

## RESEARCH ARTICLE

# Factors causing medication errors in an electronic reporting system

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**Abstract**

**Aim:** To analyse medication error data from a hospital's electronic reporting system and identify the factors affecting error types and harmfulness.

**Design:** A retrospective study.

**Methods:** The 805 near misses and adverse events reported to the hospital's electronic reporting system between January 2014 and December 2018 were analysed using descriptive statistics, chi-square tests and logistic regression analyses.

**Results:** A total of 632 near misses and 173 adverse events were reported. Near misses and adverse events were the most common error type during the dispensing stage and medication administration, respectively. The odds of medication errors reported by nurses with 1–9 years of clinical experience were relatively low. After adjusting for confounders, the odds of medication errors directly observed by nurses were 65% lower than the odds of medication errors not directly detected. In clinical practice, nurses must be educated about errors in reporting depending on their degree of clinical experience.

**KEYWORDS**

adverse events, hospital incident reporting, medical errors, medication errors, near miss, quality and safety, university hospitals

## 1 | INTRODUCTION

Medical errors present a serious public health problem, and they are a leading cause of death, globally (Makary & Daniel, 2016). As the standards for medical services become more stringent, we must overcome medical errors to improve the quality of care provision. Medication errors are a common medical error (Jachan et al., 2021; Morelock & Kirk, 2019) and compromise the quality of medical systems by increasing hospitalization and medical costs in developed and developing countries (Ahmed et al., 2015).

## 2 | BACKGROUND

In South Korea, medication errors accounted for 27.8%–36.6% of all patient safety incidents reported between 2016–2019, and they are the most common incidents after falls (Ministry of Health & Welfare, K. I. f. H. A., 2020). The medication process can be divided into five stages: ordering/prescribing, transcribing/verifying, dispensing/delivering, administering and monitoring and reporting; medication errors can occur in any stage (Cottell et al., 2020). The European Medicines Agency estimated the incidence of medication errors to

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be 0.3%–9.1% in the ordering/prescribing stage, 1.6%–2.1% in the preparation stage and 10.5% in the administration stage (Airaksinen et al., 2007). In a systematic review, the incidence of medication errors was 20.5%–25.15% in the ordering/prescribing stage, 1%–25.15% in the preparation stage and 0.02%–88.6% in the administration stage, widely varying between the different stages (Salmasi et al., 2015).

Error analysis is needed to prevent medical errors. Healthcare workers must detect errors that occur regularly and learn how to report patient safety incidents (Oyebode, 2013). Recurrent near misses can lead to unfavourable results, necessitating accurate identification and appropriate management. However, nurses tend to report medication errors to doctors (Dirik et al., 2019; Lee, 2017) or verbally communicate them to other nurses or colleagues (Yung et al., 2016) instead of reporting them using an internal system; thus, medication errors are formally underreported (Chiang et al., 2010). Low error reporting rates can be attributed to nurses' fear of punishment (Gök & Sari, 2017) and criticism (Yung et al., 2016); the legal consequences of reporting errors (Lee, 2017); organizational barriers such as a "blame culture" in the workplace; a reporting system that is not user friendly; and management behaviour that discourages feedback (Vrbnjak et al., 2016). In a questionnaire survey among South Korean nurses, medication error reporting rates ranged between 6.3%–29.9% (Lee, 2017). In another study, while 63.6% of participants experienced medication errors, only 28.3% reported them (Kim et al., 2011).

