Mitigating Nursing Errors in Medication Administration

A Literature Review

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Abstract

Medication Administration Error, refers to any avoidable mistake during the treatment process that harms patients, potentially leading to disability or death. These errors impact human relationships, erode trust in the healthcare system, and can be life-threatening. Medication errors worldwide incur an estimated annual cost of $42 billion USD. Nurses are usually the first course of contact and as well the last call of contact. Nurses are involved in the administration of medication during hospital stay and advice on medication administration when discharging. Mitigating nursing errors in medication administration will improve patient trust with the healthcare service, reduce financial expenditures, increases patient safety, improves patient outcomes and provides a better work environment.

The aim of this literature review was to discover the interventions to mitigate nursing errors in medicine administration. The purpose was to acknowledge interventions of mitigating nursing errors in medicine administration for nursing staff.

The research was conducted as a literature review by utilizing Cinahl and PubMed databases. 11 articles met the predetermined inclusive criteria and were included in the review. The data extracted were organized to determine themes and sub-themes.

This literature review found that nursing errors occurred due to failures in ensuring the 7 Right´s in medication administration. However, these failures were mitigated by organizational strategies such as, implementing policies, providing educative campaigns, providing reasonable human resources as well as providing a non-punitive safety reporting system. Furthermore, nursing personnel and strategies such as, nurse´s attitude, adherence to guidelines, no interruption zone and situation awareness were some of the methods used in mitigating nursing errors in medication administration.

Targeted interventions such as standardization of protocols, staff education, electronic health records significantly reduce medication errors. Furthermore, recommendations such as, mini reminder flash cards could be distributed to nurses and advocation of additional Rights to medication administration as well as, improvements on nursing workloads and resource availability.

Keywords/tags (subjects)

Nurses, mitigating nursing errors, medication administration

Miscellaneous (Confidential information)

None

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1 Introduction

A medicinal substance is designed to treat, prevent, or diagnose a disease, or to restore, correct, or modify physiological functions through pharmacological, immunological, or metabolic actions. MAE, or Medication Administration Error, refers to any avoidable mistake during the treatment process that harms patients, potentially leading to disability or death. These errors impact human relationships, erode trust in the healthcare system, and can be life-threatening. They often occur due to failures in ensuring the rights of medication administration: right patient, right medication, right time, right dose, right route, right documentation and right reason. (Boyd, 2013).

Medication errors worldwide incur an estimated annual cost of $42 billion USD. These errors can happen at various stages of the medication process, influenced by factors like weak medication systems, human factors (such as fatigue, poor environmental conditions, or staff shortages), and impact prescribing, transcribing, dispensing, administration, and monitoring. The consequences can be severe, leading to harm, disability, and even death (World Health Organization, 2017). Nurses provide services and are involved with health care in hospitals, outpatient clinics and homecare services. Nurses are usually the first course of contact and as well the last call of contact. Nurses are involved in the administration of medication during hospital stay and advice on medication administration when discharging (Tsegaye, 2020). Mitigating nursing errors in medication administration will improve patient trust with the healthcare service, reduce financial expenditures, increases patient safety, improves patient outcomes and provides a better work environment (Boyd, 2013).

The author has encountered individuals who have been victims of medication administration errors incurred by nurses. As a pharmacist from Nigeria, the author has encountered several cases during consultation in the community pharmacy. As an upcoming nurse in Finland, the author has discovered the loopholes in which these errors thrive, in both a third world country and a developed nation. Patient safety is utmost. Several factors which contribute to medication administration errors by nurses will be investigated and discussed as well as processes to mitigate such errors.

The aim of this literature review is to discover and break down the potential causes of medication administration errors caused directly and indirectly by nurses and discover methods used in mitigating such errors.

2 Background

2.1 Medicine and Medicine Administration

Medicines are classified according to the disease they are being used for. They are medicinal compounds used in the treatment of diseases such as cancers, non-infectious diseases and more. Medicines are classified according to their functions, such as analgesics used in relieving pain, which are further classified into two groups: narcotic analgesics and non-narcotic. Antacids, which relieves heartburn and indigestion. Antianxiety medication which suppresses anxiety and act also as a muscle relaxer. Antibacterial or antibiotics medication used in treating infections, thrombolytics prescribed for arterial or venous thrombosis and thrombolytics while anticoagulants prevent blood clots. Anticonvulsants are medications used in preventing seizures. Antiemetic medication used in preventing vomiting and nausea, antihistamines medications used for allergic reactions, antifungals for treating fungal infections, antihypertensives which are further divided into several groups used for the treatment of high blood pressure, anti-inflammatories, antineoplastics used in the treatment of cancer, antipsychotics, antipyretics, bronchodilators, corticosteroids, cough suppressants, decongestants, hormones, hypoglycaemics, immunosuppressants, laxatives, sedatives, sex hormones, tranquilizers and many more (FDA, 2015).

2.2 Medicine Administration

Medications are given in different ways, for example, swallowing a pill or injecting into a vein. The choice depends on factors such as, convenience, patient adherence, and how the drug works in the body. It is important to know the details of each method. Nurses play a huge role in giving medications to patients. Medication administration can be divided into two routes: enteral and parenteral route (Kim J, 2023).

2.2.1 Enteral Route of Administration

The oral route of medication is common, easy, and affordable. Usually, the small intestine absorbs the drug, and how much gets into the body is affected by absorption there. The "first-pass effect" is crucial for oral drugs, as it means the drug may be broken down in the liver before reaching the bloodstream, reducing its concentration (Mathias et al, 2010).

Sublingual or buccal administration is another way to give medication without it going through the liver first. Placing the drug under the tongue or on the cheek allows it to be absorbed directly into the bloodstream through the veins in the mouth, skipping the liver's initial processing. Sublingual absorption is faster due to the highly permeable mucosa, while buccal absorption is slower because the tissue is less permeable (Mathias et al, 2010).

Rectal administration is another way to give medication through the rectal mucosa, which absorbs drugs quickly due to its rich blood supply. Like sublingual and buccal routes, rectal administration allows for some bypass of the first-pass metabolism, where the drug is broken down in the liver. Approximately half of the absorbed drug from the rectum avoids immediate processing by the liver (Van Hoogdalem et al, 1991)

2.2.2 Parenteral Route of Administration

Intravenous injection is a common way to administer medication directly into the bloodstream, avoiding the liver's initial breakdown. Peripheral veins, located near the skin's surface, are often used for this purpose in the arms and hands, with a preference for the upper extremities due to lower risks of vein-related issues. Veins like the median basilic, cephalic, or metacarpal veins in the hand are commonly chosen. In the lower extremities, the dorsal venous plexus of the foot can also be utilized (Benbow et al, 2018).

2.2.3 Medication Process

Medication administration is solely not a mechanical task that follows the doctor´s written instructions strictly. It involves thinking and using professional judgment. There are four parts to medication process:

- Prescribing: Frequently, a nurse may be the one to recognize if a doctor has prescribed something the patient is allergic to, possibly due to the nurse's better understanding of the patient (Benbow et al, 2018).
- Dispensing and preparation: “A nurse should avoid using brand names for drugs to prevent confusion. For instance, using "Voltarol" instead of "diclofenac sodium" may lead to misunderstandings” (Boyd, 2013, p.5). It is possible that the pharmacist may have mixed the medication with an incorrect diluent, such as using sodium chloride instead of water for injection (Boyd, 2013).
- Administration: It is crucial to clearly determine the administration route for a medication and ensure that the dosage has been accurately calculated (Boyd, 2013).
- Monitoring: Assess both the administration and the impact of a medicine on the patient. For instance, patients prescribed diclofenac sodium should be checked for asthma. Those with hypertension or heart failure require careful monitoring when given diuretics. Regular checks on blood pressure, fluid intake and output, as well as levels of sodium and potassium, are essential (Boyd, 2013).

