THERAPEUTIC ADVANCES in
Drug Safety

Original Research

Characterizing medication safety incidents in surgical patients: a retrospective cross-sectional analysis of incident reports

Ther Adv Drug Saf

2024, Vol. 15: 1–16

DOI: 10.1177/20420986241271881

Noah Sagua, Andrew Carson-Stevens and Kathryn Lynette James

Abstract

Background: Medication-related safety incidents (MSIs) are among the most frequent contributors to preventable harm in hospital patients. There is a paucity of research that explores the factors that contribute to MSIs across the departments of high-risk specialties such as surgery.

Objectives: To characterize MSIs involving surgical patients across two secondary care sites at a University Health Board.

Design: Retrospective cross-sectional convergent analysis of anonymous MSI reports extracted from the risk management system between 1st January 2017 and 31st October 2020 was undertaken.

Methods: Incident reports contained categorical data pertaining to the type and nature of the incident as well as free-text reporter accounts. Categorical data were analyzed quantitatively, undergoing descriptive analysis using IBM SPSS Statistics © software (Version 26.0.01; 2019). Content analysis of free-text responses was undertaken using the Organizational Accident Causation model as the underpinning theoretical framework.

Results: Of a total of 670 incidents, most MSIs did not result in harm ($n = 495$, 73.9%). Most MSIs occurred during administration ($n = 439$, 65.5%). Half of the incidents ($n = 335$, 50%) were related to one of three medication types: opioids, antimicrobials, and antithrombotic agents. Communication failures were the most frequent error-producing condition ($n = 39$, 5.8%) and drug omission was the most frequent active failure ($n = 156$, 23.3%).

Conclusion: To the knowledge of the authors, this is the first study in the United Kingdom that reports the medications most frequently involved in MSI reports for surgical patients. Staff in the surgical setting should be informed of the high frequency of incidents involving opioids, antimicrobials, heparin, and other antithrombotic agents as they appear in half of MSI reports in the surgical setting. Further research should explore administration error reduction strategies as well as tools to improve communication between staff to mitigate the risk of medicines-related harm associated with key medications.

Plain language summary

Types of medicines-related errors occurring in patients undergoing surgery

Introduction: Errors with medications not only often happen in hospitals but also have the potential to cause great harm to patients. They can occur at any time, from prescribing a patient the correct dose of medication to finally administering them the correct medication. Reducing the risk of errors is particularly crucial for surgical patients, where medication-related safety incidents can complicate the safety of surgical

Correspondence to:
Andrew Carson-Stevens
Division of Population Medicine, School of Medicine, Cardiff University, Neuadd Meirionnydd, Heath Park, Cardiff, CF14 4XN, UK.
carson-stevensap@cardiff.ac.uk

Noah Sagua
Division of Population Medicine, School of Medicine, Cardiff University, Neuadd Meirionnydd, Heath Park, Cardiff, CF14 4XN, UK.
noah.sagua@nhs.net

Kathryn Lynette James
Pharmacy Department, University Hospital of Wales, Cardiff, UK

procedures. This study looked at the types of medication incidents reported by staff for patients who were having surgery.

Methods: We reviewed the incident reports involving medications for patients on surgical wards and in theatres, as reported by staff. These included reports from between 1st January 2017 and 31st October 2020 from two university hospitals in Wales.

Results: A total of 670 incidents were reported by staff, most of which did not result in any harm (n = 495, 73.9%). Half of the incidents that were reported involved at least one of three types of medications: opioids, antimicrobials and blood thinning medication. Communication failures were attributed to be the most common factor leading to errors occurring, whilst a failure to give the medication was the most common error reported.

Conclusion: Staff that are working with patients on surgical wards and in theatres should be alerted to the high frequency of incidents involving opioids, antimicrobials and blood thinning medication. Moreover, strategies that improve staff communication should be employed to avoid medication-related safety incidents.

Keywords: medication safety incidents, surgery, Wales

Received: 5 November 2023; revised manuscript accepted: 1 July 2024.

Introduction

Medication-related safety incidents (MSIs) are "an unintended or unexpected incident" specifically associated with the use of one or more drugs, which have the potential to lead to patient harm.[1,2] Panagioti et al. estimated that 6% of patients worldwide are exposed to preventable harm from MSIs, highlighting the necessity of identifying effective interventions to mitigate the risk of harm.[3] Systematic analysis of incident reports is paramount to achieving the target set by the World Health Organization to reduce avoidable patient harm from medicines use by 50%. This is especially important in high-risk and specialized environments such as surgery and theatres, where preventable harm in general has been documented more frequently than in other clinical areas.[3–8]

Reason's Organizational Accident Causation model is often considered the gold standard in the analysis of safety incident data.[9] It assigns more weight to the upstream system failures that interact with inevitable human fallibility[10] to produce an MSI. Faults in the managerial and organizational process (latent conditions) as well as the immediate working situation (error-producing conditions) can create "holes" in existing barriers that would usually prevent MSIs from taking place. Reason's model[9] has been frequently referred to within medicines safety literature and provides a useful standard for comparing the types of incidents occurring within various clinical settings. By applying this model to incident reports, contributory factors can be identified to develop targeted and effective improvements to the quality and safety of patient care. While many studies have provided the basis for understanding the extent of the MSI problem and propelling error-related research on an international scale, they often involve a review of hospital records to assess the prevalence of errors in management.[8,11,12] The advantage of analyzing incident report data itself is that unlike hospital records they are written to provide further insight into the circumstances and consequences of underlying MSIs.[1]

Voluntary reporting systems present an inherent selection bias as not all incidents are reported.[13,14] Incidents causing harm are more frequently reported compared to no harm or prevented incidents (near-misses).[15] Therefore, the nature of the incidents that remain unreported is perpetually

unknown. Although a large-scale collation of MSI reports across secondary care sites does not completely offset the limitations of underreporting, by focusing on specific clinical specialties like surgery, targeted local improvement strategies can be identified that are tailored and most appropriate to this setting.[16]

Little is known about the nature of medicines-related errors from incidents occurring in the perioperative setting. Hence, there remains an opportunity for focused evidence-based improvements in clinical practice that could mitigate the risk that MSIs pose to surgical patients. This study aimed to characterize MSIs reported by surgical specialties at a University Health Board by determining the type, severity, and factors contributing to the occurrence of the incidents.

