related to the specific incident as well as reviewing specific medication error cases as learning opportunities. Currently, a root cause analysis is done in the research hospital with the nursing staff who are involved in a medication error. It is possible that the respondents who indicated that they need feedback regarding the occurrence of medication errors are keen to utilise other medication error incidents as a learning opportunity. Interestingly, another argument put forward by the ISMP (2003:1) is that failures are not preventable 'when dealing with humans and complex systems, regardless of how hard the humans involved try to avoid errors'. As a solution, it is suggested that hazards and errors be anticipated so that processes can be designed to avoid failures and 'to prevent patient harm when a failure occurs' (ISMP, 2003:1).

The essence and diversity of the unit manager's role in medication error prevention is reported in several studies (Brady et al., 2009:679; Kagan & Barnoy, 2008:360; Poe, 2005:198). Nursing managers need to be role models by 'setting the tone, encouraging staff, coaching and taking an active role in education and systems improvement' (Kagan & Barnoy, 2008:360). Nursing leaders therefore have to 'declare error reduction as a goal; replace complacency; remove barriers; challenge punishment; and move toward an environment that views patient care as a top priority'. This viewpoint is supported by Poe (2005:198), who stressed the importance of instilling patient safety principles in the hearts and minds of staff. Unit managers' responsibility also includes having to establish or improve unit safety culture by aiming to reduce staff's fear of reporting medication errors and by rewarding nurses for reporting medication errors (Lefrak,

2002:79). However, the strongest reward for nurses may be in seeing that their reports have led to real changes to ensure a safer practice environment (Lefrak, 2002:79).

5.2.3.4 Mandatory staff education and review of knowledge and skills

The findings from Question 70 revealed that a number of respondents identified the need for 'double-checking of medication with orders'. In order to prevent medication errors, nurses need to adhere to the medication rights, and they must know how the rights should be checked. These findings seem to correlate with the findings from question 8. Sulosaari et al. (2011:465) found that nurses' involvement in a patient's medication process is so vital that nurses need adequate competence to fulfil their role of being a 'solid knowledge base'. They must be able to apply knowledge in complex and dynamic patient medication processes and present decision-making competence. These researchers regard decision-making competence as an essential part of nurses' theoretical and practical competence (Sulosaari et al., 2011:476). Through strengthening nurses' decision-making competence, nurses' adherence to safety precautions in maintaining medication safety could be enhanced.

According to the findings from Question 70, a number of respondents also indicated that a 'strict adherence to check the five medication rights and other medication rights is required' and that nursing 'double-checks were recommended as a safety strategy to prevent medication errors'. It may be valuable to teach staff how a near-miss and latent error could occur when safety standards are not followed through checking the medication rights and performing effective nursing double-checks. In this regard, Johnson and Young (2011:134) emphasise that the five medication rights should be reinforced for all newly employed staff to check prior to medication administration. According to the ISMP (2003:1) nurses must be trained in how to perform independent double-checks. Simulations may be valuable in training staff to carry out independent double-checks effectively. Staff should be trained to perform double-checks 'properly as an independent cognitive task, not a superficial routine task' strategically during the medication process (ISMP, 2003).

Clifton-Koeppel (2008:78) describes double-checking practices as being 'inconsistent and often performed casually'. The minimum requirement is to check the five rights (patient, drug, dose, time and route) with another nurse. Additional rights are recommended by Clifton-Koeppel (2008:78), namely the 'reason, medication expiration, checking the medication levels and documentation'. The same researcher recommends the importance of performing double-checks correctly, but they have to be 'performed completely' (using the five rights); 'performed

independently' (two nurses are checking independently without verbal prompting); and 'performed uniformly' (the five rights are checked in the same order each time) (Clifton-Koeppel, 2008:77). According to the ISMP (2009), an independent double-check is seen as being effective when two people calculate a dose separately and then compare their answers, rather than having one share his answer with the other before double-checking occurs. Through double-checking, a mistake or near-miss can be intercepted. It can be deduced that it is valuable to randomly observe the way in which double-checks are performed in the practice environment.

Both Johnson and Young (2011:134) and Hohenhaus and Powel (2008:108) confirm that staff should be taught how to minimise distractions in the clinical setting. Hohenhaus and Powel (2008:108) recommend that a 'sterile cockpit rule' be adopted from the aviation industry. In a 'sterile cockpit' situation 'crew members are prohibited to perform non-essential duties or activities while the aircraft is involved in "high-threat" times such as take-off, landing and other flight operations'. These authors also recommend implementing prohibitions such as not allowing social commentary, and being assertive when colleague interruptions occur during medication administration.

In view of the above-mentioned, a standardised curriculum is proposed, with components for teamwork, communication techniques, respectful assertion and situation awareness, to name a few.

The above-mentioned strategies, namely medication safety awareness, awareness of the role of the nurse and the nursing manager, mandatory staff education and review of knowledge and skills, could potentially reduce or eliminate medication errors in the research hospital. They are all interlinked and could be focused on at unit level.

5.3 LIMITATIONS OF THE STUDY

The study aimed at exploring the IV medication safety practices of registered nurses working with neonatal and paediatric ICU patients. A limitation of the study was that only a small number of respondents (n=25) provided open ended responses in Question 70 regarding what could be done specifically to prevent medication errors. Valuable information could have been collected from those respondents who did not provide the requested information, which could have contributed in identifying more IV medication safety strategies. However, this did not have an effect on the outcome of the study, as the research design was quantitative in nature and open

ended responses formed a small part of the study with the purpose of clarifying responses on the closed ended questions. .

Some items in the questionnaire measured more than one concept at a time which undermined the construct validity of the questionnaire. This was unfortunately not revealed in the pre-testing of the questionnaire prior to commencement of the main study.

Furthermore some respondents unfortunately gave more than one answer per question in the main study while they were clearly asked to 'select the most important reason'. The instruction to 'select one' was repeated in brackets after each question in the questionnaire. However, this was not revealed as a problem during the pilot study as the respondents selected one answer per question. The data from 10 questions were therefore considered as spoilt (as discussed in paragraph 4.2.

5.4 RECOMMENDATIONS FOR FURTHER STUDIES

The questions in section C related to nursing double-checks and were all structured as closed-ended questions. Future research could potentially explore the standard of nursing practice of double-checks through open-ended questions that could potentially provide valuable information to determine the safety precautions being adhered to for vulnerable patients cared for in the ICUs.

Since a significant number of respondents (43.9%) indicated in question 63 that the fear of punishment prevents them from reporting medication errors in the ICU, it could add value for future research to explore the factors and/or barriers involved in reporting medication errors. Patient safety is affected if medication errors are not reported. The opportunity could be lost to make corrective action plans for nursing practice standards if medication errors are not reported.

As discussed in paragraph 2.6, Aronson's classification of underlying medication error causes, ensure specific, retrospective analysis of a medication error because the occurrence and cause of a medication error are analyzed (Aronson, 2009:602). Further studies are needed in applying this classification, when causing factors are further studied.

