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REVIEW

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An umbrella review of systematic reviews on contributory factors to medication errors in health-care settings

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ABSTRACT

Introduction: Medication errors are common events that compromise patient safety and are prevalent in all health-care settings. This umbrella review aims to systematically evaluate the evidence on contributory factors to medication errors in health-care settings in terms of the nature of these factors, methodologies and theories used to identify and classify them, and the terminologies and definitions used to describe them.

Areas covered: Medline, Cumulative Index to Nursing and Allied Health Literature, Embase, and Google Scholar were searched from inception to March 2022. The data extraction form was derived from the Joanna Briggs Institute (JBI) Reviewers' Manual, and critical appraisal was conducted using the JBI quality assessment tool. A narrative approach to data synthesis was adopted.

Expert opinion: Twenty-seven systematic reviews were included, most of which focused on a specific health-care setting or clinical area. Decision-making mistakes such as non-consideration of patient risk factors most commonly led to error, followed by organizational and environmental factors (e.g. understaffing and distractions). Only 10 studies had a pre-specified methodology to classify contributory factors, among which the use of theory, specifically Reason's theory was commonly used. None of the reviews evaluated the effectiveness of interventions in preventing errors. The collated contributory factors identified in this umbrella review can inform holistic theory-based intervention development.

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KEYWORDS
Contributory factors; medication errors; methodology; umbrella review

1. Introduction

Medication errors are prevalent events that take place across the entire spectrum of the medication use process [1,2]. The National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) in the United States (U.S.) defines a medication error 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" [3].

Consequences of medication errors can range from no or mild harm to severe harm and death [4,5]. For instance, in U.K., 237.3 million medication errors occur every year, with 66 million considered potentially harmful [5]. The same report noted that medication errors caused 712 deaths and contributed to more than 1700 deaths in 1 year [5]. The World Health Organization (WHO) estimated the global impact of medication errors to be approximately $42 billion annually [6]. Additionally, medication errors can have a deleterious psychological impact on patients, families, and health practitioners [7,8].

Evidence suggests that up to 60% of medication errors are under-reported [9,10]. The practice of detecting and reporting medication errors by health-care providers, as well as investigating and analyzing such errors through rigorous research, is imperative to promote patient safety [11].

A myriad of potential strategies have been proposed to decrease medication errors and improve patient outcomes, including pharmacist-led interventions, educational interventions, technology-driven interventions, and multidisciplinary team implementation. While a number of studies have demonstrated a reduction in the incidence of errors due to intervention, negative or no effects have also been reported [12–17]. In addition, there is a dearth of the literature that describes the rationale and theoretical basis for intervention development targeting relevant contributory factors [18,19].

Several primary studies and systematic reviews have explored factors contributing to medication errors. Given the plethora of systematic reviews investigating contributory factors to medication errors, there is a need to identify, critically appraise, and synthesize these factors via an umbrella review. This will enhance access to high-quality evidence, provide recommendations to improve the robustness of future work, increase the understanding of contributory factors, and inform decision-making regarding the development of evidence-based and holistic interventions to reduce medication errors.

This study aimed to undertake an umbrella review of systematic reviews on contributory factors to medication errors in diverse health-care settings in terms of the nature of these

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Article highlights

- The dominant contributory factors were decision-making mistakes, which include failure to consider risk factors (e.g. chronic kidney disease and pediatrics), and system failures, such as inadequate opportunities for training, work overload, inadequate staffing levels, and suboptimal work environment.
- Among studies that had a prespecified methodology to identify and classify contributory factors, the use of theory, specifically Reason's Accident Causation Model, was predominant.
- Methodological limitations were mainly related to search strategy, quality assessment, and data extraction processes. The lack of a predetermined methodology to classify contributory factors was also noted.
- "Contributory factors" and "causes" were the most frequently used terms to refer to contributory factors.
- Multiple definitions for contributory factors have emerged in the included reviews; however, the summary presented in our review does not reflect all proposed definitions in the literature.
- The findings of this review will inform the development of holistic theory-based interventions that target different levels of the health-care system. Such theory-based interventions have the potential to reduce the occurrence of medication errors and promote patient safety.
- Our findings emphasize the need for consistent use of terminology, definitions, and methodology used in research aiming to identify and quantify contributory factors to medication errors.

This box summarizes key points contained in the article.

factors, methodologies and theories used to identify and classify these factors, and the terminologies and definitions used to describe them.

2. Methods

2.1. Methodology reporting and registration

This umbrella review followed the recommendations provided by the Joanna Briggs Institute (JBI) reporting methodology manual and the Preferred Reporting Items for Overviews of Reviews (PRIOR) reporting guidelines-preprint (Supplementary material, Tables 1) [20–22]. The review protocol was registered in PROSPERO (CRD42022321425) [23].

2.2. Data sources and search strategy

Searches were undertaken using four electronic databases and search engines from their inception to 29 March 2022: Ovid Medline, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Google Scholar (first 500 records). The process also included cross-referencing of included papers.

Search terms related to categories A (related to medication errors) and B (related to systematic reviews) were combined with Boolean operators (AND/OR). The search was limited to "English language," "Human species," "Systematic reviews," and "Meta-analysis" as applicable to each database (Table 1). The detailed search strategy, MeSH, and other search terms were modified to suit each information source.

2.3. Eligibility criteria

Reviews were considered eligible if they met the following criteria: (1) reported factors contributing to medication errors, (2) systematic review with or without meta-analysis, (3) published in English language. For the purpose of this umbrella review, we included studies using different causation terms (e.g. contributory factors, causes, and risks). Systematic reviews focusing on adverse drug events (ADEs, i.e. harm experienced by a patient as a result of exposure to a medication. ADEs encompassing a wide range of incidents, such as adverse drug reactions and medication errors) with lack of clear relevance to medication errors were excluded [24]. Narrative reviews, scoping reviews, or any other types of reviews were also excluded. No restriction on age, gender, or clinical specialty reported in the reviews was imposed.

2.4. Study selection

All retrieved articles were exported to EndNote 20® (2021 Clarivate), duplicates removed, and the remaining papers imported to Rayyan Qatar Computing Research Institute (QCRI) software for the titles and abstracts screening. This was followed by a full-text screening via Microsoft Excel. The two-phase screening process was conducted by two independent reviewers (L.N., R.A.A.), and discrepancies were resolved through a consensus discussion with a third reviewer (V.P.).

2.5. Data extraction

Data were extracted by one reviewer (L.N.) and verified by second reviewer (V.P.) using a Joanna Briggs Institute (JBI) Reviewers' Manual informed data extraction form [22]. Data on terminology, definitions, classifications, nature of contributory factors, methodologies, theories, models, and frameworks used to identify and classify these factors were extracted. In addition, information related to recommended interventions, characteristics of the interventions, and associated methods and outcomes was also extracted.

2.6. Quality assessment

The methodological robustness of the included systematic reviews was assessed by one reviewer (L.N.) and verified by a second reviewer (V.P.). The JBI 11-item critical appraisal tool for systematic reviews was utilized for the quality assessment [22].

Table 1. Search terms.

Category	Search terms
Medication errors	Medication error [MeSH] OR ((medication* OR transcrib* OR prescrib* OR dispens* OR administ*) adj3 (incident* OR mistake* OR error*))
Systematic review	Systematic review* OR Meta-analysis

2.7. Data synthesis

Given that the outcomes of interest were qualitative, statistical pooling in meta-analysis was not appropriate. Synthesis of the findings was undertaken using a narrative approach. Narrative synthesis can be defined as "an approach to the systematic review and synthesis of findings from multiple studies that relies primarily on the use of words and texts to summarize and explain the findings of the synthesis" [25]. Findings are presented in textual form and summary tables. Overlap between included systematic reviews was not assessed, as the primary aim was to assess the methodological quality of existing systematic reviews.

3. Results

3.1. Study selection

A total of 1252 citations were identified from the database searching and reference screening. Following duplicate removal, the remaining 853 articles were screened according to title and abstract. Twenty-seven systematic reviews were included in the final synthesis (Figure 1). The most frequent reason for exclusion at the full-text screening stage was the lack of investigation into contributory factors to medication errors.

3.2. Characteristics of the included systematic reviews

Table 2 summarizes the characteristics of the included reviews. The majority were published in the last 10 years, except for one each in 2007 [26], 2009 [27], and 2010 [28]. It is noteworthy that the context of included reviews was not always the study setting. For example, in some cases, it was a certain geographical location or route of administration. Descriptions of the studied contexts are reported in Table 2 and further described in this section. Of the 27 reviews, 16 focused on specific populations/settings including community-dwelling adults [18,29–31], home care setting [32,33], neonatal intensive care setting [26,34], inpatient setting [27,35], pediatrics [36], elderly [37], hematopoietic stem cell transplantation patients [38], mental health patients [39], perioperative setting [40], and acute care setting [28].