Methods

Retrospective mixed-methods analysis of MSIs affecting patients treated in surgical wards and theatres at two main hospitals forming an 1800-bed University Health Board in Wales between January 1st, 2017 and October 31st, 2020 were analyzed (Table 1). MSIs are voluntarily reported by healthcare professionals using the electronic risk management system (Datix). Data recorded included quantitative categorical data on incident date, location, specialty, incident descriptor, and details of the drug involved. The national reporting system uses the Dictionary of Medicines and Devices descriptors for medication names, which are linked to the British National Formulary drug classification.[17,18]

The severity of patient harm was categorized according to the former England and Wales National Patient Safety Agency risk classification framework.[19] This considers the duration of exposure, long-term consequences, and permanence of harm. The reporter assigned severity from the options available on the reporting system, which aligned with the National Patient Safety Agency definitions. Further details of the incident were provided by staff as free-text descriptions. Study inclusion and exclusion criteria are shown in Table 1.

Where applicable, the reporting of this study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE; Supplemental File) statement for cross-sectional studies.[20]

Table 1. Inclusion and exclusion criteria for incident reports.

Inclusion criteria	Exclusion criteria
Incident reports pertaining to adults (>18 years)	Reports prior to 2017
Adult perioperative and postoperative patients	Patient safety incidents other than MSIs Patients treated in primary care and outpatients

Data analyses

Categorical data. MSI data that fulfilled the inclusion criteria (Table 1) were extracted from the hospital risk management software in the form of an Excel spreadsheet, using Microsoft Office Excel © Version 16.47.1 (2021). A codebook was constructed for categorical data as reported by staff (incident type, route administered, actual harm, and specialty) and coded data were imported into IBM SPSS Statistics © software (Version 26.0.01; 2019) for quantitative analysis. Prior to data analysis, quality assurance checks were performed to ensure accurate data import. Excel random number functionality was used to generate 20 random incident numbers. The data for these 20 randomly selected incident numbers were compared in the Excel and SPSS spreadsheet to confirm accurate data import. Frequency tables were also generated in Excel and SPPS to verify the accuracy of data import. Data were then analyzed in SPSS using descriptive statistics and cross-tabulations. All quantitative data and analyses were verified by project supervisors LJ and ACS. Medicines involved in incidents were categorized during analysis according to the APINCH classification system for high-risk medicines developed by the Australian Commission on Safety and Quality in Health Care in Healthcare (Table 2).[21,22] APINCH classification was used as it represents the most common medicines identified by research as contributing to medication errors and adverse drug reactions.

Free-text data. Content analysis of the qualitative free-text incident reports was undertaken using Reason's Organizational Accident Causation model as the underpinning theoretical framework.[23] Data were coded iteratively within NVivo

Table 2. Drug classes on which codes were based.

High-risk medicine groups	Example medicines within the sample
A: Antimicrobials	Piperacillin/tazobactam Metronidazole Cefotaxime
P: Potassium and other electrolytes	Sodium chloride 0.9% Compound sodium lactate Injections of concentrated electrolytes such as potassium
I: Insulins	All insulins
N: Opioids	Naloxone Oxycodone Morphine sulfate
C: Chemotherapeutic drugs	Methotrexate Cyclophosphamide Fluorouracil
H: Heparin and other antithrombotic agents	Enoxaparin Warfarin Rivaroxaban
Other	Locally identified high-risk medicines

Source: Adapted from the Australian Commission on Safety and Quality in Health Care.[21]

(Version 12.6.1; 2019) by NS and confirmed by LJ, with any discordance being discussed.

Ethical approval and research governance

The study met the NHS Health Research Authority's definition of a service evaluation.[24] To ensure confidentiality and information governance, anonymized data were on password-protected computers. There was no means of identifying staff or patients involved in incidents and free-text reports were screened by researcher LJ to ensure there were no patient or staff identifiers. This retained the integrity of the researcher's judgment in complying with the Data Protection Act and duties in research governance.[25]

Results

In all, 670 MSIs involving surgical patients were reported between January 2017 and October 2020, with most errors reported from general surgery ($n = 260$, 38.8%) and trauma and orthopedics ($n = 124$, 18.5%; Table 3). Staff provided data on the drugs involved and their respective specialties for 633 reports.

Incident types

Incidents most commonly occurred during medication administration ($n = 439$, 65.5%) and prescribing ($n = 116$, 17.3%; Table 4). Administration errors most frequently involved the omission of medication doses ($n = 90$, 20.5%) and administration of the incorrect medication ($n = 44$, 10.0%). By contrast, prescribing the wrong dosage of medication ($n = 28$, 24.1%) was the most common prescribing error (Table 4).

Severity of harm

The majority of MSIs resulted in no patient harm ($n = 495$, 73.9%; Figure 1). Of the 175 incidents that resulted in patient harm, the majority were categorized as minor harm ($n = 150$, 85.7%) and moderate harm ($n = 23$, 13.1%) with two incidents resulting in major harm (1.1%; Figure 1). Most incidents that resulted in patient harm stemmed from an error in the administration of medication ($n = 116$, 66.3%), with both major harm incidents involving a failure to administer a medication. Incidents resulting in harm occurred most frequently in renal transplant surgery ($n = 28$, 33.3%) and trauma and orthopedics ($n = 40$, 30.5%).

Table 3. Most common drugs associated with incidents by specialty.

