DOI: https://doi.org/10.54393/pbmj.v9i6.1371

PAKISTAN BIOMEDICAL JOURNAL
https://www.pakistanbmj.com/journal/index.php/pbmj/index
ISSN (E): 2709-2798, (P): 2709-278X
Volume 9, Issue 06 (June 2026)

Original Article

OPEN ACCESS

Factors Associated with Nurses' Knowledge Regarding High-Alert Medication Administration, Relevant Regulations, and Perceived Obstacles in Tertiary Care Hospitals of Karachi: An Analytical Cross-Sectional Study

Daman Ali[1], Rukhsana Muhammad Haroon[2], Madiha Saleem[2*], Muhammad Yaqoob[2] and Tanseer Ahmed[2]

[1]Illahi Bux Institute of Nursing, Nawabshah, Pakistan
[2]Department of Nursing, Dow University of Health Sciences, Karachi, Pakistan

ARTICLE INFO

Keywords:
High-Alert Medications, Nurses, Administration, Regulations, Medication Errors, Obstacles

How to Cite:
Ali, D., Haroon, R. M., Saleem, M., Yaqoob, M., & Ahmed, T. (2026). Factors Associated with Nurses' Knowledge Regarding High-Alert Medication Administration, Relevant Regulations, and Perceived Obstacles in Tertiary Care Hospitals of Karachi: An Analytical Cross-Sectional Study: Nurses' Knowledge Regarding High-Alert Medication Administration and Perceived Obstacles. Pakistan BioMedical Journal, 9(6), 09-15. https://doi.org/10.54393/pbmj.v9i6.1371

***Corresponding Author:**
Madiha Saleem
Department of Nursing, Dow University of Health Sciences, Karachi, Pakistan
madihasaleem.8142@duhs.edu.pk

Received Date: 7th May, 2026
1st Revision Received: 29th May, 2026
Acceptance Date: 23rd June, 2026
Published Date: 30th June, 2026

ABSTRACT

Medication safety during administration is crucial and a global concern and is directly linked to patient care, quality, and safety. High alert medications (HAMs) have an increased risk of causing harm if misused and must be administered correctly. Nurses play a primary role in drug administration and regulation, so it would be important to assess the level of knowledge of HAMs possessed by nurses. **Objectives:** To assess nurses' knowledge regarding the administration of HAMs, their understanding of relevant regulations and the perceived obstacles to safe high-alert medication practices in tertiary care hospitals of Karachi. **Methods:** An analytical cross-sectional study was conducted. 263 registered nurses were recruited in the study from Dow University Hospital and Civil Hospital, Karachi, using a non-probability convenience sampling method. Data were collected using a validated self-administered questionnaire and analyzed using SPSS version 27.0. **Results:** Nurses in both hospitals were aged 25–30 years (48%), with 53% males and 47% BSN graduates in the majority. The level of knowledge of the majority of nurses was moderate. Overall knowledge levels were (31%) good knowledge, moderate (52%), and poor (17%). The lack of rigorous regulations (46%) out of all obstacles was a systemic and institutional challenge to safe HAM management. **Conclusions:** Nurses had moderate knowledge about administration and regulations, with age and work experience influencing knowledge levels. To reduce medication errors, organized training sessions and simulated workshops, standard operating procedures, and frequent competency assessments are needed in hospitals.

INTRODUCTION

In tertiary care environments where acute and complex patient cases are common, nurses must focus on the safe administration and regulation of high-alert medications as a fundamental part of their professional duties. High-alert medications (HAMs) present a significant risk of severe side effects if misused. This category includes anticoagulants, insulin, chemotherapeutic agents, and opioids, all of which carry a heightened risk of causing patient trauma if administered incorrectly [1, 2]. Nurses must remain alert and strictly follow established safety protocols, as errors in the handling of these medications and drugs can lead to terrible consequences, including the patient's disability or even death [3, 4]. The World Health Organization (WHO) has identified medication error as a major global threat to patient safety, emphasizing the need for healthy systems and continuous education to diminish risks associated with HAMs [5, 6]. Medication errors are defined as unintentional mistakes or lapses that happen during different stages of medication treatment, including prescribing, dispensing, storing, preparing, and