Six reviews focused on the geographical location of the Middle East [41,42], Iran [43,44], Africa [45], or Southeast Asia

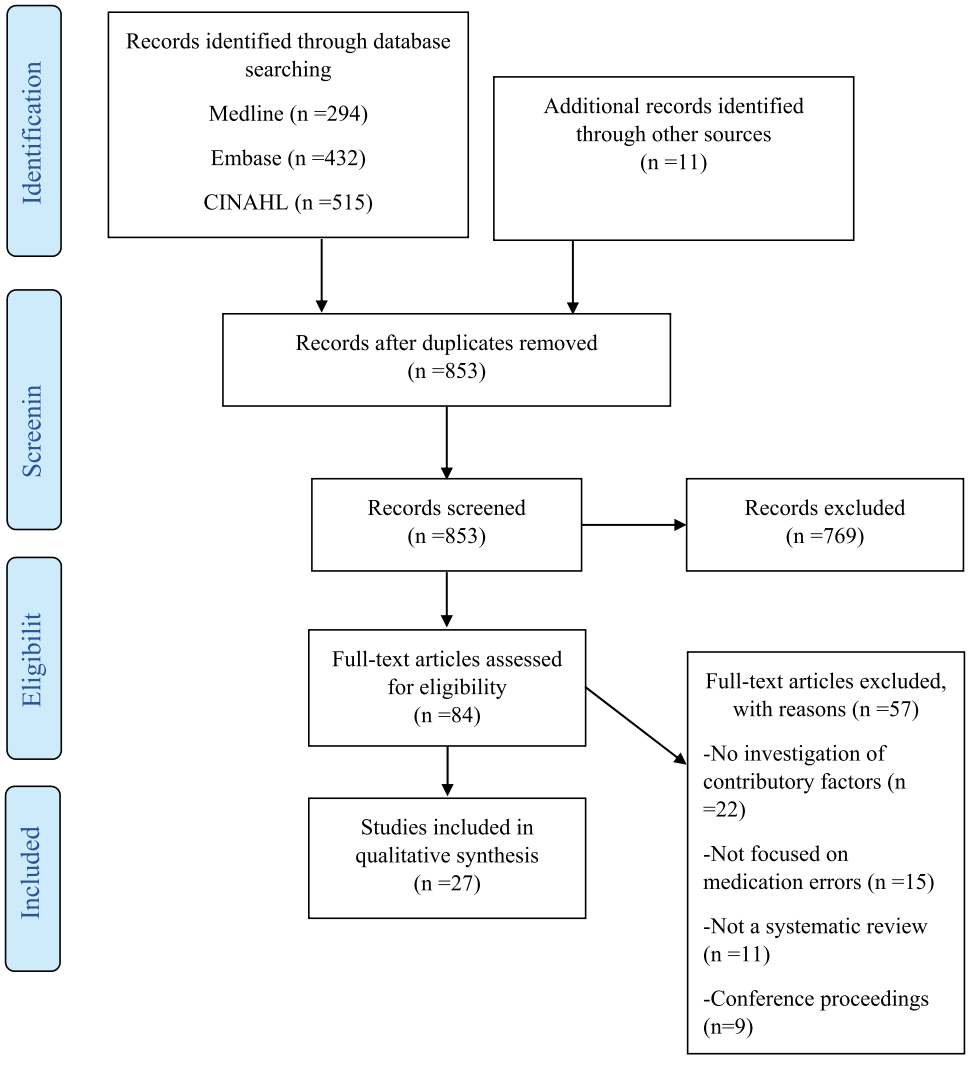

Figure 1. PRISMA flow diagram of the study selection process.

Table 2. Characteristics of included reviews.

Author, Year	Study design	Context	Aim	Total number of primary studies	Inclusion criteria	Exclusion criteria
Al Rowily A, 2022 [47]	Systematic review and meta-analysis	Direct oral anticoagulants (DOACs) in adult patients	To estimate the prevalence, contributory factors, and severity of ME associated with DOACs	32	Studies which reported or investigated the rate of prescribing, administration, or dispensing errors associated with DOACs in adult patients (≥18 years)	Studies of ADE that are not classified as errors, as were review articles, letters, opinion papers, and editorials
Aldila F, 2021 [29]	Systematic review	Community-dwelling older adults	To identify the types of medicine self-administration errors (MSEs) and their contributing factors among community-dwelling older adults	11	Older adults (≥50 years), self-administering of prescription or non-prescription medicines. Outcomes which met the inclusion criteria were any types of administration errors, including but not limited to, wrong medicine, wrong dose, wrong frequency, and wrong administration route	Formal caregivers or healthcare professionals administered or assisted in the administration of medicines; the studies took place in institutional care settings, and studies were not primary literature, such as non-peer–reviewed publications, letters to editors, commentary, or conference presentations
Alshehri G, 2017 [39]	Systematic review	Mental health hospitals (inpatient and outpatient services)	To provide an up-to-date and critical assessment of the frequency and nature of ME and ADE in mental health hospitals	20	Studies that reported the rate of ME/ADE in one or more stage(s) of the treatment process for patients in mental health hospitals (inpatient and outpatient services), as were studies that examined the rate of unintentional medication discrepancies at the point of transition of care between mental health hospitals and other settings. Studies that examined the impact of interventions on ME or ADE rates were only included if a baseline error rate could be determined. Conference abstracts were included if they provided data sufficient to allow the rate of ME or ADE to be calculated	Studies that utilized incident reports as the primary source of collecting data (as they greatly underestimate the error rate) and studies that used an estimated denominator to calculate the rate of ME or ADE (as the provided rate may not be reflective of the actual rate). Studies that reported ME or ADE rates for a single drug, single drug class, or disease, as were studies that only examined specific prescribing, administration, transcription, or dispensing error subtypes. Studies that reported the rate of potentially inappropriate prescribing in mental health hospitals, as they were not considered to be ME. Review articles and studies that failed to differentiate between intentional and unintentional discrepancies using a robust method
Alsulami Z, 2013 [41]	Systematic review	Middle East countries	To identify and review studies of the incidence and types of MEs in Middle Eastern countries and identify the main contributing factors	45	All types of studies that reported the incidence of ME or identified the causes of MEs in the Middle East countries, either in adults or children	Reviews, letters, conference papers, opinions, reports, or editorial papers
Assiri G, 2018 [18]	Systematic review	Adults managed in community care contexts	To investigate the epidemiology of ME, error-related ADE, and risk factors for errors in adults managed in community care contexts (i.e. primary care, ambulatory, and home settings)	60	Adults (≥18 years) who were looked after in the community and living in their own or family homes without home healthcare or nursing home. The studied patients could have been self-managing, receiving care in primary care or ambulatory care settings, or any combination of the above. Studies that are population-based, cross-sectional or cohort studies, which were suitable to estimate the incidence and prevalence of ME or ADE. These study designs and case–control studies were considered eligible to study risk factors. Studies with prescribed and/or over-the-counter medications	Pediatric studies (<18 years) and studies on patients receiving care in hospital at home settings, in nursing homes, as hospitalized inpatients or in emergency departments. RCTs since these could not be used to reliably assess the incidence and/or prevalence and reviews. Incompletely reported studies (e.g. abstracts). Studies on illegal substance abuse, herbal products and those focusing on a single medication

(*Continued*)

Table 2. (Continued).

