Case Study

Evaluation of Resuscitation Medications' Knowledge among Pakistani Nurses: A Cross-Sectional Analysis

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Abstract

Medication errors are associated with significant morbidity and mortality worldwide. Of various types of medication errors, administration errors are the most common. This study evaluated nurses' knowledge of resuscitation medication administration and the obstacles they encountered while administering these medications. This multicenter, cross-sectional study was conducted among registered nurses working within public and private sector hospitals in Lahore, Pakistan. Participants were recruited using a convenient sampling technique and data were gathered using a self-completed, pre-validated questionnaire. This study included 409 nurses (age 30.09 ± 4.45 years), of whom, around 55% were found to have adequate knowledge (score > 70%) of resuscitation medications. Increasing age, experience, and hospital, and cardiovascular life support training were associated with higher knowledge scores. Furthermore, nurses from oncology, intensive care units, and emergency rooms had better knowledge ($P < 0.05$) than those working in other departments. Interruptions during the drug administration method (75.6%), a lack of understanding between health professionals (69.4%), and a reluctance to ask inquiries (67.7 %) were the three most common barriers encountered during the administration process. Only 55 percent of nurses had adequate knowledge, necessitating educational measures to improve nurses' knowledge of resuscitation medications.

Keywords: Resuscitation medications, High alert medications, Knowledge, Nurses

Introduction

Patient safety is the fundamental right of patients and it must be ensured while delivering healthcare services [1]. However, "To err is human", so expecting faultless performance from those working in complicated and high-stress situations is impractical. A medication error is defined as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health professional, patient, or consumer" [2]. These errors can occur while prescribing, transcription, dispensing, distribution, and drug administration. Of these, the greatest number of medication errors are administration-related errors [3-5]. Medication errors place an enormous burden not only on patients but also on the healthcare system worldwide. In high-income countries, medication errors result in at least one fatality every day and harm about 1.3 million individuals annually [6]. In low and middle-income countries (LMICs), about 134 million adverse events occur each year as a result of unsafe care, resulting in 2.6 million deaths [7]. LMICs have a similar incidence of medication-related adverse events as the high-income countries, however, the impact of medication errors on patient safety is far worse [6]. In Pakistan, medication errors claim the lives of roughly 500,000 people each year, including men, women, and children [8]. Regarding the morbidity associated with medication errors or adverse drug events, globally 2-5% of hospital admissions are due to medication errors, and most of them are preventable [9]. The economic burden of drug errors worldwide is estimated to be US$ 42 billion per year or about 1% of total global health expenditures [6].

Resuscitation is an integral part of intensive care. it is a time-critical process that needs fast and crucial action as soon as a life-threatening medical emergency occurs [10]. This process is not a one-person job and it should be handled by a healthcare team consisting of physicians, nurses, and technicians [11]. The Resuscitation Council recommends that resuscitation medications should be administered as soon as a cardiac arrest has been identified [12]. A recent review reported that the chances of errors in resuscitating patients are connected to lower survival from in-hospital cardiac arrest in

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adults [13]. A significant proportion of adverse reactions can be prevented by simple interventions such as better training, patient engagement, and compliance with relevant patient safety protocols.

Nurses are regarded as the nucleus of the healthcare system [14]. They are always at patients' bedside to provide timely care and one of the most important tasks they perform is the administration of medicines [15]. Therefore, a nurse who practices her profession in a particular specialty owes her patients the duty of possessing adequate knowledge and skills [16]. As the data related to resuscitation medication knowledge among Pakistani nurses is limited, this study aimed to evaluate Pakistani nurses' knowledge regarding resuscitation medication administration.

Materials and Methods

Study Design and Settings

This was a descriptive, cross-sectional study. Both public and private hospitals in Lahore city were targeted as Lahore is the capital of the most populated province (Punjab) of Pakistan. It is the country's second-largest metropolitan. Patients are regularly referred to healthcare settings in Lahore because of the superior healthcare delivery system compared to other cities. Highly qualified medical professionals are present within public and private hospitals in Lahore. Overall, there are 11 teaching hospitals, 2 district headquarters (DHQ) hospitals, 4 tehsil headquarters (THQ) hospitals, 6 rural health centers, and 37 basic health units in Lahore [17]. The present study was conducted in eighteen healthcare settings (10 private, 6 public, and 2 teaching hospitals). Data were collected from the intensive care unit, coronary care unit, high dependency unit, emergency rooms, surgical, gynecology, pediatric, and oncology wards of each hospital because resuscitation medications are frequently used in these units/wards.