5.5 SUMMARY

The problem statement and aim of the study were identified (paragraph 1.1.2 and 1.1.3) and supported by an extensive literature review on the topic (Chapter 2). An appropriate

methodology was selected for the study (Chapter 3). An analysis (Chapter 4) as well as a synthesis (Chapter 5) of the findings was done according to the objectives set for this study (paragraph 1.1.4). The synthesis was based on the main empirical findings and literature review that relate to the topic of this study throughout this chapter by means of cross references and that a conclusive summary of each section was done.

The overall conclusion from this study, according to RNs working in the NICU, PICU and paediatric CSICU in a particular tertiary Saudi Arabian hospital, was that there are multiple perceived factors that influence IV medication safety practices of registered nurses working with these patients. The main recommendation was that there are more nursing medication administration strategies that could be implemented for medication error prevention. These strategies relate to medication safety awareness, the role of the nurse and nursing managers, mandatory staff education and reviewing of knowledge and skills.

The standard is safe medication administration. As discussed in paragraph 2.3, safe medication administration practice is seen within the context of the ‘five rights of medication administration’, to ensure that the right patient receives the right drug (and form of drug), the right dose (strength and rate of the infusion), via the right route, and at the right time (Shane, 2009:546). The ‘five rights’ principle, the basis of the medication administration policies as set standards in the research hospital, states that the medication rights should be checked prior to medication administration, as witnessed with another RN (KFSHRC-J, 2008a:2). Two specific policies guide medication safety practice at the research hospital, namely ‘Medication Administration’ and ‘Medication System: Nursing responsibilities’ (KFSHRC-J, 2008a:1; KFSHRC-J, 2008b:1). Therefore, safe medication administration practice, and the factors influencing safe medication administration practice, is depicted in the researcher’s conceptual framework (paragraph 2.6). Therefore, the conclusions in this study can be justified by describing what constitutes safe medication administration practice, in terms of the perceived factors that affects this safe medication practice.

REFERENCE LIST

Anderson, P. & Townsend, T. 2010. Medication errors: Don't let them happen to you. *American Nurse Today 5(3):*23–28.

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.

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.

Aronson, J.K. 2009. Medication errors: Definitions and classification. *British Journal of Clinical Pharmacology* 67(6):599- 604.

Balguer, J.A.S., Fernandez, J.D.B. & Escribano, J.S. 2001. Usefulness of a software package to reduce medication errors in eonatal care. *Spanish Annuals of Pediatrics* 55(6):541–545.

Batalden, P. & Davidoff, F. 2007. What is 'quality improvement' and how can it transform healthcare? *Quality and Safety Health Care* 16:2–3.

Bates, D.W., Vanderveen, T., Seger, D.L., Yamaga, C.C. & Rothschild, J. 2005. Variability in intravenous medication practices: Implications for medication safety. *Joint Commission Journal of Patient Safety and Quality* 31(4):203–210.

Benjamin, D. 2003. Reducing medication errors and increasing patient safety: Case studies in clinical pharmacology. *Journal of Clinical Pharmacology* 43(7):768–783.

Biron, A.D., Lavoie-Tremblay, M. & Loiselle, C.G. 2009. Characteristics of work interruptions during medication administration. *Journal of Nursing Scholarship* 41(4):330–336.

Brady, A.M., Malone, A.M. & Fleming, S. 2009. A literature review of the individual and systems factors that contribute to medication errors in nursing practice. *Journal of Nursing Management* 17(6):679–697.

Brink, H. 2006. *Fundamentals of research methodology for health care professionals.* Second edition. Cape Town: Juta.

Buck, M., Hofer, K.N. & McCarthy, M.W. 2008. *Improving paediatrics medication safety. Part I: Research on medication errors and recommendations from the Joint Commission.* Available at: http://www.medscape.com/viewarticle/585293 [Accessed 4 April 2009].

Buckley, M.S., Erstad, B.L., Kopp, B.J., Theodorou, A.A. & Priestley, G. 2007. Direct observation approach for detecting medication errors and ADEs in a pediatric intensive care unit. *Pediatric Critical Care Medicine* 8(2):145–152.

Burns, N. & Grove, S.K. 2007. *Understanding nursing research: Building an evidence-based practice.* Fourth edition. St. Louis, MO: Elsevier.

Camire, E., Moyen, E. & Stelfox, H.T. 2009. Medication errors in critical care: Risk factors, prevention and disclosure. *Canadian Medical Association Journal* 180(9):936–943.

Campbell, G.M. & Facchinetti, N. 2000. Using process control charts to monitor dispensing and checking errors. *American Journal of Health-System Pharmacy* 55:946–952.

Campino, A., Lopez-Herrera, M.C., Lopez-de-Herdia, I. & Valls-I-Soler, A. 2008. Medication errors in a neonatal intensive care unit: Influence of observation on the error rate. *Acta Paediatrica* 97(11):1591–1594.

Carlton, G. & Blegen, M.A. 2006. Medication-related errors: A literature review of incidence and antecedents. *Annual Review of Nursing Research* 24:19–38.

Chedoe, I., Molendijk, H.A., Dittrich, S.T., Jansman, F.G., Harting, J.W., Brouwers,

J.R. & Taxis, K. 2007. Incidence and nature of medication errors in neonatal intensive care with strategies to improve safety: A review of the current literature. *Drug Safety Journal* 30(6):503–513.

Chiang, H.Y., Lin, S.Y., Hsu, S.C. & Ma, S.C. 2010. Factors determining hospital nurses' failures in reporting medication errors in Taiwan. *Nursing Outlook Journal* 58(1):17–25.

Choo, J., Hutchinson, A. & Bucknall, T. 2010. Nurses' role in medication safety. *Journal of Nursing Management* 18(7):853–861.

Chuo, J., Lambert, G. & Hicks, R. 2007. Intralipid medication errors in the paediatric intensive care unit. *Joint Commission Journal on Quality & Patient Safety* 33(2):104–111.

Clifton-Koeppel, R. 2008. What nurses can do right now to reduce medication errors in the Paediatric Intensive Care Unit. *Newborn and Infant Nursing Reviews* 8(2):72–82.

Cohen, H., Robinson, E.S. & Mandrack, M. 2003. Getting to the root of medication errors: Survey results. *Nursing* 33(9):36–45.

Cohen, H. & Shastay, A.D. 2008. Getting to the root of medication errors. *Nursing* 39(12):39–47.

Cologna, M., Pederzini, F., Capretta, F., Malossi, R. & Barelli, P. 2005. Medication errors: Preventive measures in neonatal intensive care. Abstract. *Assistenza Infermieristica e Ricerca (AIR)* 24(1):6–13.

Conrad, C., Fields, W., McNamara, T., Cone, M. & Atkins, P. 2010. Medication room madness: Calming the chaos. *Journal in Nursing Care Quality* 25(2):137–44.