Author, Year	Study design	Context	Aim	Total number of primary studies	Inclusion criteria	Exclusion criteria
Boytim J, 2018 [40]	Systematic review	Perioperative setting	To analyze the factors contributing to perioperative ME	19	Articles of any design involving the perioperative setting, ME, and human subjects	Studies not in the perioperative area; not related to MEs; animal studies; letters, opinions, reviews, or comments; and studies classified as case reports and interventions. Articles that noted the incidence of errors but had no specific details about ME and attributing causes
Di Muzio M, 2019 [50]	Systematic review	Shift work in inpatient nurses	To analyze the correlation between the clinical risk management and the occurrence of ME and the effects of the shift work (such as excessive fatigue and sleep deprivation after a shift) on inpatient nurses	19	Intervention studies, including RCT, Controlled Clinical Trials and all observational studies; papers reporting the administration of medications by registered nurses; studies performed in hospitals/inpatient settings; studies focusing on adult and pediatric patients; and peer-reviewed research articles	Studies reporting educational interventions; studies reporting the administration of medications by other HCP and studies reporting the prescription and the dispensing of drugs; studies carried out in outpatient centers, assisted living facilities and nursing homes; gray literature, such as dissertations, conference papers, proceedings
Dionisi S, 2021 [32]	Systematic review	Home care setting	To identify the main risk factors that affect the genesis of ME and the possible solutions to reduce ME in the home care setting	17	All study designs analyzing ME in the home care setting. The studies included must focus on the causes that lead to the generation of ME. Studies dealing with transitional care from any care setting to the home setting have been included. Studies in which the reference population is nurses, either as the sole reference population or in conjunction with other HCP	Grey literature (such as dissertations, conference papers, commentary, editorials) and literature reviews. All studies whose setting is different from home care, concerning hospital readmissions. Caregiver- and/or patient-centered studies, pediatric studies. Studies related to the treatment of specific diseases. The reference population is considered an exclusion criterion
Hansen C, 2016 [49]	Qualitative systematic review	Intern doctors	To synthesize the evidence of the qualitative literature on the views and experiences of intern doctors to identify the factors impacting safe prescribing and to examine the role of the pharmacist to assist in improving prescribing practices of interns	7	Only studies with qualitative data collection methods (e.g. semi-structured interviews, in-depth interviews, and original research) if they reported on newly qualified doctors' views and opinions on prescribing, and if the data from the intern doctors could be isolated from the views of other levels of staff	NR
Keers R, 2013 [35]	Systematic review of quantitative and qualitative evidence	Inpatient	To systematically review and appraise empirical evidence relating to the causes of MAE in hospital settings	55	Studies that reported data on the causes of MAE made in inpatient hospital settings. Identified causes in relation to specific errors or near misses that staff members either made themselves or were directly involved with	Review articles, conference, abstracts if they did not provide enough relevant data. Studies that reported on results based on simulation, or concerned with only one subtype of MAE, as were studies reporting results obtained from incident or case reports as it could not be determined whether the person reporting the incident had been directly involved

(*Continued*)

Table 2. (Continued).

Author, Year	Study design	Context	Aim	Total number of primary studies	Inclusion criteria	Exclusion criteria
Lampert A, 2014 [48]	Systematic review	Transdermal patches	To systematically review the literature on nature and etiology of potential administration errors associated with the use of transdermal patches and characterized these errors according to the affected administration subprocess	42	All types of publication that reported an actual faulty administration of a transdermal patch. Demographic data (age, sex) were considered mandatory to eliminate duplicate reports and prevent subsequent distortion of results regarding the frequency of errors	Solely characteristics of a new transdermal patch were presented; the safety profile of a drug in a transdermal patch was evaluated; ADR were reported while the transdermal patch was used correctly; intentional misuse, abuse, or suicide because prevention strategies would largely differ from those applicable for unintentional errors; or no indication for causality between the faulty administration and the outcome was given
Lermontov S, 2018 [38]	Systematic review	Hematopoietic stem cell transplantation	To identify in the literature the incidence, related factors, consequences, and prevention mechanisms of ME in the context of hematopoietic stem cell transplantation	11	All study designs that report ME in the bone marrow transplantation scenario	Conference, abstracts, editor letters, book chapter, editorial, review, comment, and dissertation/thesis
Lopez-Pineda A, 2022 [36]	Systematic review	Pediatric ME by parents or caregivers at home	To review the current literature on the frequency of pediatric ME by parents or caregivers at home, their associated factors, and pediatric ME reporting systems	19	Original articles on ME, either prescribed or non-prescribed drugs, that parents or other caregivers of children make at home, influencing factors and pediatric ME reporting systems. Any type of study design if they investigated ME in pediatric population in the outpatient setting (at home)	Studies on therapeutic adherence, any type of review, non-citable paper, such as editorials or letters to the editor, or studies for which access to complete information was not available, even after contacting the authors
Mansouri A, 2014 [43]	Systematic review	Iran	To detect and evaluate the studies on source of ME, reasons for ME under-reporting, preventive measures of ME and the most common drugs related to ME in Iran	25	All types of original studies on adults and children that reported sources of ME, reasons for not reporting ME, preventive measures of ME, and most common drugs involved in ME in Iran	Letters, case reports, conference papers, organizational reports, opinions, or editorial papers. Articles focused on medical errors and nursing practice errors. Articles on preventive measures which were solely focused on usability and acceptability of the measures themselves, not on the outcome of reducing ME
Marznaki Z, 2020 [44]	Systematic review	Iran emergency departments	To review the literature describing the prevalence and factors affecting ME among emergency ward nurses in Iran	8	Full-text, peer-reviewed published studies that evaluated ME among emergency ward nurses in Iran	Studies conducted among any other healthcare providers, or among nurses who worked in other wards. Reviews, letters, RCTs, case studies, conference papers, opinions, dissertations, reports, and editorial papers. No access to full text. Grey literature as they usually do not portray the whole picture of the results, and when fully published, the results may change substantially

(*Continued*)

Table 2. (Continued).

Author, Year	Study design	Context	Aim	Total number of primary studies	Inclusion criteria	Exclusion criteria
Mekonnen A, 2018 [45]	Systematic review	African hospitals	To systematically investigate the literature on the extent of ME and ADE, and the factors contributing to ME in African hospitals	41	Peer-reviewed original published articles, irrespective of the study design, that investigated the frequency and nature of ME and/or ADE. Studies that addressed ADE were included only if injuries due to medications were reported. Studies that assessed HCP experiences or possible causes of ME. Studies should be carried out in an African hospital setting	Studies that investigated failures in optimizing drug therapy (e.g. dosage adjustment in renal failure patients), pharmaceutical issues, events caused by single drugs or drug classes or disease condition, and studies that aimed to assess knowledge and attitude to ADR reporting. Studies evaluating non-adherence to medication or self-harm. Conference abstracts, case studies, commentaries, and reviews
Mira J, 2015 [30]	Systematic review	Self-administering medications at home	To review and describe the methodological approaches and results of published studies on the frequency, causes, consequences, and avoidance of ME committed involuntarily by patients on self-administering medicines at home	69	Studies that focused on empirical, review or assessment work in relation to errors made by patients in their homes. Studies on types of errors on taking medication prescribed by a doctor or as the result of self-medication, factors that brought them about and their consequences. Studies on involuntary non-adherence that contributed data on ADE due to forgetting one's medication or failing to correctly follow the therapeutic regimen. Peer-reviewed research	Studies on the frequency and causes of voluntary non-adherence. Studies on self-medication when not related to the occurrence of patient harm according to the classification of errors by Buetow et al. Studies on patients acting as vigilant partners in safety (second control) thereby helping professionals avoid ADE or on the use of medicines for suicide attempts
Parand A, 2016 [33]	Systematic review	Domiciliary setting	To review studies of how carers cause and/or prevent MAE within the patient's home; to identify types, prevalence, and causes of these MAE and any interventions to prevent them	36	Errors occurred in the home, carers were responsible for the delivery of medication and empirical data were provided. Papers describing multiple case studies and qualitative studies where there was more than one care recipient participant	Papers describing a single case study, such as a MAE legal case. Papers that did not report data for carer-caused MAE separately to other ME or from other administrators (e.g. patients themselves), unless over 80% of combined data related to carers
Salmasi S, 2015 [46]	Systematic review	Southeast Asian countries	Aimed systematically to identify and review research done on ME in Southeast Asian countries to identify common types of ME and estimate its prevalence	17	All study designs. Patients of all ages from Southeast Asian countries	Reviews, letters, case studies, conference papers, opinions, reports, or editorial papers
Salmasi S, 2017 [37]	Systematic review	Older people	To systematically review studies on the incidence and categories of ME in older people in any setting	18	Original peer-reviewed research studies if they comprised ME in people aged ≥55 years. The more conservative cutoff point of 55 years was chosen to ensure no relevant study was excluded. Studies were only included if they were designed to assess ME	Studies focusing on ME caused by patients, such as self-medication. Unpublished or gray literature. Studies that reported ME as a secondary or additional outcome and those not specifically designed to assess and analyze ME. The prescribing of Beers medication was not considered a ME
Santesteban E, 2015 [34]	Systematic review	Neonatal Intensive Care Units (NICU)	To review the literature on the frequency and types of ME in NICU and the effectiveness of preventive strategies	13	Original studies or systematic reviews that measured ME in NICU and original studies or systematic reviews that measured interventions to reduce ME in NICU	Case studies or case reports, studies about errors in parenteral nutrition preparation, editorial articles or narrative reviews of ME, and abstracts without concrete results
Schroers G, 2020 [51]	Systematic review	Not specific	To critique and synthesize the qualitative evidence on perceived causes of MAE as reported by nurses in health-care settings	16	Studies that used a qualitative or mixed methods design and reported qualitative data on nurses' perceived causes of MAE in health-care settings	NR

(*Continued*)

Table 2. (Continued).