Study Population

The targeted population included nurses registered with the Pakistani Nursing Council. Both female and male nurses having a diploma or higher qualifications such as a bachelor's or master's and currently providing services in the aforementioned wards of the study settings were eligible for inclusion. Nurses working in other departments, intern nurses, nursing students, and those who refused to provide written informed consent were excluded from the study.

Sample Size

The sample size was calculated using a proportional formula on the OpenEpi calculator. The required sample size was 382 nurses by setting a population size of 64,846 [18], 95% confidence interval, and 50% response distribution. However, the sample size was slightly increased to account for potential bias and data errors.

Sampling Method

A convenient sampling approach was used to recruit study participants and the data were collected during three months (March-June 2021). Head nurses of the aforementioned department of the study settings were visited and briefed about the objectives of this study. A list of nurses working under each department and their respective working timings were obtained from the head nurses. Departments were re-visited on different days and times to access all the employed nurses to prevent sampling bias. During the data collection, all standard COVID-19 preventative procedures were used.

Study Instrument

The study instrument was adapted from a previous study after obtaining permission from the concerned [10]. The English language was preferred for the questionnaire as all the nursing education in Pakistan is in English medium [19, 20]. The study instrument was subjected to content validation by a panel of pharmacy and nursing experts (2 academicians 2 hospital/clinical pharmacists and 1 nurse). All members of the panel critically reviewed the items and their response options and indicated them as relevant or irrelevant. The content validity index for all the items reached 1, indicating good content validity. The panel members gave a few suggestions to improve the clarity and comprehensibility of questions. The study instrument was comprised of four sections.

- **Section-1:** This section gathered demographic details of the study participants such as age, qualifications (master or bachelor), working experience, designation, working ward, type of hospital, and training in cardiopulmonary resuscitation, advanced cardiovascular life support, and intensive care units.
- **Section 2:** This section contained 20 items to evaluate nurses' knowledge regarding resuscitation medication administration and regulation. Each correct answer was given 5 points whereas the wrong and do not know answers were scored zero. The total possible score ranged from 0 to 100, with a higher score indicating better knowledge
- **Section 3:** This section contained 12 items to assess all the obstacles nurses encounter during the administration of resuscitation medications that contribute to medication errors.
- **Section-4:** This section determines nurses' subjective self-evaluation on the following two factors.
    - Self-evaluated knowledge level: nurses were asked to rank their knowledge between five levels from "sufficient" to "extremely insufficient".
    - Training needs: nurses were asked about their need for resuscitation medications training. Participants answered this by choosing from three response options ("no need", "no comment" or "need").

Validation of the Study Instrument

We conducted cognitive debriefing interviews among 10 nurses to assess the appropriateness, clarity, and understandability of all questions in the study questionnaire.

All participants responded that the questions were clear, understandable, and appropriate to evaluate the study outcomes. Furthermore, a pilot study was undertaken to assess the reliability of the study instrument Results showed that the instrument had adequate internal consistency (Cronbach's $\alpha > 0.70$).

Ethical Approval

The Research Ethics Committee of the Department of Pharmacy Practice, Faculty of Pharmacy, The University of Lahore, reviewed and approved the study's protocol. Moreover, authorization from the study settings was also obtained. Each nurse who took part in this study provided verbal consent. An anonymized questionnaire was used to protect the study participants' identities. The data collection was carried out by COVID-19 preventive measures and safety standards.

Statistical Analysis

The data analysis was performed using IBM SPSS version 27. Continuous data were expressed as mean ± standard deviation (SD). Categorical variables were presented as frequencies and percentages. Knowledge score was compared among dichotomous demographic variables using an independent t-test whereas ANOVA was used to determine significant differences between the means of three or more independent groups. A p-value of less than 0.05 was considered statistically significant.