Cousins, D., Sabatier, B., Begue, D., Schmitt, C. & Hoppe-Tichy, T. 2005. Medication errors in intravenous drug preparation and administration: A multicentre audit in the UK, Germany and France. *Quality and Safety in Health Care* 14:190–195.

De Giorgi, I., Guignard, B., Fonzo-Christe, C. & Bonnabry, P. 2010. Evaluation of tools to prevent drug incompatibilities in paediatric and neonatal intensive care units. *Pharmacy World and Science* 32(4):520–529.

De Vos, A.S. 2001. *Research at grass roots: A primer for the caring professions.* Pretoria: Van Schaik.

De Vos, A.S., Strydom, H., Fouché, C.B. & Delport, C.S.L. 2005. *Research at grass roots: For the social sciences and human service professions*. Third edition. Pretoria: Van Schaik.

Dilles, T., Van der Stichele., Van Rompaey, B., Van Bortel, L. & Elseviers, M. 2010. Nurses' practices in pharmacotherapy and their association with educational level. *Journal of Advanced Nursing* 66(5):1072–1079.

Elganzouri, E., Standish, C. & Androwich, I. 2009. Global insight into the medication administration process. *Studies in Health Technology and Information Journal* 146:424–428.

Elliott, M. & Liu, Y. 2010. The nine rights of medication administration: An overview. *British Journal of Nursing* 19(5):300–305.

Fahimi, F., Sistanizad, M., Abrishami, R. & Baniasadi, S. 2007. An observational study of errors related to the preparation and administration of medications given by infusion devices in a teaching hospital. *Iranian Journal of Pharamaceutical Research* 6(4):295–299.

Fernandez, V.F. & Gills-Ring, J. 2003. Strategies for the prevention of medical error in Paediatrics. *Medical Progress* 143:155–162.

Folkmann, L. & Rankin, J. 2010. Nurses' medication work: What do nurses know? *Journal of Clinical Nursing* 19:3218–3226.

Forni, A., Chu, H.T. & Fanikos, J. 2010. Technology utilization to prevent medication errors. *Current Drug Safety* 5(1):13–18.

Franke, H.A., Woods, D.M. & Holl, J.L. 2009. High-alert medications in the pediatric intensive care unit. *Pediatric Critical Care Medicine* 10(1):85–90.

Fry, M.M. & Dacey, C. 2007. Factors contributing to incidents in medicine administration. Part 1. *British Journal of Nursing* 16(9):556–558.

George, E.L., Henneman, E.A. & Tasota, F.J. 2010. Nursing implications for prevention of ADEs in the intensive care unit. *Critical Care Medicine* 38(6):136–144.

Ghaleb, M.A. & Wong, I.C.K. 2005. Medication errors in paediatric patients. *Archives of Diseases in Childhood Education and Practice* 91:20–24.

Gurses, A.P. & Carayon, P. 2007. Performance obstacles of intensive care nurses. *Nursing Research* 56(3):185–194.

Hall, I.W., Moore, S.M. & Barnsteiner, J.H. 2008. Quality and nursing: Moving from a concept to a core competency. *Urology Nursing Journal* 28(6):417–425.

Hall, L.M., Ferguson-Paré, M., Peter, E., White, D., Besner, J., Chisholm, A., Ferris, E., Fryers, M., Macleod, M., Mildon, B., Pedersen, C. & Hemingway, A. 2010. Going blank: Factors contributing to interruptions to nurses' work and related outcomes. *Journal in Nursing Management* 18(8):1040–1047.

Han, P.Y., Coombes, I.D. & Green, B. 2005. Factors predictive of intravenous fluid administration errors in Australian surgical care wards. *Quality and Safety in Health Care* 14(3):179–184.

Hassan, E., Badawi, O., Weber, R.J. & Cohen, H. 2010. Using technology to prevent ADEs in the intensive care unit. *Critical Care Medicine* 38(6):97–105.

Hennessy, S. 2007. Developing standard concentrations in the paediatric intensive care unit. *American Journal Health-System Pharmacy* 64(1):28–30.

Hicks, R. & Becker, S. 2006. An overview of intravenous-related medication administration errors as reported to MEDMARX, a national medication error-reporting program. *Journal of Infusion Nursing Standards of Practice* 29(1):20–27.

Hicks, R.W., Becker, S.C. & Chuo, J. 2007. A summary of NICU fat emulsion medication errors and nursing services: Data from MEDMARX. *Advances in Neonatal Care* 7(6):299–308.

Hicks, R.W., Becker, S.C., Windle, P.E. & Krenzischeck, D.A. 2007. Medication errors in the PACU. Abstract. *Journal of Perianesthesia Nursing* 22(6):413–419.

Hohenhaus, S.M. & Powell, S.M. 2008. Distractions and interruptions: Development of a healthcare sterile cockpit. *Newborn and Infant Nursing Reviews* 8(2):108–110.

IOM (Institute of Medicine). 2003. *Patient safety: Achieving a new standard for care*. Available at: http:// http://www.iom.edu/Reports/2003/Patient-Safety-Achieving-a-New-Standard-for-Care.aspx [Accessed 30 May 2011].

IOM (Institute of Medicine). 2008. *Addressing the barriers to paediatric drug development.* Workshop Summary. Available at: http:// http://www.iom.edu/CMS/3740/24155/57679.aspx?printfriendly=true [Accessed 17 April 2011].

ISMP (Institute for Safe Medication Practices. 2003. *The virtues of independent checks – they really are worth your time.* Available at: http://www.ismp.org/Newsletters/acutecare/articles/20030306.asp [Accessed 4 May 2011].

ISMP (Institute for Safe Medication Practices Alert). 2007. *Another heparin error: Learning from mistakes so we don't repeat them.* Available at: http://www.ismp.org/Newsletters/acutecare/articles/20071129.asp [Accessed 4 February 2010].

ISMP (Institute for Safe Medication Practices Alert). 2008. *Safe practice environment chapter proposed by United States Pharmacopia.* Available at: http://www.ismp.org/Newsletters/acutecare/articles/20081204.asp [Accessed 4 May 2011].

ISMP (Institute for Safe Medication Practices Alert). 2009. *Santa checks his list twice. Shouldn't we?* Available at:

http://www.ismp.org/Newsletters/acutecare/articles/20091217.asp [Accessed 4 May 2011].

ISMP (Institute for Safe Medication Practices Alert). 2011a. *Oops, sorry, wrong patient! A patient verification process is needed everywhere, not just at the bedside.* Available at: http://www.ismp.org/Newsletters/acutecare/articles/20110310.asp [Accessed 4 May 2011].

ISMP (Institute for Safe Medication Practices Alert). 2011b. *Preventing medication errors during codes.* Available at: http:// www.ismp.org/Newsletters/acutecare/articles/20110210.asp [Accessed 4 May 2011].

ISMP (Institute for Safe Medication Practices Alert). 2011c. *That's the way we do things around here.* Available at: http://www.ismp.org/Newsletters/acutecare/articles/20110224.asp [Accessed 4 May 2011].