Nurses perform the last stage of medication administration (Moyen et al., 2008) and play a central role in medication error reporting. While nurses may make medication errors during clinical practice, they are also on the frontline of preventing these errors (Alrabadi et al., 2021). It is important to investigate the factors affecting the risk of medication errors by analysing data entered into a medication error reporting system by nurses to help prevent future medication errors (Airaksinen et al., 2007). Patient-to-nurse ratio, heavy workload and fatigue from additional workload have been identified as factors contributing to medication errors (Zarea et al., 2018). Another study reported that at least one of the following factors—nurses' personal negligence, workload and new healthcare workers—can affect the risk of medication errors (Tang et al., 2007). According to a narrative review, environmental factors such as workload and work environments have a greater impact on medication errors than personal factors such as personality and clinical experience (Parry et al., 2015). In a study in paediatric hospitals, factors such as lack of practical experience or knowledge, not following regulations or procedures and frequent work interruptions contributed to medication errors (Manias et al., 2019). About near misses by nurses, carelessness, patient safety culture and workload, but not fatigue, have been shown to be contributing factors (Hee & Nam, 2019).

Most studies on medication errors have investigated nurses' awareness of medication errors or conducted a questionnaire survey, with few analysing medication error data reported by nurses. Furthermore, while many survey studies (Chiang et al., 2010; Gök &

Sari, 2017; Lee, 2017; Vrbnjak et al., 2016; Yung et al., 2016) have recommended an increase in the low reporting rate of medication errors, few (Härkänen et al., 2015; Morelock & Kirk, 2019) have used medication error data to examine factors affecting the risk of near misses and adverse events. Furthermore, no study has examined the characteristics of medication errors reported by nurses according to different error detection methods. We analysed data pertaining to near misses and adverse events reported by nurses using an electronic reporting system in a tertiary university hospital in South Korea to identify the factors affecting medication errors based on the method of error detection. We examined and compared the general characteristics of different types of medication errors reported in 2014–2018 to investigate the factors affecting error types and harmfulness.

### 3 | THE STUDY

#### 3.1 | Design

This was a retrospective survey study.

#### 3.2 | Setting

The study hospital is in the capital area and has over 850 beds and 38 clinical departments. The number of outpatients visiting the hospital per year is approximately 800,000, and the number of inpatients is approximately 260,000. The hospital was accredited by the Korea Institute for Healthcare Accreditation in 2015.

#### 3.3 | Sample

Data on medication errors voluntarily reported to an electronic reporting system by nurses were analysed. The system classifies a medication error as a near miss, an adverse event or a sentinel event. Nurses are required to choose the severity and stage of the medication error and describe the medication error in free text. A near miss (also referred to as a "close call" or "good catch") can be defined as a patient safety incident that the patient is not aware of. An adverse event is an event resulting in patient harm. Furthermore, a sentinel event is one that reaches the patient and results in death, permanent harm or severe temporary harm (Joint Commission International, 2015).

The sample inclusion criteria were as follows: (a) medication errors reported by a nurse from 1 January 2014 to 31 December 2018; (b) inpatient medication errors; and (c) near misses and adverse events. The exclusion criteria were as follows: (a) sentinel events reported during the research period; (b) outpatient medication errors; (c) reports without the required input variables; and (d) reports that were filled out inaccurately. After applying these criteria to 912 cases of near misses and adverse events reported during the 5-year period, the remaining 805 samples were analysed.

### 3.4 | Method

Data were classified according to the built-in classification method of the hospital's electronic reporting system. The system classifies medication errors into nine National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) categories based on severity. NCC MERP category A includes "near misses" that are not errors. NCC MERP categories B, C and D include "non-harmful errors" or adverse events in which an error has occurred but has not caused harm. NCC MERP categories E and F include "harmful errors" or adverse events in which an error has occurred and caused harm. NCC MERP categories G, H and I were excluded as they met the exclusion criteria.

The following input variables related to medication errors from the electronic reporting system were examined. We referred to the results of previous studies by Cabilan et al., 2017; Härkänen et al., 2015; and Morelock & Kirk, 2019: date of the error report, error type, severity, location, date of detection, date of error occurrence, clinical experience, detection method, medication process stage, medication error type, work hours and detection time. Locations included internal medicine wards and surgical medicine wards. Special units included the intensive care unit and operating rooms. The methods of error detection included "directly observed or experienced," "reported by another person" and "detected during an incident or electronic medical record (EMR) review." Error detection methods were optional inputs in the system. The medication error types included "wrong drug," "wrong dose," "wrong patient, route, time, and place" and "omission, duplicate, etc. (adverse drug reaction, inappropriate intravenous injection site, phlebitis, communication errors, etc.)."

