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Magnitude of medication administration error and associated factors in adult intensive care units of public hospitals in Addis Ababa, Ethiopia, 2019

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Abstract

Introduction: *the provision of patient´s care is based on the use of medications. Even while proper drug use can enhance and save millions of lives, mistakes in medication administration can have serious effects. Medication mistakes are widespread in intensive care units, and they have substantial consequences in terms of morbidity and mortality. To lead concentrated efforts to prevent medication errors, it is vital to identify the most common error types, medications linked with errors, and variables contributing to errors. The aim of this study was to determine magnitude of medication administration error and associated factors in adult intensive care units of public hospital´s in Addis Ababa, from April 4th-April 27th, 2019, Gregorian Calendar (GC).* ***Methods:*** *using a systematic random sampling method, a multi-center institutional cross-sectional study was conducted. Data were collected using a structured questionnaire and checklist. Result was summarized and presented by tables and charts. Logistic regression was used to reveal factors associated with medication administration error.* ***Results:*** *the rate of medication administration error in adult intensive care unit of governmental hospitals in Addis Ababa city was 61.1% with the most frequent type of error being technical error (59.7%), followed by wrong time (52.3%) and documentation error (24.8%). Nurse to patient ratio, inexperience, multiple medications, shift of medication administration and interruption of a nurse during the time of medication administration were predictive factors for medication administration error.* ***Conclusion:*** *medication administration errors in adult intensive care unit of public hospital of Addis Ababa were highly prevalent. More than three fourths of patients admitted to adult intensive care unit were exposed to at least one type of medication administration error.*

Introduction

Medicines are biochemical compounds administered for the purpose of diagnosis, treatment, and prevention. Hence, all medications have toxic effects, and all medications are expected to be administered carefully to attain the desired outcome and to avoid adverse drug reactions [1]. Even though the safe use of medications can improve and save the lives of millions, errors in the use of these substances can lead to equally significant consequences [2]. According to the USA National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP), medication error can be defined as "any preventable event that may cause or lead to inappropriate medication use or patient injury while the medication is in the control of the health care professional, patient, or consumer". Such events can be related to professional practice, health care products, procedures, and systems, comprising prescribing, order communication, product labeling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use. It can happen at any point during the prescription, dispensing, preparation, or administration of a medication [3,4].

When the drug received by the patient differs from the drug therapy recommended by the doctor or the manufacturer's preparation and administration instructions, administration errors occur [5]. In the United States of America alone, medication errors are responsible for at least one death and 1.3 million injuries every year. While low- and middle-income countries are expected to have similar rates of medication-related adverse events as high-income countries, many lack good data, which will be collected as part of a quality health-care initiative [6].

In African hospitals, at least one medication administration error was reported in 56.4% of all

observations, with 4.5-20.1% of patients reporting any suspected adverse drug event, with a median mortality rate of 0.1% (interquartile range 0.0-0.3%) [7]. Medication errors not only harm people physically, psychologically, and in extreme circumstances, take their lives, but they also cost a lot of money. Medication errors are projected to cost $42 billion per year globally, accounting for over 1% of total global health expenditure, with a cost of $17-$29 billion per year in the United States [8,9]. Medication errors have far-reaching consequences that go beyond financial compensation; they can substantially undermine public trust in medical services, and they can have far-reaching consequences for the entire society, resulting in reduced productivity and lower levels of population health [10].

Patients in the intensive care unit (ICU) are at a higher risk of medication mistakes for the following reasons: 1) critically ill patients are given nearly twice as many medications as hospital patients who are not in the intensive care unit (ICU); 2) most ICU medications are administered parenterally, necessitating bolus and continuous infusion calculations; and 3) ICU patients are frequently sedated, making it difficult for them to detect potential errors on their own. Intensive care unit patients have multiple physical issues and limited physiologic reserve as a result; even small errors may cause severe damage to them or may even result in their death [11,12].

Even at the greatest institutions in the world, drug errors occur despite best efforts, increased use of technology, and high standards of invasive and non-invasive monitoring in anesthesia and critical care [13]. Despite the fact that Addis Ababa is home to the majority of Ethiopia's specialty hospitals with ICUs, there is no documented evidence of medication administration errors. The goal of this study was to investigate the extent of medication administration errors and associated factors in adult intensive care units of public hospitals in Addis Ababa between April 1 and April 30, 2019 GC.

