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EMPIRICAL RESEARCH QUANTITATIVE

Analysis of the Incidence and Factors Influencing Medication Administration Errors Among Nurses: A Retrospective Study

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ABSTRACT

Aims: To explore the incidence and factors influencing medication administration errors (MAEs) among nurses.

Background: Medication administration is a global concern for patient safety. Few studies have assessed the incidence of MAEs or explored factors that considered the interplay between behaviour, the individual and the environment.

Methods: This retrospective study included 342 MAEs reported in the electronic nursing adverse event reporting system between January 2019 and September 2023 at a university-affiliated teaching hospital in China. Data on nurses' demographics and medication administration were extracted from the nursing adverse event reports. The reports were classified according to the severity of patient harm. The causes of the 342 MAEs were retrospectively analysed using content analysis based on Bandura's social cognitive theory. Descriptive statistics were used to calculate the proportion of medication errors and the distribution of subcategories.

Results: In total, 74.3% of MAEs were adverse events owing to mistakes and resulted in no harm or only minor consequences for patients. Nurses aged 26–35 years and those with 6–10 years of experience were the most common groups experiencing MAEs. Factors influencing MAEs included personal ('knowledge and skills' and 'physical state'), environmental ('equipment and infrastructure,' 'work settings' and 'workload and workflow') and behavioural ('task performance' and 'supervision and communication') factors. The study further highlighted the interrelationships among personal, behavioural and environmental factors.

Conclusion: Multiple factors influence MAEs among nurses. Nurse-related MAEs and the relationship between behaviours, individual factors and the environment, as well as ways to reduce the occurrence of MAEs, should be considered in depth.

Relevance to Clinical Practice: Understanding the factors influencing MAEs can inform training programs and improve the clinical judgement of healthcare professionals involved in medication administration, ultimately improving patient prognoses and reducing MAEs.

Patient or Public Contribution: The findings can help develop clinical guidelines for preventing MAEs.

Summary

- What does this paper contribute to the wider global clinical community?
  - Evaluating the incidence of MAEs among nurses in clinical practice and exploration of its factors are crucial for preventing MAEs.
  - MAEs are mainly related to nurses' personal ('knowledge and skills' and 'physical state'), environmental ('equipment and infrastructure,' 'work settings' and 'workload and workflow') and behavioural ('task performance' and 'supervision and communication') factors.
  - Nursing managers should focus on the complex relationships between individuals, their behaviours and the environments affecting nurse-related MAEs.

1 | Introduction

Medication administration is a global concern regarding patient safety. Nurses spend approximately 40% of their time administering pharmaceutical therapy as primary administrators, reviewers, final performers and clinical observers (Kavanagh 2017). A medication administration error (MAE) is defined as any preventable event that causes improper drug use or harm to patients by medical professionals, patients, or consumers during the medication process, including errors in prescribing and the transcription of medical orders, errors in medication storage and administration, and errors in medication use and monitoring (Ledlow, Patrician, and Miltner 2021). Globally, the annual costs associated with MAEs have been estimated at $42 billion (World Health Organization (WHO) 2002). One survey found that approximately 59%–78% of MAEs were related to nurses (Parry, Barriball, and While 2015). Errors can occur and affect patients during one out of every five MAEs in hospitals, causing substantial medical and psychological injuries, prolonged hospitalisation, diminished quality of life and a monetary burden on individuals and society (Araújo et al. 2019; Xie et al. 2023). Consequently, this frequently performed nursing task has been identified as a critical issue for patient safety and a core issue for the nursing profession.

To mitigate the risk of MAEs, the WHO has emphazied the need for increased global attention to the harm caused by MAEs, urging governments, health industry-related organisations and healthcare institutions to prioritise medication administration safety, improve medication safety-related systems and implement medication safety administration actions to ensure patient safety (WHO 2017). In the Special Action Program for Patient Safety (2023–2025), the National Health Commission of the People's Republic of China encouraged healthcare organisations to take focused corrective actions for safety hazards identified in adverse events as well as targeted measures to prevent the occurrence of adverse events (National Health Commission of the People's Republic of China 2023). Nursing managers should use this call as a starting point to examine possible deficiencies in the nursing management system and provide a foundation for continuous nursing quality improvement. Several nations have implemented national incident reporting systems in response to requests from international organisations. The National Monitoring Network for Clinically Safe Medication in China was established by the Medication Safety Panel in China Core Group of the International Network for the Rational Use of Drugs in 2012. Additonally, several hospitals have designed systems to report medication error events for internal hospital staff. Nurses in China must report the risk of adverse events and potential accidents, as regulated by the Nurses Regulation (The State Council of the People's Republic of China 2020).