### 3.5 | Analysis

Data were analysed using SPSS version 23.0 (IBM Corp.). The incidence rates of near misses and adverse events were compared. To validate the research questions of this study, we explored them in the order given below. First, frequency analysis and descriptive statistics were used to analyse the general characteristics of medication errors, and chi-square tests were conducted to analyse the incidence of near misses and adverse events according to these general characteristics. General characteristics included the gender and age of the patient in the reported medication error data and the clinical experience of the nurse who reported it. Second, a cross-tabulation analysis was done to analyse the stages and types of medication errors. Third, to identify the factors affecting the incidence of medication errors, a multiple regression analysis was performed using error type (near miss/adverse event) and error harmfulness (harmless/harmful) as dependent variables. Fourth, to investigate the effect of the error detection method on the incidence of medication errors, unadjusted Model 1 and adjusted Model 2, which were created by introducing the detection method as a major independent variable to the existing model, were used in logistic regression and multiple

logistic regression analyses. The results of each regression model were expressed as odds ratios (ORs) and 95% confidence intervals (CIs). Significance was set at  $p < .05$ .

### 3.6 | Ethics

The Institutional Review Board of the hospital approved this study (no. OC19EISI0175). The data in this study, the electronic reporting system report, include the patient's registration number, name, gender, age and diagnosis, and the nurse's employee number, name, clinical experience and type of medication error. After deliberation by the Institutional Review Board Committee, the researcher deleted personally identifiable information (such as patient registration numbers, and employee numbers and names) of nurses or patients who reported errors through the quality improvement department. The data were managed using unique numbering and identification, and classification of dosage errors was confirmed by two researchers from December 2019 to February 2020 to preserve data integrity and ensure uniformity.

## 4 | RESULTS

### 4.1 | General characteristics by incident type

Table 1 summarizes the general characteristics of medication errors according to incident type. A total of 632 (78.5%) near misses and 173 (21.5%) adverse events were reported. Statistically significant differences in the incidence of medication errors were found according to year, time of occurrence, day of occurrence, detection day, clinical experience, location and detection method. No statistically significant differences were observed according to patients' sex or age. The highest number of medication errors was reported in 2015. Of these, 73.3% were near misses and 26.7% were adverse events. Medication errors over time were reported as occurring during the day (40.8%), night (35.2%) or evening (24%), and adverse events were reported as occurring during the day (56%), evening (31.5%) or night (12.5%). The rate of reporting medication errors was 31.9% for nurses with <1 year of experience and 38.3% for those with  $\geq 10$  years of experience, higher than the rate found among nurses with 1–4 years (14%) and 5–9 years (17%) of experience. Medication errors detected after the date of occurrence were three times more probably to be reported than those detected on the day of occurrence. The incidence of medication errors was higher in general wards than in special units (Table 1).

### 4.2 | Medication error stage and type by incident type

Table 2 shows the stages and types of medication errors with incident types. Dispensing errors ( $N = 488$ ) were the most commonly