Jain, S., Basu, S. & Parmar, V.R. 2009. Medication errors in neonates admitted in intensive care unit and emergency department. *Indian Journal of Medical Sciences* 63(4):145–151.

Johnson, M. & Young, H. 2011. The application of Aronson's taxonomy to medication errors in nursing. *Journal of Nursing Care Quality* 26(2):128–135.

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.

Kagan, I. & Barnoy, S. 2008. Factors associated with reporting of medication errors by Israeli nurses. *Journal of Nursing Care Quality* 23(4):353–361.

Kane-Gill, S. & Weber, R.J. 2006. Principles and practices of medication safety in the ICU. *Critical Care Clinics* 22(2):273–290.

Kaushal, R., Bates, D., Landrigan, C. & Adams, C. 2001. Medication errors and adverse drug events in pediatric settings. *Journal of American Medical Association* 285(16):2114–2120.

Keeling, P., Scales, K., Keeling, S. & Borthwick, M. 2010. Towards IV drug standardization in critical care. *British Journal of Nursing* 19(19):30–33.

Kerfoot, M. 2005. Offer safe passage to patients. *Nursing Management* 36(6):36-40.

KFSHRC-J. (King Faisal Specialist Hospital and Research Centre, Jeddah). 2008a. *Policy & Procedure. Medication administration*. Hospital Policy no. NA-J-CL-08-02. Jeddah, 1–7.

KFSHRC-J. (King Faisal Specialist Hospital and Research Centre, Jeddah). 2008b. *Policy & Procedure. Medication system: Nursing responsibilities*. Hospital Policy no.NA-J-CL-08-05. Jeddah, 1–7.

KFSHRC-J (King Faisal Specialist Hospital and Research Centre, Jeddah). 2010. Computerised Physician Order Entry (CPOE) through ICIS. Unpublished information leaflet. Jeddah, September, 1–2.

Kovner, C.T., Brewer, C.S., Yingrengreung, S. & Fairchaild, S. 2010. New nurses' views of quality improvement education. *Joint Commission on Quality and Patient Safety* 36(1):29–35.

Kunac, D.L. & Reith, D.M. 2005. Identification of priorities for medication safety in neonatal intensive care. *Drug Safety* 28(3):251–261.

Larsen, G.Y., Parker, H.B., Cash, J., Connell, M. & Grant, M.J.C. 2005. Standard drug concentrations and smart-pump technology reduce continuous medication infusion errors in pediatric patients. *Pediatrics* 116:21–25.

Lefrak, L. 2002. Moving toward safer practice: Reducing medication errors in paediatric care. *Journal of Perinatal & Paediatric Nursing* 16(2):73–84.

Lenclen, R. 2007. Medication errors in neonatology: A review. Abstract. *Archives de Pediatrie* 14, Suppl 1:S71–S77.

Ligi, I., Arnoud, F. & Jouve, E. 2008. Iatrogenic events in admitted neonates: A prospective cohort study. *Lancet* 371:404–410.

Lucas, A. 2004. Improving medication safety in a paediatric intensive care unit. *American Journal Health-System Pharmacy* 61(1):33–37.

Matthew, L. 2007. Injectable medication therapy: A patient safety challenge. *Nursing Standard Journal* 21(31):45–48.

Mayo, A.M. & Duncan, D. 2004. Nurse perceptions of medication errors: What we need to know for patient safety. *Journal of Nursing Care Quality* 19(3):209–217.

Momtahan, K., Burns, C.M., Jeon, J., Hyland, S. & Gabriele, S. 2008. Using human factors methods to evaluate the labelling of injectable drugs. *Healthcare Quarterly* 11(3):122–128.

Montalvo, I. 2007. The National Database of Nursing Quality Indicators™(NDNQI®). *The Online Journal of Issues in Nursing* 12(3):1–9.

Neoh, C.F., Hassali, M.A., Shafie, A.A., Awaisu, A. & Tambyappa, J. 2009. Compliance towards dispensed medication labelling standards: A cross-sectional study in the state of Penang, Malaysia. *Current Drug Safety* 4(3):199–203.

Otero, P., Leyton, A., Mariani, G. & Ceriani, C.J.M. 2008. Medication errors in pediatric inpatients: Prevalence and results of a prevention program. *Paediatrics* 122(30):737–743.

Ozkan, S., Kocaman, G., Ozturk, C. & Seren, S. 2011. Frequency of paediatric medication administration errors and contributing factors. *Journal of Nursing Care Quality* 26(2):136–143.

Parshurram, C.S., To, T. & Seto, W. 2008. Systematic evaluation of errors occurring during the preparation of intravenous medication. *Canadian Medical Association Journal* 178:42–48.

Petrova, E. 2010. Nurses' perceptions of medication errors in Malta. Nursing Standard 24(33):41–48.

Pflege, Z. 2010. Survey in hospitals: Nursing errors, error culture and error management. Abstract. *Fakultät Gesellschaftswissenschaften der Hoshschule Bremen* 63(9):552–555.

Poe, S.S. 2005. Patient safety: Planting the seed. *Journal of Nursing Care Quality* 20(3):198–202.

Raja, L.R.J., Boo, N.Y, Rohana, J. & Cheah, F.C. 2009. A quality assurance study on the administration of medication by nurses in a neonatal intensive care unit. *Singapore Medical Journal* 50(1):68–72.

Reason, J. 2008. Human error. *West Journal Medical* 172:393–396.

Reason, J.T. & Hobbs, A. 2003. *Managing maintenance error: A practical guide.* Manchester: Ashgate.

Rosen, R.K. 2004. Medication errors: A 21st-century perspective. *Archive of Proceedings Bayl University Medical Centre* 17(4):464–467.

Rothschild, J.M., Keohane, C.A., Cook, E.F., Orav, E.J., Burdick, E., Thompson, S., Hayes, J. & Bates, D.W. 2005. A controlled trial of smart infusion pumps to improve medication safety in critically ill patients. *Critical Care Medicine* 33(3):533–540.

Shane, R. 2009. Current status of administration of medicines. *American Journal Health-System Pharmacy* 66(3):542–548.

Simpson, J., Lynch, R. & Grant, J. 2004. Reducing medication errors in the paediatric intensive care unit. *Fetal Paediatric Education* 89:480–482.

Snijders, C., Van Lingen, R.A., Klip, H., Fetter, W.P., Van der Schaaf, T.W. & Molendijk, H.A. 2009. Specialty-based, voluntary incident reporting in neonatal intensive care: Description of 4846 incident reports. *Archives of Disease in Childhood and Fetal Neonatal Education* 94(3):10–15.

Stievano, A., Jurado, M.G., Rocco, G. & Sasso, L. 2009. A new information exchange system for nursing professionals to enhance patient safety across Europe. *Journal of Nursing Scholarship* 41(4):391–398.