Author, Year	Study design	Context	Aim	Total number of primary studies	Inclusion criteria	Exclusion criteria
Sears K, 2012 [31]	Systematic review	Community setting	To identify the incidence, prevalence and contributing factors associated with ME for children and adults in the community setting	21	All types of studies that included adults and children living in the community (including home/residential homes) that have experienced a ME and evaluated the incidence, prevalence and contributing factors	NR
Snijders C, 2007 [26]	Systematic review	NICUs	To examine the characteristics of incident reporting systems in NICU in relation to type, etiology, outcome, and preventability of incidents	10	Systematic reviews, RCT, observational studies, or qualitative research concerning incident reporting. NICU data can be extracted from articles	Non systematic reviews, expert opinion, case reports, letter from the editor
Thomas B, 2019 [42]	Systematic review	Hospitalized patients in Middle Eastern countries	To critically appraise, synthesize and present the evidence of ME amongst hospitalized patients in Middle Eastern countries, specifically prevalence, nature, severity, and contributory factors	50	Primary research studies of any design conducted in hospital settings in the Middle East (defined) which quantified ME (i.e. prescribing, administration or dispensing errors). Studies which reported error nature, severity or associated causative factors were also included	Studies of ADE which were not classified as errors, as were review articles, letters, opinion papers, editorials, and conference abstracts
Tully M, 2009 [28]	Systematic review	Inpatient	To identify all informative published evidence concerning the causes of and factors associated with prescribing errors in specialist and non-specialist hospitals, collate it, analyze it qualitatively and synthesize conclusions	17	Studies that reported on the causes of and/or factors associated with prescribing errors in handwritten prescriptions written by doctors for adult and/or child hospital inpatients. Studies reporting ME more broadly were only included if they describe the causes of or factors associated with prescribing errors in sufficient detail to allow extraction and analysis to be carried out. Any study design with data concerning causes and associated factors collected empirically	Studies where causality or associated factors were surmised (e.g. based on professional experience of the data collector). Conference abstracts
Wimpenny A, 2010 [28]	Systematic review	Acute care settings	To undertake a comprehensive systematic review of roles and systems for preventing ME during routine medication administration in hospital-based acute care settings	19	Participants were nurses, pharmacists, pharmacy technicians, medical and surgical staff, and adult patients in hospital-based, acute care settings. Intervention related to administration systems and related to roles of those who administer medicines were considered. The perceptions of causes of error was the phenomena of interest. Quantitative studies of ME error rates for differing medication systems and roles of those administering medications. Qualitative and descriptive studies of perceived causes of errors	NR

ME: medication errors; ADE: adverse drug events; RCT: randomized controlled trials; HCP: healthcare providers; ADR: adverse drug reactions; NR: not reported; MAE: medication administration errors

[46] and systematically reviewed contributory factors in a variety of settings. Two reviews encompassed a specific pharmacological class or dosage form of direct oral anticoagulants [47] and transdermal patches [48]. One review included intern doctors only [49], while another one examined a single prespecified contributory factor (shift work) in inpatient nurses [50]. Schroers et al. (2020) were the only review that did not specify a population or a setting of interest [51].

3.3. Search details

The number of databases reported in the systematic reviews ranged from 2 [40,48] to 21 [28]. The most commonly recurring databases were Medline/PubMed, CINAHL, Embase, Cochrane, and British National Index (Supplementary material, Table 2). Most reviews applied language as a filter, largely limiting their results to English language. Few reviews (n = 7) included studies of a number of languages, mainly those spoken by the research team.

Most reviews, except for four [27,35,50,51], did not integrate keywords specific to contributory factors in their search strategy. The keywords used were as follows: cause(s); causality; causalities; reason(s); etiology; etiology; factor(s); risk factor(s); contributing factor(s); determining factor(s); predictor(s); association(s); and determinants.

3.4. Quality assessment

All but six [26,27,30,34,43,48] of the reviews reported quality assessments of the included articles. The two most common quality assessment tools were the Allan and Barker instrument (with or without modifications) and the Critical Appraisal Skills Program checklist. As reported by the authors, the overall quality of primary studies included in the systematic reviews was variable (Supplementary material, Table 3); with a considerable number reporting moderate overall quality.

According to the appraisal of the included systematic reviews using the JBI tool, the overall quality varied, with common areas of bias noted across reviews (Supplementary material, Table 3). Most reviews described their aim (n = 19; 68%) and future research directions (n = 20; 74%), while 16 (59%) and 14 (52%) reviews lacked information about eligibility criteria and data extraction, respectively. Some reviews did not incorporate sufficient description of their search strategy (52%; n = 14) and resources (e.g. databases, gray literature, or reference lists) used to search for studies (41%; n = 11).

3.5. Medication errors: terminology, definitions, and classifications

Most reviews investigated medication errors without associating them with the stages of the medication use process (n= 17), of which one review used the terms "medication errors" and "adverse drug events" (ADEs) interchangeably [50]. The remainder of the reviews focused on a single stage in the medication use process, specifically administration errors (n = 4), administration errors by patient or caregiver (n = 4), and prescribing errors (n= 2).

Of those reporting medication errors, four stated that they adopted the NCCMERP definition [37,39,44,46] and four adopted the definitions provided in the primary studies [18,26,31,47]. Two reviews on administration errors by patients or caregivers provided definitions in their methods section, of which one was suggested by the authors themselves [29,38]. Two different definitions were reported for administration errors [33,35]. Both were adopted from previous studies and entailed deviation between prescribed and administered medication. As for prescribing errors, one of the reviews reported that they adopted the working definitions in the original studies [27].

Medication errors were classified in eleven of the included reviews (Table 3), of which 10 reported errors according to the medication use process stages (e.g. prescribing errors). The remainder investigated self-administration errors and reported according to the incident type (e.g. wrong dose) [29]. Among the 10 reviews, six further classified medication errors according to the incident type [36,39,41,45–47].

3.6. Contributory factors to medication errors: terminologies, definitions, methodologies, and classifications

The terms used to describe the contributory factor are presented in Table 4. The most common term was 'contributory factor,' with some reviews using 'factor' alone or proceeded with another terms such as "risk," "associated," "related," "influencing," "causal," "causative," or "etiological." The other commonly reported term was "cause" and its derivatives including "root cause," "causation," and "causality." Other less commonly used terms were "reason," "etiology," "predictor," and "source."

Two included reviews defined risks/contributory factors [27,36], while another adopted the definition of hazard/contributory factors suggested by the WHO [31]. Tully et al. (2009) differentiated between the terms "causes" and "contributory factors", in which the latter was suggested to refer to those assessed by the researcher, while the former referred to those identified by practitioners [27].

All but three [37,39,46] of the included reviews specifically aimed to explore contributory factors (Table 2). Ten systematic reviews had a prespecified methodology to identify and classify contributory factors, namely the use of theories/frameworks/models and thematic analysis. Four adopted Reason's Accident Causation Model [27,35,42,47], of which three classified contributory factors into categories of active failures, error-producing conditions, and latent conditions. In their review of administration errors, Keers et al. (2013) adopted a version of the theory that had been modified for administration errors [35]. Among the included reviews that used the Reason's model, active failures, and decision-making mistakes were the most prevalent categories of contributory factors (Table 5).

The Framework for Analyzing Risk and Safety in Clinical Medicine was used by one review [42]. This framework categorizes factors into six groups: individual, work environment, organization and management, team, tasks, and medications [43,52]. Another review utilized the Conceptual Framework for the International Classification for Patient Safety proposed by

Table 3. Data pertaining to medication errors.