Drug in error[a]	Specialty *n* (% within specialty)								
	Theatre and anesthetics	General surgery[a]	Cardiothoracic	Head and neck[b]	Renal and transplant	Neurosurgery	Trauma and orthopedics	Other[c]	Total
Antimicrobials	7 (16.3%)	55 (21.2%)	3 (15.8%)	13 (26.5%)	14 (16.9%)	5 (13.2%)	10 (8.1%)	4 (23.5%)	111 (17.5%)
Potassium and other electrolytes	1 (2.3%)	10 (3.8%)	1 (5.3%)	2 (4.1%)	2 (2.4%)	0 (0.0%)	2 (1.6%)	0 (0.0%)	18 (2.8%)
Insulin	0 (0.0%)	11 (4.2%)	2 (10.5%)	3 (6.1%)	8 (9.6%)	1 (2.6%)	7 (5.6%)	1 (5.9%)	33 (5.2%)
Opioids	14 (32.6%)	47 (18.1%)	1 (5.3%)	4 (8.2%)	8 (9.6%)	7 (18.4%)	27 (21.8%)	7 (41.2%)	115 (18.2%)
Chemotherapeutic agents	1 (2.3%)	4 (1.5%)	0 (0.0%)	2 (4.1%)	1 (1.2%)	0 (0.0%)	3 (2.4%)	0 (0.0%)	11 (1.7%)
Heparin and other antithrombotic agents	0 (0.0%)	46 (17.7%)	5 (26.3%)	5 (10.2%)	15 (18.1%)	11 (28.9%)	26 (21.0%)	1 (5.9%)	109 (17.2%)
Angiotensin-converting-enzyme inhibitors	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	1 (0.2%)
Diuretics	0 (0.0%)	2 (0.8%)	1 (5.3%)	1 (2.0%)	3 (3.6%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	8 (1.3%)
Paracetamol	0 (0.0%)	11 (4.2%)	0 (0.0%)	2 (4.1%)	3 (3.6%)	2 (5.3%)	5 (4.0%)	1 (5.9%)	24 (3.8%)
Nonsteroidal anti-inflammatories	0 (0.0%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.6%)	0 (0.0%)	3 (0.5%)
Steroids	0 (0.0%)	2 (0.8%)	0 (0.0%)	2 (4.1%)	1 (1.2%)	0 (0.0%)	4 (3.2%)	1 (5.9%)	10 (1.6%)
Multiple	0 (0.0%)	7 (2.7%)	0 (0.0%)	2 (4.1%)	3 (3.6%)	1 (2.6%)	8 (6.5%)	0 (0.0%)	21 (3.3%)
All other medications	20 (46.5%)	64 (24.6%)	6 (31.6%)	13 (26.5%)	25 (30.1%)	11 (28.9%)	28 (22.6%)	2 (11.8%)	169 (26.7%)
Total	43 (100.0%)	260 (100.0%)	19 (100.0%)	49 (100.0%)	83 (100.0%)	38 (100.0%)	124 (100.0%)	17 (100.0%)	633 (100.0%)
% by specialty of total incidents ($n = 670$)	6.4%	38.8%	2.8%	7.3%	12.4%	5.7%	18.5%	2.5%	94.5%

[a]Included gastrointestinal, urological, vascular, hepatobiliary, and breast surgeries as well as short-stay surgical unit surgery.
[b]Included head and neck, otolaryngological, dental, and oral surgery.
[c]Included reports under nurse bank services and patients reported under an "unknown" or "not applicable" specialty.

Table 4. Stages at which incidents were reported ($n = 670$).

Stage of incident	Number of reports	Harmful, *n* (%)
Administration to patient	**439**	116 (26.4)
Failure to administer	90	
Incorrect medication/fluid	44	
Incorrect frequency of dose	38	
Incorrect dose	32	
Prescribing processes	**116**	28 (24.1)
Incorrect dose	28	
Delay in prescribing	22	
Medication not prescribed	19	
Contraindication due to a history of allergy	9	
Other medication/biologics/fluids incident	**63**	16 (25.4)
Other	45	
Delayed delivery to unit/ward	7	
Drugs missing/not accounted for	6	
Incorrect advice provided	5	
Dispensing processes	**36**	10 (27.8)
Incorrect dose	9	
Incorrect medication/fluid	6	
Dispensed to incorrect patient	5	
Incorrect frequency	4	
Preparation/formulation processes	**16**	5 (31.3)
Incorrect preparation/formulation	10	
Medication delayed	4	
Calculation error	1	
Use of damaged/contaminated ingredients	1	
Total	670	175 (26.1)

Total at each main stage in **bold**.

Drugs involved

Most reported MSIs involved opioids ($n = 115$, 18.2%), antimicrobials ($n = 111$, 16.5%), heparin, and other antithrombotic agents ($n = 109$, 16.3%), followed by insulin ($n = 33$, 4.9%). MSIs involving opioids were most commonly reported in theatres/anesthetics ($n = 14$, 32.6%). In contrast, MSIs involving antimicrobials, heparins, and other antithrombotic agents were most commonly reported by wards (Table 3). Unfortunately,