Stommel, M. & Wills, C.E. 2004. *Clinical research: Concepts and principles for advanced practice nurses.* Philadelphia, PA: Lippincott Williams & Wilkins.

Sulosaari, V., Suhonen, R. & Leino-Kilpi, H. 2011. An integrative review of the literature on registered nurses' medication competence. *Journal of Clinical Nursing* 20(3/4):464–478.

Suresh, G., Horbar, J., Plsek, P., Gray, J., Edwards, W.H., Shiono, P.H., Ursprung, R., Nickerson, J., Lucey, J.F. & Goldmann, D. 2004. Voluntary anonymous reporting of medical errors for paediatric intensive care. *Pediatrics* 113(6):1609–1619.

Swanson, A. 2006. Nix the six: Raise the bar on medication delivery. *Newborn and Infant Nursing Reviews* 6(4):230–236.

Tang, F.I., Sheu, S.J., Yu, S., Wei, I.L. & Chen, C.H. 2007. Nurses relate the contributing factors involved in medication errors. *Journal of Clinical Nursing* 16(3):447–457.

Thomka, L.A. 2007. Mentoring and its impact on intellectual capital: Through the eyes of the mentee. *Nursing Administration Quarterly* 31(1):22–26.

Toth, J.C. 2007. Development of the basic knowledge assessment tool (BKAT) for the neonatal intensive care unit: The NICU BKAT3, its uses and effect on staff nurses. *Journal of Perinatal and Neonatal Nursing* 21(4):342-348.

Trbovich, P.L., Pinkney, S., Cafazzo, J.A. & Easty, A.C. 2010. The impact of traditional and smart pump infusion technology on nurse medication administration performance in a simulated inpatient unit. *Quality and Safety in Health Care* 19(5):430–434.

Trossman, S. 2005. Bold new world. *The American Journal of Nursing* 105(5):75-77.

Tucker, J., Parry, G., McCabe, C., Nicolson, P. & Tarnow-Mordi, W. 2002. Patient volume, staffing, and workload in relation to risk-adjusted outcomes in a random startified sample of UK neonatal intensive care units: A prospective evaluation. *The Lancet* 359(9301):99–108.

Van der Schaaf, T.W. 1992. Near miss reporting in the chemical process industry. Unpublished PhD dissertation, Eindhoven University of Technology, the Netherlands.

Walsh, K., Landrigan, C. & Adams, W. 2008. Effect of computer order entry on prevention of serious medication errors in hospitalized children. *Pediatrics* 121(3):421–427.

Walsh, K.E., Landrigan, C.P., Adams, W.G., Vinci, R.J., Chessare, J.B., Cooper, M.R., Hebert, P.M., Schainker, E.G., McLaughlin, T.J. & Bauchner, H. 2008. Effect of computer order entry on prevention of serious medication errors in hospitalized children. *Paediatrics* 121(3):421–427.

Wanzer, L. 2005. Implementing National Safety Goal 3. *Association of Operating Room Nurses* 82(3):471–473.

Wright, K. 2007. A written assessment is an invalid test of numeracy skills. British Journal of Nursing 16(13):828–831.

Wright, K. 2009. The assessment and development of drug calculation skills in nurse education: A critical debate. *Nurse Education Today* 29(5):544–548.

Wright, K. 2010. Do calculation errors by nurses cause medication errors in clinical practice? A literature review. *Nurse Education Today* 30(1):85–97.

ADDENDA

Addendum A: Final HREC approval of research study

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot • your knowledge partner

16 May 2011 **MAILED**

Miss L Cronje
Department of Nursing
2nd Floor
Teaching Block

Dear Miss Cronje

Intravenous medication safety practices of registered nurses in neonatal and paediatric critical care areas.

ETHICS REFERENCE NO: N11/04/126

RE : APPROVAL

A panel of the Health Research Ethics Committee reviewed this project on 28 April 2011; the above project was approved on condition that further information is submitted.

This information was supplied and the project was finally approved on 15 May 2011 for a period of one year from this date. This project is therefore now registered and you can proceed with the work.

Please quote the above-mentioned project number in ALL future correspondence.

Please note that a progress report (obtainable on the website of our Division: www.sun.ac.za/rds should be submitted to the Committee before the year has expired. The Committee will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly and subjected to an external audit.
Translations of the consent document in the languages applicable to the study participants should be submitted.

Federal Wide Assurance Number: 00001372
Institutional Review Board (IRB) Number: IRB0005239
The Health Research Ethics Committee complies with the SA National Health Act No.61 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 Part 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

Please note that for research at a primary or secondary healthcare facility permission must still be obtained from the relevant authorities (Western Cape Department of Health and/or City Health) to conduct the research as stated in the protocol. Contact persons are Ms Claudette Abrahams at Western Cape Department of Health (healthres@pgwc.gov.za Tel: +27 21 483 9907) and Dr Hélène Visser at City Health (Helene.Visser@capetown.gov.za Tel: +27 21 400 3981). Research that will be conducted at any tertiary academic institution requires approval from the relevant hospital manager. Ethics approval is required BEFORE approval can be obtained from these health authorities.

Approval Date: 15 May 2011 Expiry Date: 15 May 2012

16 May 2011 10:04 Page 1 of 2

Fakulteit Gesondheidswetenskappe · Faculty of Health Sciences

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Addendum B: Approval from Nursing Research Council – KFSHRC (J)

مستشفى الملك فيصل التخصصي و مركز الأبحاث
King Faisal Specialist Hospital & Research Centre
Gen. Org. مؤسسة عامة
Jeddah Branch - فرع جدة

NURSING AFFAIRS
INTERNAL MEMORANDUM

MBC J-73 EXT. 65836 3113 FAX EXT. 63442

TO: **LIZA CRONJE**
Head Nurse, NICU
Nursing Affairs

DATE: 14 Jumada Al-Thani 1432
17 May 2011

FROM: **SANDY LOVERING, RN, DHSc**
Chief
Nursing Affairs

REF#: NA-J 740-32

SUBJECT: **APPROVAL FOR PERMISSION TO CONDUCT RESEARCH STUDY ON "INTRAVENOUS MEDICATION SAFETY PRACTICES OF REGISTERED NURSES IN NEONATAL AND PEDIATRIC CRITICAL CARE AREAS"**

Thank you for submitting your proposal to Nursing Affairs for a study entitled: "***Intravenous Medication Safety Practices of Registered Nurses in Neonatal and Pediatric Critical Care Areas***".

The Nursing Research Council has reviewed your proposal and hereby gives approval for the study from a Nursing Affairs perspective. You thus can now proceed with submitting your proposal to IRB.

We do recognize medication safety a very important topic and may contribute to a better understanding of the factors impacting on the occurrence of the errors.

We recommend:

1. Participation in this research is voluntary. It is suggested for the researcher to ask respondents to complete the questionnaire in their own time;
2. The Head Nurse and Clinical Nurse Coordinator of each unit as well as the Program Director needs to be informed by the PI of the intended research prior to sending out email to the nurses;
3. No patient records may be removed from the Hospital at any given point in time;
4. The PI needs to acknowledge that findings based on responses by respondents are not necessarily a true, objective reflection of the medication safety practices in Nursing Affairs.