Methods

Study design: the study was a prospective cross-sectional institution-based study design. The STROBE guidelines were applied to verify that this cross-sectional study was properly reported. A manuscript contains the completed STROBE checklist. All medication administration interventions to patients admitted to adult ICUs of public hospitals in Addis Ababa (AA) were used as the source population, and all medication administration interventions to patients admitted to adult ICUs of randomly selected public hospitals in AA were used as the study population.

Study area and study period: the study was conducted at public hospitals in AA city which is the capital city of Ethiopia and seat for Africa Union. Addis Ababa has 41 hospitals (14 government and 28 private). All 14 public hospitals were included in the study. This study was conducted from April 1st- April 30th, 2019 GC.

Inclusion criteria: all medication administration intervention to the patient admitted in adult ICU public hospitals in AA were included in the study.

Exclusion criteria: over the counter drugs were excluded.

Sample size determination: the single population proportion formula was used to determine the actual sample size for the study:

$$n = \frac{(Z\,\alpha/2)^2 * p\,(1-p)}{d^2}$$

Where n = estimated sample size; Z = confidence level (alpha, α); P = prevalence; d = marginal error. To determine sample size, the following assumption was used. Prevalence of medication administration error was taken from a previous related study at Jimma University which was 51.8% [14]. A 95% confidence level, margin of error (0.05).

$$n = \frac{(1.96)^2 * 0.518\,(1-0.518)}{(0.05)^2} = 383.86 \approx 384$$

With 10% non-response rate = 422.4 ≈ 423 medication administration intervention.

Sampling procedure: out of 14 hospitals, 3 were selected randomly, and based on the estimated medication administration sample, proportionally assigned to each hospital. A total of 15,899 medication administration interventions were counted from the prior month based on this sample. They were assigned proportionally for each hospital, and finally, sampling units were taken using systematic random sampling.

Data collection tool and procedure: direct observation of nurses providing drugs was used to collect data on medication administration, which was supplemented with a self-administered questionnaire to obtain nurse socio-demographic information. Data from the recorded observation was compared to the physician's order by referring to the patient's records immediately after the observation, and patient-related data was acquired by checking the patient's history. Data was gathered throughout the course of a 24-hour period, including both working hours and night duties. In addition, a checklist was created based on prior similar investigations [15-18]. Six Bachelor of Science (BSC) nurses were in charge of data collection, while three Master of Science (MSC) nurses were in charge of supervision.

Dependent variable: medication administration error.

Independent variable: socio-demographic characteristics of nurse: age; experience; and; educational level.

Patient related variable: complexity of clinical case: polypharmacy; complex drug preparation; and sedation.

Work environment related variable: workload; nurse to patient ratio; distractions and interruptions; lack of standardized protocols and procedures; insufficient resources; and working shift.

Operational definition

Medication: a chemical compound used to diagnose, treat, cure, mitigate, or prevent disease.

Medication administration: preparing, administering, and documenting medications.

Medication administration error: a mismatch between the medication given to the patient and the drug therapy prescribed by the doctor.

Adverse drug reaction: intolerance and unexpected reaction are examples of undesired responses.

Poly pharmacy: patient taking 5 or more medications at a time. Omission error: drug ordered and not administered. Unordered drug error: drug administered but not ordered. Route error: drug given by wrong route of administration, example, drug injected intravenously instead of intramuscularly. Administration technique error: drug administered using the wrong technique, for example too rapidly. Dose error: dose too high or too low. Time error: drug given ≥30 minutes earlier or later. Documentation error: drug administered but not documented on patient chart. Patient error: drug administered for another patient instead of the ordered one.

Data processing and analysis: data were entered and analyzed using SPSS version 25. Descriptive statistics such as frequencies and percentages were calculated to explain the study population in respect to key variables. The relationship between the dependent and independent variables was investigated using logistic regression analysis.