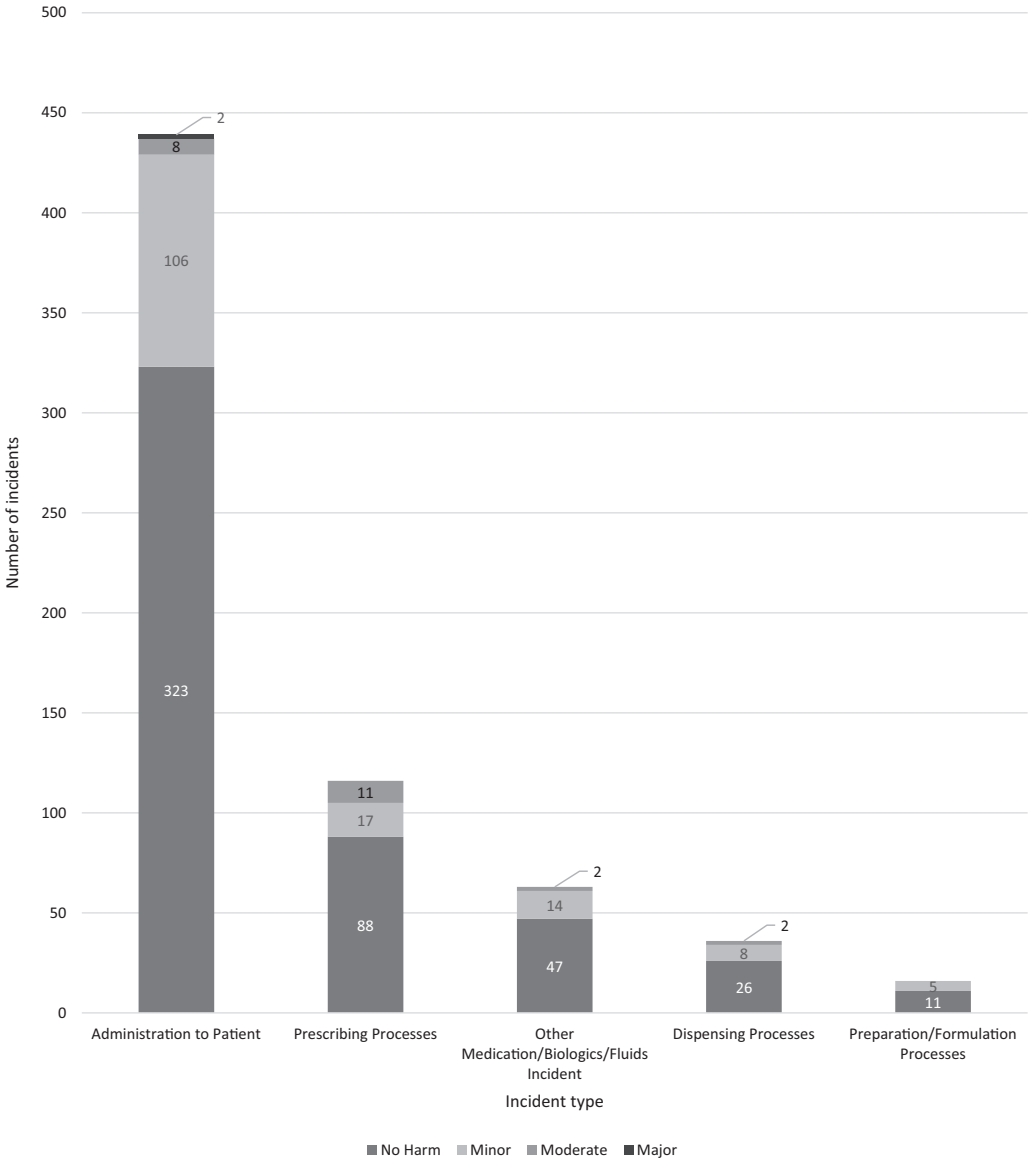

Figure 1. Stacked bar chart illustrating the proportion of cases causing harm by incident type ($n = 175$, 26.1%).

41 reports did not report the medication that was involved in the incident and therefore this missing data could not be included in the analysis.

The medicines involved in MSIs that resulted in the most severe patient harm were insulin ($n = 4$, 31%), opioids ($n = 4$, 20%), and corticosteroids ($n = 1$, 25%; Table 5).

The level of harm was determined and categorized by the reporter. These were the actual rather than potential consequences of the MSI for the patient. Specific details of the patient outcome were not always given as part of the "free-text" report; however, both cases ($n = 2$) that caused "major" harm described irreversible damage to the patient:

> went into cardiac arrest and admitted to critical care. With evidence of hypoxic brain injury. (lamotrigine; administration to patient)

This is concordant with the former England and Wales National Patient Safety Agency risk classification framework, where a major incident is associated with 'permanent harm'.[26]

Table 5. Number of incidents reported for each drug class by level of harm caused ($n = 165$).

Drug in error	Level of harm *n* (% within drug class)			Total
	Minor	Moderate	Major	
Antimicrobials	21 (91.3%)	2 (8.7%)	0 (0.0%)	23 (100.0%)
Potassium and other electrolytes	4 (80.0%)	1 (20.0%)	0 (0.0%)	5 (100.0%)
Insulin	9 (69.2%)	4 (30.8%)	0 (0.0%)	13 (100.0%)
Opioids	16 (80.0%)	4 (20.0%)	0 (0.0%)	20 (100.0%)
Chemotherapeutic agents	3 (100.0%)	0 (0.0%)	0 (0.0%)	3 (100.0%)
Heparin and other antithrombotic agents	26 (86.7%)	3 (10.0%)	1 (3.3%)	30 (100.0%)
Diuretics	4 (100.0%)	0 (0.0%)	0 (0.0%)	4 (100.0%)
Paracetamol	8 (100.0%)	0 (0.0%)	0 (0.0%)	8 (100.0%)
Nonsteroidal anti-inflammatories	2 (100.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)
Corticosteroids	3 (75.0%)	1 (25.0%)	0 (0.0%)	4 (100.0%)
Multiple	5 (100.0%)	0 (0.0%)	0 (0.0%)	5 (100.0%)
All other medications	41 (85.4%)	6 (12.5%)	1 (2.1%)	48 (100.0%)
Total	142 (86.1%)	21 (13.0%)	2 (1.2%)	165 (100.0%)

Contributory factors

Staff provided free-text narrative descriptions for 650 (97.0%) MSI reports. Latent failures arising from organizational and management decisions were identified as contributing to 20 (3%) of MSIs. Thirteen of these reports specifically related to organizational processes such as inadequate staffing ($n = 10$) and shift patterns ($n = 1$):

> the night shift was poorly staffed with only 3 staff nurses, one of which was isolated to the covid-19 side of the ward and only one HCSW (healthcare social worker). (unknown drug; other medications/biologics/fluids incident)

Management decisions were also implicated as a latent failure in seven reports:

> (patients) would need re training to use different product. We were not informed by the supplier of this change. (citraflow; preparation and formulation processes)

Error-producing conditions identified in 313 reports (46.7%) as contributing to MSIs were subdivided into five over-arching themes: work environment, team, patient, task, and individual factors (Figure 2). A total of 120 reports alluded to work environment factors, most commonly delays in processes ($n = 30$) and storage and access to medication ($n = 29$):

> Contacted hospital at night to insert cannula. Had to wait approx. 2 hours for nurse prac. (sic) to arrive on ward. (Incident 310; meropenem; administration to patient)

> round tube of sando k (oral potassium replacement) was found on top of patients locker. Medication had not been locked in bedside locker. (Incident 180; sando-k; administration to patient)

Team factors were also frequently associated with incidents ($n = 119$, 17.8%) and commonly included inadequate systems of communication ($n = 39$) such as problems contacting staff. Other common contributory factors included the handover of patients ($n = 37$) between staff and poor organization ($n = 35$), for example, the involvement of too many different staff in one task:

> Both nurses from (redacted) agency failed to hand over adequate and important information regarding their patients to day staff. (Incident 355; multiple medications; administration to patient)

