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Factors associated with medication errors in health care and preventive strategies to reduce them; an integrative review.

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Master's Thesis

Novia University of Applied Science

Degree Programme in Health Care and Social Services

Finland, 2024

MASTER'S THESIS

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Degree Programme and place of study: Master's in Health Care and Social Services
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Title: Factors associated with medication errors and preventive strategies to reduce them; an integrative review.

Date: 31.05.2024 Number of pages: 50 Appendices: 4

Abstract

Medication errors (MEs) represents a major patient safety threat in healthcare system worldwide, Global estimation for medication errors related financial burden is US$ 42 billion annually and 4.5-21.8 billion for Europe. This integrative review aims to integrate knowledge related to associated factors of medication errors and synthesize evidence-based strategies to minimize those errors.

This thesis is an integrative literature review using qualitative approach. Data collection was performed systematically accessing three databases: Cinahl Complete, Academic Search Elite, and Medline respectively. Inductive content analysis approach has been chosen for data analysis.

Factors such as workload, poor interprofessional communication, nonadherence to medication guidelines, interruptions in work, lack of experience, and medication complexity were identified as associated factors of MEs. Similarly, Strategies like educational intervention, trained pharmacy assistant involvement in medication administration rounds, integration of technology and nurses' participation in prescription writing were found significantly effective preventive strategies to reduces MEs.

Future research should be focus on multidisciplinary approach in medication prescribing, education intervention and effective integration technology as well as pharmacist in safe medication.

Language: English

Key Words: medication errors, nurses, medication errors prevention and control

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List of abbreviations

MEs	Medication errors
WHO	World Health Organization
NHS	National Health Services
EMA	European Medication Agency
NCCMERP	National Co-ordinating Council for Medication Errors Reporting and prevention
ADEs	Adverse Drug Events
MAE	Medication Administration Errors
VALVIRA	National Supervisory Authority for Welfare and Health
DND	Do Not Disturb
LASA	Look Alike Sound Alike
BCMA	Barcode assisted Medication Administration
CLMS	Closed Loop Medication System
HALT	Hunger Anger Lonely Tired
TENK	Finish Advisory Board on Integrity
GP	General Practitioner
JBI	Joanna Briggs Institute
RNs	Registered Nurse
EENs	Endorsed Enrolled Nurses
RACFs	Residential and aged care facilities
QI	Quality Improvement
UOD	Unacceptable Omitted Dose
PA	Pharmacy Assistant
MR	Medication Reconciliation

1 Introduction

Medication errors (MEs) represents a major patient safety threat in healthcare system worldwide, and millions of patients suffer from unsafe health care, leading to poor clinical outcomes as well as high healthcare expenses. However, “no one should be harmed while receiving health care,” (WHO, 2019). Do no harm is the primary principle of every health care services. Unfortunately, there is powerful evidence of huge burden of preventable patient harm across the world, no matter how developed or developing health care system (WHO, 2023).

Panagiotti et al (2019) claim medication errors as the major contributory factors of patient harm in health care. Around 1 in every 10 patients experience harm, and unsafe healthcare claim more than 3 million deaths annually in global scale. Further, low to middle income countries lose as many as 4 lives in every 100 people from unsafe care (Slawomirski & Klazinga, 2020). Above 50% (1 in every 20 patients) of avoidable medical harms are preventable; among them medication errors contribute 50% (Panagiotti et al, 2019; Hodkinson et al, 2020). Medication errors have posed major financial burden in global economy by increasing health care expenses. Global estimation for medication errors related cost is US$ 42 billion annually (Aitken &Gorokhovich) and estimated economic burden for Europe is 4.5-21.8billion (Hodkinson et al, 2020). According to the research findings preventable medication errors have estimated to cost National Health Service (NHS) in England £98 million per year, and caused 1708 deaths yearly (Elliotit et al, 2021).

“To err is human: Building a safer health system” reported by the US institute of medicine generated the patient safety movements globally, as it reported up to 98000 deaths/year in USA were due to medical errors. In 2017, WHO launched third Global Patient Safety Challenge: medication without harm. This patient safety challenge aimed to reduce preventable medication errors by 50% over five years’ time, by improving health care systems. It aims to focus on patient and public, systems and practice of medication, medicines, and health care professionals (WHO, 2024).

Although, reduction of medication harm or medication error prevention is a global priority, statistical data does not show significant improvement. In-depth knowledge about the

contributing factors of medication errors and implementation of effective preventive strategies are essential endeavors to improve patient safety. Hence, this integrative literature review intends to explore the factors associated with medication errors and synthesize evidence-based preventive strategies to reduce or minimize those errors in health care. By synthesizing existing literature, this study will contribute to the advancement of comprehensive knowledge on factors associated with medication errors and inform evidence-based preventive strategies for healthcare professionals, policymakers, and other stakeholders. Ultimately, it will contribute to enhance patient safety and reduce economic burden of medication related errors on healthcare systems.

1.1 Concepts of medication errors

European Medication Agency (EMA) defines medication error as any unintended failure throughout the medication process, that lead to or has the potential to harm the patient. Medication errors can occur in any stage of medication process for instance prescribing, dispensing, storing, and handling, administrating, monitoring, and considered major public health burden (EMA ,2015). Likewise, medication errors can be stated as the as the failure to execute programmed action to accomplish as planned or the use of incorrect plan to fulfil the intended aim (Kohn et al., 2000).

The United States National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) defines medication errors as, “any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health-care professional, patient, or consumer**”** (NCCMERP, 2015). MEs represent threat in safety and quality of care, hence, it is a matter of concern for health care organizations (Coelho et al., 2023). In addition, medication errors are considered as an unintended negligence in medication process, which may appear at any stages for instance prescribing, dispensing of the prescriptions, storing, preparation or administration (Zyoud et al, 2019). Medication errors can contribute to suffering, mild to severe harm, and even death and disability (WHO, 2019; Eltaybani et al., 2018).

1.2 Classification of medication errors

There are various classification of MEs such as technical errors, systematic errors (e.g., administrational, organizational and processerrors) and human errors including diagnosis, prescription, dispension, medication administration (Khammarnia & Setoodehzadeh ,2017). According to Alrabadi et al (2021) MEs can be categorized into four sub-types based on the reasons of errors; knowledge-based errors, rule based errors, activity based errors, and memory based errors. Furthermore, MEs can be categorized based on manner of errors or how errors occurred. In other words, action omitted, or action taken resulting errors of omission or errors of commission (Hayward et al., 2005)

Errors of omissions:

Failing to record drug allergies or drug adverse reaction are the most common medication errors. In addition, most of the study findings has identified failing to administer prescribed drug as the common omission error (Hayward et al., 2005).

Errors of commissions:

Errors of commission is the quality problems for instance subtherapeutic doses of medications, delays in diagnosis, failure to provide prescribed medication care without any mistakes (Hayward et al., 2005).

Prescribing errors:

Prescription errors refers to the failure in prescription writing process which may result wrong instruction such as prescribing wrong medication, incorrect doses or frequency, inappropriate route, or wrong drug (Aronson, 2009; Jevon et al., 2010).

Dispensing errors:

Dispensing errors refers to variability between the prescription and dispension of drugs for example errors in medication preparation, or packaging from the pharmacy (Jevon et al., 2010; Maharaj et al., 2020).

Administration errors:

Medication administration errors can be defined as the differences between doctor's prescription and what the patient received (Jed et al., 2008). For example administering wrong medicine, wrong dose, wrong time, wrong route and wrong patient (Jevon et al., 2010).

Monitoring errors:

Monitoring errors refers to the failure to observe a prescribed medicine in a way which would be regarded justifiable for instance failure to recognize adverse drug reaction, or failure to respond changes in patients' well-being, failure to do blood test monitoring ((Alldred et al;2008; Jevon et al, 2010).

2 Background

Medication errors are regular topic of discussion in national level as well as international level (Isaacs et al.,2023). According to the studies MEs are the serious problem in health care and can have significant impact in morbidity and mortality in health care settings (Kandasamy et al., 2021). A systematic review conducted by Lewis et al (2009) revealed MEs as the most reported incidents in hospitals. Although, MEs result only few adverse patient outcomes (Billstein-Leber et al., 2018; Isaacs et al., 2020), economic and human cost for instance physical and emotional injury, financial burden, unresolved trauma and long term psychological pressure can be damaging to physical and mental wellbeing (Walsh et al, 2017;Merry & Wahr, 2021).Likewise, emotional trauma experienced by health professional can vary from guilt to mental distress based on the severity of MEs incidents ((Athanasakis., 2019; Stovall et al., 2020).

Tio & Young (2008) describe commencement of medication management process beginning with prescription, dispension of prescribed medicines, storage, and handling of them, followed by administration to the patients. MEs can occur any stage of medication process, as one of the study findings revealed administration errors 56.8%, and prescribing errors 23%, combination of prescribing and administration errors being 14.2%, proving that frequency of error is more prevalent during medication administration (Issac et al, 2020),

Classification and definition of MEs can vary, therefore exact estimation of prevalence of MEs is difficult. Rate of MEs can vary depending on the denominator used for instance patient, medication, or prescriptions. It is also highly affected by the variation in the health care system organization, availability, and awareness of incident reporting system (Inch et al, 2012). A cross sectional study conducted in Iran reported nurses contribute 64,55% of MEs and wrong dose and infusion rate were the most common reported errors (Ceragi et al., 2013). On the contrary, Al-Worafi (2020) reported 39% MEs from general practitioners, followed by 38% from nurses, and 23% from pharmacies. Further, a meta-analysis conducted by multiple researchers (Sutherland et al., 2020; Assiri et al., 2018) showed prevalence of MEs ranging from 32.1% to 94%. Salami et al (2019) strongly believe that each MEs are not just the unethical act but also has the potential to develop severe complications to the patients.