Errors in medication administration can occur at any stage. An early observational study validated the intricacy of medication administration by nurses and the various pharmaceutical mistakes, such as incorrect timing, dosage and patient identification (Ben Natan et al. 2017). Another study proposed that the primary determinants of the incidence of MAEs by nurses were external variables, such as the hospital's dispensing system and work environment, as well as personal characteristics, such as job title and years of experience (Brady, Malone, and Fleming 2009). Studies conducted in different regions have highlighted similar issues. Medication errors in hospitals in the Middle East have revealed a high prevalence of such errors, with significant contributory factors including a lack of proper communication, heavy workloads and insufficient training (Thomas et al. 2019; Eltaybani et al. 2020). Furthermore, Giannetta et al.'s (2021) international study across 12 countries showed a medium to high degree of agreement among nurses regarding preventive strategies for medication errors, highlighting the strong relationship between positive attitudes, adequate knowledge and correct behaviours. These findings are consistent with global observations and underscore the universal nature of MAEs and the need for comprehensive strategies to mitigate them (Giannetta et al. 2021). These studies provided some research ideas, and they also have limitations, as they primarily focused on the direct relationships between influencing factors and error events, often neglecting the complex interactions among multiple factors.

The social cognitive theory, proposed by Bandura, emphasises the connection between human behaviours and the environment and how self-regulation and observational learning influence behaviours. This theory validates the impact of unique cognitive, behavioural and environmental elements and their interactions with human behaviours. This explains the factors and regulatory mechanisms of various human behaviours in social contexts (Guerrin 2012). The social cognitive theory underpins studies such as those exploring the practice of pioneering leadership programs for registered nurses and assessing information literacy, self-efficacy and application skills of graduate nursing students. Parry, Barriball, and While (2015) emphasised the need for a more holistic approach that focuses on the interrelationships between personal characteristics, behavioural factors and environmental conditions to fully understand MAEs. This suggests that nurse-related MAEs are not merely isolated incidents. Consequently, it is feasible to use this theory as a scientific framework for understanding the factors influencing MAEs. Assessing the incidence of MAEs among nurses in clinical practice and exploring the factors involved are crucial for preventing MAEs. Currently, studies on nurse-related MAEs are primarily conducted using questionnaire surveys to measure the incidence of MAEs, the level of medication knowledge and the medication environment of

nurses (Cetin and Cebeci 2021; Alandajani et al. 2022; Arkin Han et al. 2023). The incidence of MAEs has not been fully investigated, and the factors underlying MAEs have not been thoroughly explored. This study examined MAEs among nurses in a university-affiliated teaching hospital to better understand the circumstances surrounding these errors and the reasons behind their occurrence. Based on Bandura's social cognitive theory, the study examined the factors contributing to these MAEs to provide a scientific foundation for nursing administrators and managers to target efforts to improve nurses' abilities to administer medications safely and improve the environment in which nurses administer medications. Finally, the team provided references to prevent MAEs and safeguard patient safety.

2 | Methods

2.1 | Study Design

This retrospective study was conducted using MAE data reported in the electronic nursing adverse event reporting system of a university-affiliated teaching hospital to determine the incidence and factors influencing MAEs among nurses from January 2019 to September 2023. This retrospective study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Data S1) (von Elm et al. 2007).

2.2 | Study Setting

This retrospective study was conducted in a university-affiliated teaching hospital in China with 3500 beds distributed among 103 nursing units, employing 6057 staff members and 2763 registered nurses. Additionally, it annually treats approximately 160,000 hospitalised patients and performs approximately 102,000 procedures, with an average stay of 7.3 days. All nurses are trained in medication administration, medication errors and patient safety issues by the Nursing Department once a year.

The hospital used the SH9 classification of adverse medical events developed by Chinese scholars to grade adverse events (Wei and Tian 2011). Adverse events were categorised into four levels (I–IV) based on their severity and impact on patients. Level I adverse events occurred when an error led to unexpected patient death or caused permanent functional loss not attributable to the natural progression of the disease. Level II adverse events referred to harm or functional impairment to the patient's body that arose from medical treatment rather than the disease itself. Level III adverse events occurred when an error was made in patient care, but it resulted in no harm or only minor consequences that required no treatment for full recovery. Finally, Level IV adverse events involved errors that were identified and intercepted before they could be carried out on the patient, thereby preventing any potential harm. The hospital has detailed rules for the handling and reporting of adverse events. After an adverse event occurs, the responsible person must register the facts, factors and consequences, in addition to reporting verbally to the head nurse. Adverse events should be reported in various forms, including face-to-face, telephonic and information network reports.