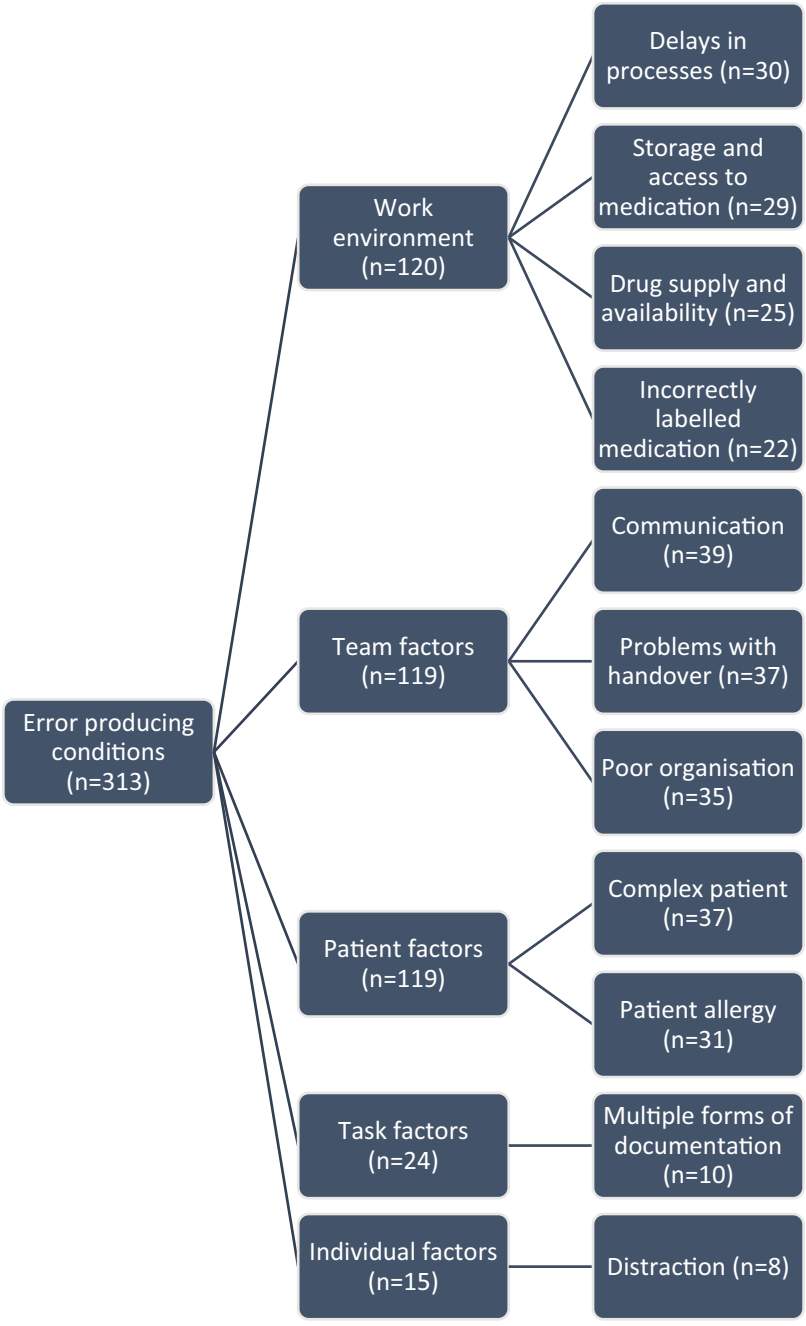

Figure 2. Error-producing conditions associated with medication safety incident reports.

Patient factors were commonly referred to in incident reports ($n=119$, 17.8%) and included reasons such as complex patients ($n=37$) and patient allergy ($n=31$). Examples of complex patients included factors such as a specific behavior or polypharmacy:

> Patient has known behaviour issues and the HCSW was urged by the patient to disconnect him from the IV infusion. (Incident 582; paracetamol; administration to patient)

Task factors were evident in 24 reports (3.6%) and commonly included multiple forms of documentation ($n=10$) and incorrect instructions ($n=4$):

> Noticed there were two current warfarin charts. (Incident 616; warfarin; administration to patient)

Individual factors were associated with some incidents but were less frequently reported ($n=16$, 2.4%). Distraction ($n=8$) and inadequate

knowledge or experience ($n=8$) were the most common subthemes:

> nobody was trained to give the drug. (Incident 442; mitomycin; administration to patient)

> I went to get him some but was asked by a member of staff to do something else. (Incident 669; Oramorph; administration to patient)

Active failures were commonly cited as contributing to MSIs ($n=620$, 92.5%). The most common active failures were drug omissions ($n=156$), wrong or inappropriate drugs ($n=140$), and poor or incorrect documentation ($n=133$; Table 6).

Discussion

Main findings

This study characterizes MSIs and examines contributing factors across all surgical specialties of the hospitals within a University Health Board. This study showed that 50% of reported incidents in surgical patients were associated with three main drug groups: opioids, antimicrobials, heparin, and other antithrombotic agents. Furthermore, 65.5% of MSIs in surgical patients occurred during medicines administration. Although most incidents did not cause harm ($n=495$, 73.9%), insulin, opioids, and corticosteroids were associated with the most severe reported patient harm. In addition, the specialties reporting the greatest number of cases causing harm were general surgery ($n=58$, 33.1%), trauma and orthopedics ($n=40$, 22.9%), and renal and transplant ($n=28$, 16.0%). The three main active failures found in MSI reports were drug omission, wrong or inappropriate drugs, and poor or incorrect documentation, while the most common error-producing conditions were communication issues ($n=39$, 5.8%).

Strengths and limitations

This study manages to capture incident reporting over several surgical specialties across a 3-year period. A large sample size allowed for the aggregation of factors most frequently associated with MSIs in surgical patients. This study also triangulates quantitative and qualitative data allowing greater insight into incidents for learning and identification of risk reduction strategies.

The study relies on staff voluntarily reporting data and so may grossly underestimate the prevalence of MSIs within a surgical unit. Moreover, the error-producing conditions discussed in this study will inherently only be those as described by staff and therefore be affected to an extent by reporter bias. Some incident reports were missing information about the medications involved in the incident and so not all medications may be represented. In addition, many reporters did not describe the incident to allow for the identification of contributory factors. Reporter characteristics were also not identified as part of this study and so the incidence of physician or nurse-related MSIs were not analyzed.