In addition, a cross sectional study conducted by Kandasamy et al (2021) identified at least one type of medication error in 65.60% of prescriptions, which constituted prescription errors, 32.62%, dispensing errors 37.80% and, both prescription and dispension errors 29.58%. Another, observational study reported 13.7% medication administration errors (MAEs) in 2576 medication administration, 11.8% were potentially harmful (Jessurun et al., 2023). According to reports presented by Kuitunen et al (2023) one third of the reported errors were related to high alert medications. Similarly, Laatikainen et al (2020) found omitted medicine (33.9%) as the most common reported MEs and 27.1% of MEs were assessed to cause moderate to severe risk to the patients. Prevalence of harm due to MEs involving high alert medication can vary from 3.8% to 100%, with the overall prevalence of death 0.01%, moderate errors 0.1% to 19.2%, serious errors 0,2% to 15.4% and 1.9% were considered lethal to the patients (Sodré et al., 2021).

Lahti et al (2021) conducted retrospective document analysis of severe MEs reported to the National Supervisory Authority for Welfare and Health (Valvira) in Finland during 2013-2017. According to the study results 52% of MEs have resulted severe harm or death, prevalence of incidence was higher (83%) among older patients aged above 60 years and most likely woman (25.43%) aged over 80 years, 91% MEs assessed as preventable. Like other studies, higher percentage of errors concerning prescribing (38.47%), followed by administration (15.19%) and monitoring (14.17%). MEs process have followed multiple failures and involvement of more than one professional. According to the profession,

involvement of physicians was highest (37.5%), followed by practical nurses (17.23%), registered nurse (13.18%) and, in 28% of MEs multiple professionals were involved (Lahti et al., (2021).

3 Aim and research questions

This integrative literature review intends to explore the factors associated with medication errors and synthesize evidence-based preventive strategies to reduce or minimize those errors in health care.

This study aims to answer following research questions.

I. What are factors associated with medication errors?
II. What are the preventive strategies to reduce or minimize medication errors in health care?

This review has adopted PICO framework to define research problem and formulate research questions. This framework well-known in evidence-based research, to frame and answer clinical and health care related questions (Miller, 2001). In PICO framework “P” stands for population/problem of interest,” I” stands for the intervention/phenomenon of interest,” C” stand for context/comparison and “O” stands for outcome. The target population (P) in this review are patients and all health care workers, (I) refers to synthesized knowledge of factors associated with medication errors and identified preventive strategies to reduce MEs (C) is all health care settings (O) is reduction in MEs, improved compliance with medication administration protocols, and overall improvement in patient health outcomes.

The PICO theory helps to formulate research questions that are easily accessible and answerable to ensure the rigor of the literature search (Fineout-Overholt, 2005; Costa Santos, 2007). Utilization of population, intervention, comparison, and outcome framework helps to generate logical research problem that is searchable and answerable. Likewise, this framework also helps to refine and tailor the concept from the broader topic to the specific.

4 Method

This thesis used an integrative literature review using qualitative approach. An integrative review is the ideal methodology to identify and summarize the current state of knowledge on a subject area (Toronto, 2020).

Creswell (2012) describe literature review as the written summary of existing scientific articles, books and other relevant documents which interpret, analyze different information, develop into themes and subthemes, document the need of further studies if needed. Xiao & Watson (2019) consider literature review as foundation of academic research. Similarly, Holly et al (2012) consider literature review as a primary research approach to understand, measure, and distinguish previously available research studies to answer purposed research question.

Landa et al (2011) explain literature review as a comprehensive tool for gathering explicit information about the intended research topic by the means of rigorous and well-defined approach. Literature review can be categorized as narrative literature review and systematic review. Narrative literature review focuses on exploring the conceptual and theoretical approaches, and popular among the experts. According to Fiegen (2010) a systematic review helps to provides an opportunity for summarizing and critically appraising the literature to enhance the future practice and encourage further research.

4.1. Integrative literature review as a research methodology

An integrative literature review is a broad and non -experimental research design, which allows diverse methodological studies to review, critique and synthesize available evidence following systematic data retrieval and transparent data analysis methods to develop holistic understanding of the research subject (LoBiondo-Wood & Haber, 2010; Sparbel & Anderson, 2000; Torraco, 2005). Integrative reviews incorporate various research designs to reach comprehensive and trustworthy conclusions (Soares et al., 2014). Furthermore, integrative review allows diverse research designs, including both qualitative and quantitative studies, which are very significant in developing evidence-based practices that guide healthcare provisions (Leppäkoski and Paavilainen, 2012; Hopia et al., 2016; Holly et al., 2012).

However, the researcher should ensure unbiased and absolute synthesis of the available evidence, following systematic and transparent methods while reviewing the evidence. A systematic approach comprises clear and concise search criteria's, well defined inclusion and exclusion criteria and quality assessment of selected studies (Whittemore, 2005). Incorporating multiple research designs is very challenging process and might lead to rigor issues, biasness, and inaccuracies (Hopia et al., 2016). Rigorous and evident data analysis methods can facilitate good evidence synthesis, which can undoubtably integrate into practices (Dwyer, 2020). The characteristics of integrative reviews are very close to systematic literature reviews, therefore integrated reviews may be regarded as rigorous (Aveyard and Bradbury-Jones, 2019).

The intended study adopted integrative literature review method to explore current level of knowledge about the associated factors of medication errors and evidence-based strategies for the reduction or the minimization of those errors in health care. The main objectives of the study are to explore previous research studies related to factors leading to medication errors and preventive strategies to reduce them, make thorough review of the selected study samples, and synthesize available evidence to generate comprehensive knowledge about the study subject. This study is s based on Whittemore & Knafl (2005) framework of integrated review.

There are several reasons for choosing integrative literature review as the research methodology. Firstly, an integrated review allows for a comprehensive evaluation of different research studies from diverse methodologies and provides holistic understanding of the study subject (Grant& Booth, 2009). According to Cronin and George (2023) an effective integrated review has the capacity to contribute predominant understanding of the current state of research on the intended study topic and can make recommendation for future research directions. This approach empowers the synthesis of diverse evidence, including experimental and non-experimental studies, thereby providing subtle analysis of associated factors of medication errors and the effectiveness of preventive measures.

An integrated review is the most suitable method to facilitates the analysis of these multifaceted aspects, allow researcher to discover underlying patterns, identify customary themes, and acquire comprehensive insights into the underlying mechanisms leading to medication errors (Whittemore &Knafl, 2005). By integrating findings from diverse study

designs, the researcher can observe repetitive patterns across diverse contexts, presenting robust and vigorous interpretation of the research subject.

Furthermore, an integrative review facilitates the identification of gaps and inconsistencies in the current research, provide guidance for the future research directions and strategies development. After critically analyzing of strength and limitations of previous research studies, researcher can identify further research areas precisely and purpose new approaches to tackle medication errors successfully (Moher et al., 2009).

4.2. Stages of integrative literature review

Whittemore & Knalf (2005) framework of integrative literature review comprises five stages; problem identification or formulation of research problem, literature search, data evaluation, data analysis and presentation of research findings (Whittemore, 2005; Whittemore & Knalf, 2005). This framework is popular among nursing researchers (Oermann & Knalf, 2021).

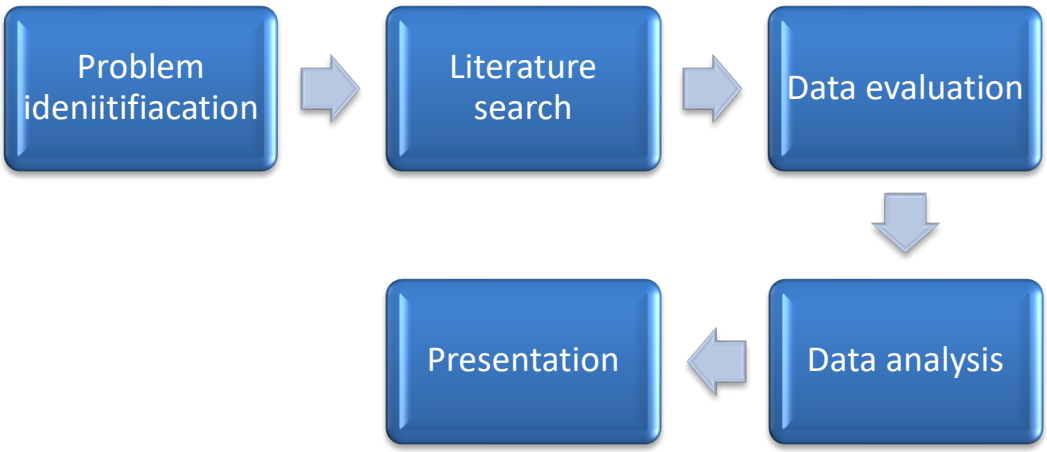


Figure 1. Stages of integrative literature review (Whittemore & Knafl, 2005)

4.2.1. Problem identification stage

The first stage of any literature review starts with clear identification of research problem that the review is going to address, precise research purpose (Whittemore & Knafl, 2005). Well-specified research purpose has the potential to facilitate accurate operationalization

of variables and extract significant data from primary sources (Whittemore & Knafl, 2005). Subsequently, the content of interest for example the concepts, target population and health care problems and suitable sampling frame are determined (Whittemore & Knafl, 2005; Oermann & Knafl, 2021).