Data quality assurance: the careful design and pretesting of the questionnaire ensured the quality of the data. Before beginning the real work, a one-day intensive training on the study's purpose, checklist, observation protocols, and reporting methods to supervisors was provided. In the adult ICU of Minillic II Hospital, 10% of the questionnaires were tested for appropriateness. At the end of each

day of data collection, the gathered questionnaire and checklist were reviewed for completeness and consistency.

Results

Socio-demographic characteristics of the study participants: a total of 419 medication administration interventions by 97 nurses were observed, making a response rate of 99%. More than half of the participants (52.6%) were male, and 47.4% were female. The mean age of the respondents was 28.77 years, with an SD of 5.354 years. The majority (83.5%) of the respondents were BSC nurses, followed by (13.4%) diploma nurses and 3% MSC nurses, respectively. They served for an average of 4.45 years in hospitals and 2.59 years in ICUs, with a standard deviation of 3.93 and 2.1, respectively (Table 1).

The characteristics of patients who were included during the observation: overall, 41 patients were involved while the nurse administered their medication. Out of 41 patients, the majority of 30 (73.2%) were male, and the mean age of the patient was 41.61 years, with an SD of 18.36 years. Thirty-four (82.9%) of the patients admitted to the ICU were exposed to at least one type of medication administration error (Table 2).

The characteristics of the observed drugs: a total of 419 medication administration interventions were observed in a randomly selected hospital adult ICU, making a response rate of 99%. The majority of 268 (64%) were observed during the day, while the remaining 151 (36%) were observed during the night shift. Concerning their route of administration, 259 (61.8%) were intravenous, 113 (27%) oral, 35 (8.35%) subcutaneous, 10 (2.4%) intramuscular (IM), and the remaining 2 (0.477) were administered topically (Figure 1). The most frequently observed drug was paracetamol 41 (9.8%), followed by vancomycin 35 (8.4%) and heparin 34 (8.1%) (Table 3).

Magnitudes of medication administration errors: out of 419 observed medication administration interventions, 256 (61.1%) of them were leveled as errors. Forty-eight (11.46%) had at least one type of error, 115 (27.45%) had two types of error, 62 (14.8%) had three types of error, and 31 (1.4%) had more than three types of error. The most frequently observed error was technical error 250 (59.7%), followed by wrong time error 219 (52.3%), documentation error 102 (24.8%) and wrong route error 29 (6.9%). Examples of medication administration errors in adult ICU of public administered public hospital in AA are listed below. Examples of medication administration errors: 1) the observer nurse was observed when ceftriaxone 1 g administered instead of 2g; 2) vancomycin was administered at 4: 15 am instead of 6 am; 3) rate of administration of dopamine was 41 drops/min which was different from what was labeled on the IV fluid bag, i.e. 28 drops/min; 4) morphine 5mg IV was administered but it was not ordered on patient chart; 5) diazepam 10mg was administered but not documented on follow up sheet; 6) heparin was administered intradermal instead of subcutaneously; 7) paracetamol 1g was not administered to the patient but documented on follow up sheet; 8) ceftazidime was not administered but it was ordered on the chart.

Factors associated with medication administration error: according to the bivariate analysis, the factors found to be significantly associated with medication administration errors were the nurse's educational level, the nurse's working experience in the intensive care unit, the interruption of the nurses during medication administration, the shift of medication administration, the number of medications administered at a time, and the nurse-to-patient ratio. At a p-value of 0.05, nurses' working experience in an intensive care unit, interruption of nurses during medication administration, shift of medication administration, number of medications administered at a time, and nurse to patient ratio were found to be significantly associated with medication administration errors. Nurses with one year of ICU experience were 10 times more likely to (AOR = 10.3, 95% CI (3.94, 26.97)). A nurse with ICU

working experience of 1-4 years was 9 times (AOR = 9.74, 95%CI (5.5, 18.79)) more likely to make medication administration errors, respectively, as compared with a nurse who had working experience of five or more years.