**TABLE 1** Overview of data collected ( $N = 805$ )

Variable	Near miss ( $N = 632$ )	Adverse event ( $N = 173$ )	$p$
Patients' sex			
Male	342 (80.7%)	82 (19.3%)	.117
Female	290 (76.1%)	91 (23.9%)	
Patients' age (years)			
0–19	51 (71.8%)	20 (28.2%)	.499
20–44	102 (80.3%)	25 (19.7%)	
45–64	235 (79.7%)	60 (20.3%)	
≥65	244 (78.2%)	68 (21.8%)	
Clinical experience (years)			
<1	111 (68.1%)	52 (31.9%)	<.001
1–4	327 (86.1%)	53 (13.9%)	
5–9	128 (82.6%)	27 (17.4%)	
≥10	66 (61.7%)	41 (38.3%)	
Year			
2014	129 (88.4%)	17 (11.6%)	.004
2015	173 (73.3%)	63 (26.7%)	
2016	118 (83.1%)	24 (16.9%)	
2017	115 (76.2%)	36 (23.8%)	
2018	97 (74.6%)	33 (25.4%)	
Work hours			
Day	250 (72.7%)	94 (27.3%)	<.001
Evening	147 (73.5%)	53 (26.5%)	
Night	216 (91.1%)	21 (8.9%)	
Detection time			
On the day of error occurrence	618 (80.4%)	151 (19.6%)	<.001
After the day of error occurrence	14 (38.9%)	22 (61.1%)	
Location			
Ward	196 (67.8%)	93 (32.2%)	<.001
Special unit	436 (84.5%)	80 (15.5%)	
Detection method			
Directly observed	375 (92.6%)	30 (07.4%)	<.001
Reported by another person	55 (44.4%)	69 (55.6%)	
Detected during an incident or EMR review	20 (36.4%)	35 (63.6%)	<.001
Unknown	182 (82.4%)	39 (17.6%)	
Type			
Wrong drug	236 (84.0%)	45 (16.0%)	<.001
Wrong dose	115 (76.7%)	35 (23.3%)	
Wrong patient, route, time or place	86 (61.0%)	55 (39.0%)	
Omission, duplication, etc.	195 (83.7%)	38 (16.3%)	

(Continues)

**TABLE 1** (Continued)

Variable	Near miss ( $N = 632$ )	Adverse event ( $N = 173$ )	$p$
Stage			
Prescribing	8 (25.8%)	23 (74.2%)	<.001
Dispensing	118 (83.7%)	23 (16.3%)	
Delivery	488 (99.0%)	5 (01.0%)	
Administration	18 (12.9%)	122 (87.1%)	

Abbreviation: EMR, electronic medical record.

reported near misses, followed by preparation errors ( $N = 118$ ). The most common type of near miss was “wrong drug” ( $N = 236$ , 37.3%), followed by “omission, duplication, etc.” ( $N = 195$ , 30.8%), “wrong dose” ( $N = 115$ , 18.2%) and “wrong patient, route, time, and location” ( $N = 86$ , 13.6%). Medication errors were the most commonly reported adverse events in the administration stage (70.5%). The most common type of these medication errors was “wrong patient, route, time, and place” (41.8%).

#### 4.3 | Characteristics of medication errors by method of detection

The detection method was “unknown” for 27.5% of all medication errors ( $N = 221$ ). Of the medication errors that were directly detected, 35.6% were “wrong drug” and 31.1% were “omission, duplication, etc.” Errors that were directly detected were the most common in the dispensing stage ( $N = 291$ , 71.9%). About half of the medication errors detected after they were reported by another person occurred in the administration stage ( $N = 60$ , 48.4%). Errors were most commonly detected during an incident or EMR chart review in the administration stage ( $n = 18$ , 32.7%). These detection methods were the least common in the prescribing stage ( $N = 9$ , 16%). Statistically significant differences in the incidence of medication errors were found according to the detection method (Table 3). Over half of the medication errors directly observed or experienced were reported by nurses with 1–4 years of clinical experience ( $N = 228$ , 56.3%). The smallest percentage of these medication errors was reported by nurses with ≥10 years of experience ( $N = 20$ , 4.9%). Most of the medication errors reported by another person were by nurses with ≥10 years of experience: 20%, 21% and 18% of these errors were reported by nurses with <1 year, 1–4 years and 5–9 years of experience, respectively (Figure 1).