Identifying medication error related research problem involve systematic approach. Firstly, thorough investigation of existing literatures related to associated factors of medication errors and effective preventive strategies were performed. The intended information was gathered searching academic databases, journal, and related websites to gather comprehensive understanding of the current state of knowledge on the topic. Furthermore, gap analysis was performed by examining earlier research limitations and identifying discrepancies in research findings and further research recommendations. Practical implication of the possible study outcomes and potential contribution toward patient safety and medication errors reduction has been considered. Subsequently, based on existing evidence on medication errors and preventive strategies, gap analysis and need for further research areas, specific research questions have been formulated to address identifying research problem.

4.2.2. Literature search

The second and most important stage of an integrated review is literature search. Literature search process should be systematic and well defined to enhance the rigor of the review ((Whittemore & Knafl, 2005). An integrated literature review requires comprehensive literature search approach using multiple bibliographic databases along with ancestry search (references of reviewed studies) or purposeful sampling if appropriate with the purpose of the study (Whittemore &Knafl, 2005; Oermann &Knafl, 2021). Literature search process should be clearly documented in method section including search terminologies, used databases, additional search strategies, inclusion, and exclusion criteria for determining relevant study samples (Whittemore & Knafl, 2005). Identification of grey literatures (unpublished thesis, dissertations, conference presentation) is very important (Oermann & Knafl, 2021).

4.2.2.a. Data retrieval

Literature reviews are the research of the previously conducted research work, hence should meet the explicit methodological standards as opted in the original research for methodological rigor and replication (Whittemore & Knafl, 2005; Coughlan et al., 2017). Data retrieval process was completed from 20th Dec.2023 to 2nd Feb.2024 accessing electronic search portal (Tritonia-Finna portal) of Novia University of Applied science, which allows it's students and staffs access to the databases holding scientific literatures. Literature search includes three databases namely Cinahl Complete, Academic search Elite, MEDLINE and same keywords or terminologies were used accompanied by Boolean operator "OR" and "AND". Literature search databases and key terminologies has presented in table 1.

Table 1. Electronic database search and search terminologies

Databases	Search Terminologies
Cinahl Complete Academic search Elite MEDLINE	medication errors OR drug errors OR medication administration errors
	"AND" nurses or nursing or nurse OR nurses' OR nurses'
	"AND" medication errors prevention and control
	medication errors prevention and control
Note: Combine database search has been performed	

Data extraction process consist of identification phase, screening phase and selection phase. Initial result of the literature search has resulted 2629 records, however 2415 studies were removed for not meeting the inclusion criteria, leaving 214 academic articles for the title and abstract screening process. Title and abstract screening excluded 102 articles, shortlisting remaining 112 studies for the full text screening. Each article was read thoroughly, and 35 articles were selected as eligible for the final screening, removing 77 articles for not answering research questions. After full text screening only 13 articles were

selected for the analysis. The selected studies were identified in chronological order as S1 to S13. The study sample selection process was based on pre-determined inclusion and exclusion criteria. Data extraction process has been presented in figure 2 as Prisma flow diagram.

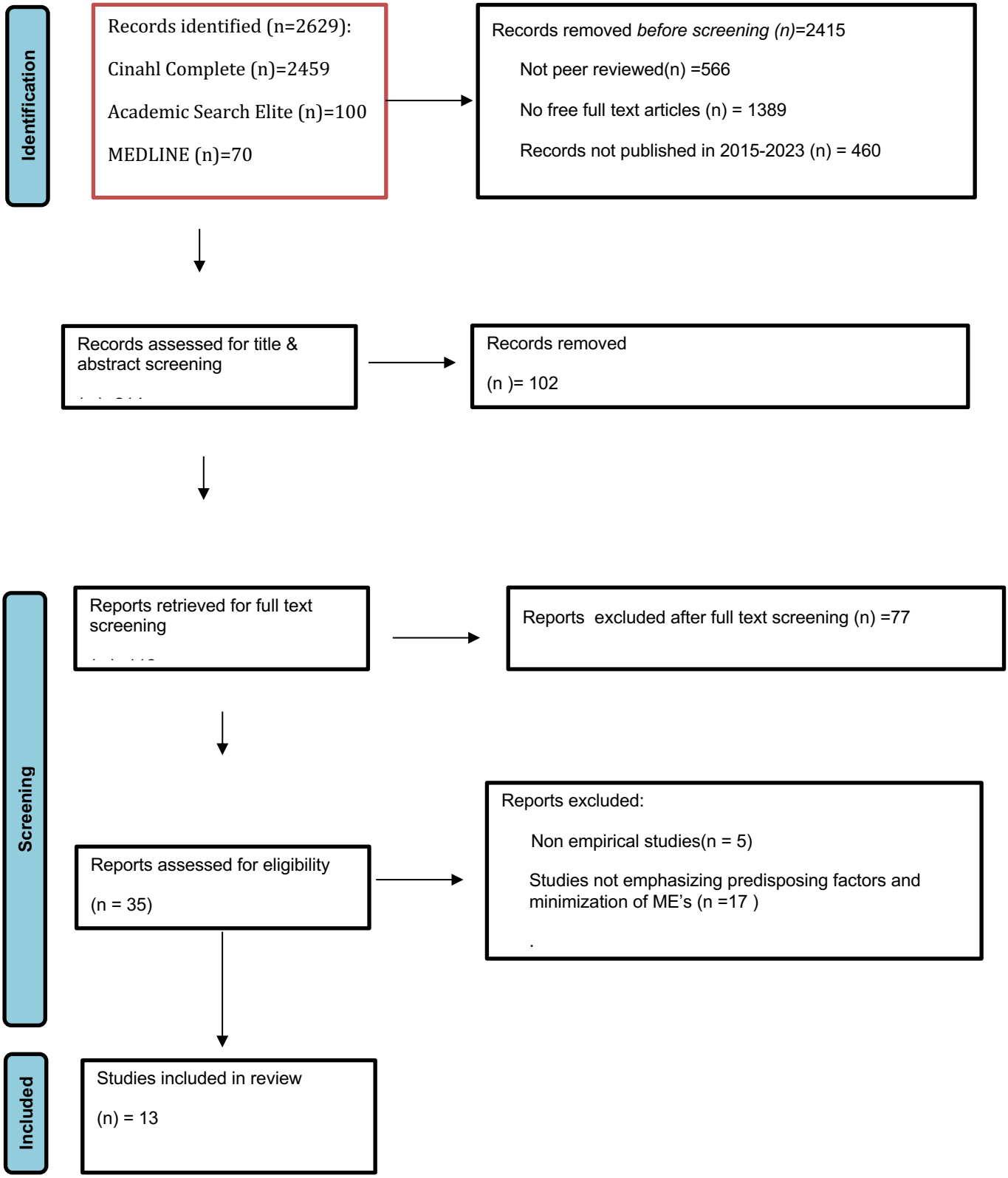


Figure 2. Prisma flow diagram of data extraction process

4.2.2.b. Inclusion and exclusion criteria

The inclusions and exclusion criteria were pre-determined. Studies related to medication errors influencing factors or medication errors prevention were considered eligible for inclusion. However, only empirical studies and studies published in scholarly journal were accepted for the review. Studies conducted by all healthcare professionals, in all health care settings has been accepted for the generalizability of the study result. Similarly, studies addressing all factors leading to medication errors and preventive strategies has been included.

4.2.3. Data evaluation

Literature searches follow the stage of data evaluation. This stage focus on data extraction and critical evaluation of the literatures. Reviewer has the option to select all studies which meet inclusion criteria regardless of their quality (Oermann &Knafl, 2021). All selected articles are critically appraised for determining methodological quality of the review. An integrative review allows diverse research designs, including qualitative as well as quantitative studies, thus, the critical appraisal requires the use of different methodologies compatible to different study designs (Whittemore & Knafl, 2005; Oermann & Knafl, 2021). For the extraction of the findings, there should be source and full reference, the study title, the author, aim of the study, used methodology, the findings, and outcomes (Whittemore & Knafl,2005; Coughlan et al., 2013).

4.2.3.a. Quality Assessment

Quality assessment, also known as critical appraisal, is a crucial step in evidence-based practice that involves evaluating the reliability, validity, and applicability of research studies. It helps to determine the trustworthiness and relevance of research findings for informing clinical decision-making and policy development. Quality assessment involves assessing various aspects of a study, such as its design, methodology, analysis, and reporting, to gauge the strength of evidence it provides (Coughlan et al., 2013).

Quality assessment of this review has been done individually by single author. Joanna Briggs Institute (JBI)critical appraisal tools has been adopted for the assessment. The main purpose of this risk of bias assessment or critical appraisal is to determine the evidence quality of a study by assessing the possibility likelihood of bias in study designs, research methodology and data analysis. JBI critical appraisal tools are also useful for clinical and educational such as creating critically appraised topics, literature search strategy, peer review process as well as journal clubs (JBI, 2019).

The selected articles have been grouped in three suitable study designs namely quasi-experimental study, cross sectional study and randomized control study, respective JBI quality appraisal checklist has been used for the risk of bias assessment. Each study has obtained own score, or percentage as determined by checklist and those scores, or percentage has been used to inform the quality of the study as well as make comparison between different study samples.

The quality of the study samples has been categorized as high (score >70%), medium (score 50%-70%) and low (score <50%). Although JBI critical appraisal checklist does not have such classification, many researchers have adopted previously mentioned classification while discussing the quality level of the study sample. Therefore, the researcher has accepted this as a justifiable categorization, which facilitate to inform overall quality of the selected study samples. None of the selected materials excluded depending upon their quality of evidence. Critical appraisal table of reviewed articles has been presented in appendices.