Medication administration shift was also discovered to be one of the strongest predictors of medication administration errors, with drugs administered at night being four times more likely to be prone to medication administration errors (AOR = 4.75, 95% CI (2.65, 8.41)). In addition to the above factor, the interruption of a nurse during the time of medication administration was another institutional factor associated with medication administration errors. Drugs administered with interruption were three times (AOR 3.4 (95%CI (1.64, 7.04))) more likely to have an error than those drugs administered without interruption.

Nurse to patient ratio was also found to be one of the strong predictors of medication administration errors. Respondents who had a nurse-to-patient ratio of 1: 4 were 18 times (AOR = 18.21, 95% CI (7.59, 43.69)), a nurse-to-patient ratio of 1: 3 was 13 times (AOR = 13.67, 95% CI (6.25, 29.99)) and a nurse-to-patient ratio of 1: 2 was three times (AOR = 3.42, 95% CI (1.43, 8.41)) more likely to make an error as compared to nurse-to-patient ratio of one to one respectively. Patients who took five or more drugs at the same time were twice as likely (AOR = 2.29, 95% CI (1.26, 4.16)) to experience medication administration errors (Table 4).

Discussion

The purpose of this study was to investigate the prevalence of medication administration errors in the ICUs of Addis Ababa public hospitals in Ethiopia. Two hundred and fifty-six (61.1%) of the 419 medication administration interventions had at least one form of medication administration error. Medication administration errors in this study were higher than in a prior study covering 205 ICUs in 29 countries (46.0%) [19]. Additionally, this finding was relatively higher as compared to a study reported by Vietnam which were 39.1% [20]. Furthermore; the rate of medication administration errors in this study was extremely higher than the findings reported from south Africa and Iran which were 12.49 and 9.8% respectively [21,22]. Possible reason for this difference could be the sitting of the studies the above studies were done in a developed country in which computerized recording system, voluntary error reporting, and follow up were performed. However, this finding was within a range of finding reported by South East Asian countries, nine African countries and American Association of Critical-Care Nurses which were within a range of 3.3% to 72.5%, 15.22% to 88.6% and 56.4% (IQR: 39.5-87.5%) respectively [2,7,23,24].

This finding was higher as compared to a report from Jimma University Hospital ICU (51.8%) [14]. Possible explanation could be complexity of patient cases and highest number of drugs administration at a single time (polypharmacy) in those specialized and referral public administered hospitals. Moreover, this finding was higher as compared to a report from Felege Hiwot Hospital (56.4%) [15]. The possible justification could be the sitting of the study, finding from Felege Hiwote Hospital were conducted in general ward while this study was conducted in ICU which has complex drug preparation and administration.

According to this study finding nurses working experience in ICU was a strong predictor of medication administration error this were also related factor reported from previous studies from 29 countries and World Health Organization (WHO) 2016 report [2]. This could be described by the fact that new nurses are unfamiliar with the medication, environment, procedures or equipment. Nurses with more year´s work experience have greater knowledge and skills related to different types of medications and medication administration. Based on this study nurse to patient ratio was also other forecaster factor for medication administration error this was also predictive factor reported from United States of America [25]. The reason could be, as a number

of patients assigned to a nurse increased the amount of medication administered at a time will increased leading to medication administration error. The other justification could be, in addition to medication administration, the nurses have too much number of duties for ICU admitted patients leading a nurse over loaded resulting medication administration error (MAE).

Polypharmacy (taking 5 and more drug at a time) were patient related factor related to MAE based on this finding, this was also a predictive factor listed by WHO in 2016 report [4]. Obviously, this could be justified as a number of drugs increased the nurse will have exposed to unfamiliar drug and would be loaded in combination with other duties leading medication administration error. Interruption of the nurse at the time of medication administration was also contributes to MAE. This finding was consistent with the study reported by WHO, USA, India and Iran [26].This could be explained by the fact that, since medication preparation and administration need concentration, interruptions in the course of these activities leads to cognitive failures between nurses in relation to working memory and alertness. According to this finding medication administered at night were 6 times more likely to expose for MAE. The reason could be nurses who work at night shifts can experience diurnal trouble resulting in disturbed sleep tiredness, and performance deficiency.

Limitation: this study was a cross-sectional study which conducted at a single point of time, it was better if it was cohort study.