DOI: https://doi.org/10.54393/pbmj.v9i6.1371

administering drugs. Healthcare nurses across the globe view medication errors as a substantial problem [7]. Medication errors are assumed to be the best patient safety and quality care issue. Globally, approximately 2-5% of patients end up in hospitals as a result of incorrect medication administration, most of which can be avoided. According to the statistics given by the Centers for Disease Control and Prevention (CDCP), in the United States, medication errors are the 3rd leading cause of mortality with 98,000 deaths per year after cancer and heart diseases [8, 9]. In Pakistan, study findings are mixed; while some studies report a majority of nurses have good knowledge and positive attitudes toward HAMs, others identify considerable deficits in understanding, especially concerning regulation, as well as poor alignment between knowledge and obstacles [5, 10]. Despite the crucial necessity of these drugs, however, HAM mistakes continue to be a major concern in healthcare, frequently resulting in serious patient threats and consequences like extended hospital stays, incapacity, or even death [11].

Limited evidence is available in Pakistan regarding nurses' knowledge of high-alert medication administration, relevant regulations, and perceived obstacles, chiefly in critical care units of tertiary care hospitals. Existing studies have mainly focused on knowledge levels and have inadequately explored the factors associated with nurses' knowledge and safe medication practices. This study aimed to assess nurses' knowledge regarding the administration of high-alert medications, relevant regulations, and perceived obstacles in tertiary care hospitals of Karachi. It also aimed to identify demographic and professional factors associated with nurses' knowledge levels.

METHODS

An analytical cross-sectional study was conducted for three months in approximately two tertiary care hospitals in Karachi, Pakistan, namely Dow University Hospital and Dr. Ruth K.M. Civil Hospital, from October to December 2025. Registered nurses employed in critical care units such as the Medical Intensive Care Unit (MICU), the Surgical Intensive Care Unit (SICU), the Neonatal Intensive Care Unit (NICU), the Coronary Care Unit (CCU), the Emergency Department, and other critical care units were recruited using a non-probability convenience sampling technique. Nurses who attended workshops in the past six months relating to high-alert medications were not included. There were 263 nurses in all, and none of them had incomplete responses. The sample size was calculated using the one-sample proportion formula based on the previously reported levels of adequate knowledge (32.9%) [2]. Based on a 95% confidence level, 80% statistical power, and an effect size of 1, the minimum sample size was 239. The size of the final sample was fixed at n = 263, adding an estimated 10% for possible failure to complete or non-response to the data. The design of this study was an analytical cross-sectional design, but sample size calculation was based on prevalence estimation, which is an accepted method used in a cross-sectional study. The Institutional Review Committee of Dow University of Health Sciences (Ref: DUHS/DION&M/2025/18-44 dated 25 August 2025) approved, and all the participants gave written informed consent before data collection. The questionnaire was an open-access, self-administered, validated instrument that was originally developed and has a reported Cronbach's alpha of 0.74. The questionnaire comprised four parts: demographic characteristics, knowledge of high-alert medication administration, knowledge of high-alert medication regulations, and perceived barriers to safe high-alert medication practices with 5-point Likert scales (1 = strongly agree to 5 = strongly disagree). In the knowledge sections, one point was allocated to each correct answer, and a score of zero points was allocated for incorrect and "don't know" responses. Based on previously published studies that employed the same questionnaire, knowledge scores were categorized as poor (less than 60), moderate (between 60–80), and good (more than 80) [2, 12]. The barriers perceived were analyzed descriptively by frequencies and percentages. Appropriate statistical methods were chosen after determining data normality with the Shapiro–Wilk test. Depending on the distribution of data, a parametric or non-parametric test was used. The dependent variables were the nurses' knowledge scores about regulations and high alert medication administration, while the independent variables were demographic and professional characteristics such as age, gender, marital status, education qualification, job experience, working unit, and affiliation to the hospital to examine the factors associated with the nurses' knowledge.

