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Centre for Clinical Effectiveness

Rapid Literature Review

Understanding contributing factors for Medication errors

Citation	Fiona Clay & Angela Melder. 2018. Understanding contributing factors for medication errors in the hospital setting: Evidence Review. Centre for Clinical Effectiveness, Monash Health, Melbourne, Australia.

Contact	CCE@monashhealth.org

Background

The Medication Safety and Therapeutics Committee requested an evidence review of the contributing factors for medication errors to guide a review of medication Structured Clinical Incident Review Templates (SCIRT) used at Monash Health to ensure the tools are capturing appropriate information for analysis.

Objective

To undertake an evidence review of the contributing factors for medication errors. The purpose of this is to guide review of medication ISR 3 and 4 SCIRT's to ensure the tools are capturing appropriate information for analysis against key performance indicators.

Methods

Appendices A1 and A2 outline the process of identifying evidence and synthesis of it for this report.

Results

This evidence review includes eleven systematic reviews of the international peer reviewed literature on factors associated with any type and any severity of medication error. Two reviews considered the elderly [1,2], two on neonates [2,3], one on critical care [4] and one on the perioperative setting [5]. Reviews also focused on medication care delivery across the hospital clinical spectrum. One review focused on registered and undergraduate nurses [6], one on information flow [7], one on medication dispensing [8] and one on medication administration [9] and one on factors leading to a clinical pharmacist intervention [10]. The final review focused on high risk medications in the hospital setting [11].

Reviews reported on the complexity that made medication safety an issue in certain clinical settings and within patient groups. Table A3 in the appendix outlines the complexity of medication safety challenges associated with particular clinical settings and patient groups.

Common risk factors for medication errors in the hospital setting

There are two main bodies of research to present:

1. Suggett and Marriott, 2016 [10] – a systematic review of the literature identifying risk factors for medication errors; including the most frequently reported drugs/classes of drugs associated with medication errors. The intention of their work was to build an evidence-based trigger tool, targeting individuals at risk of experiencing a problem with their medicines while in hospital. Main inclusion criteria: inpatients >16 years in general medical and surgical wards or secondary or tertiary care centres. Studies of inpatients in specialist centres like intensive care were excluded.
2. Research from systematic reviews published from 2013 to 2018 includes more comprehensive clinical settings: intensive care, critical care, diverse patient groups (neonates – elderly patients) and medication delivery processes across the clinical spectrum. A summary overview of the included systematic reviews is provided in in the appendix (Table 1).

Table 1: Risk factors for medication errors in the hospital setting

Suggett and Marriott (2016) [10]	Other reviews
• Prescription of certain drugs or classes of drugs • Elderly patients (60–75 years or older), • Female gender • Poor renal function • Poor liver function • History of drug allergy or sensitivity • Patient compliance issues	• Communication (between clinicians and clinician to patient) • Distraction/interruption (of clinicians) • Human factors: haste/inattention/fatigue/poor concentration/memory lapse/careless/stress • Inexperience (of clinicians) • Knowledge deficits (of clinicians) • Lack of skills: e.g. calculations (of clinicians) • Staffing Levels • Workload
Overlapping factors present in both bodies of research	
• Length of patient stay • Multi-morbidity • Polypharmacy	

**Only factors mentioned in three or more out of the 11 included systematic reviews are presented.*

Drug classes associated with an increased risk of medication errors

Six reviews provided information about most common drug classes/individual drugs associated with medication errors in the hospital setting [2,4,5,10,11,13]. Note: Drug class classification may require pharmaceutical expertise input as this was not always clearly defined.

The most common classes of drugs/individual drugs associated with medication errors in the hospital setting across all the included systematic reviews include:

- Thrombolytics / Anticoagulants / Warfarin
- Chemotherapy / Anticancer
- Opiates / Morphine
- Cardiovascular agents / Digoxin /Beta blockers
- Anti-convulsants / Anti-epileptics
- Insulin / hypoglycaemic
- Intravenous antimicrobials/ Antibiotics (IV and Oral)
- Anti-inflammatories/ Methotrexate /Acetylsalicylic acid / NSAIDS
- Theophylline
- Gastrointestinal medications

Interestingly, Suggett and Marriott presented a list of the most common classes of drugs associated with problems in the hospital setting in order of frequency [10]. This list is provided below. .