The head nurse of the nursing unit is required to organise a meeting the unit staff to analyse and discuss the factors, corrective measures and treatment opinions in the 'Nursing Adverse Event Report Form' within 1–3 days after the occurrence of Level I and II events and within 30 days after the occurrence of Level III and IV events. In the case of a Level I event, the responsible department is required to complete the root cause analysis within 45 days following the incident. The Nursing Department organises a monthly analysis and discussion of the reported adverse events by members of the Nursing Quality Management Committee, carries out statistical analyses and summarises and reports these findings every quarter and annually.

2.3 | Sampling

Data were obtained between January 2019 and September 2023 for research purposes. We reviewed the Nursing Adverse Event Report Forms submitted through the hospital's Nursing Adverse Event Reporting System by the nurse manager of each nursing unit following analysis and discussion in the unit, including the person's title, years of experience, relationship between the reporter and the person involved, patient's diagnosis, time of the incident, occurrence of the incident, reason for the discussion and analysis in the unit, nature of the incident, corrective measures, treatment and subsequent follow-up and evaluation. Each event was investigated, validated, discussed, characterised and filed by the hospital's nursing staff.

During the study period, 352 MAEs were reported in nursing units. Of these, 10 reports were removed from the analysis owing to missing data or adverse drug reactions in part of the occurrences.

2.4 | Instrument and Data Collection

For the purpose of the study, we designed our own 'Nurses' MAE Events Data Collection Form' after reviewing the literature, including the sociodemographic characteristics of nurses and MAE event-related information. The sociodemographic characteristics of the nurses included sex, age, highest level of education, professional title, working experience (years), nursing unit and information related to MAE events, including adverse event classification, type of medication, route of administration, error type of event, error procedure of event, text of the full course of events, quarter of occurrence, shift of occurrence, sex of the patient, age of the patient, timing of discovery and personnel of discovery.

After obtaining permission from the hospital administrators, staff in the hospital nursing administration retrieved the nurse-related MAE event reports from the nursing adverse event conveying system from January 2019 to September 2023. After removing any identifiable information regarding the nurses and patients, the staff provided the researchers with access to these reports. Two researchers then used the 'Nurses' MAE Events Data Collection Form' to extract and

enter relevant information into the database established for this study, and a third researcher reviewed the entered information to ensure data accuracy.

2.5 | Data Analysis

Quantitative content analysis was used to summarise the factors affecting MAEs among nurses (Giannantonio 2010). Based on Bandura's social cognitive theory framework, two researchers independently analysed and categorised factors based on the information in the database, exploring the personal and environmental factors that influence nurses' medication management behaviours. Following the analysis, the two researchers discussed their findings. In instances of disagreement, a third researcher was consulted to ascertain the root factors, thereby enhancing the credibility of the findings (Bell 2020).

The IBM Statistical Program for Social Sciences Statistics (version 26.0) was used to create a database and analyse the data using descriptive statistics. Count data were statistically analysed using frequencies and composition ratios.

2.6 | Ethical Approval

This study complied with the principles of the Declaration of Helsinki. The study protocol was approved by the Clinical Medical Ethics Committee (ethics approval no. 202307165). The data in this study, obtained from the electronic nursing adverse event reporting system, included the patient's registration number, name, sex, age and diagnosis and the nurse's employee number, name, sex, age, highest level of education, professtional title, work experience (years), nursing unit and type of medication error. To protect the confidentiality and privacy of the participants, personally identifiable information was removed from all datasets before being provided to the research team. The anonymisation process was reviewed and approved by the Ethics Committee, which ensured that the ethical standards of the study were upheld.

3 | Results

3.1 | Characteristics of MAEs

A total of 342 MAE events were included in this study, including 254 Level III and 88 Level IV adverse events, and 95.9% of the MAE events involved a nurse. The events involved a total of 330 patients, and 31.2% of the patients were aged ≥ 60 years. Table 1 lists the characteristics of the MAEs.