All our best wishes for your study and we will appreciate it if you will share with us a copy of the thesis once it is completed.

cc: Christina Copplestone, Assistant Chief of Nursing Affairs
Pauline Lagmay, Program Director, Specialty Services
Estelle Bester, RN, DCur, Program Director, Nursing Practice, Quality & Research
Khalid Al-Hroub, Head Nurse, CSICU
Rosy Naidoo, Head Nurse, PICU

SL/sp

Nursing Affairs/MEMOS/MEMOS 1432

Form 11100-14 (09-29) I.C. 82125001061

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Addendum C: Research approval from IRB Chairman- KFSHRC (J)

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King Faisal Specialist Hospital & Research Centre
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Jeddah Branch - فرع جدة
MBC-J04 | Fax # 62983 | Tel # 62984/62982

INTERNAL MEMORANDUM

TO : **Liza Cronje**
Principal Investigator, IRB 2011-16
Head Nurse, NICU
Nursing Affairs

DATE: 23 Rajab 1432
25 June 2011

REF.: RC-J 180-32

FROM : **Osman Hamour, MD**
Chairman, Institutional Review Board (IRB)
Research Centre

SUBJECT : **RESEARCH PROTOCOL - APPROVAL**
IRB 2011-16: *Intravenous medication safety practices of registered nurses in neonatal and paediatric critical care areas*

The above-mentioned research protocol was reviewed and approved at the Board meeting on **12 June 2011** (memo# RC-J 159-32). Reference to your memo of 21 June 2011 (memo# NA-902-32), correction in the title was made to indicate paediatric critical care areas. As I have mentioned in my earlier memo , I am pleased to inform you that the Board appreciates the significance of the study, as medication errors are fatal especially in vulnerable population.

On behalf of the Board, approval is granted for the change of title. Please submt to us the first Biannual Progress Report on or before **12 December 2011**.

Addendum D: Participant information cover letter

TITLE OF THE RESEARCH PROJECT

Intravenous medication safety practices of registered nurses in neonatal and paediatric critical care areas

AIM OF THE RESEARCH

This study aims to describe the perceptions of RNs regarding the factors that influence IV medication safety practices in the NICU, PICU and paediatric CSICU in a particular tertiary hospital in Saudi Arabia.

INFORMATION TO THE PARTCIPANT

You are being invited to take part in a research project focused on the factors influencing IV medication safety practices of registered nurses. 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 study entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate before or during the study. If you say no, this will not affect you negatively in any way whatsoever.

Anonymity will be ensured by the anonymous completion of the questionnaires and the collection of all the questionnaires by placing the completed questionnaires in a box provided. The researcher is not requesting identifying information, e.g. nationality. Therefore, it will not be possible to match your identity with the completed questionnaire. All the information obtained from this research study will remain confidential. Only the researcher, statistician and research supervisor will have access to the collected data. There will be no identifying information on the questionnaires and the educational institution, through which the study is done, will not be identified in any publication, report, or presentation resulting from this research. Since the researcher is in one of the areas involved in the research study, anonymity and confidentiality will be ensured through training and utilizing an administrative assistant who is not employed in any of the research areas. She will be responsible for data collection, manage information sessions (if there are any), opening the sealed boxes containing the questionnaires and data capturing so that the hand writing of registered nurses are not recognizable to the researcher.

Although there are no immediate financial or other benefits to you in this research study, **the result of the study may benefit nursing education and nursing practice by providing insight into the factors influencing IV medication safety perceptions, knowledge related to safe IV medication practice and medication error prevention strategies.** There are no risks associated with this research study, but you may experience some anxiety in the completion of the questionnaire because you are requested to reveal information related to IV medication errors that happened in your unit. Should you experience any distress, the researcher is available and can be contacted.

This research study was approved by the Human Research Ethics Council, Republic of South Africa (reference no: N11/04/126) as well as by the KFSHRC-J Institutional Review Board (IRB), reference no. IRB 2011-16 (RC-J 159-32).

INFORMED CONSENT

Participation in the completion of the questionnaire is voluntary. If you participate, completion of the questionnaire and returning it to the researcher is seen as your informed consent to participate. The success of this study depends on your truthful completion of the questionnaire. Thank you for agreeing to complete the research questionnaire. The questionnaire will take about 30 minutes to complete. Please answer all the questions by making an X in the appropriate block and/or filling in your response where requested. On completion of the questionnaire, please place the questionnaire in the envelope provided, seal and return through internal mail to: **Liza Cronje, HN- NICU. MBC-J 73 Nursing Affairs,** or e-mail the soft copy questionnaire to: **lcronje@kfshrc.edu.sa. Telephone number: 667 7777, ext. 61541.** Or, return through internal mail to **Gowah Gameeldien – Administrative Assistant, Nursing Affairs @62269.** It will be appreciated if you can return the questionnaire before/on **1st September** 2011.

Addendum E: Research questionnaire

SECTION A: BACKGROUND INFORMATION

Please provide your answer with a tick (✓) in the appropriate box.

1. What is your nursing position in the hospital?							
☐ RN	Registered nurse	☐ CNC	Clinical nurse coordinator	☐ HN	Head nurse/Assistant head nurse	☐ O	Programme Director/Quality Analyst/Computer Applications Nurse
2. Please indicate the exact number of years worked <u>at KFSHRC-J</u> in your current position:							
	_____years						
3. Please indicate the number of years that worked <u>in your unit</u> (in your current position):							
	_____years						
4. Please indicate the highest nursing qualification obtained: (Select only one option)							
☐ BSN	BSN (nursing degree)	☐ RN	RN nursing diploma	☐ PG	Post-graduate specialization		
☐ M	Master's Degree (Nursing)	☐ D	Doctoral Degree (Nursing)	☐ O	Other:		
5. Have you completed your check-off exam related to Dosage calculation, Pharmacology and IV medication administration?						☐ N	☐ Y
6. Please indicate whether you are working in the unit that corresponds with your area of specialty:							
☐ Y	Yes	☐ N	No	☐ O	Other (e.g. student):		
7. Please indicate whether you are currently in your unit orientation period or probation period:							
☐ a	Unit orientation period	☐ b	Probation period	☐ c	None		

Medication error prevention related to: medication error incidence, IV medication administration nursing practice, nursing prevention strategies, process limitations and medication safety perceptions of RN's.