Common classes of drugs associated with medical errors in the hospital setting, *in order of frequency* (Suggett and Marriott [10]) are provided below.

1. Intravenous antimicrobials
2. Thrombolytics/anticoagulants
3. Cardiovascular agents
4. Central nervous system agents
5. Corticosteroids
6. Diuretics
7. Chemotherapy
8. Opiates
9. Anti-epileptics
10. Insulin/hypoglycaemics

Saedder *et al*, 2014 [11] systematic review identified high risk medications for medication errors. Medication errors had to occur during the prescribing or monitoring process and the adverse reaction must be deemed serious according to WHO criteria. It reported that seven drugs or drug classes caused 47% of all serious medication errors Warfarin, Digoxin, Opioids, Methotrexate, NSAID, Acetylic salicylic acid and beta blockers.

Matrix of risk factors according to patient, clinician and work environment.
Risk factors are now presented under the broad categories of factors: patient; clinician; work environment. These categories are then mapped according to patient age group; setting of care; and spectrum of medication care delivery (Table 2).

Table 2 is best read by identifying the factor of interest e.g. *knowledge deficits* in the left column (common risk factors) and then following the table across to see the *patient age groups*; *settings of care;* and *medication care delivery* where the factor associated with medications errors is indicated with a tick.

Some *examples* from the table;
Knowledge deficits are associated with medication errors in the elderly, perioperative setting and more broadly in information flow, medication dispensing and medication administration. No tick means that information was not available from the included reviews.
Polypharmacy in elderly and neonate patients are at higher risk of medication errors.
Similarly, elderly and neonates patients have an increased risk of medication safety issues as a result of *clinician lack of experience, lack of skills and high workload.*

Table 2: Matrix of common factors associated with medications errors in the hospital setting

Common risk factors	Patient age group				Setting of care		Medication care delivery		
	Elderly [1,2]	Adults [2]	Paediatrics [2]	Neonate [2,3]	Peri operative[5]	Critical Care [4]	Information flow [7]	Dispensing [8]	Medication [9] administration
Patient factors									
Polypharmacy	✓	✓		✓		✓			
Clinician factors									
Knowledge deficits	✓				✓		✓	✓	✓
Lacks experience/skills	✓	✓		✓			✓	✓	
Poor communication		✓					✓	✓	
Human factors#			✓		✓	✓	✓	✓	✓
Incomplete-incorrect information			✓			✓	✓		✓
Work environment/organization factors									
Workload	✓	✓		✓	✓	✓		✓	✓
Staffing levels	✓							✓	✓
Policies, procedures, protocols*	✓							✓	✓
Equipment: insufficient, non-functioning			✓					✓	✓
Culture: Team/Organizational							✓	✓	✓

Legend: ^ noise, lighting, busy, chaotic, emergencies, alarms; *Unclear, lack of, lack of access, not followed;
#Human factors: Fatigue, Loss of concentration, Stress, Haste, memory, Forgetful, Careless, Nervousness (new starters-doctor/nurse)
Superscript numbers refer to references.

A more comprehensive matrix of factors associated with medication errors in settings of care; medication care delivery and for patient age groups is included in Table A5 in the Appendix. Individual lists of factors associated with medication errors according to patient age group, setting of care and medication care delivery are provided in Tables A6-8.

Discussion

The topic of factors associated with medication errors is a vast and complex area. Several sub topics are included and range from different clinical setting, patient groups and types of medication errors.

This evidence review has synthesized the evidence on factors associated with medication errors in the hospital setting. Two reviews focused on the elderly, two on neonates, one on critical care and one on the perioperative setting. There are a range of reasons why these patient groups and care settings may be more prone to medications error include altered pharmacokinetics and body system functioning, multimorbidity, polypharmacy, the patient not being able to contribute to their care, the complexity of the presenting condition requiring multiple medications and a high pressure work environment [2,4,5,12-14].

Specific factors identified in each of the 11 included systematic reviews were mapped to whether the factor was patient, clinician or work environment based. It is recognised that this mapping is subjective and some risk factors could be mapped to more than one category. Different factor groupings were present in many of the reviews, often without definition (e.g. performance-based deficit).