Results and Discussion

Characteristics of the Study Sample

A total of 500 nurses from both public and private hospitals were approached by the principal investigator. Of them, 429 consented nurses were administered the study questionnaire (response rate = 85.8%). The data of 409 nurses who returned adequately filled questionnaires were included in the final analysis.

Demographic details of the study participants are shown in **Table 1**. The mean age of the sample was 30.09 ± 4.45 (range 23-48 years), with the majority of females (98.3%). Around 78% had a bachelor's degree and were providing services in the hospitals as staff nurses. A wide majority (77.8%) of the participating nurses were from private settings and most of them (40.1%) had 5-10 years of work experience. The majority (33%) were working in the emergency rooms followed by 22.7% from the intensive care units (ICU).

Table 1. Demographic details of study population (N = 409)

Variable	Frequency	%
Age (years)		
≤ 30	215	52.6
> 30-35	165	40.3
> 35	29	7.1
Gender		
Female	402	98.3
Male	7	1.7
Education		
Bachelor	321	77.8
Master	88	21.5
Designation		
Head nurse	38	9.3
Staff Nurse	371	90.7
Experience		
≤5	226	55.3
>5-10	164	40.1
>10	19	4.6
Working department		
ICU	93	22.7
HDU	42	10.3
CCU	57	13.9
Surgical	42	10.3
ER	135	33.0
Gynae & labor	11	2.7
Pediatrics	18	4.4
Oncology	11	2.7
Hospital		
Private	318	77.8
Public	91	22.2
ICU training		
Yes	280	68.5
No	129	31.5
Cardiac life support training		
Yes	244	59.7
No	165	40.3
CPR training		
Yes	356	87.0
No	53	13.0

ICU-intensive care unit; HDU-high dependency unit; CCU-coronary care unit; ER-emergency room; CPR-cardiac pulmonary resuscitation.

Knowledge of Resuscitation Medication of Respondents

Responses to the questions regarding knowledge of resuscitation medication are presented in **Table 2**. Four questions generated correct answer rate above ninety percent; 96.6% of nurses knew that in the event of an emergency 10% calcium chloride ($CaCl_2$) 10 ml should not be administered as a fast intravenous push, 93.4% were aware that epinephrine (1:1000) should not be given as a fast IV push to a patient with mild allergic reaction, 90.5% correctly reported that 10% Ca gluconate and 10% $CaCl_2$ are the not the same drug and are not interchangeable. Two questions generated a very low correct rate (< 30%). Around 30% of the study sample did not know that Norepinephrine bitartrate should be added to glucose water to preserve its effects and 19.1% were unaware amiodarone is given through the tracheal route for better effects.