The data were analyzed using SPSS version 27.0. Data were summarized using descriptive statistics such as frequencies, means and proportions. Mann–Whitney U test and Kruskal–Walli's test was used to examine the association between nurses' demographic/professional characteristics and knowledge scores. There were significant associations between age (p=0.030) and work experience (p=0.021) with knowledge of medication administration and the regulations; gender, marital status, education, working unit, and hospital affiliation were not significantly associated (p>0.050).

RESULTS

In this study, 263 Critical Care Nurses from two tertiary care hospitals in Karachi participated with a 100% response rate. Most participants were aged 25–30 years (47.9%), male (53.2%), single (50.6%), and held a BSN degree (47.1%).

DOI: https://doi.org/10.54393/pbmj.v9i6.1371

The Emergency Department (22.1%), Medical ICU (20.5%), and Surgical ICU (10.3%) were the main sources of recruitment of nurses. Regarding work experience, 30.8% had 2–5 years, followed by <2 years (29.3%), 5–10 years (27.8%), and >10 years (12.2%). The distribution of participants was almost equal between Dow University Hospital (50.6%) and Dr. Ruth K.M. Civil Hospital Karachi (49.4%). There was a significant association between age and overall knowledge of high-alert medication administration and regulations (p=0.030) for the age group 25–30 years, who obtained the highest knowledge scores. There was also a significant correlation between work experience and knowledge of high-alert medication administration (p=0.021), with nurses with 5–10 years of experience attaining higher scores. None of the differences in knowledge scores were statistically significant by gender, marital status, educational qualification, working unit, or hospital affiliation (p>0.050) (Table 1).

Table 1: Demographic Variables of Nurses (n=263)

Variables	Category	n (%)
Age	< 25 Years	58 (22.1%)
	25–30 Years	126 (47.9%)
	30–35 Years	46 (17.5%)
	> 35 Years	33 (12.6%)
Gender	Female	123 (46.8%)
	Male	140 (53.2%)
Marital Status	Single	133 (50.6%)
	Married	128 (48.7%)
	Widow/Separated/Divorced	2 (0.8%)
Qualification	BSN	124 (47.2%)
	POST RN	106 (40.3%)
	Diploma	31 (11.8%)
	MSN	2 (0.8%)
Working Unit	MICU	54 (20.5%)
	SICU	27 (10.3%)
	ER	58 (22.1%)
	Gastro HDU	11 (4.2%)
	Medicine HDU	14 (5.3%)
	NICU	14 (5.3%)
	Renal Transplant Unit	4 (1.5%)
	Liver Transplant Unit	5 (1.9%)
	CCU	25 (9.5%)
	Paeds HDU	11 (4.2%)
	Paeds ICU	16 (6.1%)
	Paeds ER	7 (2.7%)
	Cardiac Emergency	9 (3.4%)
	Cardiac SICU	2 (0.8%)
	Neurology ICU	6 (2.3%)
Working Experience	< 2 years	77 (29.3%)
	2–5 years	81 (30.8%)
	5–10 years	73 (27.8%)
	> 10 years	32 (12.2%)
Hospital	D.U.H	133 (50.6%)
	C.H.K	130 (49.4%)

The study presents an assessment of nurses' knowledge about the administration of high-alert medications, the Section B question order (AQ1–AQ10), The best performance (Rank 1; 90.5%) came from the question about whether calcium gluconate and calcium chloride can be interchanged, demonstrating that nurses clearly understand these medications cannot replace each other. The second and third best scores were for epinephrine administration knowledge (87.8%) and insulin dosage expression (87.1%). On the other side, the weakest knowledge areas involved calculating chemotherapy doses for children (56.7%) and the question about fast IV administration of 3% sodium chloride (52.1%), which ranked at the bottom (Rank 10) (Table 2).