3.2 | Sociodemographic Characteristics of Nurses Involved in MAEs

A total of 355 nurses were involved in the 342 MAE events included in this study; their age range was 21–51 years, with the highest number of nurses in the age group of 26–35 years, accounting for 67.9% of the total number. Regarding job titles, senior nurses were the most commonly involved, accounting for 43.9%.

TABLE 1 | Characteristics of medication administration errors ($n = 342$).

Parameter	Frequency	Component ratio (%)
Classification of medical adverse events		
Level I events	0	0.00
Level II events	0	0.00
Level III events	254	74.27
Level IV events	88	25.73
Number of nurses involved in the event		
1	328	95.91
≥ 2	14	4.09
Sex of the patient involved in the event		
Male	179	52.30
Female	163	47.70
Age of the patient involved in the event (years)		
≤ 17	38	11.11
18~59	197	57.60
≥ 60	107	31.29
Time of occurrence		
Day (08:00–18:00)	250	73.10
Night (18:01–07:59)	92	26.90
Error procedure		
Administration	37	10.82
Preparation	34	9.94
Medication	242	70.76
Nursing paperwork	2	0.58
More than two procedures	27	7.90
Type of medication administration		
Intravenous	197	57.60
Oral	79	23.10
Intramuscular	52	15.21
Cutaneous	14	4.09
Error type		
Wrong medication	80	23.39
Wrong time	40	11.70
Wrong rate	31	9.06
Wrong patient	39	11.40
Missed release	46	13.45
Wrong dose	52	15.21

(Continues)

TABLE 1 | (Continued)

Parameter	Frequency	Component ratio (%)
Handling of the medication	54	15.79
Timing of discovery		
Pre-medication	99	28.95
During medication	41	11.99
Post-medication	152	44.44
Not found on this shift	50	14.62
Personnel of discovery		
Nurse (involved)	137	40.05
Patients or their families	39	11.40
Nurse on the next shift	82	23.98
Other nurses	53	15.50
Head nurse	15	4.39
Doctor	16	4.68

Nurses with 6–10 years of experience were the most commonly involved, accounting for 41.1%. Other details are shown in Table 2.

3.3 | Factors Affecting MAEs

A total of 165 MAEs were associated with multiple factors, including personal ('knowledge and skills' and 'physical state'), environmental ('equipment and infrastructure,' 'work settings' and 'workload and workflow') and behavioural ('task performance' and 'supervision and communication') factors. The analysis identified three primary contributors to medication errors: 'task performance,' 'supervision and communication' and 'knowledge and skills', while the most frequently observed specific items were failure to review dispensing processes, injections and infusions; failures to check the prescriptions and high workload and heavy burden.

Table 3 provides a detailed description of these factors. The examples in Table 3 illustrate how the combination of personal and behavioural factors, influenced by environmental factors, can lead to MAEs. Similarly, environmental factors can give rise to behavioural factors, especially those related to personal factors. Figure 1 further clarifies the interrelationships between personal, behavioural and environmental factors that contribute to the occurrence of MAEs.

TABLE 2 | Sociodemographic characteristics of nurses involved in medication administration errors ($n = 355$).

Parameter	Frequency	Component ratio (%)
Sex		
Female	350	98.60
Male	5	1.40
Highest level of education		
Associate degree	67	18.90
Bachelor degree	267	75.20
Master degree	21	5.90
Age (years)		
≤25	74	20.80
26–35	241	67.90
36–45	34	9.60
≥46	6	1.70
Professional title		
Nurse	65	18.30
Senior nurse	156	43.90
Supervisor nurse	127	35.80
Associate chief nurse and above	1	0.30
Others	6	1.70
Years of experience		
0–5	119	33.50
6–10	146	41.10
11–15	68	19.20
15–20	9	2.50
>20	13	3.70
Nursing unit		
Internal medicine	123	34.70
Surgery	137	38.60
Obstetrics and gynaecology	27	7.60
Paediatrics	14	3.90
Intensive care	22	6.20
Outpatient and emergency	18	5.10
Others	14	3.90

4 | Discussion

In healthcare institutions, the safe administration of medication is crucial for providing high-quality treatment. Medication administration involves various complex and often competing demands that temporally structure a nurse's entire workday. This retrospective study used Bandura's social cognitive theory as an analytical framework, focusing on the interactions

TABLE 3 | Factors affecting medication administration errors (with examples).