2.3 Common Errors in Medicine Administration

A medication error is defined as any avoidable incident that could result in incorrect medication usage or harm to the patient while the medication is under the control of a health professional, patient, or consumer. Medication errors can occur in different stages of the medication process, including prescribing, dispensing, preparation, administration, labelling, packaging, communication, education, and monitoring of treatment. Despite many errors not resulting in harm, using any medication carries inherent risks, as most drugs can cause harm if misused or administered incorrectly. It emphasizes the importance of vigilance and adherence to proper procedures throughout the medication management process. (Jevon et al,2010).

Over the last 40 years, giving medication has gotten more complicated. There are a lot more medications now than there were in 1961. Back then, there were around 1,000 different medications worldwide, but by 1996, there were about 10,000. And now, there are probably even more. Some of these medications have names that sound alike, which can make things confusing. Also, many

companies make the same medication, but they give it different brand names and packaging. This makes it even harder to manage medications (Wright, 2013).

It is a big problem when medications have names that look or sound alike. This can lead to mistakes. Also, the ways we give medications have increased. Now, we can give medications through different types of catheters, injection methods, tubes, patches on the skin, or by mouth. Sometimes, medications are given continuously using electronic devices. All these methods make prescribing and giving medications more complicated and more likely to have errors. With the various ways medications can be given, there is a risk of using the wrong catheter and giving the medication in the wrong way. For example, in operating rooms, drugs were mistakenly given through an epidural catheter instead of intravenously. To prevent these errors, there has been research on changing the infusion taps to make it easier to identify each catheter and route (Wright, 2013).

Hospitals have already adopted this by using purple syringes that cannot be connected to a cannula for oral medications, stopping oral medications from being given intravenously. The current complexities in prescribing and giving medications have raised the chances of errors in healthcare (Wright 2013). Other factors that may contribute to medication administration errors include, uncommonly prescribed medication, medications which are commonly used, in which some patients could be allergic and medicines that often require testing to ensure maintenance of proper therapeutic levels such as, Digoxin, Lithium, Warfarin and others, incorrect patient, incorrect rate when using a pump and improper dose (Wright 2013).

Medication errors and adverse reactions are classified by the NHS as follows:

- Near misses: These are medication errors that do not harm the patient. For example, if 250 mg of amoxicillin was about to be administered, but was corrected to 500 mg (the correct dose per the doctor's prescription) before being given to the patient.

- Medication errors causing harm: These occur when a medication error leads to harm, such as giving a patient an antibiotic they are allergic to. Additionally, an adverse medication reaction can happen even without a known allergy (Wright, 2013).

According to the National Patient Safety Agency (NPSA) in 2003, over a million people are safely treated daily in the NHS, often involving the use of medicines. However, the progress in medicine development and regulation has led to a single drug having various forms with different actions such as long or short-acting and multiple trade names. With patients increasingly managing multiple chronic conditions, different health professionals may prescribe, dispense, and administer their medications. These complexities raise the risk of medication errors (Jevon et al, 2010).

Medication administration errors are often seen as a failure in ensuring the right patient gets the right medication at the right time, dose, and route. While the five "rights" are standard in nursing education, recent literature emphasizes that medication administration is part of a broader, complex process involving a team of healthcare professionals working together. Common administration errors involve giving medication to the wrong patient, using the wrong route, using the wrong dosage form, giving it at the wrong time, giving the wrong dose or rate, or giving the wrong drug altogether. Other errors in this category might involve leaving out doses or missing them entirely (American Society of Health-System Pharmacists, 2018). It's now understood that just following the basic rights of medication administration may not guarantee safe administration by itself.

2.4 Causative Factors of Nursing Medication Administration Errors

Medication-related challenges involved drug products such as generic substitutes, new medications, drug interactions, allergies, demanding treatments, and look-alike and sound-alike (LASA) drugs and the handling of drugs such as irregular administration times, rearranging medications, and transcribing prescriptions. Changes in medications often result from hospitals purchasing from the least expensive providers or opting for cheaper generic substitutes. This posed challenges due to limited knowledge about substitutes and difficulties in recognizing new products with different appearances. Additionally, drug lists for generic substitutes, previously printed, are now only available electronically, requiring more effort to access during manual handling (Härkänen et al, 2018).

New medications make nurses feel insecure due to their lack of experience and knowledge about these drugs and their side effects. Drug interactions and allergies were also challenging, necessi-

tating additional patient monitoring, while nurses reported having limited skills to identify these interactions. Demanding drug treatments, such as cytostatics, required extra patient monitoring, and LASA drugs presented further complications (Härkänen et al, 2018). Furthermore, causative factors such as organizational issues, lack in knowledge and skill acquisition, pharmaceutical drawbacks, polypharmacy, technical issues, multi-tasking and patient management have contributed to medication administration errors (Härkänen et al, 2018).

Organizational issues such as unreasonable operational procedures, different starting times of procedures due to the lack of communication to nursing staff, and large amount of information contributes to medication administration errors (Jin, et al, 2018; Wondmieneh et al, 2020).

Workloads such as a very busy timetable, excessive parallel operations, high patient to nurse ratio, fewer nurses allocated to intravenous drug administration, inadequate time to conduct medication-related task, lower staff usually during night shifts and holidays and demanding drug treatment contributes to medication administration errors (Härkänen et al, 2018; Jin et al 2018).

Employee`s inexperience, lack of necessary skills and education, lack of training in safe administration of medications and demanding drug treatment (Jin et al, 2018; Härkänen et al, 2018; Wondmieneh et al, 2020).

Technical issues such as, deviation between patients own drug list and physician´s prescriptions not updated in the patient drug record. Omission of administration route in electronic records and changes made after physicians' rounds, drug interaction or other problems alerted to the nurse but the doctor is unaware of the issue (Härkänen et al 2018).

Non cooperative patients who are confused, aggressive or suffering from difficulties swallowing may contribute to medication errors and make patient management difficult (Härkänen et al, 2018).

2.5 Interventions to Mitigate Medicine Administration Errors

The "7 rights of medication administration" are commonly emphasized, which include ensuring the right patient, the right drug, the right dose, the right route, the right time, right documentation and right reason. However, this list is not fixed and may change over time. Despite its importance, there's ongoing debate and controversy about this process because there's still the potential for human error. Safe and timely medicine administration is of utmost importance. Nurses need to possess good numerical skills to confidently undertake medication calculation for accurate dose administration and giving high-risk medications to a patient, it's crucial to perform independent checks. This involves double-checking calculations and reviewing the patient's allergies (Puspitasari et al, 2022).

Accurate documentation of medication administration is crucial to prevent errors. Medications given are recorded on the patient's medication chart, either on paper or electronically. The nurse must document the date, time, and dose administered at the time of administration. It's also important to document any actions taken if medication is not administered. This includes recording details of any prescribed medication that wasn't given, along with the reason why. Reasons for not giving a prescribed medication could include the patient being away from the ward for tests or investigations, or the patient refusing the medication (Boyd 2013). Good medication administration involves safely giving medications at the right time as prescribed and following safe practices consistently, regardless of the patient or clinical setting (Pegram et al, 2015).

2.5.1 Standards for Practice in the Administration of Medicines

According to Pegram et al (2015), there are standards for practices in administering medications. These standards are as follows:

- Always ensure patients are correctly identified before administering medication.
- Before giving the medication, always confirm that the patient does not have any allergies to it.
- Understand the medicine´s intended uses, standard dosage, possible side effects, precautions, and any reasons why it should not be given (contraindications).
- Familiarize yourself with the patient´s care plan or pathway.