Table 2: Assessment of Nurses' Knowledge Regarding Administration of High-Alert Medications

Questions	Correct Responses, n (Correct %)	Incorrect Responses, n (Incorrect %)	Rank
1.The Dose of Insulin injections can be "cc" or "mL"	229 (87.1%)	34 (12.9%)	3
2.10% Calcium Gluconate and 10% Calcium Chloride are identical drugs and can be used interchangeably.	238 (90.5%)	25 (9.5%)	1
3.For mild allergic reactions, rapid IV epinephrine 4.1:1000 (1 ampule) may be used.	231 (87.8%)	32 (12.2%)	2
5.In an emergency, a 10% $CaCl_2$ 10mL fast IV push may 6.Be administered in 1–2min.	200 (76.1%)	63 (23.2%)	6
7.Chemotherapy dose is calculated by BW in adults and BSA in children.	149 (56.7%)	114 (43.4%)	9
8.IV fast push of 15% KCl, 10mL, in an emergency 9.Ventricular fibrillation happens.	205 (77.9%)	58 (22.1%)	5
10.15% KCl and Ringer's solution were added for rapid infusion.	212 (80.6%)	51 (19.4%)	4
11.A 1mL syringe may be an alternative to an 12.Insulin syringe.	184 (69.9%)	79 (30.04%)	8
13.3% Sodium Chloride 500mL may be administered as a fast IV infusion for a patient who has a low sodium level.	191 (72.6%)	72 (27.4%)	7
14.A Port-A catheter can be used for drug injection and 15.blood sampling.	137 (52.1%)	126 (47.9%)	10

Mean Section B percent score = 75.13% (SD = 18.37), Knowledge levels — Poor (<60%): 43 (16.35%), Medium (60–80%): 138 (52.47%), Good (>80%): 82 (31.18%)

The overall mean percentage score of nurses for knowledge about high alert medications was 68.3% (SD =

DOI: https://doi.org/10.54393/pbmj.v9i6.1371

20.50), which indicated a moderate level of knowledge. The overall good knowledge, moderate knowledge, and poor knowledge were 27.0%, 44.5%, and 28.5%, respectively. Good awareness of safe storage and labelling was seen with the highest scoring items: purchase of 15% KCl (81.8%), correct use of the words amp or vial to give medication dose (76.1%). Moderate knowledge was demonstrated for the pediatric dosing terminology (69.6%), labeling look-alike medications (73.0%), and storage of Heparin and Insulin (69.2%). The poorest scores were for the incorrect use of "U" for "unit" (52.1%) and for the fentanyl regulations (57.8%), indicating gaps in knowledge of safe dose expression and medication regulations.

Table 3: Assessment of Nurses' Knowledge Regarding Regulations of High-Alert Medications

Questions	Correct Responses, n (Correct %)	Incorrect Responses, n (Incorrect %)	Rank
1.Medication dosage should be expressed as 'Amp' or 'Vial' instead of 'mg' or 'g.'	200 (76.1%)	63 (23.2%)	3
2.Labeling on look-alike drugs should be distinctive.	192 (73%)	71 (27%)	4
3.Dose expression for 'Unit' should be written as 'U'.	137 (52.1%)	126 (47.2%)	10
4.Heparin and insulin can be stored together in the refrigerator for convenience.	184 (69.2%)	79 (30%)	5
5.Multiple concentrations of each drug are available for nurses to choose.	157 (59.7%)	106 (40.3%)	8
6.Potassium can be administered orally instead of the IV route if the patient can tolerate it.	167 (63.5%)	96 (36.5%)	7
7.15% KCl should be easily and freely accessible to nurses because it is frequently used.	215 (81.8%)	48 (18.2%)	1
8.Use a teaspoon for dose expression for pediatric doses.	183 (69.6%)	80 (30.4%)	6
9.A fentanyl skin patch is a regulated narcotic.	152 (57.8%)	111 (42.2%)	9
10.Atracurium should be stored with other drugs and easily accessed by nurses for tracheal intubation.	210 (79.9%	53 (20.1%)	2

Mean Section C percent score = 68.33% (SD = 20.50). Knowledge levels — Poor (<60%): 75 (28.52%), Medium (60–80%): 117 (44.49%), Good (>80%): 71 (27.00%)

The current results present nurses' perceptions regarding obstacles to safe high-alert medication practices. The most frequently reported obstacle was the absence of strict regulations for high-alert medications (46%, Rank 1), followed by the absence of a reliable drug reference source (45%, Rank 2). Other commonly identified barriers included differences in opinions between physicians and nurses (41%, Rank 3), receiving medication orders verbally (41%, Rank 4), high-alert medications being mixed with other drugs (41%, Rank 5), and lack of appropriate personnel to consult (41%, Rank 6). Insufficient knowledge (40%, Rank 7), receiving uncertain answers from colleagues (39%, Rank 8), and inconsistent opinions between nurses (37%, Rank 9) were also reported. Unclear dose calculation (37%, Rank 10) and lack of standardized operating procedures (36%, Rank 11) were perceived as additional obstacles, while confused prescriptions (35%, Rank 12) and easy access to high-alert medications (33%, Rank 13) were reported less frequently.