A further limitation is that the study was single centered and thus the results may not translate as well into other healthcare settings as other studies that have managed to pool together data on a larger scale or from multiple reporting systems.[27,28]

Relationship with existing literature

There is a paucity of studies that report on the medications involved in MSIs specifically pertaining to surgical patients. Haddad et al. performed a prospective study that aimed to identify unintentional discrepancies between medication histories obtained in routine preoperative clinics.[29] When compared to this study's findings, Haddad et al. highlighted several different medications associated with medication discrepancies in surgical patients, namely antihypertensives, nonsteroidal anti-inflammatories, and beta blockers.[29] However, Haddad et al. focus on prescribing errors, which our study suggests only account for a minority (17.3%) of reports (Table 4). Nevertheless, opioids, antithrombotic agents, and antimicrobials have previously been identified as high-risk medications in other inpatient settings.[30–32] A review of MSIs occurring in the critical care setting reported to the former England and Wales National Patient Safety Agency found morphine ($n=207$, 8.5%), gentamicin ($n=190$, 7.8%), and noradrenaline ($n=133$, 5.5%) were commonly involved in incident reports.[32] This is consistent with the prevalent opioid and antimicrobial groups which this study has identified. Opioids were most frequently associated with MSIs ($n=115$, 18.2%), particularly in theatre and anesthetics ($n=14$, 32.6%) where opioids are routinely used as primary anesthetic agents perioperatively.[33] When considering MSIs at all

Table 6. Active failures contributing to medication safety incidents ($n = 705$).

Active failure	Number of reports (*n*)	%
Actions slips or failures	**605**	93.1
Drug omission	156	
Wrong or inappropriate drug	140	
Poor or incorrect documentation	133	
Wrong or inappropriate drug frequency	104	
Wrong or inappropriate dose	92	
Prescribing error	81	
No or insufficient checks done	52	
Wrong or inappropriate route or form	34	
Dispensing error	30	
Inadequate monitoring	17	
Insufficient information collected from the patient	7	
Wrong or inappropriate preparation and formulation	6	
Incorrectly setting up equipment	5	
Administered by inappropriate personnel	4	
Poor communication with the patient	4	
Inadequate patient instruction	1	
Wrong investigation	1	
Cognitive failures—lapses	**70**	10.8
Wrong patient	38	
Other	33	
Violations	**30**	4.6
Not following protocol	24	
Other	6	
Incorrect protocol or guideline used	1	
Total	705	100

stages, targeting errors associated with just three groups of medications—opioids, antimicrobials, and antithrombotic agents—in error-reduction strategies could address a significant proportion of MSI reports in surgical patients.

Similarly to the findings of this study, Cousins et al.'s review of incident reports in England and Wales found that 50% of incidents reported to the former England and Wales National Reporting and Learning System are administration errors

across the wider clinical setting.[32,34–36] Cousins et al. suggest that this is due to the fact that more medicines are administered in hospitals than those that are prescribed leading to more opportunity for errors to occur at this stage.[13] However, other factors may be involved such as a late error identification reporting culture and limited knowledge[37] on the use of the reporting system for correct MSI classification. Goeckner et al. found that regardless of hospital bed size, administration errors made up the majority of errors occurring across the hospital data they analyzed (59%).[35] However, the findings of this study (see Table 4) suggest that administration errors represent an even greater proportion of surgical MSIs (65.5%) when compared to other clinical areas.[13] This supports the findings of Wang et al., who on analysis of a compulsory incident reporting system found the number of medication administration errors to be twice the number in surgical wards compared to medical wards.[38] Wang et al. found omission-type failures to be the most common administration error (33.4%), which corresponds with the findings of this study where failure to administer was the most frequent administration error ($n=90$, 20.5%) and drug omission was the most frequent active failure ($n=156$, 25.8%) noted among the contributory factors to MSIs.[39] Administration errors have also been previously found to be more likely to occur in hospitals of a larger bed size (greater than 500), which also reflects the secondary care sites involved in this study's University Health Board.[35] This highlights administration errors, specifically omission-type errors as an important potential target for mitigating patient harm in surgical patients.

There has been significant groundwork establishing the general prevalence of safety incidents in surgical wards.[3,4,38,40–42] Panesar et al. found trauma and orthopedics to contribute a large proportion of reported safety incidents, making up 29.4% of total incident reports to the former England and Wales National Reporting and Learning System, with 30.1% of cases resulting in harm.[43] These data support this study's findings where trauma and orthopedics contributed the second greatest number of both safety incident reports ($n=124$, 18.5%) and percentage harm ($n=40$, 30.5%). This could be due to a variety of factors, such as differences in reporting culture across surgical specialties or variations in the training of staff in incident reporting. On the other hand, it could plainly suggest a greater number of reportable incidents occurring in some specialties such as trauma and orthopedics more than others. Although there is a significant risk to patient safety across all surgical specialties, with greater than one in four incidents ($n=175$, 26.1%) being associated with harm, it is paramount that contributory factors are investigated in specialties such as trauma and orthopedics that report a high volume of incidents and associated harm.

This study has highlighted multiple error-producing conditions that contribute to MSIs, namely team factors such as communication ($n=39$, 5.8%) and problems with handover ($n=37$, 5.5%). Poor communication is widely recognized in the current evidence base as being associated with MSIs, with the Yorkshire Contributory Factor Framework developing "Communication" as an entire distinct domain for factors associated with patient safety incidents, due to its frequency in the literature.[44–46] Mushtaq et al. found 16.1% of surgical incident reports to be associated with communication systems issues, an even greater proportion than what is reported in this study. Moreover, those involved with patient care in the surgical environment recognize communication as an important factor contributing to preventable harm.[37] Lear et al. found by survey that 36.4% of vascular surgeons believed communication failures contributed to preventable harm in theatres.[37] Furthermore, in critical care, Thomas and Panchagnula found 5% of incidents to be associated with staff communication during transfer from theatre or recovery. (Thomas and Panchagnula, 2008) Given that communication is recognized both in the literature and by staff in the workplace as a factor associated with an adverse impact on patients, policy, and practice must promote improved communication between staff.

Recommendations for policy, practice, and education

To avert future MSIs, regular inquiry exploring staff perceptions of the barriers and facilitators to clear and comprehensive communication in the workplace may yield targeted improvement strategies to reduce the risk of poor communication when handling medications. Moreover, staff should receive regular departmental briefings or group discussions that share the most frequent

medication-related safety incidents currently occurring in their surgical environments. This would allow real-time learning and improvements to take place for the staff to which the data are most relevant and importantly, allow staff to learn from one another.[47] Hesselgreaves et al. conducted several incident report data-led focus group discussions and found that healthcare workers identified various educational and practice-based themes for improvement.[47] This included mandatory protected training on medicines and ensuring an appropriate skill mix for nursing staff present on the ward.[47] Ideas from group discussions could then be translated into targets that could be agreed upon amongst staff to enhance patient safety in higher-risk areas such as trauma and orthopedics.