Table 2. Awareness of resuscitation medications administration

Item	Question (%)	Answer	Correct	Wrong/ Don' t know	Rank

4	In the event of an emergency, administer 10% calcium chloride (CaCl2) 10 ml as a fast intravenous push (in 1–2 minutes)	No	96.6	3.4	1
2	Fast IV push 1:1000 epinephrine (adrenaline) 1 ampule for patients with a mild allergic reaction	No	93.4	6.6	2
3	10% Ca gluconate and 10% CaCl2 are the same drug and interchangeable	No	90.5	9.5	3
17	Use nitroglycerine to treat myocardial infarction with low blood pressure and bradycardia	No	90.2	9.8	4
5	In pediatric CPR, the body surface area is used to calculate the dosage of epinephrine.	No	89.5	10.5	5
16	Amiodarone is used to treat bradycardia	No	86.6	13.4	6
18	Each CPR medication should have multiple concentrations for nurses to choose from	No	84.4	15.6	7
15	Small venous vessels are preferred for injecting dopamine	No	80.4	19.6	8
1	In the event of an emergency such as ventricular fibrillation, administer 15% KCl 10 mls via fast intravenous (IV) push	No	79.2	20.8	9
9	Atropine is used to treat pulseless electrical activity	No	74.6	25.4	10
19	If a ward stores atracurium for trachea intubation, the drug should be stored with other drugs and easily accessed by nurses	No	69.9	30.1	11
13	To induce additive effects, sodium bicarbonate (NaHCO3) should be injected with epinephrine	No	67.5	32.5	12
8	If the drugs are given through the trachea, the dosage is 5-10 times higher than when given through the IV route	No	66.5	33.5	13
6	With cardiac arrest, administer 1 mg of epinephrine intravenously within 3-5 minutes	Yes	58.7	41.3	14
12	Adenosine should be given by slow IV drip (>10 minutes) to treat bradycardia	No	56.5	43.5	15
11	Lidocaine is the first choice to treat ventricular tachycardia or fibrillation	No	47.7	52.3	16
20	When CPR is initiated, glucose water (dextrose solution) should always be given to prevent hypoglycemia	No	42.8	57.2	17
10	In CPR, use a small dose of atropine (<0.5 mg) to prevent bradycardia	No	31.1	68.9	18
14	Norepinephrine bitartrate should be added to glucose water to preserve the drug effects	Yes	26.9	73.1	19
7	For better effects, amiodarone is best given through the trachea	No	19.1	80.9	20
	Mean		**67.6**		

CPR-cardiac pulmonary resuscitation; $CaCl_2$-calcium chloride; Ca-calcium; KCl-potassium chloride; IV-intravenous; $NaHCO_3$-sodium bicarbonate

The mean knowledge score was 67.59 ± 9.57 (range: 45-90), with 55.3% of nurses having adequate knowledge score.

Comparison of Knowledge Score among Demographic Variables

As shown in **Table 3**, there was a significant difference in resuscitation medication knowledge among age ($p < 0.001$), experience ($p < 0.001$), ward ($p = 0.001$), and hospital categories ($p = 0.032$). Furthermore, nurses who reported having obtained cardiovascular life support training had significantly better knowledge than those who had not (69.08 ± 8.57 vs 66.64 ± 10.09; P = 0.006).

Table 3. Comparison of knowledge score among different demographic variables

Variable	Mean ± SD	P value
Age (years)		
≤ 30	63.93 ± 9.17	**< 0.001**
> 30-35	71.58 ± 8.16	
> 35	72.07 ± 9.11	
Gender		
Female	67.39 ± 9.48	**0.030**
Male	79.29 ± 6.72	
Education		
Bachelor	67.96 ± 9.78	0.072
Master	67.25 ± 8.65	
Designation		
Head nurse	72.50 ± 7.32	0.14
Staff Nurse	67.09 ± 9.63	
Experience (years)		
≤ 5	64.36 ± 9.40	**< 0.001**
> 5-10	71.37 ± 8.20	
> 10	73.42 ± 8.00	
Working department		
ICU	70.36 ± 7.35	**0.001**
HDU	62.74 ± 13.53	
CCU	67.54 ± 6.95	
Surgical	65.38 ± 9.59	
ER	70.00 ± 9.16	
Gynecology & labor	62.73 ± 5.17	
Pediatric	65.56 ± 6.15	
Oncology	73.18 ± 10.3	
Hospital		
Private	67.17 ± 9.82	**0.032**
Public	69.07 ± 8.49	
ICU training		
Yes	69.61 ± 8.71	0.23
No	66.66 ± 9.81	
Cardiac life support training		
Yes	69.08 ± 8.57	**0.006**
No	66.64 ± 10.091	
CPR training		
Yes	67.87 ± 9.37	0.081
No	65.75 ± 10.67	
CPR frequency		
< 5	67.28 ± 9.62	0.49
6-9	67.98 ± 9.47	
> 10	70.50 ± 9.56	

ICU-intensive care unit; HDU-high dependency unit; CCU-coronary care unit; ER-emergency room; CPR-cardiac pulmonary resuscitation.

Post hoc analysis showed that nurses of age ≤ 30 were found to have significantly fewer scores than those between 31-35 ($p < 0.001$) and >35-year age group ($p < 0.001$). Furthermore, nurses having ≤ 5 years of working experience were found to have significantly less knowledge than those having greater work experience. Lastly, nurses working in oncology, intensive care units, and emergency rooms had better resuscitation medications knowledge ($P < 0.05$) than those working in other departments. Gender-wise comparison of knowledge score was not made as the vast majority of participants were females and only 1.7% were males.