Author, Year	Terminology	Definition	Methodology for classifying ME	Classification of ME
Al Rowily A, 2022 [47]	Medication errors	Worked with the definitions provided by original studies	Medication use processIncident type (type of prescribing errors)	Prescribing, administration, dispensing errors
Aldila F, 2021 [29]	Medicine self-administration errors (MSE)	A deviation by the patients or their caregivers from the prescriber's medication orders or the manufacturer's administration instructions during the medicine administration process (adopted)	Types of MSE were classified in accordance with how they were reported in the original studiesIncident type (type of prescribing errors)	Dosing error, missed dose, wrong medicine, duplicity of medicines, incorrect preparation methods, incorrect administration methods, wrong administration route, wrong administration time, wrong frequency, incorrect spacing (time period between doses), and use of expired medicines
Alshehri G, 2017 [39]	Medication errors	NCCMERP definition (adopted)	Medication use processIncident type (type of prescribing errors)	Overall ME, prescribing, administration, transcribing, dispensing errors
Alsulami Z, 2013 [41]	Medication errors	Not reported	Medication use processIncident type (type of prescribing errors)	Prescribing, transcribing, administration errors
Assiri G, 2018 [18]	Medication errors	Worked with the definitions provided by original studies	Medication use process	Prescribing, monitoring errors
Boytim J, 2018 [40]	Medication errors	Not reported	Not done	Not done
Di Muzio M, 2019 [50]	Medication errors and adverse events interchangeably	Not reported	Not done	Not done
Dionisi S, 2021 [32]	Medication errors	Not reported	Not done	Not done
Hansen C, 2016 [49]	Prescribing error	Not reported	Not done	Not done
Keers R, 2013 [35]	Administration errors	A deviation from the prescriber's medication order as written on the patient's chart, manufacturers', instructions, or relevant institutional policies (adopted)	Not done	Not done
Lampert A, 2014 [48]	Medication errors	Not reported	Not done	Not done
Lermontov S, 2018 [38]	Pediatric medication error at home	Any preventable and unintentional deviation from the appropriate use of prescribed or non-prescribed pediatric medication, committed by parents or caregivers in the outpatient setting	Incident type (type of errors)	Dosing errors, time administration errors, frequency errors, medication preparation method, self-decided treatment discontinuation, wrong medicine, expired medication,
Lopez-Pineda A, 2022 [36]	Medication errors	Not reported	Not done	Not done
Mansouri A, 2014 [43]	Medication errors	Not reported	Not done	Not done
Marznaki Z, 2020 [44]	Medication errors	NCCMERP definition (adopted)	Medication use processIncident type (for all stages)	Ordering, transcribing, dispensing, administration, and during medication history taking
Mekonnen A, 2018 [45]	Medicine self-administration errors (MSE)	Not reported	Not done	Not done
Mira J, 2015 [30]	Medicine self-administration errors (MSE)	Not reported	Not done	Not done
Parand A, 2016 [33]	Administration errors	Any deviation between the medication prescribed and that administered (adopted)	Not done	Not done
Salmasi S, 2015 [46]	Medication errors	NCCMERP definition (adopted)	Medication use processIncident type (type of prescribing errors)	Medication use process: prescribing, administration, dispensing, preparation, transcribing Incident type: wrong dose, omission error, incorrect time, wrong drug, incorrect administration technique, wrong dose form
Salmasi S, 2017 [37]	Medication errors	NCCMERP definition (adopted)	Medication use process	Prescribing, administration, dispensing, transcribing
Santesteban E, 2015 [34]	Medication errors	Not reported	Not done	Not done
Schroers G, 2020 [51]	Administration errors	Not reported	Not done	Not done
Sears K, 2012 [31]	Medication errors	Worked with the definitions provided by original studies	Worked with the classification provided by original studies Medication use process was identified	Prescribing, administration, dispensing errors
Snijders C, 2007 [26]	Medication errors (study concerned medical errors with focus on ME)	Worked with the definitions provided by original studies	Not done	Not done

(*Continued*)

Table 3. (Continued).

Author, Year	Terminology	Definition	Methodology for classifying ME	Classification of ME
Thomas B, 2019 [42]	Medication errors	Not reported	Medication use process	Prescribing, administration dispensing errors
Tully M, 2009 [28]	Prescribing errors	Worked with the definitions provided by original studies	Not done	Not done
Wimpenny A, 2010 [28]	Administration errors	Not reported	Not done	Not done

ME: medication errors

the WHO [31]. This framework comprises 10 high-level classes and the contributing factors segment consists of a maximum of five levels (Table 5) [53].

Qualitative synthesis was used in four of the included reviews to categorize contributory factors. Of these, thematic analysis was applied in two, detailing the generation of codes and themes [49,51]. Other methods reported were meta-regression [28] and inductive analysis [33] but with little detail provided. The review of Assiri et al. (2018) had three prespecified categories [18], while four reviews classified factors according to emerging themes [30,32,40,45].

Among those reviews that did not apply Reason's theory, the most recurring themes were practitioner-related (n = 8), work environment-related (n = 7), patient-related (n = 5), and medication-related factors (n = 4) [Table 5].

Table 5 gives the most commonly reported contributory factors. Decision-making mistakes (classified as active failure by Reason's theory) such as failure to consider risk factors (e.g. chronic kidney disease and pediatrics) were reported in multiple systematic reviews. Other recurring factors were related to the organization or environment, including lack of knowledge, insufficient training, work overload, inadequate staffing levels, illegible prescriptions, distractions and interruptions, and poor communication. Polypharmacy, extreme age (elderly or pediatrics), and limited health literacy of patients were also common across reviews.

3.7. Interventions proposed to mitigate factors contributing to medication errors

None of the reviews aimed to evaluate interventions designed to mitigate contributory factors. Nevertheless, 21 included reviews discussed interventions without specifying the characteristics, method of development, and outcomes of these interventions. Multiple reviews emphasized the need for multifactorial interventions to holistically address contributory factors [18,27–29,31–33,38,40,44,47]. Only one review suggested the use of theory to develop these interventions [47].

Pharmacist-delivered [18,29,32,40,45–47], educational [18,31,33,38,41,44,45,47,48,51] and technology-enabled interventions [18,30,32,33,38,40,44,45,47] were most frequently suggested in the included reviews. Only two included reviews incorporated organization-level interventions (e.g. increase staffing) [44,51].

Among studies that recommended pharmacist-delivered interventions, four suggested full integration of the pharmacist in the health-care team [18,40,45,46] while three recommended initiating a pharmacist-led service (e.g. anticoagulation stewardship program) [29,32,47]. Most reviews that suggested technology-enabled interventions highlighted the need for decision support systems to reduce prescribing errors [44,45]. Three studies proposed the development of innovative technological tools (e.g. mobile applications) that could be accessed by patients and tailored to their needs [18,30,33].

Proposed educational interventions varied significantly among the included studies based on the context. For instance, studies that focused on administration errors,

Table 4. Data pertaining to contributory factors to medication errors.

Author, Year	How many studies reported on contributory factors	Terminology used to describe contributory factors	Definition of contributory factors
Al Rowily A, 2022 [47]	27 out of 32 (84.4%)	Contributory factors, causation	Not reported
Aldila F, 2021 [29]	7 out of 11 (63.6%)	Contributory factors	Not reported
Alshehri G, 2017 [39]	5 out of 20 (25%)	Factors that increase the risk/rate of error	Not reported
Alsulami Z, 2013 [41]	12 out of 45 (26.7%)	Contributory factors, causes	Not reported
Assiri G, 2018 [18]	36 out of 60 (60%)	Risk factors	Not reported
Boytim J, 2018 [40]	All studies (part of the inclusion criteria)	Contributory factors	Not reported
Di Muzio M, 2019 [50]	All studies (part of the inclusion criteria)	Factors, reasons	Not reported
Dionisi S, 2021 [32]	All studies (part of the inclusion criteria)	Risk factors, causes	Not reported
Hansen C, 2016 [49]	All studies (part of the inclusion criteria)	Factors influencing/ affecting prescribing behavior	Not reported
Keers R, 2013 [35]	All studies (part of the inclusion criteria)	Causes	Reasons reported to the researcher by the person directly involved with a specific administration error or near miss as being wholly or partly responsible for said error (developed by authors)
Lampert A, 2014 [48]	8 out of 42 (19%)	Contributing factors, causes, root cause, etiology	Not reported
Lermontov S, 2018 [38]	8 out of 11 (72.7%)	Related factors	Not reported
Lopez-Pineda A, 2022 [36]	14 out of 19 (73.7%)	Associated/influencing/risk factors	Any factor that increased the chance of parents or caregivers made a ME at home (developed by authors)
Mansouri A, 2014 [43]	12 out of 25 (48%)	Contributory factors, sources	Not reported
Marznaki Z, 2020 [44]	All studies	Contributory factors, factors affecting ME	Not reported
Mekonnen A, 2018 [45]	15 out of 41 (36.6%)	Contributory factors, causality	Not reported
Mira J, 2015 [30]	36 out of 69 (52.2%)	Causal factors, causes	Not reported
Parand A, 2016 [33]	25 out of 36 (69.4%)	Contributory factors, causes	Not reported
Salmasi S, 2015 [46]	15 out of 17 (88.2%)	Contributory factors, root causes	Not reported
Salmasi S, 2017 [37]	13 out of 18 (72.2%)	Contributory factors, risk factors, reasons	Not reported
Santesteban E, 2015 [34]	5 out of 13 (38.5%)	Causes	Not reported
Schroers G, 2020 [51]	All studies (part of the inclusion criteria)	Contributory factors, causes	Not reported
Sears K, 2012 [31]	10 out of 21 (47.6%)	Contributory factors, causal factors, causative factors, predictors	The circumstances, actions or influences which are thought to have played a part in the origin or development of an incident or to increase the risk of an incident (adopted from WHO)
Snijders C, 2007 [26]	All studies	Contributory factors, etiology, factors, etiological factors	Not reported
Thomas B, 2019 [42]	24 out of 50 (48%)	Contributory factors, causative factors, causes	Not reported
Tully M, 2009 [28]	All studies (part of the inclusion criteria)	Factors associated, causes	-Factors associated: variables that were linked with the prevalence of specific prescribing errors by the researchers -Causes: reasons reported to the researchers by the prescriber, in structured or unstructured interviews (developed by authors)
Wimpenny A, 2010 [28]	11 out of 19 (57.9%)	Causes, reasons	Not reported

recommended distribution of educational material alongside the educational sessions for the nurses to refer to it when needed [30,51]. Nevertheless, a commonly suggested topic was the communication and interprofessional collaboration between different health-care providers [27,32,33,47,51]. Few reviews reported that educational sessions should be conducted periodically [38,44].