The factors identified in this evidence synthesis were compared with the top ten factors associated with medication errors identified by Suggett and Marriott [10]. The factors in common were length of stay, polypharmacy and multimorbidity. Other than the review by Suggett, none of the included reviews considered renal and liver function as a risk factor

Information flow
Information flow and how it relates to clinical errors was the focus of one review [7]. Hermon and Williams report that the majority of medication errors occur within the treatment stage within the clinical process. Information flow may fail in one area of the clinical process but this failure can affect other areas. Miscommunication of information in the clinical setting can result in medication errors. Medication errors were often a result of human factors including stress, fatigue, inexperience, lack of skills and lack of knowledge. Human factors influenced a lack of knowledge of the patient's medication history.

Medication errors as a result of communication problems were reported in most reviews. This included both verbal and written communication. Illegible handwriting was a major issue associated with written communication.

Knowledge based deficits
Knowledge based medications errors were reported in many reviews. Only one review offered a definition of knowledge based tasks and deficits [13]. Knowledge-based tasks require providers to problem solve when faced with new situations. A knowledge-based error occurs when a provider's knowledge is incomplete or incorrect. Knowledge-based tasks require metacognition (thinking about one's thinking) to avoid medication errors that reach patients. Examples of knowledge-based deficits included staff explaining they did not know enough about the medication they were administering, the infusion pump they were using or the patient to whom they were administering it.

One size does not fit all
Findings from included reviews indicate that there are factors associated with medication errors unique to particular age groups but also factors that are common across age groups (polypharmacy, multi-morbidity, length of stay). Those across each age group speak to the complexity of the presenting health issue. Those within each age group highlight specific age related factors and factors related to the care of this age group.

Medications: Specific medication classes more commonly associated with medication errors was considered in a number of reviews. The systematic review by Suggett and Marriott listed the ten most common classes of drugs associated with problems in the hospital setting [10]. Their review focused on adults in general medical and surgical wards. Saedder *et al*, 2014 review [11] listed the top 10 fatal and top 20 nonfatal drugs associated with medications errors. Comparison of these lists together with the lists from the current synthesis highlight a number of medication classes/specific drugs of concern.

Reliability of the evidence
Overall the quality of the reviews was low to moderate. Not all reviews indicated the publications years searched and most of the reviews did not include a specific methodological quality assessment of included studies.

Issues to note
Many systematic reviews reported on the types of common medication errors but did not consider risk factors for the medication errors. All the included reviews commented on the use of different definitions of medication errors. This affects interpretation and comparison of studies. There was a lack of standardized definitions of medications errors and variations in the denominators of how MAEs were expressed. Moreover, there was wide variation in nomenclature, and a lack of consistency over types of error, classifications systems for causes of error. Across the reviews, there was inconsistency in study quality and methods of data collection.

- We found no systematic reviews of paediatric medication safety.
- Focus was on scheduled medicines rather than unscheduled medicines
- The severity of medication errors was difficult to determine due to variability in definitions of medication errors.

Implications for practice

The review highlights key factors associated with medication errors in the hospital setting. We suggest that the findings can be used to:

1. Inform a review/update of the ISR 3 and 4 SCIRT medication and administration templates

The Systems Engineering Initiative for Patient Safety (SEIP) model recognises that a human factors approach can be helpful in understanding medication errors [13]. The SEIP Initiative combines human factors engineering with a structure-process outcomes conceptual model. This model recognizes the role of work system structure tasks, organization, environment, technologies together with nurses, pharmacists, and physicians and other health care team members and patients. The category of cause and category of contributing factors for the SEIP model are included in Table A9 in the appendix. They offer a potential nomenclature for consideration in an update of the SCIRT templates

2. Target interventions to common/high risk factors

For example;

- A training program to understand and practice dose related calculations
- Strategies to improve pharmacology knowledge on drug interactions

3. Facilitate a list of factors to target analyses of medications errors.

References

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Appendix

Search Strategy

Peer-reviewed publications and grey literature were searched across scientific and grey literature databases to find synthesized evidence on risk factors for medication errors. Table A1 outlines the databases and number of articles screened. Articles were screened and selected according to the criteria in Table A2. Only articles published in English, published from 2013 onwards, were considered. A summary of findings are included in Figure 1.