Obstacles Encountered During the Administration of Resuscitation Medications

The obstacles encountered by the nurses during the administration of resuscitation medication are shown in **Table 4**. The top three most significant obstacles were "interruption of the drug administration procedure when other tasks need to be handled simultaneously" (75.6%), "insufficient knowledge" (69.4%), and "hesitation to ask questions" (67.7%).

Table 4. Obstacles encountered by nurses while administering resuscitation medications

Item	Obstacles	N	%	Rank
1	Interruption of drug administration procedure when other tasks need to be handled simultaneously	309	75.6	1
4	Insufficient knowledge	284	69.4	2
11	Hesitation to ask questions	277	67.7	3
5	Confused prescription	240	58.7	4
3	Chaotic situation in CPR	234	57.2	5
7	Unclear dose calculation	227	55.5	6
8	Divergence of opinions among professionals	196	47.9	7
9	Uncertain answers among colleagues	184	45.0	8
2	Having to accept verbal/oral orders	155	37.9	9
6	Shortage of resuscitation medications	132	32.3	10
10	Lack of references for the use of resuscitation medications	114	27.9	11
12	Mixing of resuscitation medications with other drugs	72	17.6	12

CPR, cardiac pulmonary resuscitation

Self-Rated Knowledge and Training Needs

Around 17% of the study participants self-ranked their knowledge to be sufficient while 41.3% and 33.3% ranked it to be relatively sufficient and fair, respectively. Nurses who rated their knowledge as sufficient had significantly higher scores than the others. Regarding training needs, 35.5% of nurses reported that they need extensive training to improve their knowledge and practices related to resuscitation medications whereas 32.8% refrained from answering this question.

This study is the first of its kind that assessed Pakistani nurses' knowledge of resuscitation medication administration. Overall, our findings indicated nurses' knowledge regarding resuscitation medication was suboptimal.

Nurses' knowledge about electrolyte administration is of great importance to reduce unwanted effects/events. 10% $CaCl_2$ is indicated to be used in cardiopulmonary resuscitation where there is hyperkalemia, hypocalcemia, and/or calcium channel block toxicity. This injection must not be administered rapidly as an intravenous push as it can induce a burning sensation and cause vasodilation resulting in hypotension [21]. It was encouraging to see that almost all the nurses (97%) in the present study were aware that 10% of calcium chloride should not be given as IV push but administered slowly. Furthermore, the majority of nurses (91%) knew that 10% calcium gluconate and calcium chloride were not interchangeable as calcium chloride carries three times more elemental calcium than calcium gluconate [22]. Likewise, around 79% of nurses in the current study were aware that in an emergency such as ventricular fibrillation, 15% KCl should not be given via fast intravenous (IV) push as it could lead to arrhythmias and cardiac arrest, therefore, it should be diluted and infused slowly [19]. Overall, in the current study, nurses' knowledge about electrolytes was somewhat better as compared to earlier studies [10, 19, 23-25]. This could be explained by the large proportion of nurses having obtained cardiovascular life support training. Furthermore, our sample population was primarily from wards/departments where the use of resuscitation medication and/or high-alert medications is very common.

Adrenaline is a first-line treatment of anaphylactic shock and is injected intramuscularly in the anterolateral aspect of the thigh (vastus lateralis). The intramuscular route of administration allows for faster peak plasma levels than subcutaneous (SC) route [26, 27]. Nearly 93% of nurses were well aware that this drug should not be administered as an IV push. The correct answer rate of this question was relatively higher than in earlier studies [10, 19, 23-25, 28].