According to the quality assessment outcome randomized control study (S10) was assessed as high quality, scoring 100% in JBI critical appraisal checklist. This randomized control study has well-presented it's sample selection and allocation process, administration of intervention/exposure, bias related to outcome of the intervention, participants retention and statistical validity. Likewise, the quality of cross-sectional studies ranges from medium to high, JBI score ranging from 62.5% to 87.5% with the mean of 73%. Among the five studies only one (S12) sample has discussed the cofounding factors and strategies to deal with them. On the other hand, lowest scoring (62,5%) cross sectional study (S8) has not presented any inclusion criteria. However, other three studies have scored equal (75%) and assessed as high quality.

The quasi-experimental studies were assessed as medium quality, and four study sample has secured 66.6% and one study secured 77.7%, with the mean of 68.8%. None of the studies explained about the other cofounding variables that could have affected the results. Only one sample have performed multiple measurement of the outcomes in the pre-intervention as well as post- intervention.

4.2.4. Data interpretation

Data analysis is the fourth stage of an integrated review. Data relevant to the research purpose are extracted, using a standard template to ensure rigorousness and consistency, subsequently, reviewer compare the extracted data to interpret and analyze the results (Oermann & Knafl, 2021). Data analysis methods are one of the least developed aspects of integrated reviews and has the possibility of errors (Whittemore & Knafl, 20005). Therefore, method of analysis should be mapped prior to conducting research study (Whittemore & Knafl, 2005; Oermann & Knafl, 2021). Data analysis phase of an integrative review consist of four sub-categories namely data reduction, data display, data comparison, and conclusion drawing and verification ((Whittemore & Knafl, 2005).

4.2.5. Presentation

Fifth or the final stage of an integrated review is presentation of findings with conclusion or summary. The conclusion of an integrative review usually presented in table or diagrammatic forms. The presented summary should describe and exhibits findings of the primary data sources in the form of logical chain of evidence and developed themes. To ensure accuracy and thorough reporting, it is recommended to follow relevant reporting guidelines. Presentation is the stage of projecting narrative information leading to comprehensive understanding of the subject of interest as well as evaluating research methodology, outcome and, implication of the study (Whittemore 2005; Whittemore & Knafl, 2005; Oermann & Knafl, 2021).

4.3. Data Analysis

Data analysis is the crucial steps of thesis writing. It is the process of transforming raw data into meaningful insights through logical summarization of the available data and identification of themes, hence patterns and relationships can be recognized. (Braun & Clarke, 2006). According to Whittemore & Knafl (2005) researcher collect the data for the purpose of synthesizing the evidence in a creative way, thus they are comprehensive and reflects the data source in an unbiased manner.

This study used inductive content analysis for the data analysis process. According to Whittemore et al (2005) integrated reviews can adopt the data analysis methods used for mixed and qualitative research as it uses regular comparison of collected data. The main objective of content analysis is to identify and organize meaning from the collected data and extract logical interference from it.

Content analysis is a flexible method to make replicable and valid inferences by interpreting and coding textual material into concepts or categories and attempt to identify core consistencies and meanings. (Elo &Kyngäs, 2008). This can be used either inductive or deductive approach using quantitative or qualitative data. The quality of available data makes great impact on trustworthiness of content analysis. Thus, data collection, data analysis and reporting of results are equally important, and demands adequate preparation and good research skills (Elo et al, 2014).

This method allows the reduction and grouping of information using available concepts, categories and themes, and those identified concepts , categories and themes serve as the basis of reporting content analysis (Kyngas, 2020). According to Vears and Gillam (2022) content analysis almost identical to thematic analysis, a popular qualitative analysis method, which follows coding, labeling, and grouping of information to answer research questions. The previous researchers also emphasize that the coding should be followed by comparing, grouping and subgrouping and ultimately leading to categories and subcategories.

Griesheim & Lundman (2004) introduced a concept of qualitative content analysis in nursing research, using inductive approach. According to this approach, selected full text articles were read multiple times to obtain the exact picture the context. After several

reading coding and classification is done to determine the main units of analysis and manifest its contents. This study follows Graneheim & Lundman (2004)'s approach for data analysis and basically, it was completed two phases.

Phase I: reading and coding:

After the selection of the scientific articles, full-text article has been read multiple times, and most relevant informations were extracted, and notes were taken. The main keywords of the meaning units were marked using different codes, different signs, and colours.

Phase II: listing and categorizing the codes:

In this phase, the all the notes, marked keywords and other different meaning units were examined for comparing, grouping and developing subthemes. Similar subthemes were consolidated and final version of identified subthemes has been listed. Table 2 and table 3 exemplify the identified codes, subthemes, and themes.

4.4. Ethical consideration

Ethics refers to the correct rules that should be followed while conducting research activities or process. There is the moral responsibility of protecting research participants from any kind of exploitation and harms. Fry & Johnstone (2012) state ethics as system of standards and principles, which guides and controls the action and behavior that are permitted, compulsory and forbidden. This study is an integrative literature review, and the most important ethical principle in such study is to respect intellectual property of other authors and organizations. The researcher has the obligation to give full credit to the authors through proper referencing. Likewise, researcher should avoid the use of unpublished literatures and results without permission. Similarly, author has the moral responsibility to acknowledge every individual who will directly or indirectly contribute for the completion of the study. This is the important learning opportunity for the author and constructive feedbacks and criticisms will be highly welcomed.

Finnish Advisory Board on Research Integrity (TENK), which was founded on 1991, supervise the responsible conducts, address the ethical issues related to research study and works for the advancement and assurance of research ethics in Finland. This supervisory body

guarantees the ethics and research quality as well as supervises research integrity. (TENK, 2024). This study is the synthesis of available scientific literatures, and content analysis, to summarize the results. It did not involve any human subject or animal experimentation. Thus, ethical approval for this study was deemed not required.

5 Findings

This study has included thirteen peer reviewed scholarly articles. There were seven (S2,S3,S4,S5,S9,S11,S13) quasi-experimental studies, five (S1,S6,S7,S8,S12) cross sectional studies and one (S10) randomized control study. Geographically, there were equal number (3) of studies from Australia and United Kingdom, followed by 2 articles each from Finland and Canada. Similarly, one study per country from Ethiopia, Egypt, and Malaysia. Furthermore, review includes studies conducted by multiple professionals, for instance nurses, doctors, and pharmacologist. Four articles (30.8%) have studied contributing factors for medication errors and whereas rest nine articles (69.2%) have examined preventive strategies of medication errors. The comprehensive synthesis of the study units can be found in appendix 4.

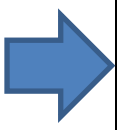
The heterogenicity of the study samples have resulted two broad themes and they are as follows:

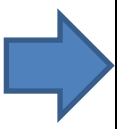
- factors associated with medication errors
- preventive strategies to reduce medication errors

5.1 Factors associated with medication errors

Four (S1, S6, S8 &S12) out of thirteen study units have answered research question one. Number of codes has been extracted from each meaning unit and grouped them into seven subthemes. Emerged themes, subthemes and codes has been tabulated below as table 2.

Table 2. Illustration of themes and sub themes; factors associated with medication errors

Theme: Factors associated with medication errors				
Meaning units	**Results**	**Codes**	**Sub-themes**	
S1: Nurses perspective on medication errors and prevention strategies in residential aged care facilities through a national survey. Kuppadakkath et al (2023)/Australia	Causes of medication errors; inappropriate staffing, unmanageable workload, use of agency staffing, LASA medications, attending phone calls.	Workload. Ineffective inter-professional communication. Interruptions during medication administration.		1. Workload. 2. Poor inter-Professional communication.
S6: Medication administration errors and contributing factors among nurses: a cross sectional study in tertiary hospitals, Addis Ababa, Ethiopia. Wondmieneh et al (2020)/Ethiopia	98.3% participants were nurses, 68.1%reported committing MEs in previous12 months. factors such as lack of adequate training, unavailability of medication administration guidelines, interruption during medication administration, inadequate work experience, and night duty were identified as the as the associated factors of MEs as p value <0.05.	Lack of training on medication safety. Interruption during medication. administration, Work shift & lack of work-experiences.		3. Inadequate knowledge of pharmacology and infection control. 4. Nonadherence to medication administration guidelines and low rate of

		Nonadherence to medication guidelines, low rate of reporting of MEs, unavailability of protocols and guidelines		reporting of MEs 5. Interruptions and distractions
S8: Nurses' self-assessments of adherence to guidelines on safe medication preparation and administration in long-term elderly care. Karttunen et al., (2020) /Finland	1/3rd of the nurses stated that they do not always follows guidelines when preparing medication, around 50% deviate from them occasionally while administering medication. Significant relationship between adherence to guidelines and nurses' self-assessment of their knowledge of pharmacology, medication calculation skills and infection control	Nonadherence to medication guidelines. Inadequate knowledge of pharmacology and infection control		6. Lack of adequate training and unavailability of medication administration guidelines 7. Medication Complexity
S12: The factors associated with medication errors in adult medical and surgical inpatients: a direct observation approach with medication record reviews. Härkkänen et al., (2015) /Finland	Prevalence of MEs 22.2%, administration errors 63.4%, documentation errors 18.3%. Statistically significant risk factors of MEs were every other weekday as compared to Sunday, moring shift threefold riskier than evening shifts, asking for helps, rush in work, increased number of regular medicines, multiple medicine administered time, administration route other than oral, interruptions.	Work shifts, Workload. Medication administration complexity. Work Interruptions.		8. Work shift and lack of work experience

After data analysis eight subthemes has been identified as the associated factors of medication errors. Each sub-themes will be discussed separately in next section.