- Ensure that the prescription or the label on the dispensed medicine is clearly written and easy to understand, without any ambiguity.
- Verify the expiry date of the medicine before administering it.
- Consider the appropriate dosage, the patient's weight, if necessary, the method of administration, the route, and the timing of the medication.
- Give or refrain from administering medication based on the patient´s condition. For instance, digoxin may not be given if the pulse is below 60 beats per minute. Consider other ongoing therapies, such as physiotherapy, when making medication decision.
- Immediately inform the prescriber or another authorized healthcare provider if contraindications to the prescribed medication are found, if the patient experiences an adverse reaction, or if the patient´s assessment suggests that the medication is no longer appropriate.
- Make a clear and accurate record of all medicines given, including those deliberately not given or rejected by the patient. Make sure the signature is easy to read. Also, document when you assign someone else to administer the medicines.

3 Aim, Purpose, and Research Question

This research aims to discover the interventions to mitigate nursing errors in medicine administration. The purpose of this study is to acknowledge interventions for mitigating nursing errors in medicine administration to nursing staff; to improve the quality of medicine care and patient safety; to minimize the economic cost caused by nursing errors in medicine administration, to increase or maintain a strong nurse-patient relationship, to provide a better conducive working environment and eventually patient satisfaction. This study addresses the research question: “What are the interventions used in mitigating nursing errors in medicine administration?”

4 Methodology

4.1 Literature Review

A formal literature review involves conducting an evidence-based and comprehensive analysis of a subject. It critically evaluates the existing collective knowledge on the topic of mitigating nursing errors in medication administration (Winchester et al, 2016).

Performing a literature review is crucial for shaping a research idea. It helps gather existing knowledge on a topic, pinpoint any gaps in understanding, and figure out how your research can add to the current understanding (Winchester et al, 2016).

A literature review is performed systematically by identifying all relevant studies, critically evaluating them, interpreting them without bias, and concluding comprehensively. This meticulous process begins with defining the research question and establishing the criteria for inclusion and exclusion. These criteria are determined by considering multiple aspects of the research process, such as the study population, setting, and design. The next step involves searching for relevant studies across various data sources, including electronic databases, using suitable keywords. Once studies that meet the inclusion criteria are found, their data or content is extracted and analysed (Fink, 2014).

The findings are then critically evaluated, and overall interpretations are made, considering the biases in the existing body of evidence (Rew, 2011). This systematic process enhances the quality and reliability of the research and offers a reproducible framework for other researchers to replicate and validate (Pollock & Berge, 2018). The literature review is a vital aspect of academic research. Essentially, progress in knowledge relies on existing work. To advance the boundaries of knowledge, it's crucial to know where those boundaries lie. Through reviewing pertinent literature insight into the breadth and depth of existing research and pinpoint areas for further exploration. By summarizing, analysing, and synthesizing relevant literature, we can examine specific hypotheses and or formulate new theories. Additionally, we can assess the validity and quality of existing research against predefined criteria, uncovering weaknesses, inconsistencies, and contradictions (Pare et al, 2015). This literature review aims to use existing studies to explore nursing errors during medication administration and processes of mitigating such errors.

4.2 Literature Search

The literature review gathered from different databases such as, PubMed and CINAHL Ultimate (EBSCO). These databases were accessible through the JAMK online student Library. The inclusion and exclusion criteria for the articles were established prior to the search, and they are detailed in Table 1.

According to Hulley et al (2013), Inclusion criteria determine the specific attributes that data must possess to be included in the analysis. The inclusion criteria included the relevant population, and the research involved nurses responsible for administering medications. Setting, studies conducted in clinical settings such as hospitals, nursing homes, or outpatient clinics. Interventions, and research assessing methods to decrease medication errors, including electronic medication administration records (eMAR), barcode medication administration (BCMA), training programs, or standardized protocols. Outcomes, Studies that measure results related to medication errors, such as error rates, adverse drug events, or improvements in medication safety. Study design for example, a range of study designs including randomized controlled trials (RCTs), cohort studies, case-control studies, and systematic reviews. Publication dates and recent studies from the past 10 years were chosen to ensure up-to-date relevance (Hulley et al, 2013).

Inclusion criteria: The Included articles needed to be written in English language, published from the year 2014 to 2024, answer the research question, peer-reviewed and be in full text.

Exclusion criteria: The articles that were excluded were those not written in English, published outside the specified timeframe, did not address the research question, were review articles, not peer-reviewed, or were unavailable in full text. Table 1 below illustrates the inclusion and exclusion criteria.

Table 1: Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Articles written in English Language.	Articles not in English.
Articles published from 2014 to 2024.	Articles outside of the selected timeframe.
Articles that answer the research question.	Articles that do not answer the research question.
Peer-reviewed research article.	Non research articles and not peer reviewed.
Full-text available.	Full-text not available.

4.3 Article Selection

The data search used was done with the combination of key words such as, Nurs*, errors, mitigat* prevent*, reducing and medic* administration. The additional terms used are illustrated in the PICOs-model in table 2 below.

Table 2. PICOs criteria for mitigating nursing errors in medication administration.

PICOs	Criteria
Population	• Population includes registered nurses, student nurses and nurses. • Hospitals, clinics, nursing homes and other healthcare facilities.
Interventions	Interventions of interest: • Education and training programs focused on medication safety. • Using double-checking system and barcode technology. • Implementation of electronic medication administration records. • Developing and enforcing standardized protocols and guidelines.
Comparison and context.	Comparative interventions: • Absence of standardized protocols and guidelines. • Routine practices without additional training or technology. • Medication administration without double-checking system or barcoding
Outcome	Outcome of interest: • Reduction in medication administration errors • Enhanced nursing adherence to medication protocols. • Decreased in adverse drug events. • Improved patient safety and health outcomes.

A total of 168 studies were retrieved from both databases, 94 through CINAHL and 74 through PUBMED. The article selection was done by further extensive search of selecting full text and year of articles between January 2014 to August 2024. Further selections were retrieved based on the title and abstract, through CINAHL, 25 articles were selected and through PUBMED 47 articles were selected. Duplicates were identified and subtracted from the selected articles. The number of duplicates summed up to 12 articles, which were eventually removed, thereby resulting to a total of 26 articles. After full-text appraisal and peer reviewing, 11 articles were selected because they answered the research question and scored above 26 due to their reliability and quality. These 11 articles or studies were then critically appraised to determine their quality and assess the

reliability of their findings (Hawker et al., 2002). Following the quality assessment criteria proposed by Hawker et al. (2002), each study was evaluated across nine different aspects: abstract and title, introduction and aims, method and data, sampling, data analysis, ethics and bias, results, transferability or generalizability, and the implications and usefulness of the findings. Each aspect was rated on a scale from 1 to 4, with 1 representing the lowest quality (very poor) and 4 representing the highest quality (good), resulting in a maximum total score of 36.