Around 90% of nurses knew that body weight is used to calculate dosages of epinephrine in pediatric cardiopulmonary resuscitation and not the body surface area [29]. The results of this question were comparatively better than earlier studies from Taiwan and Palestine [10, 24]. It is challenging to calculate doses of resuscitation medication under emergency conditions [30]. About 59% of nurses were certain that in cardiac arrest, 1 mg epinephrine should be administered intravenously within 3-5 minutes followed by an IV flush of 20 ml fluid [31, 32]. Epinephrine increases myocardial and cerebral blood flow by acting on alpha-adrenergic receptors [26]. Increasing the pH of an epinephrine solution promotes its oxidation and can reduce its biological activity. Therefore, it is widely believed that epinephrine and sodium bicarbonate should not be infused into the same IV line during CPR [32]. In the present study,

nearly 68% of nurses knew that sodium bicarbonate could not be used with epinephrine during CPR, a significantly lower correct response rate than an earlier study from Taiwan [10], however, comparable with the findings of Qedan and colleagues [24]. Nitroglycerin is a vasodilator used to treat acute coronary syndrome. There have been cases of severe hypotension and bradycardia following the administration of sublingual nitroglycerin to patients with hypertension [33]. Therefore, it is advised not to use it in patients with bradycardia and low blood pressure. Almost 90% of the study sample were aware that nitroglycerine had the potential to induce bradycardia and hypotension. The aforementioned findings are significantly better than the earlier reports from Taiwan as well as Palestine (76.1% and 66.5%, respectively) [10, 24].

Amiodarone is an antiarrhythmic drug used to treat and prevent a variety of arrhythmias. It should not be used in patients with bradycardia or heart block because it can induce symptomatic bradycardia [34]. Our results for this question showed that nurses had a correct answer rate of 87% which was greater than the findings of earlier reports [10, 24]. Only 19% of nurses knew that amiodarone should not be given through the trachea. Drugs such as naloxone and atropine can be administered through this route but not amiodarone as there is no pharmacological indication that it can be absorbed via the tracheal route [35]. The correct answer rate for this question was lower than in the previous study conducted among Taiwanese and Palestinian nurses [10, 24]. Nearly, 67% of nurses knew if drugs were to be administered through the trachea, they should not be administered at a very high dosage (5-10 times) than the dosages for the IV route. For example, The American Heart Association recommends that the epinephrine dose given through the trachea should be at least 2 to 2.5 times the peripheral IV dose [31, 32].

Atropine is a parasympathetic blocker used in the treatment of bradycardia as it eliminates the effects of the vagus nerve on SA and AV nodes. Around 75% of nurses were aware that atropine is not used in Pulseless Electrical Activity anymore as per the ACLS guidelines of the American Heart Association [35]. Atropine has been removed from the Asystole and Pulseless Electrical Activity (PEA) algorithms for cardiac arrest as it lacks therapeutic benefits. This drug can only be used concurrently with epinephrine in asystole heart rhythms out of hospital cardiac arrest [36]. In the present study, around 67% of nurses did not know the exact dose of atropine used in cardiopulmonary resuscitation to prevent bradycardia; the recommended dose of atropine for bradycardia is 0.5 mg IV up to a maximum total dose of 3 mg every 3-5 minutes [31]. Dopamine is a catecholamine neurotransmitter that is used to treat hypotension. Dopamine should not be administered through small veins [37]. Approximately 80% of nurses knew that dopamine infusion can cause tissue ischemia or necrosis due to vasospasm and extravasation, hence it should only be administered peripherally into Large veins such as veins of antecubital fossa using a long intravenous catheter [38]. Our findings regarding dopamine administration were better than the findings of Qedan and colleagues [24], but the correct response rate was less than the results of Chen and colleagues [10].

Surprisingly, 73.1% of nurses did not know that norepinephrine bitartrate (Levophed) is added to glucose water to preserve its effects. This drug is used as a vasoconstrictor to treat life-threatening hypotension. Dextrose water protects this drug from losing its potency which occurs due to oxidation reaction [39]. The stability of norepinephrine bitartrate is enhanced when added to glucose or dextrose water as compared to normal saline solutions [39]. Lidocaine is classified as a class Ib antiarrhythmic drug that is used in the acute management of ventricular arrhythmias in patients with myocardial infarction/ischemia. About 52% of the study sample did not know that lidocaine was not a first-line treatment drug in the treatment of ventricular tachycardia as this drug reduces ventricular fibrillation (VF) [40]. Therefore, lidocaine can be used only as an alternative to amiodarone in the treatment of ventricular arrhythmias [35]. Adenosine is a standard treatment for stable narrow-complex supraventricular tachycardia. This drug is injected into a large vein within 1 to 3 seconds at a dose of 6 mg and then flushed with 20 mL saline [41]. Around 44% of the study sample did not know the administration technique [42]. The correct answer rate for this question was lower than the previous studies among Taiwanese and Palestinian nurses (62.8% and 65%, respectively) [10, 24].