SECTION B: FACTORS INFLUENCING IV MEDICATION ERRORS IN THE CSICU/NICU/PICU

8. <u>Human factors</u> may contribute to the incidence of medication errors. Please select THE MOST IMPORTANT REASON for medication errors by providing your answer with a tick (✓) in the appropriate box (SELECT ONE):			
☐ a	Nurse's fatigue or exhaustion	☐ b	Missing one or more than one of the medication rights, i.e. right pt, right drug, right dose, right route, right frequency and due time
☐ c	Work pressure, e.g., running out of time before handing over to the next shift	☐ d	Error prone situations, e.g. when policy is not followed or asking another nurse for clarification, and not the physician directly, use of abbreviations
☐ e	Hesitance to request clarification from the physician's order, if it is unclear	☐ f	Unfamiliarity with the medication

☐ g	Distractions and interruptions during medication administration	☐ h	Incorrect dilution calculations
☐ i	Incorrect dosage calculations	☐ j	Incorrect rate calculations
☐ k	Nurse's lack of concentration	☐ l	Misplaced decimal points, e.g. when programming IV pump rate.
☐ m	High patient/nurse ratio, e.g. ICU patient condition that deteriorates quickly	☐ n	Only one RN checking the rate of the pump with another colleague
☐ o	Advanced drug preparation without re-checking	☐ p	Dilution errors
☐ q	Failed communication, e.g. unclear verbal order	☐ r	Administration of wrong IV medication dilute to central line/peripheral line
☐ s	Misidentification	☐ t	RN not performing double-checks or incomplete double-checks
☐ u	Other		

9. <u>System factors</u> may contribute to the incidence of medication errors. Please select THE MOST IMPORTANT REASON for medication error by providing your answer with a tick (✓) in the appropriate box (SELECT ONE):

☐ a	Complicated/incomplete prescriptions	☐ b	Smart Pump difficult to operate/not user-friendly
☐ c	Insufficient unit-specific training re: medication administration standards.	☐ d	The narrow therapeutic index of medication for neonates and children.
☐ e	Large number of medications scheduled at peak times	☐ f	Standard medication labelling
☐ g	Lack of neonate-specific commercial medicinal products for neonatal use, e.g. the adaptation of adult dosages for neonatal/paediatric use	☐ h	Computerised Physician Order Entry (CPOE) systems, e.g. misplaced decimal points in the CPOE that can lead to confusion to staff
☐ i	Look alike, sound alike drugs	☐ j	Other:

10. <u>Environmental factors</u> may contribute to the incidence of medication errors. Please select THE MOST IMPORTANT REASON for medication errors by providing your answer with a tick (✓) in the appropriate box (SELECT ONE):

☐ a	Work pressure, e.g., running out of time before handing over to the next shift	☐ b	Error prone situations, e.g. when protocol/policy is not followed
☐ c	Patient types, e.g. neonates/paediatric patients who's medication is based on gestational age/weight	☐ d	The critical condition of the patient, e.g. increased workload for RN's assigned patient
☐ e	High patient to nurse ratio	☐ f	Multiple nursing tasks done in a limited time available.
☐ g	Increased workload	☐ h	English is not the first language of the staff working at this hospital
☐ i	Other:		

Please provide your answer with a tick (✓) in the appropriate box.

In my opinion:	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
11. I feel that I have control over environmental influences, e.g. noise level in the ICU that affects my concentration.	☐ SD	☐ D	☐ A	☐ SA
12. IV medication errors are happening in our ICU because of a combination of human, system and environmental factors.	☐ SD	☐ D	☐ A	☐ SA
13. IV medication errors are happening in our ICU because patients require emergency therapy, e.g. multiple IV medications are administered.	☐ SD	☐ D	☐ A	☐ SA
14. IV medication errors occur because of device miss-programming , e.g. setting an infusion to run over one (1) hour instead of over six (6) hours	☐ SD	☐ D	☐ A	☐ SA
15. IV medication errors occur because of IV infusion rates that are accidentally switched.	☐ SD	☐ D	☐ A	☐ SA
16. Misidentification is a reason why a medication error can happen in my unit, e.g. patient misidentification or medication misidentification.	☐ SD	☐ D	☐ A	☐ SA

17. In my opinion, the drug class most often involved in medication errors, is: (please tick ONE)

☐ a	TPN/IL	☐ b	Antibiotics	☐ c	Inotropes	☐ d	Stat IV medications
☐ e	Continuous IV medications	☐ f	Intermittent IV medication	☐ g	Maintenance Infusion	☐ h	Other:

18. In my opinion, medication errors occur mostly during the following times: (please tick ONE)

☐ a	On day duty	☐ b	On night duty	☐ c	During shift change	☐ d	I don't know
☐ e	When 12-hour checks are not done	☐ f	When 24-hour checks are not done	☐ g	Any time during the 24 hours	☐ h	Other:

19. In my opinion, medication errors occur mostly because the following was missed: (please tick ONE)

☐ a	Right medication	☐ b	Right dose	☐ c	Right route	☐ d	Right frequency
☐ e	Right time	☐ f	Other				

SECTION C: INTRAVENOUS MEDICATION ADMINISTRATION PRACTICES OF REGISTERED NURSES

Please provide your answer with a tick (✓) in the appropriate box

In my opinion:	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
20. Routine nursing double-checks by 2 RNs **can** reduce the risk of IV medication administration errors for neonatal/paediatric ICU patients.	☐ SD	☐ D	☐ A	☐ SA

21. Routine nursing double-checks by 2 RNs are conducted during handover at shift change, e.g. double-check infusion rates and physician orders.	☐ SD	☐ D	☐ A	☐ SA
22. The current standard of nurses' practice in the ICU **is** adequate in preventing medication errors.	☐ SD	☐ D	☐ A	☐ SA
23. The implementation and maintenance of standard IV medication concentrations help to provide reliable infusion rates.	☐ SD	☐ D	☐ A	☐ SA
24. Each patient must have a dosage calculation sheet that includes emergency IV medications' dosages and volumes based on the patient's weight.	☐ SD	☐ D	☐ A	☐ SA
25. IV medications require further dilution prior to administration, dependent on whether a peripheral IV or CVC line is in place.	☐ SD	☐ D	☐ A	☐ SA
26. Titrations for IV medication (e.g. Heparin protocol, inotropes) are done by 2 RN's.	☐ SD	☐ D	☐ A	☐ SA
27. Routine checks include whether there is incompatibility with other medication or with the diluting liquid, with each IV medication that I administer.	☐ SD	☐ D	☐ A	☐ SA
28. The patient's assigned nurse **and** a second RN must check the 5 medication rights together by both performing the calculations independently without relying on each other's calculations.	☐ SD	☐ D	☐ A	☐ SA
29. It is important to question my colleague RN's calculation, if it does not correspond with my calculation.	☐ SD	☐ D	☐ A	☐ SA
Double-checks are performed in the following way:				
30. I check with another RN: the patient's identification number & IV medication label against the patient's electronic Medication Administration Record (MAR).	☐ SD	☐ D	☐ A	☐ SA
31. I check with another RN: all pump settings and trace the IV tubing to the site of injection **before** the infusions are started.	☐ SD	☐ D	☐ A	☐ SA
32. When I double-check with another RN, **one of us perform the** medication dose & concentration **calculation** at the time of checking the IV medication.	☐ SD	☐ D	☐ A	☐ SA
33. I independently perform my medication calculation checks and ask another RN to perform his/her calculations for the correct dose and concentration when he/she is finished with his/her tasks.	☐ SD	☐ D	☐ A	☐ SA
Please indicate your agreement or disagreement with the statements below:			**No**	**Yes**
34. Have you intercepted a medication error before?			☐ N	☐ Y
35. Lack of concentration during IV medication administration places my patient at risk.			☐ N	☐ Y
36. When I am in doubt regarding a prescription/calculation, I do not administer the IV medication.			☐ N	☐ Y

SECTION D: MEDICATION ERROR PREVENTION- PROCESSES AND STRATEGIES

Please provide your answer with a tick (✓) in the appropriate box.