4. Discussion

4.1. Statement of key findings

This umbrella review shows that decision-making mistakes, which include non-consideration of risk factors (e.g. chronic kidney disease and pediatrics), were the most common contributory factor, followed by factors related to the organization and environment such as the lack of knowledge/training, understaffing, and distractions. Most reviews did not pre-specify a methodology in relation to classification of contributory factors. Among the reviews that followed a structured method to classify contributory factors, the use of the theory and Reason's model was most commonly used. The included reviews were of variable quality due to issues primarily related to search strategy, quality assessment, and data extraction processes. A range of terminologies and definitions were used to refer to contributory factors. To target the contributory factors and subsequently reduce the errors, several interventions were suggested in the included reviews. These

Table 5. Contributing factors to medication errors.

Author, Year	Methodology to identify and classify contributory factors	Error classes		Examples	Most reported
Al Rowily A, 2022 [46]	Reason's accident causation model	Active failures	Slips	Duplicate therapy, transcription errors, dispensing errors	Active failures: mistakes
			Lapse	Acronym errors, wrong label	
			Mistakes	Wrong dose (non-consideration of renal function), wrong indication	
			Violation	Doctor not writing the order in time	
		Error provoking condition		Lack of knowledge and experience, inadequate monitoring, system errors, failure staff to follow policy, inadequate laboratory results, poor communication, distraction, work overload	
		Latent conditions		Lack of medication reconciliation service, lack of training	
Aldila F, 2021 [28]	Not reported	Not reported		Complex regimens, cognitive decline, lack of knowledge, negative attitudes and beliefs toward medicines, decline in physical ability, lack of social support, multiple chronic conditions, poor collaboration between patients/HCP and among HCP, pharmaceutical products and packaging design, confusion about compliance aids, limited health literacy, absence of error detection mechanisms, absence of patient education	Complex regimens
Alshehri G, 2017 [38]	Not reported	Not reported		Senior physicians, use of an electronic prescription pro forma, number of medications/doses, interruptions, patient load, nonoral route of administration, presence of organic brain disease (e.g. dementia), swallowing difficulties	Not reported
Alsulami Z, 2013 [40]	Not reported	Not reported		Lack of knowledge, poor compliance with guidelines, lack of reporting of ME, heavy workload and new staff, miscommunications between HCP	Lack of knowledge
Assiri G, 2018 [18]	Predefined categories	Patient-related		Polypharmacy, increased age, number of diseases, female, low level of education, hospital admission, middle family income	Not reported
		Healthcare professionals-related		Multiple physicians involved in care, family medicine specialty, age ≥51 years, male, frequent changes in prescription, not considering prescriptions of other physicians, inconsistency in the information and outpatient clinic visits	
		Medication-related		Multiple drug storage locations, expired medication, discontinued drugs repeats retained, hoarding of drugs, therapeutic duplication, no administration routine, poor adherence, confusion between generic and trade names, multidose drug dispensing users, receiving anticoagulant therapy, use of over-the-counter drugs	
Boytim J, 2018 [39]	Factors grouped according to emerging themes (not predefined)	Types of errors		Wrong dose, omission, wrong route, wrong dosage form	Performance deficits, distraction, haste, inattention, poor communication, knowledge deficits, labeling mistakes, and syringe swaps
		Causes of errors		Labeling mistakes and syringe swaps, performance deficit, distraction, poor communication, haste, inattention, knowledge deficit	
		Human factors		Haste, stress, pressure, distraction, decreased vigilance, fatigue, inaccurate medication reconciliation, patient lack of understanding, and knowledge deficit related to patient allergies	
		Medication types		Analgesics, antibiotics, vasopressors	
		Environmental factors		Transfers, fragmentation, change providers, work overload, federally owned facilities, facilities with 100 to 499 beds (compared to <100 or > 500), anesthesia induction period, maintenance period, longer procedures, procedures performed during the day	
		Patient characteristics		Low physical status, male, acuity	
Di Muzio M, 2019 [49]	Not reported	Study focused on shift works only		Occasional night shifts, reduced staffing, long shifts, work overload, sleep quality and quantity, stress, fatigue, workflow interruptions	Not reported
Dionisi S, 2021 [31]	Factors grouped according to emerging themes (not predefined)	Transition of care		Lack of complete documentation particularly medications, poor communication, technology errors, patient-related factors (elderly, polypharmacy, chronic diseases)	Not reported
		Medication reconciliation		Lack of a standardized process, lack of single documentation that reports the entire patient history, poor communication, poor flow of information	
		Multidisciplinary team		Poor interprofessional communication and with the patient, low health literacy, cognitive and functional impairment, inadequate integration of the pharmacist into the care team	

(*Continued*)

Table 5. (Continued).

Author, Year	Methodology to identify and classify contributory factors	Error classes	Examples	Most reported
Hansen C, 2016 [48]	Thematic synthesis (predefined)	Environmental factors	Time constraints, poor communication, defenses (I know someone else will check it), hierarchical structures, rotation	Not reported
		Patient characteristics	Complexity, poor communication, patients' influence	
		Individual factors	Wellbeing (workload), lack of knowledge, attitude and awareness, responsibility, experience	
Keers R, 2013 [34]	Reason's accident causation model	Unsafe acts	Slips, lapses, knowledge-based mistakes, deliberate violations	Slips, lapses, knowledge-based mistakes, communication, work overload, medicine supply and storage
		Error-provoking conditions (local workplace factors)	Inadequate written communication, problems with medicines supply and storage, work overload, problems with ward-based equipment (access, functionality), patient factors (acuity), staff health status (fatigue, stress), interruptions	
		Organizational (high-level) decisions	Poor feedback on errors and lack of nurse input in the process, lack of hospital policy or misguided policy (low nurse staffing), logistical strategy decisions revolve around clashes of other ward activities with medication administration, look or sound alike medication may have roots beyond hospitals with the pharmaceutical industry	
		Latent conditions	Local working culture and high-level managerial decisions	
Lampert A, 2014 [47]	Not reported	Not reported	Lack of knowledge and awareness of the importance of a correct administration practice, patch designs	Not reported
Lermontov S, 2018 [37]	Not reported	Not reported	Over-the-counter medications, polypharmacy, lack of double checking, look alike and sound alike medications, stress, dose calculation error, poor communication, illegible prescriptions	Not reported
Lopez-Pineda A, 2022 [35]	Not reported	Not reported	Poor comprehension, complex regimens, low health literacy, primary language of the parent was different from the language of written discharge instructions, male sex, younger age, polypharmacy, use of dropper (versus cup and syringe), use of a teaspoon-only label, receiving text only instructions (versus text and pictogram), decreasing child age, limited understanding about medications, lack of reassessment by HCP	Not reported
Mansouri A, 2014 [42]	Framework of factors influencing clinical practice and contributing to adverse events (with modification, added an extra category entitled medication)	Individual factors	Inadequate knowledge, miscalculations of doses, physical and mental health	Individual factors: inadequate knowledge
		Work environment	Heavy workload, working overtime, nurses' burnout, little time spent with patient	
		Organization and management	Shortage of workforce (understaffing)	
		Team	Illegibility of orders or patient charts	
		Tasks	Lack of guidelines	
		Medications	Name similarity	
Marznaki Z, 2020 [43]	Not reported	No attempt at classifying by authors	Reduced staffing, inappropriate nurse-patient ratios, inadequate knowledge, demographic factors (nurses' age, gender, and work experience), busy nature of emergency wards, managerial lapses	Reduced staffing and inappropriate nurse-patient ratio
Mekonnen A, 2018 [44]	Factors grouped according to emerging themes (not predefined)	Individual factors	Fatigue, confusion, memory lapses, rushing, inadequate monitoring/reporting, inadequate knowledge/training, rule violation, inappropriate administration technique, low morale	Individual factors: fatigue and inadequate knowledge/training Environmental factors: workplace distraction and work overload
		Working environment	Work overload, distraction, busyness, lack of resources (e.g. equipment), time of the day	
		Team	Communication deficits, no senior support	
		Task	Lack of documentation, labeling deficits, transcription error, illegible writing, multi-tasking, unfamiliar patient, look-alike drug names/labeling, syringe swap, misidentification of drugs/ampoules, careless checking/not checking	
Mira J, 2015 [29]	Factors grouped according to emerging themes (not predefined)	Intrinsic factors	Patients' profile (age, cognitive state, polypharmacy), level of health literacy	Not reported
		Extrinsic factors	Quality of the information provided, communication with caregivers, complexity of use dispensing devices	

(*Continued*)

Table 5. (Continued).