Dextrose is used to prevent or treat hypoglycemia. Around 57.2% of nurses were unaware that the use of dextrose during resuscitation in individuals with in-hospital cardiac arrest was linked to a lower percentage of survival and even worse neurological prognosis [43]. Furthermore, hypoglycemia has been removed from the list of reversible causes of cardiac arrest since the 2010 guidelines ACLS guidelines [35] Nurses' knowledge regarding this question was comparable to findings from a recent study (56%) among Palestinian nurses, however, it was significantly lower as compared to an earlier study from Taiwan where the correct answer rate was 78.2% [10]. Contrary to the findings of earlier studies, the majority of our study participants knew that resuscitation medications should not have multiple concentrations for nurses to choose from. Atracurium is a neuromuscular blocking agent that should be stored in the refrigerator at temperatures of 2° to 8°C (36° to 46°F) to retain its potency [44]. Similar to the findings of an earlier study from Pakistan [19], around 70% of nurses were aware of the proper storage of this drug.

Overall, the mean correct response rate in our study of nurses was 67.6%, with only 55% of nurses having had knowledge score > 70%. Previous studies among Taiwanese [10] and Palestinian [24] nurses showed a mean correct response rate of 58.6% and 70.5%, respectively. As expected, age and experience were found to be significantly associated with better knowledge as with age nurses get more clinical

experience which may translate into better knowledge of medication administration. Similar findings have been reported in Taiwanese nurses where resuscitation medication knowledge scores improved significantly with experience [10, 45]. Contrary to this, Qedan *et al*. found that resuscitation medication knowledge did not improve with age and experience [24]. We also observed better knowledge scores among nurses providing services in public hospitals as compared to nurses working in private hospitals. This might be due to the intensive selection criteria (competitive exams and interviews) within public hospitals where recruitment and selection are done by the Punjab Public Service Commission [46]. We found that nurses working in the intensive care units, emergency rooms, coronary care units, and oncology wards had better knowledge regarding the administration of resuscitation medication as compared to nurses from other hospital departments. This could be explained because resuscitation medications are widely used in these areas as compared to other hospital departments. Similar to the findings of Chen *et al*. [10], we observed that the nurses who had obtained cardiovascular life support training had significantly higher knowledge scores than those who did not. This indicates that there is a need to promote such training and/or certifications in both public and private hospitals to improve knowledge of resuscitation medication administration. We assumed education level to be a statically significant element, but bachelor-qualified nurses had similar scores with master graduates which may be due to the reason that a master's degree primarily focuses on research rather than extensive course work.

Our study has highlighted major obstacles faced by nurses during the administration of resuscitation medication. Appropriate measures need to be taken to address these issues e.g. comprehensive training periodically and effective communication between health professionals.

The results of this study should be interpreted in the context of the study's limitations. Firstly, as this was a descriptive cross-sectional study, we could not determine any cause-and-effect relationship. Secondly, a convenient sampling method was used to recruit study participants, hence, disadvantages associated with non-probability sampling methods may exist (e.g., sampling biases, non-generalizability, and under or over-representation of the population). Lastly, this study was conducted within public and private hospitals of Lahore city; therefore, results may not be representative of the entire nursing population of Pakistan.

Conclusion

Only 55 percent of nurses in our study had adequate knowledge, necessitating measures to improve nurses' knowledge of resuscitation medications and overcome obstacles highlighted by nurses. Periodic BLS training should be conducted for all nurses and the nursing staff should be encouraged to get ACLS certification.

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