Table A1. Database searches

Search term: "medication errors" and "causes"

Source	Results
Google scholar	200
Google	140
BMJ Quality and Safety (Reviews)	23
Joanna Briggs Database of Systematic reviews and Implementation reports	31
Epistemonikos	190
Trip (including Prospero)	97
Pubmed	496 *
Pubmed Clinical queries	98
PubMed "systematic review [sb] AND (causes of medication errors)"	

** deduplicated*

Table A2. Inclusion/Exclusion criteria

Population	Include: All types of hospital patients Exclude: Community, Primary Care, Nursing Homes
Concept	Include: Risk factors for medication errors Exclude: Interventions to address medication errors
Context	Include: All but with a focus on UK, US, Canada, Australia, Europe, New Zealand
Types of evidence	Include: Peer-reviewed, grey literature (synthesized) Exclude: All other types of information, qualitative systematic reviews
Limits	Published in English; Humans; 2013 – current

Figure 1 indicates how articles from different sources were searched included.

A total of 1,309 articles were identified from multiple grey literature sources, and two scientific databases. The title, abstract and summary of the articles were screened by one reviewer.

18 articles were shortlisted.
After review and discussion with the second author, a total of 11 articles were included for the purpose of this review.

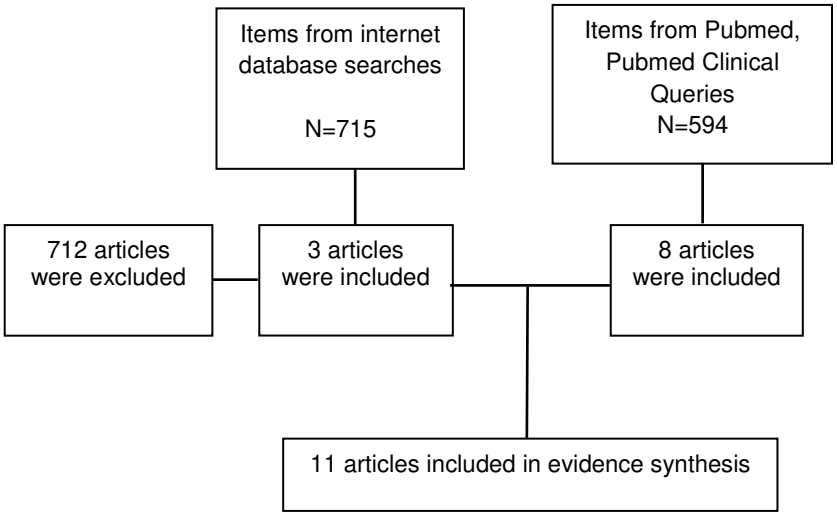

Table A3: Why is medication safety an issue in some settings of care and for some age groups?

Intensive care [13]	• Patients are not able to participate in their care in many situations • Complexities of patient conditions • Multiple medications administered • Frequent changes in medication orders • Need for weight based dosages • Potential for incompatibilities with intravenous medications • Requirement for calculations of infusion rates for iv medications
Critical care [4]	• A reduced physiological reserve, and reduced ability to metabolise drugs • Alterations in pharmacodynamics. • Polypharmacy is common • Medications prescribed to which patients have not been previously exposed. • Use of high risk substances and varied routes of administration is common • Busy, high pressure work environment.
Perioperative [5]	• Complexity of care • Fast- paced work environment • Fragmented nature of service delivery
Neonates [2, 12]	• Lack of neonate specific or appropriate medications available • Changing pharmacokinetic parameters at various developmental stages • Inability to communicate with care providers about their therapy • Need for multiple calculations, dilutions and manipulations to individualize doses based on age, weight, body surface area, and/or available dosage forms. Calculations need to be frequently repeated as patients grow and gain weight leading to dose adjustments. • Lack of drug delivery systems specifically developed for neonates, leading to inconsistency in measurement of oral and parenteral drug preparations • Lack of published drug information and product labeling addressing the dosing, pharmacokinetics, safety, efficacy, and clinical use of medications for neonates. • Many medications are used off-label and are therefore often only available in adult formulations and concentrations • Potential for drug interactions when medications are administered through a single lumen central line • Most neonates require nutritional support, administration of a small amount of fluid can have a considerable impact
Elderly [1,14]	Older people have substantial interindividual variability in health, disability, age-related changes, polymorbidity, and associated polypharmacy. • Decreased physiological reserves and altered pharmacokinetics • Age related changes in organ mass, blood circulation and body composition • Age related reductions in renal function affect the clearance of drugs • Most elderly people have complex medication regimes. • Polymedicated patients have a limited knowledge of prescribed medication • Lack of specific evidence on the efficacy/safety of medications in older persons • Underuse of comprehensive geriatric assessment, • Less availability of drug formulations offering geriatric doses, • Lack of geriatric clinical pharmacology and clinical pharmacy services