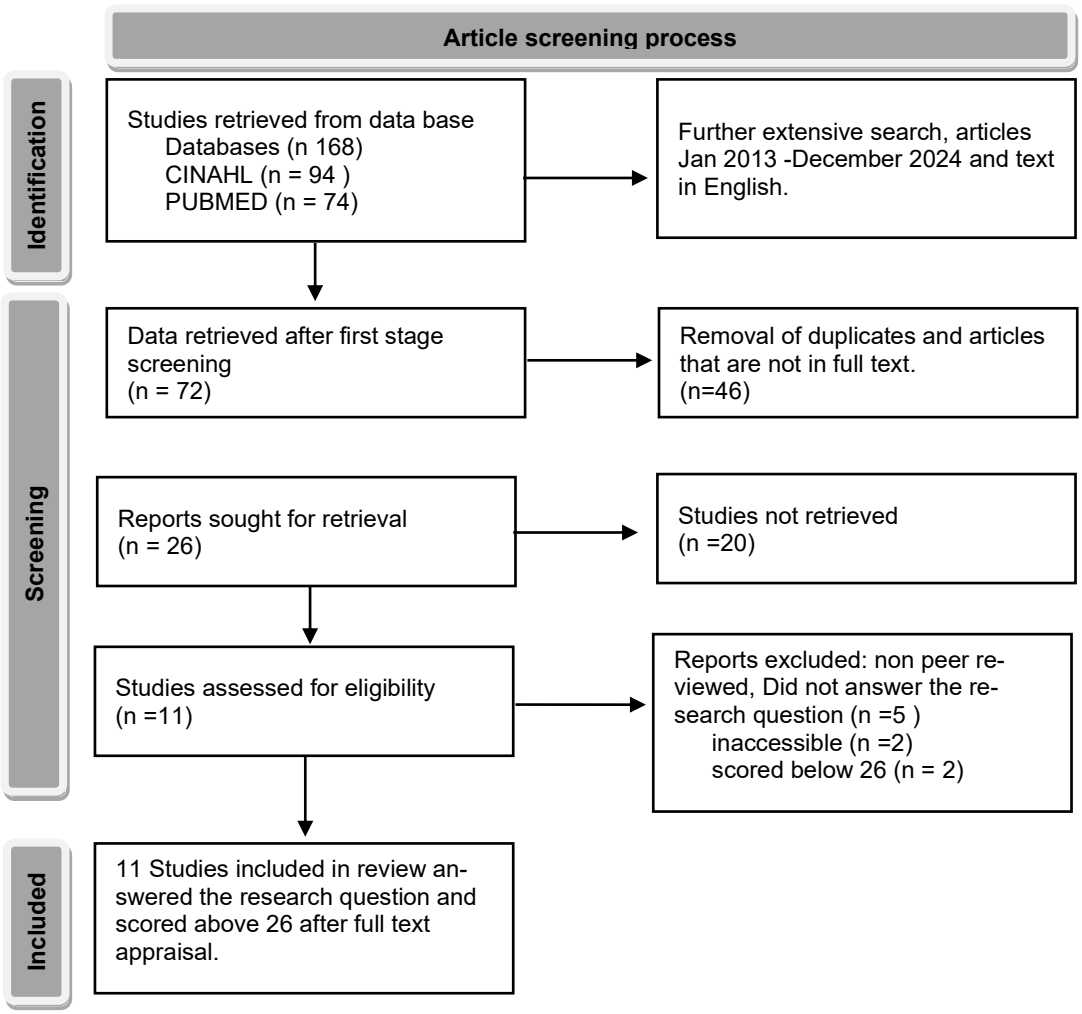

Figure 1. Article screening process

The quality of the articles included in the review was assessed using the Hawker et al. (2002) appraisal method. Each article was evaluated across nine categories, with a maximum score of 4 per category, resulting in a total possible score of 36. The articles reviewed received scores of which 27 points was the lowest score and 35 points was the highest score. Detailed critical appraisals can be found in Appendix 1.

4.4 Data Analysis

Data analysis is a crucial component of research that identifies, evaluates, and interprets complex trends and associations within the data or content (Raskind et al., 2019). In qualitative data analysis, various methods are used in standard research practices. Content analysis is one of the commonly employed methods, which can be conducted using either an inductive or deductive approach (Erlingsson & Brysiewicz, 2017). The inductive approach involves analyzing data from specific observations to broader generalizations and is preferred for novel research questions. Conversely, the deductive approach moves from general principles to specific instances and is used to address specific research questions and explore deeper concepts related to known or established ideas or processes (Elo & Kyngäs, 2008).

According to Babbie (2010), there are several key steps to data analysis, which are:

- Data Collection: Gathering raw data from sources like surveys, experiments, or databases.
- Data Cleaning: Fixing errors and removing inconsistencies or missing values in the data.
- Data Transformation: Converting data into a usable format for analysis, such as normalizing or summarizing it.
- Data Modelling: Using statistical methods to find patterns, relationships, or trends in the data.
- Data Interpretation: Understanding the analysed data, drawing conclusions, and making recommendations.

Data analysis is important in fields like business, healthcare, and social sciences. It helps to make decisions based on evidence. Find trends and patterns for new insights. Evaluate how well strategies or interventions work. Predict future outcomes or behaviours. An example in healthcare, data analysis can identify factors and correlations in the data (Babbie, 2010; Thomas, 2006).

Inductive data analysis involves deriving general principles from specific observations, typically used in qualitative research to develop new theories and insights. There are several steps to induction criteria, which are data collection, these are collected detailed information from observations, interviews, or case studies (Thomas 2006). Deductive data analysis involves testing pre-existing theories or hypotheses with collected data, often used in quantitative research. There are several steps involved in deductive data analysis, these are, hypothesis formation which begins with a clear hypothesis based on existing knowledge (Babbie, 2010).