5.1.1 Workload

The finding of study unit (S1) which intended to explore the causative factors of medication errors and provide suggestions reduce those errors in residential care facilities claims nursing shortage or inappropriate staffing is the key to busy shift or unmanageable workload. Likewise, some of those findings from study unit S6 and S12 are same as the findings of S1. The study results also informed that when there is understaffing or inappropriate staffing, chances of medication errors is always high. Similarly, understaffing can advertently lead to missed dose and wrong medications timing.

5.1.2 Poor inter-Professional communication

The study unit (S2) identified Poor communication among interprofessional staff members for example communication between nurses, physician, laboratory staffs and pharmacist has been found one of the common contributing factors of medication errors. According to the study unit (S1) findings, medication errors can occur due to dispensing delays from the pharmacy or delays in taking blood sample and delays in informing laboratory results. These factors are classified as ineffective communication issues between nurses and other professionals.

5.1.3 Inadequate knowledge of pharmacology and infection control

According to study (S8) unit results nurses' knowledge of pharmacology, medication calculation, and infection control has significant impact on adherence to medication administration guidelines. Although 90% of the participants have assessed themselves as good knowledge of pharmacology and infection control, only 69% have followed hand-hygiene. The same study unit (S8) have also claimed that nurses with better self-assessed knowledge of pharmacology, medication calculation and infection control have had high possibility of adherence to medication guidelines and vice versa.

5.1.4 Non-adherence to medication guidelines and low reporting of MEs

One of the four study unit (S6) have studied magnitude and contributing factors of medication errors among nurses finds nonadherence and unavailability of medication administration guidelines as catalyst of medication errors. According to this study findings 68.1% nurses have made medication errors at least once in last 12 month. Similarly, most of the observed samples (98%) have breached medication safety at least once. Nurse who did not follow the guidelines were two times more likely to make mistakes. Similarly, another study(S8) findings shows one third of the study participants do not follow the guidelines when they prepare medications. For instance, crushing of undercoated and sustained released tablets, crushing different medication tablets, and mixing the powder together, opening capsules, and splitting tablets without splitters were the common deviations. The study also reveals that almost half of the participants claimed to deviate from guidelines when administering medications. In addition, study findings also claim big lapse in error reporting. One of study (S6) reported 83.4% nurse did not report medication errors to the concern authority.

5.1.5 Lack of adequate training and unavailability of medication guidelines

The study unit (S8) reported lack of adequate training in medication safety and unavailability of medication administration guidelines strongly associated with medication administration errors. The same study (S8)also reported that nurses who did not followed guidelines were two times more likely to make medication errors. Similarly, nurses who lacks medication safety training were three times more likely to make mistakes. The study units (S8) findings also claim strong correlation between medication adherence and nurses' knowledge of pharmacology, infection control and medication calculation. The nurses with good knowledge of pharmacology have had the high possibility of adherence to medication guidelines.

5.1.6 Interruptions and distraction

According to the study unit (S12) findings interruption while performing medication administration have significantly increased medication errors risk by 2.42 times. Similarly, another study unit (S6) findings work environment for instance interruptions and distractions for instance presence of other staffs in the medication rooms, supervising

students, rush in the work, answering phone calls, use of agency staffs and managing orientation to them, and distraction by co-workers were the common distractions influencing medication errors.

5.1.7 Work shifts and lack of work experience

One of the study units (S6) claim there is significant relationship between work shift and medication errors. Night shift was considered riskier than daytime shift as risk of MEs was five times higher in night shift. The study finding also claim nurse working in night shifts were five times more likely to make medication errors than nurses working in day and evening shifts. However, another study (S12) findings shows every other weekday having high risk of medication errors compared to Sunday, and risk was very significant on Saturday and morning shift were threefold riskier than evening shift.

5.1.8 Medication Complexity

The study unit (S12) reported use of look-alike and sound alike (LASA) medicines also increased risk of medication errors. LASA medicines looks visually similar in names or physical appearance or similar packaging or have similar spelling similarities or phonetics. Furthermore, physician's verbal medication order via phone or adjustable medication prescription were also responsible for medication errors. According to study (S12) results increase number of regular medications, frequency of medication administration, increased number of medicines taken as needed and route of administration other than per oral also pose risk of medication errors.

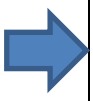
5.2 Preventive strategies to reduce medication errors

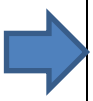
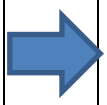
Nine study units (S2, S3, S4, S5, S7,S9,S10,S11,S13) have answered research question two. One of the articles (S2) have studied the effect of leveraging tenologi for medication safety. Three study unit (S5, S7&S11) have focused on educational interventions, including medication errors room simulation. Two of the articles (S3, S9) have studied interprofessional reconciliation, emphasizing participation of nurses in medication prescribing, with significantly positive outcomes.

Similarly, one of the study units (S4) have focused on do not disturb (DND) strategies, rest of the studies have examined the impact of pharmacist assisted medication administration rounds, introduction of hunger, anger, lonely and tired (HALT) model and multiple intervention quality improvement initiative. Number of codes has been extracted from each meaning unit and grouped them into six sub-themes. Emerged themes, subthemes and codes has been tabulated below as table 3.

Table 3. Illustration of themes and subthemes; preventive strategies to reduce medication error

Theme: preventive strategies to reduce medication errors				
Meaning units	Results	Codes	Subthemes	
S2: Closed-Loop Medication System: Leveraging Technology to Elevate Safety. Burkoski et al (2019)/Canada	A total of 1712 medication errors were reported in five years. BCMA intervention resulted significant gradual decrease in reported MEs and ADE rate at 0.002 percentage points per month (p = 0.003). Post CLMS intervention resulted absolute and immediate decrease in reported MEs and ADE rates of 0.010% (p = 0.020).	Integration of technology		1. Integration of technology
S3: Does a checklist reduce the number of errors made in nurse-assembled discharge prescriptions? Byrne et al (2017)/United Kingdom	Post intervention re-audit presented significant reduction in number of assembled discharge prescription with one or more errors. Reduction in MEs 75%.	Interprofessional medication reconciliation during discharge.		
S4: Effectiveness of 'do not disturb'	Error free discharge prescription rose significantly, from 29.7% in	Interruption free work environment.		

strategies in reducing errors during discharge prescription writing. Zamani et al (2019)/Australia	baseline audit to 52.5% in post intervention re-audit.			2. Interprofessional medication reconciliation.
S5: Evaluation of pharmacist-led educational interventions to reduce medication errors in emergency hospitals: a new insight into patient care. Mostafa et al (2020)/Egypt	Reduction in medication errors rate 34.2% preintervention to 15.3% post-intervention ($p<0.001$). Post -intervention reduction in all type of medication errors.	Pharmacist led educational intervention.		3. Interruption free work environment.
S7: Medication errors room: a simulation to assess the medical, nursing and pharmacy staffs' ability to identify errors related to the medication-use system. Daupin et al (2016)/Canada	Length of simulation period 100 hours, all hospital staffs as the participants.230 professional visited simulation, 207 handed response grid, and satisfactory survey answered by 130 participants. Overall rate of correct answer was 67.2% for doctors, 67.1% for nurses, 78.4% for pharmacist, 65.5% for pharmacy	Multidisciplinary educational intervention; simulation approach.		

	technicians and 58.3% for other professionals			
S9: Reducing missed medications in surgical patients. Williams &Halstead (2023)/United Kingdom	9.8% to 3.9% decrease after intervention 1, 1.9% decrease after intervention 2, and 1.9% to 0% reduction after intervention 3 and 4. Overall decrease in missed medication dose 9.8% to 0% post-intervention.	Interprofessional medication reconciliation (nurse's participation in medication prescribing).		4. Educational intervention.
S10: Reducing unacceptable missed doses: pharmacy assistant-supported medicine administration. Baqir et al (2015)/United Kingdom	Total number of assessed patients were 778. Patients with one or more unacceptable omitted dose (UOD) were 12.4% in intervention groups and 18.5% in control group. Eventually, fewer critical UOD (1.1%) in intervention group in comparison to 7.4% in control group.	Pharmacy assistant's involvement in medication administration		

S11: The effect of education intervention on parenteral medication preparation and administration among nurses in a general intensive care unit. Tan et al (2017)/Malaysia	Significant reduction in error rate from 79% Pre-intervention to 50% post-intervention (P<0.001), and improvement in medication adherences. Although, not remarkable differences in error rate of drug infusion prepared in pre and post intervention 48% and 53% respectively (p=0.70)	Educational intervention		5. Pharmacy assistant's involvement in medication administration
S13: Using the HALT model in an exploratory quality improvement initiative to reduce medication errors. Ragau et al (2018)/Australia	Overall MEs reduction in post-intervention 31.7%. Human factor associated MEs reduced by 35.3%. Reduction in documentation and communication 22.9%. Overall, response to HALT approach was extremely positive	Adoption of HALT model to address human factor.		6. Adoption of HALT model to address human factor

After data analysis six sub-themes has been identified as the effective preventive strategies to reduce or minimize medication errors and each sub-themes will be discussed separately in next section.

5.2.1 Integration of technology

One of the study unit (S2) studied the integration of technology in medication process and evaluated the impact of BCMA and CLMs in medication error reduction. According to the study findings BCMA intervention generated significant gradual decrease in reported MEs

and ADE rate at 0.002 percentage Points per month (p = 0.003). Post CLMS intervention resulted absolute and immediate decrease in reported MEs and ADE rates of 0.010% (p = 0.020).