Theme	Sub-theme	Item description	Example	Interaction and impact	Frequency
Person	Knowledge and skills	Lack of drug knowledge	The nurse did not consider that the chemotherapy drug vincristine needed to be kept refrigerated	Lack of knowledge (personal factors) lead to improper task performance (behavioural factors)	19
		Lack of ability to use infusion pumps and syringes	The patient returned to the surgical nursing unit after surgery and required an infusion pump to infuse 3 m/h of tirofiban. The nurse was unfamiliar with the infusion pump resulting in the drug being infused at a rate of 4 drops/min	In non-ICU nursing units, infusion pumps and syringe pumps are scarce and not frequently needed (environmental factors), and nurses lack the abilities to use them (personal factors), leading to task performance errors (behavioural factors)	14
	Physical state	Poor concentration	As a result of the nurse's trance-like disorientation in the ICU, an alteplase needle was administered intravenously in excess of the medically prescribed dose of 5–6 mg	Poor cognitive state (personal factors) leads to errors in task performance (behavioural factors) under high-stress work environments (environmental factors)	8
Behaviour	Task performance	Failure to check for dispensing medicines, injections, and infusions	The nurse mistakenly switched acetylglutamine 0.5 g from bed 01 to bed 03 without rigorously checking the patient's information. After 10 min, the patient's family found the wrong information on the infusion bottle	Poor task performance (behavioural factors) is caused by high workload (environmental factors) and poor concentration (personal factors)	260
		Failure to check the prescription	Nurses failed to identify errors in medical prescriptions and carried out incorrect prescriptions	Inadequate prescription checking (behavioural factors) is jointly caused by personal factors (lack of knowledge and concentration)	104
		Failure to conduct effective shift handovers	A lack of proper handover amidst noise led to a surgical error	Inadequate handover (behavioural factors) is due to personal factors (poor concentration) and environmental factors (noisy working environment)	29
		Failure to write correct nursing paperwork	The nurse incorrectly recorded the test results and mislabeled the positive result as a negative result	Nursing documentation errors (behavioural factors) are influenced by personal factors (poor concentration) and environmental factors (high workload in documentation tasks)	15

(Continues)

TABLE 3 | (Continued)

Theme	Sub-theme	Item description	Example	Interaction and impact	Frequency
	Supervision and communication	Inadequate supervision of nursing students	The teaching nurse did not ask the students not to allocate drugs without authorization. While the teaching nurse was changing the medication for a patient, the students injected 250 mL of 168 mL of normal saline originally added to the chemotherapy pump, resulting in the wrong concentration of drug ratio	Inadequate supervision (behavioural factors) is caused by environmental factors (high workload)	16
		Inadequate supervision and communication with patients and families	The nurse did not prompt the family members of the children in a timely manner, resulting in the antiepileptic drugs not being administered to the children as scheduled	Inadequate communication (behavioural factors) is caused by personal factors (poor skills) and environmental factors (the need for multitasking)	15
		Inadequate communication with colleagues	The attending doctor informed the nurse that the patient needed withdrawal (15 mg). However, the nurse did not communicate this in a timely manner, and the epirubicin configuration had been completed	Inadequate communication (behavioural factors) results from environmental factors (workload and multitasking demands)	15
Environment	Equipment and infrastructure	Malfunctioning or insufficient number of medical instruments	The doctor prescribed 50 mL of propofol 3 mL/h to be pumped into the patient via an infusion pump, which malfunctioned, resulting in an overdose of propofol being infused into the patient's body 30 min later	Equipment malfunction (environmental factors) leads to improper task performance (behavioural factors), especially in the context of lack of skills (personal factors)	5
		Fault of hospital information system	A malfunction in the hospital's information system resulted in delays in the delivery of medicines to the wards	System faults (environmental factors) lead to errors in task performance (behavioural factors)	3
	Working settings	Noisy working environment	Owing to the noisy working environment, the nurse administered the injection without listening to the patient's answer and found an error upon rechecking after the injection was completed	Noisy environment (environmental factors) interacts with insufficient attention (personal factors), leading to errors in task performance (behavioural factors)	4
	Workload and workflow	High workload and heavy burden	Nurse error because of the simultaneous need for medication changes for three patients	High workload (environmental factors) combined with cognitive load (personal factors) leads to errors in task performance (behavioural factors)	24
		Interruption of care	The nurse was configuring the patient's cyclophosphamide medication when she was interrupted by the shift handler's nurse handoff, and then mistakenly injected saline, which dissolves cyclophosphamide into the doxorubicin liposome injection	Interruption of care (environmental factors) leads to improper task performance (behavioural factors), particularly when the nurse is distracted (personal factors)	4