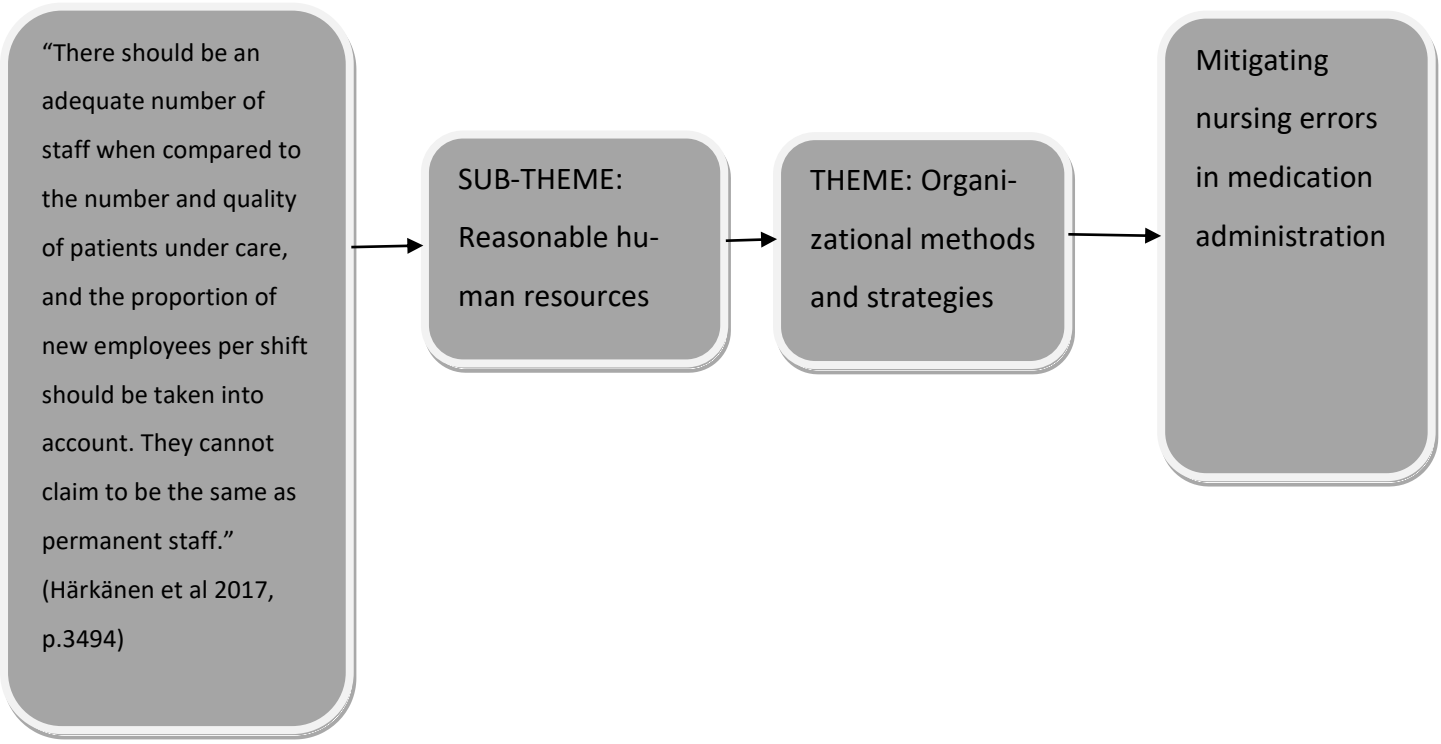

Figure 2. Example of data analysis process

5 Results

The studies included in this literature review were published in Australia (1), Brazil (1), South Africa (1), Saudi Arabia (2), Canada (1), Finland (1), United States of America (4).

The research methods of the reviewed articles were longitudinal quantitative research methods, integrative literature reviews, and mixed method research design by using self-report surveys and

semi-structured interviews. Simulation laboratory research and cross-sectional surveys. The summaries of these reviewed articles can be found in Appendix 2.

The findings of the reviewed articles, which answered the research question were divided into Eleven themes. Sub-themes are explained in text. The themes and sub-themes are both illustrated in Table 3.

Table 3. Themes and sub-themes

THEME	SUB-THEME
Organizational methods and strategies	• Implementation of policies and guidelines • Educative campaigns • Non-punitive safety reporting system • Rewarding and providing resources • Computerized provider-order entry system. • Reasonable human resources
Nursing personnel methods and strategies	• Nurse´s attitude during medication administration • Adherence to guidelines • Visual timers • No interruption zones • Speaking aloud during administration • Multidisciplinary collaboration • Situation awareness

5.1 Organizational Methods and Strategies

5.1.1 Implementation of Policies and Guidelines

The compulsory implementation of medication administration policy and guidelines is of utmost importance in mitigating medication administration errors. These policies include Prepare and give one medication to one patient at a time (Alomari et al, 2020).

Medication must be handled by the same nurse, the preparation, recording, and administration of the medication. Two nurses must independently verify the medication process for all IV, IMI, SC, and oral medications. Whenever possible, administer medication at the same time and in the same way as the parent or caregiver does at home. Ensure the medication order is written and

clear; if unclear, do not administer. Verify the correct medication, chart, patient (using an identification band), weight or ideal body weight if overweight, and dosage. If necessary, two independent personnel should calculate the dose. Consult resources or drug handbook if unsure (Alomari et al, 2020).

Administer medication at the correct time and date. Take special precautions: check for allergies and confirm with parents, verify both brand and generic names, check the dilution and administration rate for IV medication, and double-check pump settings. Confirm the prescribed route on the medication chart. Oral medications requiring a syringe must be given with an oral syringe. Check IV access before administering IV medication (Alomari et al, 2020).

It is important to determine if the medication needs to be double-checked (IV, IMI, SC, oral, rectal, and vaginal drugs) and reinforce independent double-checks in administering high-alert medications. If unsure, consult the team leader or reference materials. For IV medication, bring the medication to the patient in an individual tray with both the administering and checking nurses. Clearly explain the procedure to the child and/or their caregiver. Both nurses must witness and sign the medication chart upon administration, ensuring patient privacy and comfort (Alomari, et al, 2020; Ghezaywi, et al, 2024).

Label all prepared additive solutions accurately. Properly discard all equipment used at the bedside after the procedure. If IV medication is given over time, multiple nurses may maintain the infusion with proper handover (Alomari, et al, 2020).

Record any withheld or missed doses on the medication chart using the designated code (Alomari, et al, 2020) Both nurses must witness and sign the medication chart upon administration (Alomari, et al, 2020).

Organizational strategies such as employee and manager meetings and the Deviance positive technique, which improves processes through participant suggestions. Involving key personnel in work processes, with flexibility to design and test solutions, significantly enhances performance and processes, revealing that weak work systems are prone to medication errors (Härkänen et al, 2017; Almaqadi et al, 2022).

Effective management of high-risk medications should be prioritized, and protocols for their handling should be standardized to reduce errors. Nursing teams, being with patients around the clock, play a crucial role in ensuring safe and quality care through systematic and organized practices (Bessa, et al., (2019).

5.1.2 Educative Campaigns

Educational methods such as clinical simulations contribute to mitigating nursing medication administration errors. At an Australian university, a study with nursing students utilized clinical simulation to foster reflexive learning. This safe environment allowed students to gain positive learning experiences, improve deductive reasoning, and enhance their ability to analyze practical situations. This strategy can also be extended to practicing professionals to further minimize errors in their daily practice (Bessa, et al., (2019); Hayes, et al., (2015).

Organizing educative campaigns towards increasing awareness of medication errors. Nursing education sessions will stress the importance of preventing errors from reaching patients and ensuring thorough independent double-checking, from patient identification to medication administration. Nurses should be aware of the pharmacy's schedule for preparing and delivering compounded medications (08:00–15:00 on weekdays) and should request these medications in advance to maintain an adequate supply. Additionally, these sessions will remind nursing staff about resources for safe medication administration, storage and improve on continuous training (Ghezaywi et al, 2024; Härkänen et al, 2017; Almaqadi et al, 2022)

5.1.3 Non-punitive Safety Reporting System

Reporting near-misses and medication errors to initiate measures or plans to contain and prevent errors is of utmost importance. These can only be addressed through a non-punitive safety reporting system. This provides a way of giving nurses support who had committed medication administration errors, and these errors often have a negative psychological outcome. Emotional support to the nursing staff is of utmost importance as well as enhancing communication and cooperation within the healthcare team (Blignaut et al, 2022; Härkänen et al, 2017; Weant et al, 2014). These systems encourage healthcare workers to report errors or near misses without fear of punish-

ment, which helps improve patient safety by identifying and addressing potential risks (Blignaut et al, 2022; Härkänen et al, 2017).

Blignaut et al, (2017), indicated that a non-punitive system promotes a safety culture where learning from mistakes is prioritized over blaming individuals. Such systems increase the number of reported incidents and provides valuable data to improve processes and prevent future errors (Blignaut et al, 2022; Härkänen et al, 2017).

5.1.4 Rewarding and Providing Resources

Institutions should reward leaders who show mindfulness at all levels to help nurses understand how different factors cause errors and develop ways to prevent them. A safe environment where staff can report issues and suggest solutions is also important. Organizations need to invest in better communication, reducing confusion, improving knowledge and skills, and ensuring staff are less stressed. Nurses and healthcare providers can improve patient safety by using available resources to learn about medication errors, communicating effectively with each other and patients, and supporting a safe reporting environment to learn from mistakes (Cloete. L. 2015; Härkänen et al, 2017).

There should be a calm and efficient working environment with appropriate tools. The importance of maintaining peace and quiet when dispensing drugs or managing medication shifts is of crucial importance and as well emphasizing the need to avoid rushing and to balance the workload. The tasks should be manageable without haste, allowing for concentration. A designated space for medication tasks should be well-lit and equipped with functional and safe tools. Additionally, it is crucial to keep supplies organized to prevent confusion (Härkänen et al, 2017). Actively engaging clinical nurses in developing and implementing interventions through action research approach is of utmost benefit in mitigating medication administration errors (Alomari et al, 2020).