In addition, clinical pharmacist-led drug education could be explored when tackling errors associated with high-risk drug groups such as antithrombotic agents. Venous thromboembolism represents a significant cause of mortality for surgical patients and the use of clinical pharmacists around this perioperatively has been associated with reduced dosage errors and an improved proportion of patients appropriately receiving thromboprophylaxis.[48]

Various interventions have been evaluated for reducing administration errors including "double checking" high-risk medications, novel guidelines such as routine use of checklists and barcode-assisted technology with mixed success.[34,49–51] Wang et al. found that a comprehensive approach that targeted administration errors from various areas including organizational, educational, and streamlined technology reduced administration errors by 57.9% in inpatients.[38] Although comprehensive approaches have been found to be most effective at reducing administration errors, any quality improvement strategy must take into account the specific circumstances of the surgical environment. To improve the common error-producing conditions that lead to administration errors, the opinions of staff such as nurses, who commonly administer medicines involved in MSIs must be sought. There must also be streamlined communication between staff and senior management for these changes to be actioned.

Further research should aim to understand and capture not only MSIs but also medicines-related problems, which are medicines-related adverse events that are not associated with an identifiable system or human failure. In addition, reporting culture between specialties should be explored to establish to what degree it creates a disparity between the number of incidents reported by each specialty and the true number of incidents occurring.

Conclusion

Overall, this study identified 50% of medication patient safety incident reports in surgical patients to be associated with opioids, antimicrobials, heparin, and other antithrombotic agents. These, although likely the medications most frequently used in this clinical context, provide an important foundation for mitigating medicines-related harm in this area. Administration errors were the most frequent type of error reported whilst drug omission and communication factors were frequent contributors to MSIs. Further research should investigate averting MSIs in surgical patients through a focus on administration error-reduction strategies. Moreover, the ideas of clinical staff on improving communication should be explored, to discourage the occurrence of MSIs in the clinical environment. Staff must also be informed of the three key medication groups most frequently involved in MSI reports so that they can remain vigilant and aware of problems associated with these medications.

Declarations

Ethics approval and consent to participate

As a service evaluation, this study did not require ethical approval, however, the study was submitted for review by the Cardiff University School of Medicines Research and Ethics Committee, who identified no ethical issues.

Consent for publication

Not applicable.

Author contributions

Noah Sagua: Formal analysis; Investigation; Visualization; Writing – original draft.

Andrew Carson-Stevens: Conceptualization; Methodology; Supervision; Writing – review & editing.

Kathryn Lynette James: Conceptualization; Data curation; Methodology; Supervision; Validation; Writing – review & editing.

Acknowledgements
Cardiff University School of Medicine: project support.

Funding
The authors received no financial support to carry out the research. Cardiff University funded the Open Access publication fees.

Competing interests
Noah Sagua, Kathryn Lynette James, and Andrew Carson-Stevens have no conflicts of interest that are directly relevant to the content of this study.

Availability of data and material
The study was available to the research team for service evaluation through their employment and the study registered as a service evaluation with Cardiff and Vale University Health Board. The data are not publicly available due to privacy or ethical restrictions.

ORCID iD
Noah Sagua https://orcid.org/0000-0002-1113-6988

Supplemental material
Supplemental material for this article is available online.

References

1. NPSA. *Safety in doses: medication safety incidents in the NHS*. London: NPSA, 2007.
2. Vosburg RW and Kim JJ. A short survey can help to decrease post-operative opioid prescribing. *Updates Surg* 2020; 72: 559–561.
3. Panagioti M, Khan K, Keers RN, et al. Prevalence, severity, and nature of preventable patient harm across medical care settings: systematic review and meta-analysis. *BMJ* 2019; 366: l4185.
4. Hodkinson A, Tyler N, Ashcroft DM, et al. Preventable medication harm across health care settings: a systematic review and meta-analysis. *BMC Med* 2020; 18: 313.
5. Cramer JD, Balakrishnan K, Roy S, et al. Intraoperative sentinel events in the era of surgical safety checklists: results of a national survey. *OTO Open* 2020; 4: 2473974X20975731.
6. de Vries EN, Ramrattan MA, Smorenburg SM, et al. The incidence and nature of in-hospital adverse events: a systematic review. *Qual Saf Health Care* 2008; 17: 216–223.
7. Anderson O, Davis R, Hanna GB, et al. Surgical adverse events: a systematic review. *Am J Surg* 2013; 206: 253–262.
8. Leape LL, Brennan TA, Laird N, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *N Engl J Med* 1991; 324: 377–384.
9. Reason J. Human error: models and management. *BMJ* 2000; 320: 768–770.
10. Cooper J, Edwards A, Williams H, et al. Nature of blame in patient safety incident reports: mixed methods analysis of a national database. *Ann Fam Med* 2017; 15: 455–461.
11. Vincent C, Neale G and Woloshynowych M. Adverse events in British hospitals: preliminary retrospective record review. *BMJ* 2001; 322: 517–519.
12. Wilson RM, Runciman WB, Gibberd RW, et al. The quality in Australian health care study. *Med J Aust*1995; 163: 458–471.
13. Cousins DH, Gerrett D and Warner B. A review of medication incidents reported to the National Reporting and Learning System in England and Wales over 6 years (2005–2010). *Br J Clin Pharmacol* 2012; 74: 597–604.
14. Turner DA, Bae J, Cheely G, et al. Improving resident and fellow engagement in patient safety through a graduate medical education incentive program. *J Grad Med Educ* 2018; 10: 671–675.
15. Howell A-M, Burns EM, Bouras G, et al. Can patient safety incident reports be used to compare hospital safety? Results from a quantitative analysis of the English National Reporting and Learning System data. *PLoS One* 2015; 10: e0144107.
16. Gawande AA, Zinner MJ, Studdert DM, et al. Analysis of errors reported by surgeons at three teaching hospitals. *Surgery* 2003; 133: 614–621.
17. NHS. Dictionary of medicines and devices (dm+d), https://www.nhsbsa.nhs.uk/pharmacies-gp-practices-and-appliance-contractors/dictionary-medicines-and-devices-dmd (2024, accessed 11/06/2024 2024).
18. NICE. British National Formulary (BNF), https://bnf.nice.org.uk (2024, accessed 11 July 2024).
19. NPSA. *Seven steps to patient safety. Step 4: Promote reporting*. London: NPSA, 2004.

20. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet* 2007; 370: 1453–1457.
21. ACSQHC. APINCHS classification of high risk medicines, https://www.safetyandquality.gov.au/our-work/medication-safety/high-risk-medicines/apinchs-classification-high-risk-medicines (2019, accessed 6 April 2021).
22. Howard RL, Avery AJ, Howard PD, et al. Investigation into the reasons for preventable drug related admissions to a medical admissions unit: observational study. *Qual Saf Health Care* 2003; 12: 280–285.
23. Berelson B. *Content analysis in communication research*. United States: Free Press, 1952.
24. HRA. What approvals and decisions do I need?, https://www.hra.nhs.uk/approvals-amendments/what-approvals-do-i-need/ (2021, accessed 6 April).
25. HMG. Data protection, https://www.gov.uk/data-protection (2021, accessed 1 May 2021).
26. NHS. Policy guidance on recording patient safety events and levels of harm, https://www.england.nhs.uk/long-read/policy-guidance-on-recording-patient-safety-events-and-levels-of-harm/ (2023, accessed 1 January 2024).
27. Wang Y, Coiera E and Magrabi F. Can Unified Medical Language System-based semantic representation improve automated identification of patient safety incident reports by type and severity? *J Am Med Inform Assoc* 2020; 27: 1502–1509.
28. Yalçın N, Kaşıkcı M, Çelik HT, et al. Development and validation of a machine learning-based detection system to improve precision screening for medication errors in the neonatal intensive care unit. *Front Pharmacol* 2023; 14: 1151560.
29. Haddad N, Paranjpe R, Rizk E, et al. Value of pharmacy services in an outpatient, preoperative, anesthesia clinic. *J Am Pharm Assoc* 2020; 60: e264–e278.
30. Heneka N, Bhattarai P, Shaw T, et al. Clinicians' perceptions of opioid error–contributing factors in inpatient palliative care services: a qualitative study. *Palliat Med* 2019; 33: 430–444.
31. Rashed AN, Tomlin S, Aguado V, et al. Sources and magnitude of error in preparing morphine infusions for nurse-patient controlled analgesia in a UK paediatric hospital. *Int J Clin Pharm* 2016; 38: 1069–1074.
32. Thomas AN and Panchagnula U. Medication-related patient safety incidents in critical care: a review of reports to the UK National Patient Safety Agency*. *Anaesthesia* 2008; 63: 726–733.
33. Ferry N and Dhanjal S. Opioid anesthesia. *StatPearls*. Treasure Island, FL: StatPearls Publishing LLC, 2021.
34. Berdot S, Roudot M, Schramm C, et al. Interventions to reduce nurses' medication administration errors in inpatient settings: a systematic review and meta-analysis. *Int J Nurs Stud* 2016; 53: 342–350.
35. Goeckner B, Gladu M, Bradley J, et al. Differences in perioperative medication errors with regard to organization characteristics. *AORN J* 2006; 83: 351–352, 355–362, 365–358.
36. Cassidy N, Duggan E, Williams DJ, et al. The epidemiology and type of medication errors reported to the National Poisons Information Centre of Ireland. *Clin Toxicol (Phila)* 2011; 49: 485–491.
37. Lear R, Godfrey AD, Riga C, et al. Surgeons' perceptions of the causes of preventable harm in arterial surgery: a mixed-methods study. *Eur J Vasc Endovasc Surg* 2017; 54: 778–786.
38. Wang HF, Jin JF, Feng XQ, et al. Quality improvements in decreasing medication administration errors made by nursing staff in an academic medical center hospital: a trend analysis during the journey to Joint Commission International accreditation and in the post-accreditation era. *Ther Clin Risk Manag* 2015; 11: 393–406.
39. Teunissen R, Bos J, Pot H, et al. Clinical relevance of and risk factors associated with medication administration time errors. *Am J Health Syst Pharm* 2013; 70: 1052–1056.
40. Schwab ME, Braun HJ, Ascher NL, et al. Implementing an opioid reduction protocol in renal transplant recipients. *Am J Surg* 2020; 220: 1284–1289.
41. Saravi BM, Mardanshahi A, Ranjbar M, et al. Rate of medical errors in affiliated hospitals of mazandaran university of medical sciences. *Materia sociomed* 2015; 27: 31–34.
42. Wang YH, Chen CB, Tassaneeyakul W, et al. The medication risk of Stevens-Johnson syndrome and toxic epidermal necrolysis in Asians: the major drug causality and comparison with the US FDA label. *Clin Pharmacol Ther* 2019; 105: 112–120.

43. Panesar SS, Carson-Stevens A, Salvilla SA, et al. Patient safety in orthopedic surgery: prioritizing key areas of iatrogenic harm through an analysis of 48,095 incidents reported to a national database of errors. *Drug Healthc Patient Saf* 2013; 5: 57–65.

44. Howard R, Avery A and Bissell P. Causes of preventable drug-related hospital admissions: a qualitative study. *Qual Saf Health Care* 2008; 17: 109–116.

45. Lawton R, McEachan RRC, Giles SJ, et al. Development of an evidence-based framework of factors contributing to patient safety incidents in hospital settings: a systematic review. *BMJ Qual Saf* 2012; 21: 369.

46. Mushtaq F, O'Driscoll C, Smith F, et al. Contributory factors in surgical incidents as delineated by a confidential reporting system. *Ann R Coll Surg Engl* 2018; 100: 401–405.

47. Hesselgreaves H, Watson A, Crawford A, et al. Medication safety: using incident data analysis and clinical focus groups to inform educational needs. *J Eval Clin Pract* 2013; 19: 30–38.

48. Kiracı ZK, Yalçın N, Cennet Ö, et al. Education and clinical pharmacist-led management strategies for the risk and prophylaxis of venous thromboembolism in general surgery. *Thromb J* 2023; 21: 86.

49. Lapkin S, Levett-Jones T, Chenoweth L, et al. The effectiveness of interventions designed to reduce medication administration errors: a synthesis of findings from systematic reviews. *J Nurs Manag* 2016; 24: 845–858.

50. Koyama AK, Maddox CS, Li L, et al. Effectiveness of double checking to reduce medication administration errors: a systematic review. *BMJ Qual Saf* 2020; 29: 595–603.

51. Oak SN, Dave NM, Garasia MB, et al. Surgical checklist application and its impact on patient safety in pediatric surgery. *J Postgrad Med* 2015; 61: 92–94.