Conclusion

Medication administration errors were common in the adult intensive care units of public hospitals. More over three-quarters of ICU patients had been exposed to at least one kind of MAE. Technical errors were the most common, followed by incorrect time and documentation errors. Interruptions of nurses during medication administration, nurse to patient ratio, and shift of medication administration were institutional characteristics that predicted medication administration. The study's recommendation was to develop a medication administration protocol and procedure, train new staff, and have enough staff to achieve an ICU nurse-patient ratio of 1: 1.

What is known about this topic

- *In African hospitals at least one medication administration error has been reported from 56.4% of all medication administration, with 4.5-20.1% of patients experiencing any suspected adverse drug event;*
- *Patients in the ICU are at a high-risk for medication errors due to various reason.*

What this study adds

- *In Addis Ababa public hospitals adult intensive care unit, the rate of medication administration error was 61.1%;*
- *More than three-fourths of the patients admitted to the adult intensive care unit were exposed to at least one type of medication administration error.*

Competing interests

The authors declare no competing interest.

Authors' contributions

All authors contributed significantly to the conception and design, data collection, analysis, and interpretation of data; participated in the drafting of the article or critically revised it for important intellectual content; agreed to submit the article to the current journal; gave final approval of the version to be published; and agreed to be accountable for all aspects of the work. All the authors have read and agreed to the final manuscript.

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Tables and figure

Table 1: sociodemographic characteristics of study participant in adult ICU public hospitals of Addis Ababa, Ethiopia, 2019

Table 2: sociodemographic characteristic of observed patient in adult ICU of Addis Ababa public hospitals, Addis Ababa, Ethiopia, 2019

Table 3: top ten observed drugs in adult ICU public hospitals in Addis Ababa, Ethiopia, 2019

Table 4: bivariate and multivariate analysis of factors associated with medication administration error in adult ICUs of Addis Ababa public hospital, Addis Ababa, Central Ethiopia, April 2019 (n=419)

Figure 1: route of administration of observed drugs in adult ICU public hospitals in Addis Ababa, Ethiopia, 2019

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Table 1: sociodemographic characteristics of study participant in adult ICU public hospitals of Addis Ababa, Ethiopia, 2019

Variable		Frequency	Percent	Mean and SD	Minimum and maximum
Sex	Male	51	52.6	28.77 ± 5.35	21 and 52
	Female	46	47.4		
Age in year	18-25 years	29	29.9		
	26-30 years	45	46.4		
	30-40	21	21.4		
	>40	2	2.1		
Religion	Orthodox	64	65.98		
	Muslim	16	16.50		
	Protestant	13	13.40		
	Other	4	4.124		
Educational status	Diploma	13	13.40		
	BSc degree	82	83.51		
	MSc degree	3	3.09		
CCN training	Yes	23	23.7		
	No	74	76.3		
Type of training	BSc	10	10.3		
	MSc	3	3.1		
	Other	10	10.3		
Total service year	<10 years	90	92.8	4.45 ± 3.93	1 and 32
	>10 years	7	7.2		
ICU service year	<1 year	13	13.4	2.599 ± 2.1	0.2 and 25
	1-4 years	72	74.2		
	5-9 years	10	10.3		
	>10 years	2	2.06		

SD: standard deviation; CCN: critical care nursing; ICU: intensive care unit; BSc: bachelor of science; MSc: master of science

Table 2: sociodemographic characteristic of observed patient in adult ICU of Addis Ababa public hospitals, Addis Ababa, Ethiopia, 2019					
Variables		**Frequency**	**Percent**	**Mean and SD**	**Minimum and maximum**
Sex	Male	30	73.2	41.61 ± 18.36	15 and 77
	Female	11	26.8		
Age	<18 years	3	7.3		
	18 - 50 years	22	53.7		
	>50 years	16	39.2		
GCS <8	Yes	27	65.9		
	No	14	34.1		
No of drugs taken at a time	<5	32	78		
	≤5	9	22		
SD: standard deviation; GCS: glasgow coma scale					