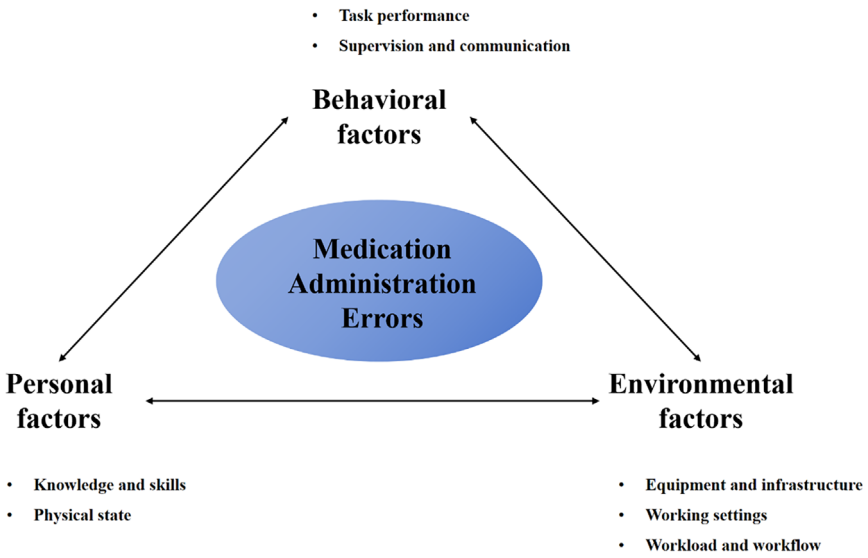

FIGURE 1 | Factors affecting medication administration errors based on the social cognitive theory. [Colour figure can be viewed at wileyonlinelibrary.com]

between individuals, environments and behaviours during MAEs. It investigated the facts and major contributing factors related to nurse-related MAEs.

The cognitive–behavioural perspective offers a different viewpoint for exploring the factors influencing medication errors, highlighting the interrelationships between individuals, environments and behaviours. However, there was an imbalance in the scholarly attention paid to the factors leading to medication management errors. Several studies exploring medication error management behaviours have failed to account for the interaction between individuals and their environments (Gracia, Serrano, and Garrido 2019; Yoon and Sohng 2021). Considering the complex relationships between individuals, their environments and their behaviours, the results of this study indicate that nurse-related MAEs are influenced by multiple factors, including personal ('knowledge and skills' and 'physical state'), environmental ('equipment and infrastructure,' 'work settings' and 'workload and workflow') and behavioural ('task performance' and 'supervision and communication') factors. In recent years, there has been an increasing emphasis on medication safety management; however, there is still no consensus on how errors occur (Parry, Barriball, and While 2015). To better understand the causes of medication management errors among nurses, the complex interrelationships between medication management behaviours, nurses' personal characteristics and the healthcare environment during medication management require further consideration.

This study included 342 cases of MAEs, with most classified as Level III or IV adverse events. These findings align with previous research and may reflect the heightened focus on patient medication safety by many healthcare organisations (Cottell, Wätterbjörk, and Hälleberg Nyman 2020). The study results showed that the incidence of MAE level III adverse events was 74.3%, which was higher than that reported by the self-reported results of nurses (Hung et al. 2016). The high frequency of MAEs and low reporting rate among clinical nurses might be attributed to concerns about misunderstanding patients and their families, fear of being punished by the hospital and insufficient support from colleagues (Rutledge, Retrosi, and Ostrowski 2018). According to a survey, up to 48.6% of nurse-related prescription mistakes went undetected (Bickel, Villasecas, and Fluxá 2020). Relying solely on incident reports does not accurately reflect nursing errors. This reliance threatens data validity because the quality of the results depends heavily on the accuracy and completeness of reporting, which can be compromised by missing data and inconsistencies (Jember et al. 2018). Research indicates that the severity of the harm caused by an error influences whether it is reported, with less severe errors often going unreported (Eltaybani, Mohamed, and Abdelwareth 2019). Additionally, barriers such as fear of disciplinary action, lack of knowledge about reporting procedures and perceptions of error severity significantly impact reporting rates (Rutledge, Retrosi, and Ostrowski 2018). To address these issues, hospital managers must improve the safety culture by establishing nonpunitive reporting policies and regulations. Continuous training programs are essential to enhance nurses' understanding of medication safety and to provide feedback systems for error reporting. Additionally, initiatives are recommended to boost nurses' confidence in disclosing errors and implementing comprehensive reporting systems for error reporting. Promoting a balanced approach between accountability and a nonpunitive culture is crucial for advancing medication safety management. Future research should explore alternative data sources and methodologies, including data mining of electronic clinical information systems, to gain a comprehensive understanding of MAEs and develop effective interventions to improve patient safety (Westbrook et al. 2015).