5.1.5 Computerized Provider-Order Entry Systems.

Implementation of computerized provider-order entry systems to reduce transcription errors and improved clarity, elimination of handwritten prescriptions and a barcoding system to verify patient and medication (Weant et al, 2014; Kruer et al, 2014; Almaqadi et al, 2022).

Closed loop medication administration system (CLMA), It was necessary to track monthly compliance and troubleshoot issues that prevents nurses from using the CLMA system, such as medication order entry methods, dose limits, QR code presence, and Wi-Fi connectivity. Conditions for acceptable manual signing also needs to be determined. The strict enforcement of CLMA use, with immediate consultation with the shift's CLMA superuser for issues. Each shift would be monitored by a designated CLMA superuser to ensure all medications were checked, regardless of CLMA use, and to understand why it wasn't used (Ghezaywi et al, 2024).

5.1.6 Reasonable Human Resources

Patient-nurse ratio and working hours significantly impacts the quality of medication administration. A high patient nurse ratio and extended working hours increases the risk of medication administration errors. Organizations should have an adequate number of nursing staff per department. Increasing the number of registered nurses recruited and reducing the number of practical nurses in hospital settings can help mitigate medication administration errors (Frith et al, 2012; Härkänen et al,2017). Keeping a good patient-nurse ratio and reasonable work hours is crucial to reducing medication errors. Adequate staffing, fewer interruptions, and addressing nurse fatigue are key to improving medication safety (Frith et al, 2012).

5.2 Nursing Personnel Methods and Strategies

5.2.1 Nurses Attitude during Medication Administration

According to Härkänen et al (2017), It is recommended that focusing on the task of medication administration and performing tasks accurately and precisely, even when busy, to prevent medication errors is necessary. It is also stressed that the person giving the medication should focus only on that task, do one thing at a time, and avoid distractions.

Verification of drug information was considered crucial for preventing medication administration errors (MAEs). It was frequently mentioned of a need to verify drug information before administering medication. This includes checking the drugs patients were taking, drugs taken at home, prescriptions, and drug lists. They also highlighted the importance of verification during medication administration. Many reporters emphasized the need for double-checking the medication,

ensuring the correct drug, verifying the functionality of the infusion route or cannula, and confirming the correct drug strength (Härkänen et al, 2017; Almaqadi et al, 2022).

5.2.2 Adherance to Guidelines

Adherence to guidelines by nurses refers to the extent to which nursing professionals follow established protocols and procedures, particularly during critical tasks like medication administration, patient care, and documentation. Ensuring adherence to guidelines is essential for maintaining patient safety, improving clinical outcomes, and minimizing errors. Nurses should adhere to established guidelines and maintain a responsible attitude towards medication administration as well as adhere to proper documentation (Härkänen et al, 2017; Kruer et al, 2014)

5.2.3 Visual Timers

Medication administration task such as the use of visual timers for intravenous pushes is of utmost importance. Previous findings showed that nurses frequently lost track of time when interrupted during the administration of IV push medications, leading to drugs being administered too fast or too slow, which can have serious effects on patients. To address this, a visual timer can be used and attached to each IV pole along with the infusion pump. Instead of functioning like a numerical stopwatch, the timer displayed time by gradually reducing a coloured visual indicator, without any audible alarms or distractions. Nurses would initiate the timer before starting manual IV pushes (Prakash et al, 2014).

5.2.4 No Interruption Zones

The primary goal of no interruption zones is to minimize the risk of medication errors by ensuring nurses can focus solely on administering medications without unnecessary distractions. Interruptions during this process have been shown to increase the likelihood of errors, such as wrong medication, wrong dose, or wrong patient, which can have serious consequences for patient safety. Designated areas can be marked, special vest could be worn. There is an exception, the no interruption zone can be broken in cases of emergencies. Research has shown that, the no interruption zone technique has resulted in the reduction of errors, enhanced patient safety and improved efficiency (Prakash et al 2014).

No interruption zones with motion-activated indicators, an example is the area around infusion pump poles which can be marked as a 'No Interruption Zone'. It has a motion-activated 'busy' indicator which lit up when nurses approached to hang bags, adjust tubing, or program infusion pumps. This signalled to others that the nurse was performing an important task and should not be disturbed (Prakash et al 2014).

5.2.5 Speaking Aloud During Medication Administration

Speaking aloud during medication administration is a practice where healthcare professionals verbalize their actions and thought processes while administering medications. This technique is often referred to as "verbalizing" or "think-aloud" and is used as a strategy to enhance safety and adherence to protocols during medication administration. Speaking aloud has resulted in improving awareness, reinforcing guidelines and enhancing accountability (Prakash et al, 2014).

Speaking aloud during infusion pump programming assisted in mitigating nursing medication administration errors and the use of a reminder signage to assist nurses in recovering from interruptions during pump programming and to ensure they correctly set infusion parameters after being interrupted, strategic signage can be placed on and around infusion pumps. This signage reminded nurses to verify infusion parameters, clamps, and tubing connections. The prominent placement of the signs on the IV pole serves as a visual reminder for nurses to double-check the infusion parameters before administering medications (Prakash et al, 2014).

5.2.6 Multidisciplinary Collaboration

A Multidisciplinary collaboration in medication administration is crucial for ensuring patient safety and enhancing the quality of care. By working together, healthcare professionals can leverage their collective expertise to minimize medication errors, improve adherence to guidelines, and provide holistic care to patients. Implementing strategies that promote teamwork, and communication can foster a culture of collaboration, ultimately benefiting both healthcare providers and patients. the involvement of the clinical pharmacists in medication rounds and review to identify and prevent potential errors, as well as collaborating with other healthcare professionals to ensure comprehensive medication management (Almaqadi et al, 2022).

5.2.7 Situation Awareness

The judgement of a nurse in awareness of a particular situation assist in managing interruptions during medication administration, thereby reducing medication errors and improving patient safety (Sitterding et al, 2014; Speroni et al, 2013). Situation awareness can be implemented using the STAR (Stop, Think, Act, Review) technique. This technique is useful in every aspect of medication administration. Nurses encounter frequent interruptions, and the STAR techniques can assist in restarting concentration and improve situational awareness (Speroni et al, 2013).

6 Discussion

6.1 Discussion of Results

Medication administration errors by nurses were mitigated by organizational strategies such as, implementing policies, providing educative campaigns, providing reasonable human resources as well as providing a non-punitive safety reporting system. Furthermore, nursing personnel and strategies such as, nurse´s attitude, adherence to guidelines, no interruption zone and situation awareness were some of the methods used in mitigating nursing errors in medication administration.

The implementation of strict policies is crucial in minimizing medication errors. Alomari et al. (2020) suggested that having clear guidelines such as administering one medication at a time, double-checking all IV, IMI, SC, and oral medications, and verifying medication details (e.g., patient identity, dosage, allergies) play a significant role in error prevention. The reinforcement of independent double-checks, particularly for high-alert medications, is critical (Alomari et al., 2020; Ghezaywi et al., 2024). Additionally, the need for flexibility and active involvement of key personnel in designing work processes reduces the risk of errors, as weak systems are prone to mistakes (Härkänen et al., 2017; Almaqadi et al., 2022).

Educational initiatives, particularly through clinical simulations, offer nurses and nursing students the opportunity to practice in a safe environment, honing their decision-making and analytical skills.