#### 4.4 | Factors affecting medication errors

A multiple logistic regression analysis was performed using error type (near miss/adverse event) and harmfulness (harmless/harmful) as dependent variables to investigate the factors affecting the incidence of medication errors. Clinical experience, shift during which the error occurred, detection time and location of occurrence were

TABLE 2 Medication error stage and type by incident type (N = 805)

Variable	Near miss (N = 632)				Adverse event (N = 173)			
	Prescribing error (N = 8)	Dispensing error (N = 488)	Preparation error (N = 118)	Administration error (N = 18)	Prescribing error (N = 23)	Dispensing error (N = 5)	Preparation error (N = 23)	Administration error (N = 122)
Wrong drug	0 (00.0%)	199 (40.8%)	32 (27.1%)	5 (27.8%)	3 (13.0%)	3 (60.0%)	17 (73.9%)	22 (18.0%)
Wrong dose	2 (25.0%)	78 (16.0%)	31 (26.3%)	4 (22.2%)	5 (21.7%)	2 (40.0%)	3 (13.0%)	25 (20.5%)
Wrong patient, route, time or place	2 (25.0%)	46 (9.4%)	34 (28.8%)	4 (22.2%)	3 (13.0%)	0 (00.0%)	1 (04.3%)	51 (41.8%)
Wrong patient			23 (67.6%)	3 (75.5%)	1 (33.3%)			23 (45.1%)
Wrong route	2 (100%)			1 (25.0%)			1 (100%)	11 (21.6%)
Wrong time					2 (66.7%)			17 (33.3%)
Wrong place		46 (100%)	11 (32.4%)					
Omission, duplication, etc.	4 (50.0%)	165 (33.8%)	21 (17.8%)	5 (27.8%)	12 (52.2%)	0 (00.0%)	2 (08.7%)	24 (19.7%)

identified as the factors affecting error type and harmfulness. Based on the regression model, the odds of medication errors reported by nurses with 1–4 or 5–9 years of clinical experience were higher than those of nurses with ≥10 years of clinical experience. The odds of medication errors during the day and evening were higher than the odds of those at night. The odds of medication errors detected a few days after occurrence were higher than the odds of those detected on the day of occurrence. Compared with general wards, special units had higher odds of medication errors (Table 4).

According to a multiple logistic regression model, examining the effect of various factors on harmful/harmless medication errors, the odds of harmful medications were higher during the day and evening shifts than during the night shift. The odds of harmful errors detected on the day of occurrence were higher than the odds of harmful errors detected a few days after occurrence. The odds of harmful errors detected in general wards were higher compared with special units (Table 4).

#### 4.5 | Effect of method of detection on medication errors

To investigate the effect of the method of error detection on the incidence of medication errors, logistic regression and multiple logistic regression analyses were performed by introducing method of error detection as a major independent variable to the existing model with error type (near miss/adverse event) and harmfulness (harmless/harmful) as the dependent variables (Table 5). According to Model 1, which was not adjusted for confounders, the odds of medication errors directly detected by a nurse were greater compared with those instances when the detection method was unknown. The odds of medication errors reported by another person or those detected during an incident or EMR review were also higher than those with an unknown detection method.

According to Model 2, adjusted for confounders, the odds of medication errors directly detected by a nurse were lower than the odds of those with an unknown detection method. The odds of errors reported by another person or those detected during an incident or EMR review were also higher as compared to the odds of those with an unknown detection method (Table 5).