Table A4. Overview of the eleven systematic reviews included in this review

First author	Year	Objective of systematic review	Setting/Focus	Number of articles	Studies published time period	Country
Hermon [7]	2013	To conduct an analysis of medication error as a result of information failure	Clinical	18	1991-2012	Not specified
Aldhwaihi [8]	2016	To review types of dispensing errors in hospital pharmacies and factors that contribute	Hospital Pharmacies	15	1/2000-1/ 2015	UK- 6 USA- 4
Keers [9]	2013	To review evidence relating to the causes of medication administration errors in hospital settings	Inpatient Hospital Settings	54	1985–5/ 2013	UK-12 USA-12 AUS-6
Saedder [11]	2014	The purpose of this study was to define drugs that actually cause serious medication errors.	Hospital	74	Not specified	EUR-34 USA-30 AUS-3 NZ-3
Macfie [4]	2016	To determine the prevalence of medication errors in critical care, the drugs most commonly associated and the consequences	Excluded Paediatric	40	1995 to 6/2015	USA- 13 AUS- 1 EUR-10
Suggett [10]	2016	To determine the evidence for risk factors that predispose patients to the need for a clinical pharmacist intervention	> 16 years	38	1966- 7/2013	AUS-3 USA-13 EUR-15
Metsala [1]	2013	To improve the prerequisites of medication safety in the acute care of the elderly by establishing what medical errors happen in elderly acute care	Elderly	20	2001-2011	USA–8 EUR-7 CAN-1 AUS-1
Hayes [6]	2015	Explore what is known about interruptions and distractions on medication administration in the context of nurses	Registered and Undergraduate Nurses	19	Not specified 2005-2012	USA-9 CAN-3 AUS-4
Boytim [5]	2018	Identify factors associated with perioperative medication errors	Perioperative	19	2000 to 2016	Not specified
Kryyzaniak [2]	2016	To describe medication errors in hospitalized patients, comparing those in neonates with medication errors across the age spectrum.	Neonates Compared to Other Ages	38	1987-2014 Not specified	USA-20 EUR-6 AUS-1
Santesban [3]	2015	To review the frequency and types of medication errors in neonatal intensive care units and the effectiveness of preventive health strategies	Neonates Intensive Care	13	2000-2013	USA -3 UK-3

Superscript numbers refer to references

Table A5: Full matrix of common factors associated with medications errors in the hospital setting

	Patient age group				Setting of care		Medication care delivery		
No tick=no information available	Elderly [1,2]	Adults [2]	Paediatrics [2]	Neonate [2]	Peri Operative [5]	Critical Care/ICU [4]	Information flow [7]	Dispensing [8]	Medication Administration [9]
Patient factors									
Patient behaviour								✓	✓
Female	✓								
Polypharmacy	✓	✓		✓		✓			
Multi-morbidity	✓								
Length of stay	✓			✓		✓			✓
Unable to understand/communicate				✓	✓				
Physical health, illness severity			✓	✓	✓				✓
Doctor-patient communication							✓		
Patient availability									✓
Look alike/sound alike patient names				✓					✓
Clinician factors									
Knowledge deficits	✓				✓		✓	✓	✓
Lacks experience/skills	✓	✓		✓			✓	✓	
Poor communication: Verbal and written)		✓					✓	✓	
Look alike/sound alike patient, medication									✓
Human factors[#]			✓		✓	✓	✓	✓	✓
Calculation errors									✓
Perceived workload									✓
Incomplete-incorrect information			✓			✓	✓		✓
Distractions/interruptions									
Pressure to proceed, pressure from others					✓			✓	✓
Work environment/organization factors									
Workload	✓	✓		✓	✓	✓		✓	✓
Staffing levels	✓							✓	✓
Policies, procedures, protocols*	✓							✓	✓
Working environments^								✓	
Time of Day					✓			✓	
Pressure to proceed					✓				
Insufficient training								✓	✓
Equipment: insufficient, non-functioning			✓					✓	✓
Skill mix								✓	✓
Team communication							✓		
Culture: Team/Organizational							✓	✓	✓