Multifactorial and multicomponent variables can affect MAEs among nurses. Regarding the personal factors ('knowledge and skills' and 'physical state') of nurses, lack of medication knowledge, lack of ability to use infusion pumps and syringes and poor concentration were the main factors affecting the occurrence of MAEs. The study's findings indicated differences

in the composition of medication error events between general units and critical care units. These differences might be influenced by several factors, including the complexity of patient care, the intensity of the work environment and the specific skill sets required in each unit. It is important to recognise that nurses in different units face unique challenges that could affect their likelihood of making medication errors. One of the most crucial requirements for safel medication administration is possessing adequate knowledge and skills (Coyne, Needham, and Rands 2013). However, most nurses lack systematic training and assessments of their medication knowledge, and few take the initiative to check for pertinent medication instructions (Chedoe et al. 2012). The WHO has emphasised that strengthening the competence of health professionals through skill training is the main strategy for reducing medication errors. To improve nurses' comprehensive quality of medication safety, administrators should regularly combine the most recent medication practice guidelines with specialised pharmacological knowledge and medication use guidance (WHO 2017). They should also conduct targeted training based on nurses' use of medical devices to enhance their competency in using medical equipment, ensuring the safety of patients' medication administration and the use of medical equipment. Additionally, nurses working night shifts may experience sleep deprivation, poor concentration and fatigue. To minimise sleep disturbances and improve concentration during night shifts, nurses should engage in 30 min of excercise, moderate caffeine intake at night and take naps (Wondmieneh et al. 2020).

The study's results demonstrated that one of the behavioural factors (task performance), failing to follow procedures correctly and violating the nursing work system, was the primary factor affecting medication mistake incidents. Errors are common when performing heavy nursing responsibilities (Westbrook et al. 2011). Administering intravenous medications involves numerous steps, a wide range of individuals and various medication types, leading nurses to oversimplify the procedure and neglect to strictly adhere to the checking work system. The administration of intravenous medication resulted in the highest frequency of medication errors (49.12%). Additionally, the high proportion (50.6%) of medication error events involving key populations (older adult patients, children and pregnant women) in this study may be related to the varying levels of medication health literacy among primary caregivers (Xu et al. 2022). Nursing managers should optimise the nursing workflow to improve nurses' safe medication administration by establishing safety checks, providing technical support and constructing a medication management system for key populations. The Institute for Safe Medication Practices suggests that an independent and complete assessment of medications by two different nurses before medication administration (a completely independent evaluation by a second nurse before administration) can be effective in intercepting errors before the administration of critical high-risk medications (Yu et al. 2018). Nursing managers should consider the existing nursing workload and current medication use practices, optimise the workflow for higher-risk drugs and routes of administration, implement medication grading management measures for older adult patients with different risk levels, formulate individualised medication plans for children of different ages and strengthen the management of all aspects of rational medication use in pregnancy and childbirth with other characteristics to ensure that different types of patients can receive the correct medications and ensure the safety of medications for key populations. To reduce medication confusion errors, nursing managers should improve nursing risk management systems, raise nurses' awareness of drug safety and help nurses implement workflows and core systems. They should also strengthen their supervision of drug management through barcode management and other information technologies for nurses during the drug administration process.

Supervision and communication can also affect patient medication safety, particularly in high workload conditions. In this study, owing to the unsatisfactory oral medication compliance in hospitalised patients, clinical nurses did not adequately supervise patients taking oral medications, which resulted in patients missing medications, taking medicines at the wrong times and taking incorrect doses of medications. Using standardised communication strategies when exchanging information can ensure accurate medication administration by healthcare professionals (Syyrilä, Vehviläinen-Julkunen, and Härkänen 2020). Therefore, nursing managers should develop standardised communication strategies to promote effective communication between healthcare professionals and patients. When nurses encounter a medical order that differs from the norm, they must confirm with the physician that it is correct before implementing it (Bryant 2011). Nurses should use clear and easy-to-understand patient education strategies to encourage active patient participation in patient safety (Han et al. 2023). Patients are responsible for identifying their medications and the corresponding medication information. To reduce MAEs, nurses should communicate information on medication usage, dosage and side effects to patients. They should also reinforce medication reminders for older adult patients and advise them to double-check the dosage and type of medication when using medications that differ from one another.