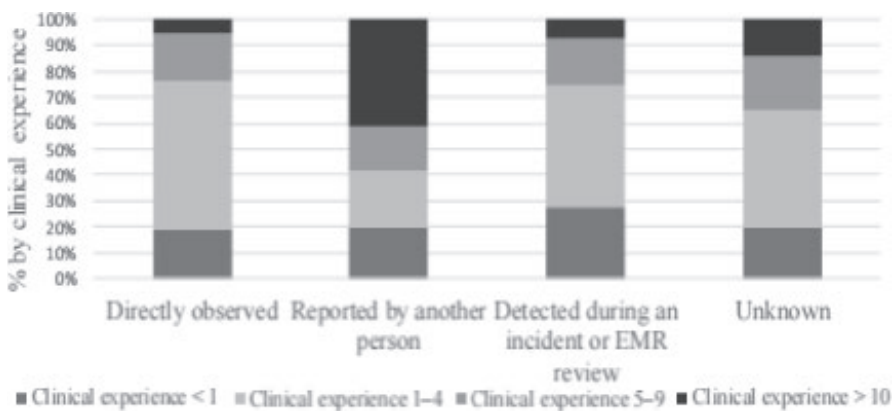
In Model 1, which examined the ORs of harmless and harmful medication errors, the odds of medication errors directly observed by a nurse were higher than the odds of those that were not directly observed. The odds of medication errors reported by another person and those detected during an incident or EMR review were also higher than the odds of those that were not directly observed (Table 5).

In Model 2, adjusted for confounders, the odds of medication errors reported by another person and those detected during an incident or EMR review were higher than the odds of those detected by an unknown method. The ORs of medication errors that were directly observed were non-significantly higher than those of medication errors with an unknown detection method (Table 5).

**TABLE 3** Medication error by detection method (N = 805)

	Directly observed (N = 405)	Reported by another person (N = 124)	Detected during an incident or EMR review (N = 55)	Unknown (N = 221)	p
<b>Type</b>					
Wrong drug	144 (51.2%)	42 (14.9%)	18 (06.4%)	77 (27.4%)	.464
Wrong dose	76 (50.7%)	26 (17.3%)	10 (06.7%)	38 (25.3%)	
Wrong patient, route, time or place	59 (41.8%)	27 (19.1%)	14 (09.9%)	41 (29.1%)	
Omission, duplication, etc.	126 (54.1%)	29 (12.4%)	13 (05.6%)	65 (27.9%)	
<b>Stage</b>					
Prescribing	6 (19.4%)	11 (35.5%)	9 (29.0%)	5 (16.1%)	<.001
Dispensing	77 (54.6%)	15 (10.6%)	14 (09.9%)	35 (24.8%)	
Delivery	291 (59.0%)	38 (07.7%)	14 (02.8%)	150 (30.4%)	
Administration	31 (22.1%)	60 (42.9%)	18 (12.9%)	31 (22.1%)	

Abbreviation: EMR, electronic medical record.

**FIGURE 1** Detection method by years of clinical experience

EMR: electronic medical record

## 5 | DISCUSSION

In this study, data pertaining to near misses and adverse events reported to an electronic reporting system by nurses working in a tertiary university hospital were analysed to investigate the factors affecting the incidence of medication errors detected via diverse methods. Four-fifth of the reported errors were near misses, and one-fifth were adverse events. These ratios were similar to those reported from 2007–2016 in England and Wales (Härkänen et al., 2019). However, in the medication error data available on the website of a Finnish university hospital, 70% were adverse events and 30% were near misses (Härkänen et al., 2015). Such variations may be attributed to differences in participants, study durations and data sample sizes. However, the need to increase the reporting rate of near misses and reduce the ratio of actual errors is irrefutable. It is also necessary to identify the stages and types of medication errors and the factors affecting them by analysing the reported data to devise practical error prevention measures. We identified the factors affecting the incidence of near misses and medication errors reported to an electronic system in a hospital by first examining their stages and types.

The most frequently reported dosage error stage in this study was the dosage process stage (70.5%). In a retrospective analysis of 359 drug errors reported by computer, the administration error was 71.5% during the administration phase (Redley & Botti, 2013).