Legend: ^ noise, lighting, busy, chaotic, emergencies, alarms; *Unclear, lack of, lack of access, not followed;
[#]Human factors: Fatigue, Loss of concentration, Stress, Haste, memory, Forgetful, Careless, Nervousness (new starters-doctor/nurse)

Table A6: Patient factors associated with medication errors

Elderly [1,2]	• Poor physical or psychological condition • Multiple diagnoses • Female • Old age • Medications: >5 • Polypharmacy • Length of stay: >13 days • Chronic disease: >1
Adults [2]	• Polymedication
Paediatrics [2]	• Seriously ill patients
Neonates [2]	• Low birth weights and Gestational ages • Multiple-birth babies • Similar sounding baby names • Inability to communicate • Polypharmacy • Longer length of stay • More vascular lines
Perioperative [5]	• Lack of understanding by patient before or after surgery • Poor physical status
Critical care [4]	• Medication reconciliation not prioritised • Polypharmacy • Prescription of drugs to which patients not been previously exposed • Use of high risk substances
General medical and surgical wards (Adults) [10]	• Elderly patients (defined as over 60–75 years or older) • Female gender • History of drug allergy or sensitivity • Length of patient stay • Patient compliance issues • Polypharmacy • Poor liver and renal function • Prescription of certain drugs or classes of drugs • Presence of multiple co morbidities • Communication difficulties including confusion • Refusal to comply with recommended treatment
Medication dispensing [8]	• Patient demanding/aggression
Medication administration [9]	• Patient availability: absent/sleeping patients during drug rounds • Severity of illness • Misidentification of a patient • Look alike/sound alike patient names • Patient requests • Lack of, difficulty with or delays waiting for intravenous access
Information flow [7]	• Poor communication/ miscommunication between doctor-patient

Table A7: Clinician factors associated with medication errors

Elderly [1,2]	• Lack of Maths skills (nurses) • Lack of pharmacy knowledge and experience: drug interactions, delivery route, drug preparation, drug-dispensing systems (nurses)
Paediatrics [2]	• Inexperienced physicians • Human error • Communications failure
Adults [2]	• Lack of pharmacy knowledge (physicians) • Staff performance deficits • Failure to consider patient information • Memory lapses
Neonates [2,3]	• Lack of physician experience • Off label medication prescribed
Intensive Care [13]	• High stress • Perceived workload and caseload
Perioperative [5]	• Performance deficit • Knowledge deficit related to patient allergies • Haste, Stress, Pressure to proceed, Distraction, Fatigue • Decreased vigilance
Medication dispensing [8]	• Poor communication • Urgent deadline • Fatigue, Loss of concentration • Lack of knowledge/experience/familiarity with task
Nursing [6]	• Miscommunication: Illegible handwriting • Distractions/interruptions • Stress
Information flow [7]	• Forgetfulness, poor communication between nurse and physicians • Poor physician listening skills, • Physician-patient miscommunication, poor communication • Physician provides incomplete information • Inexperienced trainees making errors in judgement • Lack of technical competence • Human performance, skill, rule, knowledge based.
Medication administration [8]	• Confusing look-a-like or sound-a-like medication names, patient names, medication packaging, • Misreading medication label/ product, prescription or other documentation • Misidentification of either medication or a patient • Forgetting to sign medication order due to being busy and/or distracted • Being careless due to heavy workload, poor staffing or being distracted • Selecting the wrong medication due to pressure from others/distractions • Staff did not know enough about the medication they were administering, the infusion pump they were using or the patient to whom they were administering it • Poor supervision/drug knowledge (associated with fast bolus iv administration), • Lack of staff (intentionally giving drugs early/late) • Calculation errors • Lack of basic information to help safely mix and administer iv meds • Insufficient training and experience • Physical feelings of fatigue, tiredness/sleep deprivation, sickness, physical exhaustion, stress, boredom, nervousness (being busy and young) and poor mood Communication: • Illegible and unclear/messy prescriptions. • Nurses/doctors failed to pass on information or successfully passed on incorrect information to their colleagues leading to drug administration delays, drugs being given that should have been withheld and incorrect doses being administered. • Poor supervision: pressuring students to administer drugs more quickly, • Pressure from staff: confronting and intimidating behaviour, social isolation-colleagues • Workload and skill mix. Heavy staff workload (including end of shift/patient transfer pressures, patient load and multitasking