5.2.2 Interprofessional medication reconciliation

Two of the study units (S3 &S9) have evaluated the impact of interprofessional medication reconciliation. The study unit (S3) investigated the nurses assembled discharge prescription along with the comprehensive checklist during discharge, and there were outstanding results as post intervention audit showed 75% reduction in MEs rate. Subsequently, another study unit (S9) QI project also multiprofessional participation in medication prescription with the aim of reducing missed medication doses. This included a driver diagram which incorporated multiple interventions, including modification of elective proformas, admission interviews and nurse-based prescribing. Outcome of this intervention was outstanding as post intervention audit revealed 9.8% to 0% missed medication doses.

5.2.3 Interruption free work environment

The study unit (S4) evaluated the impact of do not disturb strategy with the aim of reducing prescription errors in discharge prescription writing. This intervention has resulted significantly positive outcome as error free discharge prescription rose, from 29.7% in baseline audit to 52.5% in post intervention re-audit.

5.2.4 Educational intervention

Multiple study units (S5, S7&S11) have examined the impact of educational intervention on medication error reduction. The study unit (S5) evaluated pharmacist led educational intervention to reduce medication errors among nurses and post intervention audit found reduction in medication errors rate 34.2% pre-intervention to 15.3% post-intervention ($p<0.001$) along with reduction in all type of MEs. Similarly, (S7) studied simulation approach creating medication error room with the target of assessing nursing, medical and pharmacy staff's capability to identify errors associated with medication use system. Overall rate of correct answer was 67.2% for doctors, 67.1% for nurses, 78.4% for pharmacist, 65.5% for pharmacy technicians and 58.3% for other professionals. Further,

another study sample (S11) evaluated the impact of educational intervention on parenteral medication preparation and administration and found significantly reduced MEs rate from 79% to 50% ($p<0.001$), improved adherence to good practices, but no significant changes in the concentration error rate of drug infusion.

5.2.5 Pharmacy assistant's involvement in medication administration

The study sample (S10) examined the impact on omitted doses as trained pharmacy assistant supported nurses on medication administration rounds and post intervention revealed patients with one or more unacceptable omitted dose (UOD) were 12.4% in intervention groups and 18.5% in control group. Eventually, fewer critical UOD (1.1%) in intervention group in comparison to 7.4% in control group.

5.2.6 Adoption of HALT approach to address human factor

One of the study sample (S13) conducted exploratory QI project using HALT model to reduce medication errors by addressing human factors such as hungry, angry, lonely, and tired. Overall MEs reduction rate in post-intervention audit 31.7%. Human factor associated MEs reduced by 35.3%. Reduction in documentation and communication 22.9%. Overall, response to HALT approach was extremely positive.

6 Discussion

This integrative review findings presents the comprehensive knowledge on factors associated with medication errors and evidence based preventive strategies to reduce those errors. Primarily, it has explored two crucial aspects of medication errors. Firstly, it thoroughly investigated the factors leading to medication errors in health care. Secondly, it explored and synthesized the preventive strategies to reduce or minimize MEs. The findings presented by these studies are supported by several previous research work conducted by researchers from different health care professions. This study revealed that medication errors were associated with several predisposing factors such as workload and long working hours, poor interpersonal communication, lack of pharmacological knowledge, and infection control, nonadherence to medication administration guidelines or unavailability of guidelines, use of look-alike sound alike (LASA) drugs or other drug complexities, and interruption during medication administration. These study findings are

strongly supported by previous research works conducted by different researchers from various profession in health care.

Implementing prevention strategies to reduce medication errors is vital for enhancing patient safety, improving healthcare outcomes, and maintaining operational efficiency. This review identified that the integration of technology, quality improvement projects, implementation of DND strategies, participation of multiprofessional team such as clinical pharmacist intervention in medication administration rounds, medication error room; a multidisciplinary simulation activity as well as other educational interventions are effective preventive strategies to reduce medication errors.

6.1 Discussion of findings

According to this integrative review findings unmanageable workload and long working hours increases the risk of medication errors. Nursing manpower shortage and inappropriate staffing leads to busy work shift, which pose high risk of medication errors. Other multiple studies (Choi et al., 2021; Henderson et al., 2018) have found similar findings as they state inadequate staffing may lead to missed medication doses and incorrect medication time. Likewise, Shohani & Tavan (2018) claim that high nurse/ patient ratio and inadequate staffing heavy workload and occupational fatigue and exhaustion were the most common factors for the incidence of medication errors. Similarly, other multiple researchers from different settings have also identified inadequate staffing as the major cause of medication errors (Barber et al., 2009; Ehsani et al., 2013 Salmasi et al., 2015).

Similarly, this research identified that ineffective communication between different health professionals such as nurses, pharmacists, laboratory staffs also affect the medication errors significantly. Medication errors could occur due to delays in medication dispension, or delays in laboratory result or delays in taking blood samples. Further, medication error can occur due to delayed dispension as reported by Al-Ahmadi et al (2020). Similarly, this study result found ineffective communication between nurses, pharmacist and physicians such as making telephone prescription or adjusting medication dose over phone calls or using inappropriate abbreviations as the leading cause of medication errors and this resembles to the findings of Tariq (2013).

Furthermore, this study has found medication complexity is also a significant factor for medication errors. Use of look-alike and sound-alike medications (LASA), lack of clear instruction about those medicines creating confusion are the major factors of medication errors. Similar findings has been reported by Aljadhey et al (2013) as similaritie between names, packaging and varying levels of LASA medication impose great threat in medication safety. LASA related medication errors has been reported more frequently from hospitals. Similarities of the name of the medications has the possibility of resulting prescription errors in electronic databases as well. Likewise, high number of regular medications, frequency of medications administration, multiple number of medications used as per needs, and medicine routes other than per oral were found as the influential factors of medication errors.

This study results highlight nurse's work experience plays the significant role in MEs. Medication administration is one of the important aspects of nursing practice and work experience help to enhance knowledge as well as improve competency. Lack of adequate training and insufficient knowledge of pharmacology and unavailability of guidelines were also significantly associated with medication errors. There were similar findings from the previous studies (Feleke et al., (2015); Berdot et al., (2015)). Mekonnen et al., (2018) has reported inadequate training/knowledge on safe medication administration as one of the major contributing factors of medication errors. Not surprisingly, Tsegaye et al., (2020) has found similar findings and presented significant association between lack of training, unavailability of guidelines and failure to comply with medication administration rights and medication errors. Thus, nonadherence to medication administration guidelines and lack of availability of protocols and guidelines makes great impact on medication safety.

Likewise, this study identified important relationship between work environment and incident of medication errors. Work interruption such as answering phone call, providing orientation to agency staffs, or answering questions from other staffs, or presence of other individuals in medication room could lead to medication administration errors. Similar findings were reported by Atiya et al.,2012; Jones and Treiber, 2010; Feleke et al.,2015, Manias et al., 2021). Medication preparation and administration is a critical activity and need a lot of concentration. Thus, presence of any interruptions or distraction could lead to cognitive failure regarding working memory and attentiveness (Feleke et al., 2015).

Prevention of medication errors could save millions of lives, minimize waste, and improve patient safety. Medication errors are considered as the most prevalent but preventable threat for patient safety. Thus, identifying and utilizing effective strategies to reduce such errors should be a priority.

This review identified several strategies that could be used to minimize medication errors. Integration of technology in medication administration can have significant positive impact on reducing medication errors and adverse drug reactions (ADEs). These technologies reduce the incidence of medication errors by several means such as using alert messages, and by verifying the rights of medication administration. Technologies such as BCMA and CLMS have been effective to reduce MEs and ADEs (Miller et al., 2011), and reduced the mortality and morbidity associated with preventable medication errors (Saleem, 2023).

Similarly, this study result emphasizes interprofessional medication reconciliation practices, as it has significantly positive impact in reducing MEs. The interventions like impact of nurse assembled discharge medication checklist to reduce nurse assembled discharge prescriptions errors and use of comprehensive discharge medication checklist have resulted positive outcomes in MEs prevention. This finding is supported by Latimer et al (2023) as it states increasing nurses' involvement and standardization of interprofessional medication reconciliation process will help to reduce discharge delays, improve patient, and reduce workload pressure. Even though nurses 'have important role in medication safety, their contribution in medication reconciliation at hospital discharge is poorly described.

This study result has found multidisciplinary medication reconciliation (MR) as one of the effective preventive measures of MEs. Quality improvement projects like creating driver diagram to examine current pathway which feature multiple interventions such as changes to pro formas, the initial clerking process and nurse-based prescribing found to be very beneficial. This project highlights the importance of multidisciplinary prescribing practice to ensure safe medication and improve patient safety and reduce medication errors. This finding is supported by a recent study (Zhu et al., 2024) findings as it claims multidisciplinary collaboration during patient discharge helps to identify possible medication errors before reaching to patients and suggested further research on nurse's participation on MR and purposed MR based education and training for nurses and nursing students.

Similarly, this study identified Pharmacist led quality improvement also presented significant positive outcomes as the post intervention results showed reduction in the number patients with one or more medication errors. Further, another Quality improvement (QI) study adopted less recognized contributory elements human factor for instance hunger, anger, tiredness. This QI project aimed to reduce medication errors by 25% by introducing hunger, anger, lonely and tired (HALT) model in hospital setting. Post implementation audit surpassed the target along with reduction in communication and documentation errors. These findings were supported by Brennan & open (2022) study results that claim recognizing and mitigating human factors have significant impact on individuals and teams, thus improving human factors there is the possibility of active reduction in medical errors and ensure patient safety. Similarly, the use of DND strategies may be useful to reduce the ME but the findings are not consistent, some reporting effectiveness (Berdot, 2021, Zamani, 2019). However, this strategy needs effective teamwork, availability, and accessibility of do not disturb signs in the workplace and education program should not be limited to those who administer drugs. Thus, this may or may not be practical in all workplaces.