“Wrong drug” was the most common medication type followed by “wrong dose,” consistent with studies emphasizing the Five Rights of Medication Administration. Examining medication errors among emergency unit nurses, Cabilan et al. (2017) reported that a number of errors occurred during the administration stage (62.7%), prescribing stage (28.6%) or both stages (18.5%). These results could provide basic data for the future management of medication errors and the development of educational materials on medication errors. Moreover, further research identifying the risk factors for medication errors in greater detail is needed (Cabilan et al., 2017). Thus, we analysed the differences in the rate of reporting near misses and adverse events according to general characteristics of medication errors and found statistically significant differences associated with clinical experience, such as work hours, location and detection time.

We created a multiple logistic regression model to investigate the effect of the general characteristics of medication errors and their detection methods on the risk of adverse events and harmful

**TABLE 4** Factors affecting medication error risk

	Near miss versus. adverse event					Harmless versus. harm				
	AOR	95% CI			<i>p</i>	AOR	95% CI			<i>p</i>
Patients' sex										
Male	0.802	0.544	-	1.182	.265	0.696	0.412	-	1.174	.174
Female	1.000					1.000				
Patients' age (years)										
0-19	1.653	0.846	-	3.233	.142	2.337	1.000	-	5.460	.050
20-44	0.801	0.456	-	1.408	.441	0.772	0.355	-	1.677	.513
45-64	0.818	0.522	-	1.281	.380	0.671	0.361	-	1.249	.208
≥65	1.000					1.000				
Clinical experience (years)										
<1	1.174	0.652	-	2.114	.594	0.838	0.387	-	1.815	.654
1-4	0.357	0.205	-	0.619	<.001	0.444	0.219	-	0.900	.024
5-9	0.336	0.180	-	0.629	.001	0.362	0.156	-	0.839	.018
≥10	1.000					1.000				
Year										
2014	0.376	0.182	-	0.779	.009	0.510	0.208	-	1.250	.141
2015	0.860	0.485	-	1.526	.607	0.540	0.252	-	1.158	.114
2016	0.494	0.254	-	0.960	.038	0.327	0.130	-	0.819	.017
2017	0.905	0.492	-	1.666	.750	0.607	0.271	-	1.358	.224
2018	1.000					1.000				
Work hours										
Day	3.597	2.039	-	6.345	<.001	4.147	1.734	-	9.920	.001
Evening	3.077	1.701	-	5.566	<.001	3.486	1.414	-	8.599	.007
Night	1.000					1.000				
Detection time										
On the day of error occurrence	0.119	0.051	-	0.278	<.001	0.165	0.068	-	0.404	<.001
After the day of error occurrence	1.000					1.000				
Location										
Ward	2.254	1.500	-	3.389	<.001	2.314	1.322	-	4.050	.003
Special unit	1.000					1.000				

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.

errors. The general characteristics affecting medication error type (near miss/adverse event) and harmfulness (harmless/harmful) were clinical experience, work hours, detection time and location. Based on a model investigating the effect of detection method on medication error types (near miss/adverse event) and harmfulness (harmless/harmful), the risk of medication errors was 63% lower for direct detection than an unknown detection method. The risk was significantly higher if the error was detected after another person reported it and if it was detected during an incident or EMR review. Errors were less probably to be harmful if they were directly observed than if they were not. Errors were also more probably to be harmful if they were detected after another person informed a nurse about them and if they were detected during an incident or EMR review.

Previous studies on medication errors have mentioned documentation, appropriately medicating the patient and verifying medicines, as methods of error detection in the administration stage, suggesting that the error detection method can improve medication error reporting systems (Härkänen et al., 2015). Examining medication errors or near misses detected through different methods is meaningful as it enhances error monitoring. In this study, nurses directly detected half of the reported medication errors, 93% were near misses and 7% were adverse events. Furthermore, 56% and 4.9% of the errors directly observed or experienced were reported by nurses with 1-4 years of experience and those with ≥10 years of experience, respectively. "Reported by another person" was the second most common method of error detection after excluding "unknown," and adverse events were more common than near misses for this