A non-punitive safety reporting system is essential to encourage healthcare professionals to report errors or near-misses without fear of punishment. This approach fosters a safety culture where learning from errors is prioritized over individual blame. Blignaut et al. (2022) and Härkänen et al. (2017) found that such systems improve reporting, providing valuable data to prevent future incidents and reducing the negative psychological impact on nurses involved in errors.

Maintaining an appropriate nurse-patient ratio is fundamental in mitigating errors, as higher ratios and extended working hours increase the risk of mistakes. Frith et al. (2012) found that ensuring adequate staffing and managing nurse fatigue can improve medication safety. By increasing the number of registered nurses and reducing the reliance on practical nurses, hospitals can create safer environments for medication administration.

Adhering to established guidelines is essential for ensuring patient safety and reducing errors. Nurses must follow protocols meticulously to ensure proper medication administration, as outlined by Härkänen et al. (2017) and Kruer et al. (2014).

Mieiro et al. (2019) and Almaqadi et al. (2022) maintain that the said components helped greatly in reducing medication errors. They contended that with educational campaigns and descriptive manuals and continuous training programs, the level of knowledge of the nurses increases, thereby making them more compliant with safe medication practices. Technological solutions, such as electronic health records and barcode medication administration, offer a further layer of protection by removing human error from the equation—ensuring that the right medication is given. That explains why these strategies have been so important in many studies concerning medication safety.

Some important contributory factors identified for making medication errors include workload, problems with stocks, and poor communication. Better resource management, effective communication protocols, and a supportive work environment are ways of addressing such factors that could lead to a reduction in errors. This demonstrates that health care setting organization and

environmental issues are just as important as individual training and technological interventions (Blignaut et al, 2022; Härkänen et al, 2017).

Sitterding et al (2014), stated that both experiments show that interruptions carry a high risk of errors, but the effect can be mitigated through interventions aimed at effectively controlling the interruptions. Enhancing nurses' situational awareness and the development of strategies for handling structured interruptions is vital to ensure safe medication practice in these dynamic, sometimes unpredictable, healthcare settings.

According to Speroni et al. (2014), it is of a higher essence to understand the causes of near-misses and how preventive techniques in reducing the risk are effective. Inherent personal and institutional factors predisposing near-misses have to be emphasized for the seeking of interventions either through the STAR model (Stop, Think, Act, and Review) or checking whether proper procedures are being adopted. These preventive techniques are mandatory to develop a proactive safety culture for ensuring a fall in serious reportable events.

6.2 Ethical Considerations, Validity, Reliability and Generalizability

Ethical considerations in research ensure the protection of human subjects, maintain public trust, and keep the integrity of the scientific process intact. These generally include informed consent, confidentiality, minimal harm or discomfort, and an upheld scientific validity of the research. Ethical guidelines ensure that the rights and well-being of participants are safeguarded. This involves the provision of informed consent, voluntariness, and protection of vulnerable populations. Conducting ethical research preserves public trust in the entire process and in the findings obtained thereof. When the public observes that studies are carried out in an ethical manner, it will more likely accept and engage in scientific research. Application of ethical research practices allows for prevention of scientific misconduct that includes fabrication of data and plagiarism, thereby promoting the reliability and validity of research findings. The advancement of knowledge and practice in medicine relies on this factor (Shamoo & Resnik, 2009).

Ethical research practices entail evaluating risks and benefits to reduce the possible harm to the participant. This comprises conducting of rigorous ethics reviews for assessing the risks in protocol used in the research. (Emanuel, et al., 2000).

Respect for privacy and confidentiality holds as a sub ethic on which the very edifice of the principles stands since it helps in providing privacy protection to the individuals and in developing trust of the participants in researchers (O'Brien, et al., 2011). Informed consent was obtained from participants, maintaining confidentiality and privacy, and securing approval from an ethics review board (Alomari et al, 2020; Blignaut et al, 2020; Ghezaywi et al, 2024; Prakash et al, 2014; Härkänen et al, 2017; Almaqadi et al, 2022; Sitterding et al, 2014; Speroni et al, 2014).

The studies summarized demonstrate a high degree of validity, as they use a variety of rigorous research methodologies, such as action research, integrative literature reviews, mixed methods design, and quality improvement projects. It was evident that there is always a well-articulated statement of purpose, always with corresponding approaches fitting the purpose. The outcomes have evidence to substantiate them through a detailed data analysis, and it enhances the general validity of the outcomes.

Reliability has been secured in the studies that were reviewed by ensuring systematic and steady data collection and analysis procedures. Several studies have adopted widely accepted research instruments and protocols, including surveys, cognitive task analysis, and simulation experiments. This means that the findings are highly replicable and consistent, as shown by the consistent application of these methodologies in various studies.

The results can be generalized to the diversity of settings and geographical locations represented in this review: paediatric wards, emergency units, public hospitals, and critical care units in Australia, Brazil, South Africa, Saudi Arabia, Canada, and the United States. However, some studies may be bounded in generalizability by the nature of their specific focus on some population or healthcare environment. Generalizability could be increased in future research that tests the application of these findings across broader and more varied settings.

7 Conclusion and Recommendations

7.1 Conclusion

Mitigating nursing errors in medication administration is vital for patient safety, cost savings, and better care quality. This can be achieved through systemic changes, better education, and target-

ed interventions. Targeted interventions like standardization of protocols, staff education, and electronic health records significantly reduce medication errors. Continuous education and technological tools, such as barcode medication administration, effectively reduce errors by improving nurses' knowledge and compliance. A supportive work environment and effective communication are crucial for reducing medication errors. Reducing interruptions and improving situation awareness are vital for medication safety. Combining technology, training, system improvement, and safety culture effectively addresses medication administration challenges. Understanding and preventing near-misses significantly reduces serious medication errors.

7.2 Recommendations

Based on the results from this research the following recommendations are proposed.

- More education should be emphasized on drug-to-drug and drug-to-food interactions and mini flash cards could be distributed to nurses as reminders.
- In addition to existing Rights of drug administration other Rights such as the right atmosphere, the Right attitude, the Right to refuse, the Right education, and the Right response should be advocated.
- Nursing workload and resource availability should be improved.

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Appendices

Appendix 1. Critical appraisal of chosen articles (Hawker et al., 2002)

Author	Abstract and title	Introduction and aim	Method and data	Sampling	Data analysis	Ethics and bias	Results	Transferability	Implication and/ or usefulness	Total
Alomari et al, (2020)	4	3	4	3	4	4	4	4	3	33
Mieiro et al, (2019)	4	2	2	3	3	2	4	4	3	27
Blignaut et al, (2022)	4	3	3	3	4	4	2	3	3	29
Ghezaywi et al, (2024)	3	2	3	2	3	2	4	4	4	27
Härkänen, et al,(2017)	4	3	4	4	4	4	4	4	4	35
Prakash et al, (2014)	4	4	2	4	4	4	4	4	4	34
Kruer et al, (2014)	3	4	4	3	3	4	4	4	3	32
Almaqadi et al, (2022)	4	3	3	4	2	4	4	3	4	31
Sitterding et al, (2014)	4	3	3	2	2	4	4	4	3	29
Speroni et al, (2014)	3	3	3	3	4	3	4	4	4	31
Frith et al, (2012)	4	4	2	3	3	2	3	4	3	28