Furthermore, educational interventions often led by pharmacists to improve the knowledge about the pharmacology of the medicine, preparation of medication, medication guidelines etc. seem to be effective ways to reduce MEs. This review has identified that lack of training, poor knowledge of pharmacology, and medication calculation as the predisposing factors of medication errors, thus educational interventions can be a good strategy to implement. Several studies identified in this review reported a reduction in MEs after running an educational intervention (Baqir et al., 2015; Tan et al., 2017; Mustafa et al., 2020; Falhenia et al., 2023) However, it is important to note that not all intervention work equally good and some might reduce a specific type of medication error but not others.

It is also possible to reduce the medication errors by running simulation activities to train the healthcare staffs involved in medication process. These activities should focus on identifying the errors and incorrect practices and how to respond to them. Simulation activity involving a multidisciplinary teams can be effective way to identify incorrect practices (Daupin et al., 2016). Several studies support that simulation-based learning can

be more effective and interesting to all health care workers and can lead to significant reduction in medication errors (Ford et al,2010; Pauly &Prion ,2013).

6.2 Implication of the study

This integrated review has explored the predisposing factors of medication errors and strategies to minimize those errors. The evidence-based findings discussed in this review present comprehensive knowledge and understanding in this subject matter. Hence, the findings from this review can be useful information to minimize MEs by incorporating these effective strategies in workplace to reduce medication errors and improve quality of care and patient safety.

6.3 Strength and Limitation of the study

This integrated review has followed systematic method for data collection and literature search process has been presented in Prisma flow chat. Quality assessment has been done following JBI critical appraisal checklist. This study findings demonstrate the thorough understanding of current level of knowledge on factors associated with medication errors and preventive strategies to reduce them, thus it provides comprehensive understanding of the research topic. It has used multifaceted approach, incorporating multidisciplinary perspectives from all healthcare worker for instance nurses, physicians, pharmacist or pharmacy assistants or other stake holder to get a holistic understanding of the research subject. This review focus on medication error, a major challenge in patient safety used multifaceted approach, incorporating multidisciplinary perspectives from all healthcare worker for instance nurses, physicians, pharmacist or pharmacy assistants or other stake holder to get a holistic understanding of the research subject.

Even though this integrative review offers valuable insights about the factors associated with medication errors and strategies to reduce them, might have several limitations. The sample size is confined to only 13 empirical studies, potentially limiting the presentation of heterogenicity of study samples. Only three databases were used for the literature search and only free and full text articles were selected, so there is the possibility of exclusion of quality articles. Consequently, the study findings could not be fully generalized beyond the study samples considering the factors like health care setting variation, study participants

variations or other differences. Furthermore, authors knowledge and understanding of research topics and own experience in research subject might have influenced the interpretation of the study findings. In addition, only one author has completed the research study, thus possibility of limitation of diversity of perspectives and one author risk bias in interpretation or analysis.

6.4 Reliability and Validity

Validity and reliability ensure the credibility and trustworthiness of a study findings in research study. It ensures accuracy and allows other researchers to replicate the performed study. Subsequently, Validity and reliability help to enhances the overall quality and rigor of the research (Kirk &Miller, 1986).

This study is an integrative literature review with qualitative approach and included different research designs as the study samples. The literature search was done systematically and searched multiple scientific databases using same keywords. The data extraction process has been presented in Prisma flow diagram. Inclusion and exclusion criteria's have been applied while selecting study articles. Quality assessment has been performed following JBI critical appraisal tools to assesses the trustworthiness and relevance of studies.

Inductive content analysis approach has been selected for the data analysis. The identified codes, sub-themes and themes ensures the clarity and understandability of the results. Discussion of findings were done comparing existing literatures in the subjected study.

Tables and figures were used to present research findings followed by in-depth description. Findings of the study has been summarized and possible biasness has been considered. Implication of the study and recommendation for the future search areas has been made.

7 Conclusion & Recommendation

This integrated review has explored factors associated with medication errors in health care setting and strategies to minimize them. Factors such as workload and use of agency staffs, lack of adequate training on medication safety and work experience, poor

knowledge of pharmacology and poor medication calculation skills, interruption and distraction during medication administration process, lack of effective interprofessional communication, non-adherence to medication administration guidelines as well as unavailability of protocols and policies were identified as the predisposing factors of medication errors.

Similarly, this integrated review has synthesized preventive strategies of medication errors and variety of single and combined interventions type were identified as the effective strategies to medication errors. Integration technology for example barcode medication administration (BCMA)and closed loop medication system (CLMs), multidisciplinary medication prescribing or nurse-based prescribing in medication reconciliation process were significantly effective to reduce administration errors and prescription errors. Do not disturb strategy was also very effective to reduce prescription errors.

Pharmacist led multiprofessional educational interventions, and multidisciplinary simulation approach were proved beneficial in enhancing knowledge and raise awareness of medication errors and improve the capacity recognizing errors situations. Educational intervention via videos, memory aids, power point presentation was significant in reducing administration errors and improved adherence to guidelines. Pharmacy assistant supported medication administration and human factor strategies like HALT model were also equally effective to reduce medication errors.

Based on the above findings there should be strong road map to tackle global shortage of nursing workforce, healthcare workers should be trained regularly, medication administration guidelines, protocol and policies should make available, and interruption free medication preparation and administration should be facilitated. Efforts should be made to increase nurses' knowledge on pharmacology and raise awareness of medication errors. Education interventions are the best approach of enhancing knowledge and raising awareness.

Future research should be focus on multidisciplinary approach in medication prescribing, integration of technology in medication care, multidisciplinary education intervention and effective integration of pharmacist in safe medication.

8 References

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9 Appendices

Appendix 1. JBI Critical appraisal table for quasi-experimental studies

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Score by study
Burkoski et al(2019)	Y	Y	NA	N	N	Y	Y	Y	Y	6|9=66.6%
Byrne et al (2017)	Y	Y	NA	N	N	Y	Y	Y	Y	6|9=66.6%
Zamani et al (2019)	Y	Y	NA	N	N	Y	Y	Y	Y	6|9=66.6%
Mustafa et al (2020)	Y	Y	NA	N	N	Y	Y	Y	Y	6|9=66.6%
Tan et al (2017)	Y	Y	NA	N	N	Y	Y	Y	Y	6|9=66.6%
Ragau et al (2018)	Y	Y	NA	N	N	Y	Y	Y	Y	6|9=66.6%
William's & Halstead (2023)	Y	Y	NA	N	Y	Y	Y	Y	Y	7/9=77.7%

JBI critical appraisal checklist for quasi-experimental studies;

Q1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?

Q2. Were the participants included in any comparisons similar?

Q3. the participants included in any comparisons receiving similar treatment/care, other than the exposure Were or intervention of interest?

Q4. Was there a control group?

Q5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?

Q6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?

Q7. Were the outcomes of participants included in any comparisons measured in the same way?

Q8. Were outcomes measured in a reliable way?

Q.9. Was appropriate statistical analysis used?

Note; Y=yes, N=No, NA=Not applicable

Appendix 2. JBI Critical appraisal table for cross sectional studies

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Score by study
Kuppadakkath et al (2023)	Y	Y	Y	Y	N	NA	Y	Y	6/8=75%
Wondmieneh et al (2020)	Y	Y	Y	Y	N	NA	Y	Y	6/8=75%
Daupin et al (2016)	Y	Y	Y	Y	N	NA	Y	Y	6/8=75%
Karttunen et al (2020)	N	Y	Y	Y	N	NA	Y	Y	5/8=62.5%
Härkkänen et al (2015)	N	Y	Y	Y	Y	Y	Y	Y	7/8=87.5%

Checklist for analytical cross-sectional studies:

Q1. Were the criteria for inclusion in the sample clearly defined?

Q2. Were the study subjects and the setting described in detail?

Q3. Was the exposure measured in a valid and reliable way?

Q4. Were objective, standard criteria used for measurement of the condition?

Q5. Were confounding factors identified?

Q6. Were strategies to deal with confounding factors stated?

Q7. Were the outcomes measured in a valid and reliable way?

Q8. Was appropriate statistical analysis used?

(Note; Y=yes, N=No, NA=Not Applicable)

Appendix 3. JBI Critical appraisal for randomized control study

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Score by study
Baqir et al (2015)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	13/13= 100%

Q1. Was true randomization used for assignment of participants to treatment groups?

Q2. Was allocation to treatment groups concealed?

Q3. Were treatment groups similar at the baseline?

Q4. Were participants blind to treatment assignment?

Q5. Were those delivering treatment blind to treatment assignment?

Q6. Were outcomes assessors blind to treatment assignment?

Q7. Were treatment groups treated identically other than the intervention of interest?

Q8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?

Q9. Were participants analyzed in the groups to which they were randomized?

Q10. Were outcomes measured in the same way for treatment groups?

Q11. Were outcomes measured in a reliable way?

Q12. Was appropriate statistical analysis used?