TABLE 5 Effect of error detection method on medication error risk

	Incidence of adverse event						
	Model 1 <sup>a</sup>			Model 2 <sup>b</sup>			
	AOR	95% CI	<i>p</i>	AOR	95% CI	<i>p</i>	
<b>Near miss versus. adverse event</b>							
Detection method							
Directly observed	0.373	0.225 – 0.620	<.001	0.355	0.201 – 0.626	<.001	
Reported by another person	5.855	3.568 – 9.605	<.001	4.465	2.493 – 7.998	<.001	
Detected during an incident or EMR review	8.167	4.267 – 15.631	<.001	7.470	3.493 – 15.972	.048	
Unknown	1.000			1.000			
<b>Harmless versus. harm</b>							
Detection method							
Directly observed	0.358	0.163 – 0.785	.010	0.453	0.189 – 1.086	.076	
Reported by another person	4.646	2.435 – 8.866	<.001	3.651	1.686 – 7.907	.001	
Detected during an incident or EMR review	6.233	2.918 – 13.315	<.001	6.067	2.490 – 14.781	<.001	
Unknown	1.000			1.000			

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; EMR, electronic medical record.

<sup>a</sup>Unadjusted logistic regression model.

<sup>b</sup>Regression model adjusted for sex, age, clinical experience, year of occurrence, work hours, detection time and location.

method of error detection. This suggests that nurses did not directly observe or experience errors but reported them after another person did. Most errors were reported by nurses with  $\geq 10$  years of experience, detected during the administration stage. It is important to note that the nurses proceeded to report medication errors after discussing them with another person.

Self-reporting errors makes individuals feel as if they are reporting themselves and not their errors (Ashcroft & Parker, 2009). Since near misses occur frequently in clinical settings, it is important that they are reported anonymously (Crane et al., 2015). In other words, anonymity may promote accurate reporting by reducing the stigma and burden associated with admitting an error. In our study, most near misses were reported by nurses with less clinical experience; thus, it is important to educate this group to report errors that they detect themselves or become aware of through others. Nurses with  $\geq 10$  years of clinical experience must also be educated to report errors raised by other nurses in full detail. Most studies on medication errors have focused on examining error types and stages rather than the methods of error detection.

In this study, most harmful medication errors were not directly reported by nurses but first raised by another person. There were more errors that were reported by another person than those with unknown methods of detection. Errors reported by other persons were also more probably to be adverse events than near misses. Therefore, future medication error guidelines or education must consider nurses' years of experience. Moreover, a reporting system that considers the detection method as an input must be established. Since medication error reporting systems differ across medical facilities, there are limited data available for analysis and direct comparison.

## 5.1 | Limitations

There are some limitations of this study. First, only a few reported medication errors that occurred in one hospital were used for analysis. The results of this study cannot be hastily generalized because medication errors are usually underreported. Second, the study does not include sentinel events because only near misses and adverse events were accessible. In the future, it is necessary to analyse sentinel events. Finally, the variables entered by the reporters were analysed, but the descriptive contents they entered as free text were not analysed, requiring subsequent qualitative research.

## 6 | CONCLUSION

This study was conducted to analyse medication errors in the electronic reporting system. We explored which factors affect a particular type of error and whether it is harmful. The factors that significantly affected the type of error and risk of medication errors were clinical experience, work hours, detection methods and location. In particular, the probability of medication errors reported by nurses with less than 10 years of clinical experience was lower than that of nurses with more than 10 years of experience, and the probability of errors was lower than that. Therefore, adding "detection methods" to the electronic reporting system may be helpful to encourage reporting of medication errors. Moreover, it is important to choose reporting methods based on clinical experience, work hours and detection methods.



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## CONFLICT OF INTEREST

There are no conflicts of interest to declare.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available owing to privacy and ethical restrictions.

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