Author, Year	Methodology to identify and classify contributory factors	Error classes	Examples	Most reported
Parand A, 2016 [32]	Contributory factors inductively identified and grouped into a new framework	Individual care recipient factors	Younger child age	Not reported
		Individual carers factors	Age of carer, educational level of carer, carer's time and other responsibilities, language of carer, health of carer, carer marital status	
		Medication factors	Polypharmacy, type of medication, route of administration, medication supply	
		Environmental factors	Storage, equipment	
		Prescription communication factors	Communication with healthcare professionals & carers' understanding of instructions or medication/illness, dosage change	
		Psychological factors	Panic/cognitive failure, fear of spillage, carer-to-carer communication	
Salmasi S, 2015 [45]	Not reported	Not reported	Factors extrapolated from original studies: staff shortage, work overload, distraction, incorrect interpretation of prescription/medication chart, lack of knowledge, lack of experience Factors provided based on the authors of the reviews assessment: poorly designed work environments and systems, patients factors (forgetfulness, lack of cooperation or confusion)	Not reported
Salmasi S, 2017 [36]	Not reported	Not reported	Polypharmacy, inappropriate administration scheduling, understaffing, similar packaging, stress and time constraints, lack of staff training, medications associated with complex tasks (crushing), interruptions during ward rounds	Not reported
Santesteban E, 2015 [33]	Not reported	Not reported	Human factors, use of unlicensed medicines	Human factors
Schroers G, 2020 [50]	Thematic synthesis (methods predefined)	Knowledge-based factors	Lack of knowledge about medications, protocols, technology, calculations, lack of skills required for administration, misinterpretation of preparation protocols	Contextual factors (most common): heavy workloads and interruptions Knowledge-based factor: medication knowledge Personal factors: fatigue and complacency
		Personal factors	Complacency, lack of confidence, fear of looking incompetent, overconfidence, negligence, forgetfulness, lack of attentiveness, not following protocol, practice beyond scope of practice, fatigue, tendency to make assumptions, stress, lapses, nervousness, lack of concentration, lack of care, unpreparedness, drowsiness, talking, multitasking, personal or family health issues, deliberate deviations from guidelines	
		Contextual	Interruptions, poor communication, challenging professional relationships, understaffing, heavy workloads, lack of supervision/support, inexperience, lack of training, improper physical working conditions, work-related pressure, lack of time, unsafe practice norms	
Sears K, 2012 [30]	Analyzed using the Conceptual Framework for the International Classification for Patient Safety proposed by the WHO	Staff factors	Cognitive factors: lack of knowledge, confusion about medicationsPerformance factors: dosing errors, misreading prescriptions, calculation errorsBehavior factors: fatigue, carelessness, lack of concentrationCommunication factors: poor communication, lack of communication between doctor and patient or between staff, patient, and carers Emotional factors: low satisfaction	Not reported
		Patient factors	Cognitive factors: confusion, lack of awareness of medicationsPerformance factors: dosing errors	
		Work/environment factors	Physical environment/infrastructure: hot, airless, poorly lit, short of space, busy environment, pressured, noisy and fraught, interruptions	
		Organizational/service factors	Resources/workload: busy, distraction	
		External factors	Products, technology, and infrastructure: similar looking medications/containers/packaging, similar drug names	
Snijders C, 2007 [25]	Not reported	Not reported	Failure to follow procedures, inattention, poor documentation or communication, lack of training, negligence, poor regulation, incorrect orders, faulty preparation, increased level of care, verbal orders differed from written order, lack of double check, dose miscalculations -Some studies reported the stage of the medication use process or the incident type as the contributory factor	Not reported

(*Continued*)

Table 5. (Continued).

Author, Year	Methodology to identify and classify contributory factors	Error classes		Examples	Most reported
Thomas B, 2019 [41]	Reason's accident causation model	Active failure	Slips	Look-alike sound-alike medications, selecting wrong medication, wrong patient, memory lapses	Active failures: slips, lapses, and mistakes
			Lapses	Dispensing errors, failure to give medication, lack of documentation, faulty dose checking	Error-provoking conditions: lack of knowledge, insufficient staffing levels
			Mistakes	Wrong dose, wrong packaging, incomplete medication orders, incorrect transcription	
			Violation	Use abbreviations, poor adherence to protocol, using acronyms	Latent conditions: heavy workload
		Error- provoking conditions		Fatigue, illegible handwriting, work overload, patient condition (illiteracy, elderly)	
		Latent conditions		Lack of training, lack of staffing, poor communication, supervisory issues, lack of policy and procedures, performance deficit	
Tully M, 2009 [26]	Reason's accident causation model	Active failure	Slips	Skill-based	Active failure: mistake
			Lapses	Memory-related	
			Mistakes	Knowledge-based, rule-based	
			Violation	Inadequate monitoring, not following policy	
		Error- provoking conditions		Lack of training or experience, fatigue, stress, high workload for the prescriber and inadequate communication between HCP	
		Latent conditions		Reluctance to question senior colleagues, inadequate provision of training	
Wimpenny A, 2010 [27]	Results were combined in a meta-aggregative view	Quantitative data from nurses' perception		Nurse fails to check patients name band with the medication administration record, tired and exhausted, order difficult to read or illegible, distracted by other patients, coworkers or events, dose miscalculation	
		Qualitative data from nurses' perception		External factors: use of policies, protocols, and guidance; context and organization of care; and roles of people within the systemInternal factors: interpersonal skills and relationships; individual knowledge and skills; and personal responsibility	
		Qualitative data from patients' perception		Patients not included in the medication administration process; nurses may not listen to their concerns; and patients unaware of the medication administration process and the drugs being administered	

HCP: healthcare providers; ME: medication errors

included pharmacist-provided, educational, and technology-based interventions. The discussion of interventions lacked details on the development, evaluation, and implementation.

4.2. Interpretation of findings

Decision-making mistakes (also known as errors of judgment), which include failure to consider risk factors (e.g. chronic kidney disease and pediatrics), were the predominant contributory factor to medication errors across diverse health-care settings. Decision-making mistakes and other types of human errors are foreseeable in the context of the complex and often challenging clinical practices [54]. Additionally, healthcare is dynamic in nature, with a great deal of uncertainty and potential subjectivity surrounding clinical decisions [54,55]. Therefore, although it is imperative to attempt at mitigating these mistakes, it is unrealistic to expect an error-free system. However, innovative theory-based interventions that promote multidisciplinary team working, blame-free culture, use of technology, and expertise of pharmacists can minimize errors.

Another common contributory factor identified in our umbrella review is related to organizational and environmental factors. These factors have been poorly reported in the previous literature as less attention has been given to error-prone systems [56].

Although the use of the theoretical framework has been strongly recommended to undertak exploratory and interventional research to identify and target different behaviors [57,58], most of the reviews did not report a prespecified method to synthesize contributory factors, with only six using a theory-based approach. One recurring model to classify contributory factors was Reason's model. This model shifts the focus of human error investigation from person-centered to system approach considering errors occurring at both the sharp (active failures) and blunt (latent conditions) ends of the system [59,60]. The model also moves away from blame culture while still being easy-to-use; thus, it has been extensively utilized in the safety field [60,61]. Nonetheless, Reason's model has limitations that should be considered by researchers who use it as well as practitioners who interpret findings from studies that have used it. The model is considered a complex linear model, which assumes that accidents are the result of a series of events that interact sequentially in a linear fashion [62]. This approach may overlook the complexity of the system and the interrelations between its components, particularly when the contributory factors are far from the incident in terms of time or location [62,63]. Furthermore, some researchers argue that Reason's theory may not account sufficiently for the interactions between defense layers and the errors produced by the defense mechanisms [59].