Table A8: Work organisation-environment factors associated with medication errors

Elderly [1,2]	• Staffing levels • Workload • Unclear or lack of policies and procedures on medication administration • Deliberate negligence • Fear of punishment when reporting medication errors.
Adults [2, 4]	• Stressful • High paced work environment • Dose checking processes • New drug initiation in hospital
Paediatrics [2]	• Equipment dysfunction
Neonates [2]	• High-intensity physician workloads
Peri-operative 5	• Workload • Long procedure • Time of Procedures • Pressure to proceed
Medication dispensing [8]	• High pharmacy workload • Low staff numbers • Distraction/interruption • Noise • Time of day • Protocols not followed
Nurses [6]	• Monitors alarming leading to interruptions • Distractions
Information flow [7]	▪ Poor delineation of discharge responsibilities among hospital staff ▪ Failed leadership and inadequate communication ▪ Hierarchical differences, miscommunication ▪ Ineffective team communication ▪ Inexperienced trainees; team work breakdowns, errors in judgment ▪ Clinical culture, miscommunication,
Medication administration [9]	• Local working culture: Nurses passed on bad practices (e.g. administering without a prescription) • Levels of trust between colleagues and working double shifts or not taking breaks (leading to exhaustion) • Lack of staff (intentionally giving drugs early/late) • Working environments: noise, lighting, emergencies, busy or chaotic • Poor supervision by senior colleagues: manifesting as pressuring students to administer drugs more quickly, not supervising or assisting closely enough or giving unclear/incorrect instructions • Insufficient equipment (computers or gloves), malfunctioning equipment and ambiguous equipment design (e.g. syringe driver, drug packaging) Leading to doses being administered incorrectly due to being un-calibrated or malfunctioning or not administered at all due to different pump properties or pumps that were not connected. • Insufficient training and experience • Lack of access to suitable administration protocols • Workload and skill mix. • Heavy staff workload (including end of shift/patient transfer pressures, patient load and multitasking

Table A9: SEIP model code category of cause and code category of contributing factors [13]

Code Category of Cause	Code Category of Contributing Factor
81.0 Communication 81.1 Verbal miscommunication 81.2 Written miscommunication 81.3 Misinterpretation of the order 83.0 Name confusion 83.1 Proprietary (trade) name confusion 83.2 Established (generic) name confusion 85.0 Labeling 85.1 Immediate container labels of product—manufacturer, distributor, or repackager 85.2 Labels of dispensed product—practitioner 85.3 Carton labeling of product—manufacturer distributor, or repackager 85.4 Package insert 85.5 Electronic reference material 85.6 Printed reference material 85.7 Advertising 87.0 Human factors 87.1 Knowledge deficit 87.2 Performance deficit 87.3 Miscalculation of dosage or infusion rate 87.4 Computer error 87.5 Error in stocking/restocking/cart filling 87.6 Drug preparation error 87.7 Transcription error 87.8 Stress (high volume workload, etc) 87.9 Fatigue/lack of sleep 87.10 Confrontational or intimidating behavior 89.0 Packaging design 89.1 Inappropriate packaging or design 89.2 Dosage form (tablet/capsule) confusion 89.3 Devices	90.1 Lighting 90.2 Noise level 90.3 Frequent interruptions and distractions 90.4 Training 90.5 Staffing 90.6 Lack of availability of health care professional 90.7 Assignment or placement of a health care provider or inexperienced personnel 90.8 System for covering patient care (eg,floating personnel, agency coverage) 90.9 Policies and procedures 90.10 Communication systems between health care practitioners 90.11 Patient counselling

Excluded references

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