In my opinion:	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
37. The way toward safe IV medication administration practices is to create a process that prevents medication errors.	☐ SD	☐ D	☐ A	☐ SA
38. IV pumps enable nurses to work safely and efficiently	☐ SD	☐ D	☐ A	☐ SA
39. The reporting of medication errors is part of my responsibility as an RN	☐ SD	☐ D	☐ A	☐ SA
40. It is valuable for the unit manager to analyze IV medication errors with the unit staff.	☐ SD	☐ D	☐ A	☐ SA
41. Neonatal and paediatric patients require additional safeguards to adult patients.	☐ SD	☐ D	☐ A	☐ SA
42. Nursing double-checks function like 'safety nets' to prevent a medication error from happening.	☐ SD	☐ D	☐ A	☐ SA
43. I believe it is appropriate to check the patient's name and MRN (two identifiers) **before** administering any medication.	☐ SD	☐ D	☐ A	☐ SA
44. There should be a paediatric pharmacist available at all times for critical care patients.	☐ SD	☐ D	☐ A	☐ SA
45. A 'near miss' that did not cause harm to the patient, is **not** a medication error.	☐ SD	☐ D	☐ A	☐ SA
46. I think that technology prevents IV medication errors on my unit.	☐ SD	☐ D	☐ A	☐ SA

47. Examples of technology that prevents medication errors THE MOST, are as follows (please tick ONE):

☐ a	Computerised physician order entry (CPOE)	☐ b	Internet	☐ c	Syringe drivers for administration of IV medication
☐ d	Volumetric pumps for administration of IV fluids	☐ e	Other:		

48. Which method do you consider as the BEST STRATEGY to prevent medication errors? (please tick ONE)

☐ a	Computerised physician order entry (CPOE)	☐ b	Telling a friend
☐ c	Volumetric pumps	☐ d	Reporting of the medication error
☐ e	Root Cause Analysis (RCA) through case review	☐ f	Pharmacy dispensing processes (unit dose dispensing method)
☐ g	Frequent reminders and discussion of medication administration/safety with staff	☐ h	Other:

49. How can medication safety awareness be IMPROVED in your unit? (please tick ONE)

☐ a	Through analysis of medication errors, e.g. case reviews	☐ b	Through the monitoring of practice

☐ c	Regular reviews of protocols and policies	☐ d	Review of IV medication administration standards during orientation of new staff
☐ e	Education related to Medication Error reporting	☐ f	Mathematical Skills Review
☐ g	Other:		

In my opinion:	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
50. Experience, training and skill play a role in safe IV medication administration.	☐ SD	☐ D	☐ A	☐ SA
51. Serum medication levels are done at the correct interval for Phenobarbital and nephrotoxic or oto-toxic antibiotics	☐ SD	☐ D	☐ A	☐ SA
52. It is **not** important to report a medication error if no harm was caused to the patient.	☐ SD	☐ D	☐ A	☐ SA
53. The medication administration procedure in my hospital is time-consuming.	☐ SD	☐ D	☐ A	☐ SA
54. **New staff** receive sufficient unit-specific training related to safe medication administration.	☐ SD	☐ D	☐ A	☐ SA
55. **Experienced staff** receive sufficient ongoing reviews of safe medication administration.	☐ SD	☐ D	☐ A	☐ SA
56. We have access to a formulary/reference specific to neonatal and paediatric patients.	☐ SD	☐ D	☐ A	☐ SA

57. If a medication error occurs on my unit, it immediately gets reported to (please tick ONE):

☐ a	The physician	☐ b	The nurse manager during business hours or nursing supervisor after hours	☐ c	The physician and nurse manager
☐ d	Nobody	☐ e	The clinical nurse coordinator	☐ f	The shift charge nurse
☐ g	Other				

Please provide your answer with a tick (✓) in the appropriate box.

In my opinion:	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
58. IV medication errors may happen at every step of the medication administration process.	☐ SD	☐ D	☐ A	☐ SA
59. It is important to create a unit-specific culture of IV medication safety.	☐ SD	☐ D	☐ A	☐ SA
60. Safe IV medication administration practice ensures the delivery of quality nursing care.	☐ SD	☐ D	☐ A	☐ SA
61. Medication error reporting supports ethical nursing conduct because the patient's rights, health and safety are promoted, advocated for and protected.	☐ SD	☐ D	☐ A	☐ SA
62. Rules should be built in the computer physician order entry system that alert the prescriber& pharmacist that an entered dose falls outside the acceptable dosage range based on the patient's weight.	☐ SD	☐ D	☐ A	☐ SA

63. The fear of punishment prevents me from reporting a medication error.	☐ SD	☐ D	☐ A	☐ SA
64. Most medication errors occur when one, some or all 5 rights of medication administration are omitted.	☐ SD	☐ D	☐ A	☐ SA
65. It is important to have no interruptions during the IV medication administration process.	☐ SD	☐ D	☐ A	☐ SA
Please indicate your agreement or disagreement with the statements below:			**No**	**Yes**
66. I always think about the patient's well-being and safety.			☐ N	☐ Y
67. Staff perceptions of medication safety can affect nursing practice.			☐ N	☐ Y

68. What do you think is the main reason for medication error reporting? (please tick ONE)

☐ a	Don't know	☐ b	To write an incident report	☐ c	To do an analysis of the information obtained to understand why the error has occurred
☐ d	Other:				

69. Is it possible to implement more safety strategies **<u>in your unit</u>** in order to prevent IV medication errors from happening?	☐ N	☐ Y

70. If you have indicated 'yes', what more could be done to improve medication safety in your unit?

Thank you for taking the time to complete this questionnaire.

Addendum F: Language editor's declaration

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DECLARATION

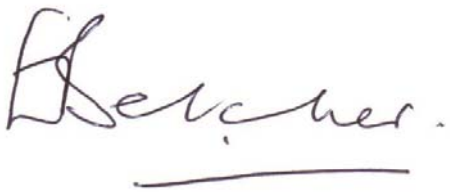
I hereby certify that the Master's thesis named below has been properly language edited.

Title of thesis

Intravenous medication safety practices of registered nurses in neonatal and paediatric critical care areas

Candidate

Liza Cronje



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26 November 2011