Appendix 2. Summary of reviewed articles

Authors, year, country	Title	Purpose, aim of study	Research method	Sample (s)	Main results	Critical appraisal (Hawkers et al. 2002)
Alomari. A., Sheppard-Law. S., Lewis. J., Valerie J. Wilson. 2020. Australia.	Effectiveness of Clinical Nurses' Interventions in Reducing Medication Errors in a Paediatric Ward.	The aim was to develop and implement a bundle of interventions to reduce medication administration errors in a paediatric ward.	Action Research (AR) three-phase quantitative design	The study involved six clinical paediatric nurses who were part of the Action Research team.	After the interventions, medication errors decreased by 56.9%, even though more patients were admitted, and more medications were prescribed. Medication errors per 1,000 prescriptions significantly dropped from 2014 to 2016. After the changes, nurses followed medication policies more closely. Safety attitudes among nurses improved in five out of seven areas measured by the Safety Attitudes Questionnaire (SAQ).	33
Mieiro, D. B., Oliveira, É., Fonseca, R. E. P. da, Mininel, V., Zem-Mascarenhas, S., & Machado, R. C. (2019). Brazil.	Strategies to minimize medication errors in emergency units	To assess the strategies used by the Nursing team to minimize medication errors in emergency units.	Integrative literature review.	Integrative review by using databases and analysing, evaluating, and assessing interventions.	Educational strategies (campaigns, explanatory manuals, multidisciplinary committee), organizational strategies (meetings, creation of protocols, work process changes), and new technologies (computerized prescription systems, unit doses, barcoding) were effective in minimizing medication errors in emergency units.	27
Blignaut, A., Coetzee, S., Ellis, S., & Klopper, H. (2022). South	Nurses' Perceptions of Medication Administration	To determine factors perceived to impact on medication administration errors and possible	Mixed-methods research design	683 medication administrators using self-report	Solutions to mitigate medication errors should be tailored to the specific causes identified within a particular context. In Gauteng Province, South Africa, the foun-	29

Africa.	Safety in Public Hospitals in the Gauteng Province: A Mixed Method Study.	solutions in medical and surgical units of public hospitals in Gauteng Province, South Africa.	with a sequential approach.	surveys, and 16 nursing unit managers using semi-structured individual interviews.	dation for improving medication administration safety could include multidisciplinary collaboration and communication, support for nurses from hospital administration, effective hospital systems, procedures, and initiatives, better resource management, and enhanced pharmacological training.	
Ghezaywi, Z., Alali, H., Kazzaz, Y., Ling, C. M., Esabia, J., et al. (2024). Saudi Arabia.	Targeting zero medication administration errors in the paediatric intensive care unit: A Quality Improvement project.	To target zero medication administration errors in the paediatric intensive care unit through a series of quality improvement interventions.	Longitudinal quantitative research. Baseline data reviewed and analysis of medication errors that occurred in 2019.	Pediatric intensive care unit staff and patient records. 28/bed paediatric intensive care unit	The project resulted in a significant reduction in medication administration errors. The implementation of standardized protocols, staff training, and the use of technology such as electronic medication administration records contributed to the improvements.	27
Prakash, V., Koczmara, C., Savage, P., Trip, K., & Stewarts, J. (2014). Toronto, Ontario, Canada.	Mitigating errors caused by interruptions during medication verification and administration: interventions in a simulated ambulatory	To assess the effects of interruptions on medication verification and administration errors, and to design and test the effectiveness of targeted interventions at reducing these errors..	Simulation laboratory experiment.	Experiments in phases A and C were conducted in a high-fidelity simulation laboratory. In this setting, nurses were tasked with	Significantly more nurses committed medication errors when interrupted than when uninterrupted. With interventions, error rates during medication verification and administration tasks significantly decreased. The interventions were effective in reducing errors in verifying medication volumes, programming ambulatory pumps, and performing intravenous push tasks.	34

	chemotherapy setting			performing medication verification and administration within a highly realistic yet controlled environment.		
Härkänen, M., Saano, S., & Vehviläinen-Julkunen, K. (2017). Finland.	Using incident reports to inform the prevention of medication administration errors.	To outline methods for preventing medication administration errors based on the insights from reporters in medication administration incident reports.	Qualitative, descriptive study using inductive content analysis.	Data was collected from two hospitals in Finland between 1 January 2013 to 31 December 2014. 1012 incident reports evaluated.	Reporters' views on preventing medication administration errors were divided into categories related to individuals (accuracy, verification, following guidelines), teams (distribution of work, information flow, documentation), and organizations (work environment, resources, training, guidelines). Recommendations include high moral awareness in medication administration and system support for health professionals	35
Kruer, R. M., Jarrell, A. S., & Latif, A. (2014). United States of America.	Reducing Medication Errors in Critical Care: A Multimodal Approach	To discuss a multimodal approach to reducing medication errors in critical care settings, focusing on changes in technology, training, systems, and safety culture.	Review article.	A review of multiple articles and data sources, not a primary study with a specific sample size.	Medication errors are the most common type of error in health care, representing a significant portion of adverse events. A multimodal approach involving changes in technology, training, systems, and safety culture is recommended to address the multifaceted challenges of medication errors in critical care settings	32
Almaqadi, A. M., Al-anber, W. J., Rubaian, M. O.	Investigating Nurses' Strategies for Reduc-	To explore effective strategies used by nurses to reduce medication	The study analysed data from	The review included multiple studies,	Identified strategies include thorough double-checking procedures, use of technology such as electronic health records	31

M., Almaiteeq, A. M., et al. (2022). Saudi Arabia.	ing Medication Errors	errors in clinical settings.	several databases, including PubMed and CINAHL, using keywords related to medication errors, nursing strategies, and interventions. A systematic approach was employed to identify, evaluate, and synthesize relevant studies.	focusing on various interventions aimed at reducing medication errors by nurses from various hospital departments.	and barcode medication administration, ongoing education and training programs, and effective communication within healthcare teams.	
Sitterding, M. C., Ebright, P., Broome, M., Patterson, E. S., & Wuchner, S.	Situation Awareness and Interruption Handling During Medication	To describe situation awareness (SA) during medication administration and strategies for handling interruptions.	Cross-sectional, descriptive design using cog-	The study involved direct-care nurses in acute critical	Findings revealed that nurse SA involves noticing stimuli, managing uncertainty, assessing relevance, and anticipating interventions. Cognitive time-sharing during medication administration was common.	29

(2014). United States of America.	Administration		nitive task analysis (CTA) methods.	care and medical-surgical environments, analysing 230 interruptions.	SA is crucial for managing interruptions effectively, and CTA helps understand nursing cognitive work during medication administration.	
Speroni, K. G., Fisher, J., Dennis, M., & Daniel, M. (2014). United States of America.	What Causes Near-Misses and How Are They Mitigated	To determine the reasons hospital RNs attribute to near-misses and the techniques they used to mitigate these near-misses to prevent serious reportable events.	Cross-sectional survey study	123 respondents, including 43 self-reported near-miss events and 80 witnessed near-miss events.	Medication administration (19%) and transcription errors (10%) were the most frequent types of near misses. Personal factors (not following policy, inappropriate decision making) and institutional factors (work-related interruptions, poor communication) were identified as causes. Techniques like STAR (Stop, Think, Act, Review) and verification of proper procedures were used to mitigate near-misses.	31
Frith, K. R., Anderson, E., Tseng, F. T., Fong, E. (2012) United States of America.	Nurse Staffing is an Important Strategy to Prevent Medication Error in Community Hospitals	The purpose of the study was to investigate the relationship between nurse staffing levels and medication errors in community hospitals	Quantitative research method	Multiple community hospitals. Participants: hospital staff (particularly nurses) and hospital records related to medication errors.	The study found a statistically significant inverse relationship between nurse staffing levels and medication errors. Higher nurse-to-patient ratios resulted to reductions in medication errors, suggesting that adequate nurse staffing is crucial for improving patient safety in community hospitals.	28