Q13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial? Note; Y=Yes, N=No, NA= Not applicable

Appendix 4. Overview of selected articles

S.N	Title/Author /Year/Place	Aims/Objectives	Research design and Sample / Instrument	Results and conclusions	Rating of reporting quality
S1	Nurses perspective on medication errors and prevention strategies in residential aged care facilities through a national survey. Kuppadakkath et al., 2023/Australia	to asess the contributing factors of medication errors (MEs) and explore preventive strategies to minimize them in residential aged care facilities.	A cross sectional study, performed online survey among the nurses working in residential and aged care facilities (RACFs), 140 completed responses from registered nurses (RNs) and endorsed enrolled nurses (EENs).	Study finding identified use of the agency staffing and delays in laboratory result as the main reasons of medications errors. However, workload, interprofessonal involvement and interruption also contributed for errors. Likewise, electronic alert, medication safety improvement, and effective reporting were suggested for the preventive starategies.	6/8 75%
S2	Closed-Loop Medication System: Leveraging Technology to Elevate Safety. Burkoski et al., 2019/Canada	to evaluate the effects of barcode medication administration (BCMA) and the closed-loop medication system (CLMS) interven- tions on medication errors and adverse drug event (ADE) rates.	A retrospective audit of self reported medication errors (ME)and adverse drug events (ADEs) over 5 year period. Descriptive statistics were generated to evaluate the types of error and their gravity. Nurses and other health care workers participated in the study.	A total of 1,712 MEs and ADEs were reported. Intro- duction of the BCMA intervention was associated with a statistically significant gradual decrease in reported medication error and ADE rates at 0.002 percentage points per month (p = 0.003). The introduction of the CLMS intervention was asso- ciated with an immediate absolute decrease in reported medication error and ADE rates of 0.010% (p = 0.020).	6/9 66.6%
S3	Does a checklist reduce the number of errors made in nurse-	to evaluate whether a discharge medication	A quality improvement project;a discharge medication	The error rate per assembled discharge prescription reduced from 0.85 in the baseline audit to	6/9

	assembled discharge prescriptions? Byrne et al., 2017/United Kingdom	checklist could reduce errors on nurse-assembled discharge prescriptions.	checklist and training programme were designed.56 assembled discharge prescriptions were audited pre and post intervention. Study participants were	0.21 in the re-audit when the checklist was used (75% reduction). Introduction of nurse assembled discharge medication checklist demonstrated a significant reduction in errors Hence, the study recommends this checklist to be adopted across medical wards to facilitate safe discharge.	66.6%
S4	Effectiveness of 'do not disturb' strategies in reducing errors during discharge prescription writing. Zamani et al., 2019/Australia	to determine the combined effect of two 'do not disturb' (DND) strategies in decreasing the average number of prescribing errors by reducing distractions during discharge prescription writing.	A non randaomized observational study; 392 discharge prescriptions were audited over 10 week period in a prospective interventional pre and post audit. Study participants wereunior medical officers and nurse unit managers.	The percentage of error-free discharge prescriptions increased from 29.7% before to 51.5% after the intervention ($p < 0.0001$). The mean number of errors per prescription decreased from 1.7 to 1.1 ($p < 0.01$) in both wards combined. DND strategies remarkably decreased prescription errors	6/9 66.6%
S5	Evaluation of pharmacist-led educational interventions to reduce medication errors in emergency hospitals: a new insight into patient care. Mostafa et al.,2020/Egypt	to evaluate the impact of pharmacist-led educational implementations in reducing medication errors made by nurses in an emergency hospital in Cairo, Egypt.	A prospective pre–post-interventional study was conducted in an emergency hospital using direct observation for the detection of errors. 392 discharge prescriptions were analyzed.	Pharmacist interventions resulted in a significant reduction in the medication error rate from 351 (34.2%) in the pre-intervention phase to 157 (15.3%) in the post-intervention phase ($P < 0.001$).	6/9 68.8%

S6	Medication administration errors and contributing factors among nurses: a cross sectional study in tertiary hospitals, Addis Ababa, Ethiopia. Wondmieneh et al., 2020/Ethiopia	to assess the magnitude and contributing factors of medication administration error among nurses in tertiary care hospitals, Addis Ababa, Ethiopia.	A cross sectional study, 298 randomly selected nurse participants, adopted, self-administered survey questionnaire and checklist to collect data via self-reporting and direct observation of nurses while administering medications.	68.1% nurses admitted committing medication errors. Lack of adequate training,unavailability of the medication administration guidelines, inadequate work experience, interruption during medication administration,and night shift were the causative factors for medicaton errors Study recommends continuous staff training on safe administration of medications, availability of medication administration guidelines, creating an enabling environment for nurses to safely administer medications, and retaining more experienced nurses.	6/9 66.6%
S7	Medication errors room: a simulation to assess the medical, nursing and pharmacy staffs' ability to identify errors related to the medication-use system. Daupin et al., Qubec, Canada/ 2016	to assess the medical, nursing and pharmacy staffs' ability to identify errors related to the medication-use system using a simulation	A Cross-sectional study; conducted in 500 bed mother child university hospital. All hospital staff, including nurses, physicians, pharma- cists, pharmacy technicians and other professionals, was invited to participate in the simulation.	Participants mainly considered the simulation as effective in identifying incorrect practices (132/136, 97.8%) and relevant to their practice (129/136, 95.6%). Most of them (114/136; 84.4%) intended to change their practices in view of their exposure to the simulation This simulation was an effective, relevant and innovative tool to raise the health care professionals' awareness of critical processes.	6/8 75%
S8	Nurses' self-assessments of adherence to guidelines on safe medication preparation and administration in	to determine nursing staff's self-assess- ments of how they adherence to guidelines on safe medi-	A Cross-sectional study, total sampling at the communal long-term elderly care wards of one healthcare district	One-third of the nurses stated that they do not always follow guidelines when preparing medication, and around a half deviate from them occasionally, when administering	5/8

	long-term elderly care. Karttunen et al., Finland/ 2020	cation preparation, administration and asepsis in the medication process in long-term elderly care and to identify factors affecting this adherence.	in Finland during November 2016. Data were collected using a web-based questionnaire, n=492	medication. The most serious deviation on preparation stage was crushing of sustained release and enteric-coated tablets and mixing of crushed tablets together. Deviation from guidelines often causes an error.There is a need to review the teaching of pharmacology, infection control and medication calculations during undergraduate and continuing education	62.5%
S9	Reducing missed medications in surgical patients. Williams & Halstead, United Kingdom/ 2023	To reduce missed medications in elective surgical patients	Quality Improvement project, used four interventions; A driver diagram was produced to interrogate the current pathway which highlighted multiple interventions, including changes to elective pro formas, the initial clerking process and nurse-based prescribing	Overall, missed medication dose percentage decreased from 9.8% to 0% after the interventions. our interventions two of them have been deemed sustainable and have been integrated into elective patient pathways, improving both patient safety and streamlining surgical elective patient services. Empowering nursing staff to take the lead in the medication management of patients can reduce the likelihood of negative outcomes in a patient's admission.	7/9 77.7%
S10	Reducing unacceptable missed doses: pharmacy assistant-supported medicine administration.	to assess the impact on omitted doses when medicine administration was supported by pharmacy assistants (PAs).	Randomized control Trials, Pharmacy assistants were trained to support nurses on medicine administration rounds. Using stratified random sampling, two intervention and	The overall proportion of patients with ≥1 UOD was 12.4% (n = 96). The proportion of patients with ≥1 UOD was 1.1% (n = 2) in group A (intervention) and 18.5% (n = 68) in group C (control). There were significantly fewer patients with cUOD in group A (1.1%;	13/13

	Baqir et al., United Kingdom/ 2015		control wards were selected. Three study groups were defined	n = 2) compared with group C (7.4%; n = 27). PA-supported medication rounds can significantly reduce the rate of omitted doses.	100%
S11	The effect of education intervention on parenteral medication preparation and administration among nurses in a general intensive care unit. Tan et al., Malaysia/2017	to describe the fre- quency, types, and severity of medication errors in medical and surgical inpatients as well as to study the relationship between medication errors and associating factors.	Quasi-experimental study; a prospective pre and post interventional study using observation study. The preparation and administration of parenteral medications by the nurses was observed directly during pre- and post-intervention.	The education intervention significantly reduced the error rate from 79% to 50% ($p < 0.001$), and improved good practices' adherence. However, there was no significant difference in the concentration error rate of the drug infusions prepared in pre- (48%) and post-intervention (53%) ($p = 0.70$).	6/9 66.6%
S12	The factors associated with medication errors in adult medical and surgical inpatients: a direct observation approach with medication record reviews. Härkkänen et al., Finland/ 2015	to describe the fre- quency, types, and severity of medication errors in medical and surgical inpatients as well as to study the relationship between medication errors and associating factors.	A Cross-sectional study, direct observations and medication record reviews was conducted to assess how 32 registered nurses administered 1058 medications to 122 inpatients in four medical and surgical wards at a university hospital in Finland	Medication errors were detected in 22.2%. Administration errors constituted 63.4%, followed by documentation errors (18,3%). Among the observed errors 24.3% didn't reach to the patients, just over fifty percent (51,1%) reached the patients but didn't cause harm, 21.3% errors required patients monitoring and 3% errors caused prolonged hospitalizarion	7/8 87.5%
S13	Using the HALT model in an exploratory quality improvement initiative to reduce	to reduce medication errors by 25% on a medical ward, through the introduction of the hunger, angry, lonely, tired (HALT)	An exploratory quality improvement study, the HALT (hunger, angry, lonely, tired) model was used within the	ost-implementation, the HALT model appeared to have resulted in a total reduction in medication errors over a 2-month period by 31%. Mistakes related to human error were reduced by 25%, and those linked to communication	6/9 66.6%

	medication errors. Ragau et al., Australia/2018)	model to address the human factors associated with medication errors.	context of medication errors.	and documentation errors by 22% This model significantly reduced medication errors. However, caution should be used when addressing other contributing factors associated with medication errors as using HALT alone will not address these.	