Table 3: top ten observed drugs in adult ICU public hospitals in Addis Ababa, Ethiopia, 2019		
Drugs	**Frequency**	**Percentage**
Paracetamol	41	9.8%
Vancomycin	35	8.4%
Heparin	34	8.1%
Tramadol	32	7.6%
Omeprazole	26	6.2%
Cimetidine/ranitidine	23	5.5%
Metronidazole	18	4.3%
Meropenem	18	4.3%
Phenytoin	16	3.8%
Ceftriaxone	16	3.8%
Other	160	38.2%

Table 4: bivariate and multivariate analysis of factors associated with medication administration error in adult ICUs of Addis Ababa public hospital, Addis Ababa, Central Ethiopia, April 2019 (n=419)

Variable		Medication administration error		OR with 95% CI	
		Yes	No	Crude OR	Adjusted OR
Educational level	Diploma	33	20	3.1 (1.11, 8.59)	1.1 (0.39, 1.34)
	BSc	215	128	3.15 (1.19, 7.64)	1
	MSc	8	15	1	1
Training	Yes	39	48	1	
	No	217	115	2.3 (1.44, 3.75)	1
Interruption	Yes	85	21	3.4 (1.99, 5.7)	3.4 (1.64, 7.04) **
	No	171	142	1	
ICU work experience	< 1 year	35	11	4.8 (1.19, 8.0)	10.3 (3.94, 26.97) **
	1- 4 years	216	128	2.8 (1.25, 5.95)	9.74 (5.05, 18.79) **
	≥5 years	11	18	1	
Shift of MA	Day	92	125	1	1
	Night	164	38	5.9 (3.8, 9.1)	4.75 (2.65, 8.41)**
Nurse to patient ratio	1 to 1	60	112	1	1
	1 to 2	46	16	5.4 (2.8, 10.3)	3.42 (1.43, 8.41) *
	1 to 3	65	16	7.6 (4.0, 14.3)	13.67 (6.25, 29.99) **
	1 to 4	85	19	8.4 (4.6, 15.0)	18.21 (7.59, 43.69) **
No of medication administration at a time	<5 medication	109	124	1	
	≥5 medication	132	54	2.8 (1.4, 4.0)	2.29 (1.26, 4.16) *

*: p value <0.005; **: p value<0.001; AOR: adjusted odd ratio; COR: crude odd ratio

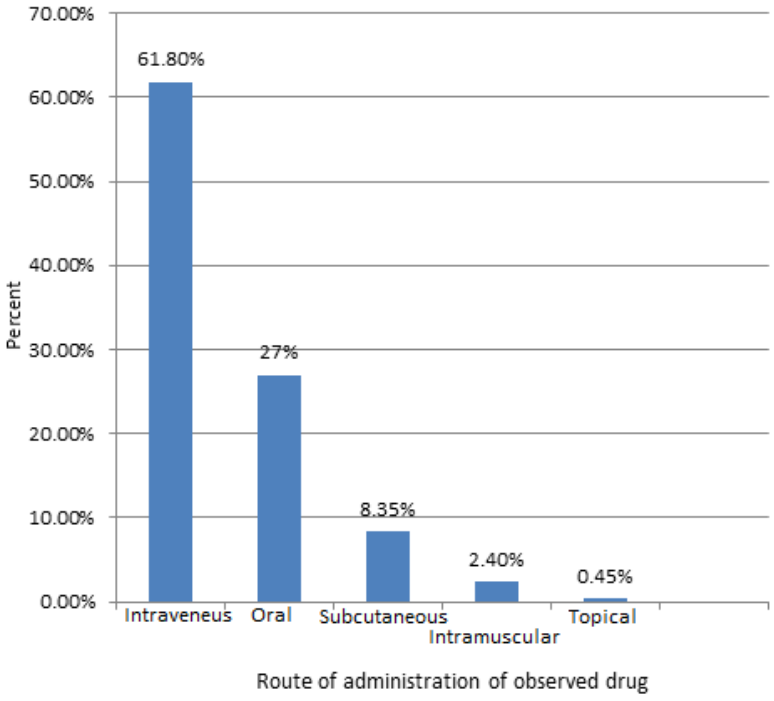

Figure 1: route of administration of observed drugs in adult ICU public hospitals in Addis Ababa, Ethiopia, 2019