Environmental factors ('equipment and infrastructure,' 'work settings' and 'workload and workflow') such as high workload, noisy environments and interruption of care significantly interact with personal and behavioural factors to influence MAEs among nurses. A survey has shown that the medication safety competency of nurses with 5–15 years of work experience is higher (Han et al. 2023), whereas in this study, the incidence of medication errors was higher among nurses aged 26–35 years, with 6–10 years of work experience, and with the titles of nurse practitioner and charge nurse practitioner. This is because middle-aged and mid-level nurses are typically the backbone of the unit, acting as liaisons for unit programs, instructors and other related roles. Consequently, they are vulnerable to external interruptions during nursing operations, which can lead to high rates of MAEs. According to Schroers' research, interruptions and diversions increase the effort and danger of mistakes for nurses (Schroers, Ross, and Moriarty 2021). It is critical to provide nurses with a work environment that minimises care interruptions (Wang et al. 2021). The American Association for Prescribing Safety proposed the No Interruption Zone, which provides nurses with a separate operating space in the patient area to prepare

and verify medications and minimise medication errors (Anthony 2010). Therefore, hospital administrators could improve the nursing environment, provide consistent procedures and train nurses on coping mechanisms to reduce nursing interruptions during medication administration. To ensure patient safety and high-quality nursing care, new nurses should receive training in interruption management techniques using scenario-based simulation instructions.

In addition, managers' behaviour and error management climate can affect employees' behavioural choices and habits (Welch 2024). The change in nurse-related medication error behaviours consists of the behaviour of individual nurses and should be incorporated into the management system for continuous improvement. Hospital administrators should continuously increase their attention to the medication safety of nurses and fully utilise evaluation indexes, such as rational medication assessment and quality control target management, as important references for medical and nursing staff, such as merit assessment and evaluation, to comprehensively reduce medication error events.

4.1 | Limitations

This study had several limitations. First, it only included medication error incidents from a single hospital in China, which limits the generalizability of the findings. Second, owing to the anonymisation of nurse and patient information, this retrospective study could not compare nurses who made errors with those who did not, nor could we directly contact nurses for further information. Consequently, we were unable to identify any relationships between medication errors and other potentially influential factors. Future studies using multicenter designs with larger sample sizes and more detailed data on potential influencing factors will provide a more comprehensive understanding of the contributors to MAEs. These studies will also help to develop targeted interventions to reduce the incidence of MAEs.

5 | Conclusion

Medication safety is critical for human health, and the prevention of MAEs is crucial. Attention has focused on exploring nurses' competence for safe drug use; however, the actual occurrence of nurse-related MAEs and the reasons behind their behaviours have not been explored scientifically. In this study, based on Bandura's social cognitive theory, we analysed the incidence and factors of MAE among nurses in a university-affiliated hospital and identified the current incidence of medication errors among nurses. MAEs among nurses were dominated by level III adverse events. MAE events are mainly related to personal ('knowledge and skills' and 'physical state'), environmental ('equipment and infrastructure,' 'work settings' and 'workload and workflow') and behavioural ('task performance' and 'supervision and communication') factors. To reduce nurses' MAEs and guarantee patient medication safety, nursing leaders and managers need to consider the reasons for nurses' behaviours and MAEs and the relationships between behaviours, individuals and work environments.

6 | Relevance to Clinical Practice

Understanding the multifaceted factors that influence MAEs can significantly inform clinical practice. Nursing managers can implement targeted interventions to enhance medication safety by comprehensively addressing personal, environmental and behavioural factors. Strengthening nurses' knowledge and skills through regular training programs, optimising nursing workflows and establishing standardised communication strategies are crucial. Additionally, fostering a nonpunitive error reporting culture and improving work environments to minimise interruptions can further reduce MAEs. Implementing these measures can lead to better clinical judgement, improved patient outcomes and reduced medication errors in practice, ultimately enhancing the overall healthcare quality and patient safety.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All data generated or analysed in this study are included in the published article. The datasets used and/or analysed in the current study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.