Seventeen different terms and five definitions were used by the reviews to describe contributory factors. Variations in the definition of medication error (and subclasses) were also noted among the reviews. This reinforces findings from previous arguments suggesting multiplicity in the use of patient safety practice-related terminologies [31,47,64,65]. It is likely that an array of definitions for both medication errors and contributing factors used in other literature may not be captured by reviews included in our study.

It is worth noting that the primary studies that focused on interventions to mitigate errors were prospective/retrospective cohort studies or cross-sectional studies [66–73]. A definitive evaluation utilizing randomized controlled trials was missing. Additionally, the majority of studies had a short follow-up duration, a small sample size, and were conducted in a single center [66–73]. The primary outcome measure evaluated in these studies mainly related to the number of interventions offered, such as changing one of the components of a medication regimen (e.g. dose and duration) or highlighting the interaction between prescribed drugs. Another outcome measure was the total number of errors that were assessed to be potentially preventable upon implementing the interventions [66–73].

4.3. Strengths and limitations

To our knowledge, this is the first attempt to systematically report the terminology, methodology, and classes of contributory factors to medication errors via an umbrella review. A comprehensive search of several databases followed by citation checking allowed retrieval of all relevant systematic reviews.

This review was limited by the lack of assessment for the potential overlap of individual studies within the included reviews. In addition, our summary of terms and definitions of contributory factors and medication errors relied on what has been reported by the included reviews. Lastly, only publications in the English language were included.

4.4. Implication for practice and research

Although the context of existing systematic reviews varied, several contributory factors were common across the reviews. A comprehensive synthesis of these factors could enable the development of holistic theory-informed interventions to target the identified factors. The contributory factors identified included decision-making mistakes and organizational factors. Accordingly, multifaceted theory-based interventions are required to prevent medication errors. These interventions should target contributory factors from the organizational level to specific tasks at the individual level.

Failure to account for risk factors was a common example of decision-making mistakes. Previous studies have shown that pharmacist-led and technology-enabled interventions minimize medication errors, including those occurring in high-risk cohorts [74–76]. Although the role of pharmacists and technology has expanded in recent years [74–76], their expertise remain underutilized [77–80].

System failures due to top-level management decisions were also identified among the most recurring contributory factors. Inadequate training and knowledge was the predominant latent condition. This indicates that limited continuing professional development activities alone might be insufficient in terms of quantity or quality. A previous systematic review showed that pharmacist-conducted educational interventions led to a significant reduction in medication error

rates [12]. Accordingly, implementation of educational sessions that are based on a structured need assessment to address the exact gaps in knowledge are likely to impact positive changes [81].

Despite the continuous growth of health-care costs, issues related to understaffing and poor work environment were still prominent in our review. Hence, strategic allocation of available resources and implementation of cost-effective mitigation mechanisms are recommended. Moreover, organizational and environmental factors that lead to breakdowns in communication and collaboration between health-care providers have been repeatedly reported across the included reviews. Thus, interdisciplinary collaborations could be considered in future interventions as they represent an important facet of facilitating communication [82]. This is particularly important as medication errors are a complex problem affecting diverse health-care disciplines and contexts.

It is evident from the findings of this review that there are certain populations/settings for which contributory factors to medication errors have not been systematically synthesized yet. Thus, future systematic reviews should focus on these clinical areas, such as oncology patients or outpatient and ambulatory settings.

This study has also identified a dearth of reviews incorporating theories in classifying contributory factors and developing interventions. This issue has been discussed before in the literature after some interventions that were implemented on a wide-scale have been proven ineffective or sometimes even had negative effect [83]. The first crucial step to prevent an undesirable event is to explore and diagnose the behaviors and mediating pathways leading to it, which in our case would be contributory factors. This could be achieved through the explicit use of behavioral theories [84,85]. Accordingly, we strongly encourage future researchers to utilize behavior theoretical frameworks, such as the Theoretical Domain Framework (TDF) for both understanding contributory factors and developing interventions that address these factors [86].

Given the range of terminologies used to refer to contributory factors to medication errors, future research should utilize consistent terminology. Based on our findings, the consistent use of 'contributory factors' is recommended. Although the term "causes" and "reasons" might be acceptable, we advise against their use. This is important to avoid confusion as these two terms have been used in different contexts in the literature. For example, some reviews represented fundamentally different concepts between 'contributory factors' and 'causes' [27,87]. Others used the terms "reasons" and "causes" interchangeably with "type" or "nature" of medication errors [13,88].

It is pivotal to remove ambiguity and reach international consensus on all patient safety terminology, including contributory factors and their subclasses. This will enable the accurate quantification of the burden of each factor, analysis of data, and comparison of research outcomes [1,64,89,90]. We also suggest maintaining consistency in the terms used across each study and to provide definitions for each term. This is of particular importance, as variation might lead to the inclusion of papers that may not actually be studying the phenomenon of interest. This could enhance the reliability of the outcomes and subsequently facilitate the development of possibly effective interventions.

Similarly, multiple definitions for contributory factors have emerged in the included reviews; however, our summary does not reflect all proposed definitions in the literature. Therefore, future research should focus on developing and validating definitions of key terminologies used in research related to patient safety such as medication errors and contributory factors.

5. Conclusion

This umbrella review highlights a significant variation in terminology and definitions used to describe contributory factors in the published literature. Decision-making mistakes, which included failure to consider risk factors (e.g. chronic kidney disease and pediatrics) were the most common contributory factors, followed by factors related to the organization and environment such as understaffing and distractions. However, a lack of prespecified methodology to identify and classify contributory factors was noted. Additionally, none of the reviews evaluated the effectiveness of interventions to prevent errors.

The recommendations offered in this review have the potential to enhance consistency in the use of terminology, definitions, and methodology used in contributory factors to medication error research. This will subsequently enable practitioners, policymakers, and other stakeholders to develop theory-informed interventions to promote patient safety. In addition, the comprehensive network of contributory factors synthesized in this review will inform future evaluations and classification of contributory factors and assist in the development of holistic interventions that target different levels of the healthcare system.

6. Expert opinion

Our umbrella review provides a comprehensive synthesis of the network of contributory factors to medication errors across diverse health-care settings. Decision-making mistakes, which included failure to consider risk factors (e.g. chronic kidney disease and pediatrics), particularly in cohorts requiring dose adjustments, were the most common contributors to medication error. This was followed by organizational and environmental factors, including insufficient knowledge/training, work overload, inadequate staffing levels, and suboptimal work environment. There is a need for theory-driven holistic interventions that incorporate pharmacist services, effective use of technology, multidisciplinary teamwork, educational sessions, and organizational-level strategies (such as effective allocation of resources and promoting blame-free culture).

Medication errors pose a substantial threat to patient safety, creating a serious public health problem, yet they are a common occurrence. Several interventions have been implemented to reduce medication errors previously, however some of these interventions have been proven ineffective. The development of these interventions was based mainly on a pragmatic approach or ISLAGIATT (It Seemed Like A Good Idea At The Time) principle, which lack the theoretical basis at the design stage [83,85,91–94]. Our findings suggest a paucity of research that used theory to diagnose and classify contributory factors and to develop interventions. Thus, future research needs to be undertaken through the explicit use of theoretical frameworks. Undertaking research utilizing frameworks for complex interventions can be

a substantial undertaking. However, in the long run, such interventions have the potential to deliver important influence on medication errors.

Additionally, it is pivotal that health-care systems move to a blame-free and non-punitive culture. It is also important that subject matter and safety experts provide timely and system-oriented solutions and feedback to the reported errors in a confidential manner [95]. This will encourage health-care providers to report and disclose medication errors, which will allow policymakers to accurately estimate the extent of the problem and understand the exact contributory factors and offer support.

Several terms have been utilized to refer to the factors contributing to medication errors in the included systematic reviews. Additionally, some reviews have used multiple terms (e.g. contributory factors, reasons, and causes) interchangeably. This practice creates confusion about the phenomenon of interest and subsequently could lead to the development of ineffective interventions. Based on the findings from this review, the consistent use of the term 'contributory factors' is encouraged. Future research should attempt to define the term 'contributory factors' as well as other terms reported in the included reviews through consensus methodology.

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Author contribution

L Naseralallah contributed to: study design, screening, developing data extraction tool, piloting the data extraction tool, data extraction, quality assessment, data synthesis, writing original draft, writing (review and editing). D Stewart contributed to: study design, developing data extraction tool, writing (review and editing), supervising. RA Ali contributed to: screening, piloting the data extraction tool, writing (review and editing). V Paudyal contributed to: study design, developing data extraction tool, verifying data extraction and quality assessment results, writing (review and editing), supervising.

Data availability

All relevant data are within the manuscript and its supplementary material.

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