Table 4: Perceived Obstacles to Safe High-Alert Medication (HAM) Practices

Questions	Strongly Disagree [1] %	Disagree [2] %	Unsure [3] %	Agree [4] %	Strongly Agree [5] %	Dominant Response %
1.Differences in opinions between physicians and nurses	11.0%	36.88%	4.94%	41.44%	5.70%	41.44%
2.Lack of standardized operating procedures for high-alert medication	11.03%	42.59%	7.22%	35.74%	3.42%	42.59%
3.Absence of a reliable drug reference source	12.17%	45.25%	6.46%	33.08%	3.04%	45.25%
4.Receiving medication orders verbally	17.87%	41.44%	7.60%	29.66%	3.42%	41.44%
5.Insufficient knowledge	16.73%	39.92%	8.37%	29.66%	5.32%	39.92%
6.Confused prescription	20.15%	34.98%	8.37%	31.18%	5.32%	34.98%
7.Unclear dose calculation	17.11%	36.50%	8.37%	31.94%	6.08%	36.50%
8.Lack of appropriate personnel to consult	16.73%	41.06%	10.65%	29.28%	2.28%	41.06%
9.High-alert medications are mixed with other drugs	19.77%	41.44%	6.46%	27.76%	4.56%	41.44%
10.Absence of strict regulations for high-alert medications	13.69%	46.01%	8.75%	28.14%	3.42%	46.01%
11.Receive uncertain answers from colleagues	17.11%	38.78%	11.41%	28.90%	3.80%	38.78%
12.Inconsistent opinions between nurses	19.01%	37.26%	6.46%	32.70%	4.56%	37.26%
13.Easy access to high-alert medications	21.67%	31.18%	6.08%	33.46%	7.60%	33.46%

Scale: 1=Strongly Disagree, 2=Disagree, 3=Unsure, 4=Agree, 5=Strongly Agree. Descriptive statistics. Percentages (%)

The age and work experience were significantly associated with nurses' knowledge regarding high-alert medication administration (p=0.042 and p=0.021, respectively). Nurses aged 25–30 years (79.2 ± 15.5%) and those with 5–10 years of experience (80.5 ± 15.4%) achieved the highest mean knowledge scores, while nurses aged >35 years (68.3 ± 20.5%) and those

DOI: https://doi.org/10.54393/pbmj.v9i6.1371

with <2 years of experience (70.2 ± 18.5%) scored the lowest. No statistically significant associations were observed for gender or hospital affiliation (p>0.050).

Table 5: Association between Demographic Characteristics and HAM Administration Knowledge Scores (Section B)

Variables	Category	n (%)	Mean Knowledge Score (%)	Test Statistic	p-value
Age	< 25 Years	58 (22.1%)	73.5 ± 17.8	H (3) = 7.82	0.042*
	25–30 Years	126 (47.9%)	79.2 ± 15.5		
	30–35 Years	46 (17.5%)	75.0 ± 19.2		
	> 35 Years	33 (12.6%)	68.3 ± 20.5		
Working Experience	< 2 Years	77 (29.3%)	70.2 ± 18.5	H (3) = 9.72	0.021*
	2–5 Years	81 (30.8%)	76.0 ± 17.2		
	5–10 Years	73 (27.8%)	80.5 ± 15.4		
	> 10 Years	32 (12.2%)	71.2 ± 20.0		
Gender	Female	123 (46.8%)	75.8 ± 18.3	U = 8,320.0	0.378
	Male	140 (53.2%)	74.5 ± 18.8		
Hospital	D.U.H	133 (50.6%)	75.2 ± 18.2	U = 8,510.0	0.701
	C.H.K	130 (49.4%)	75.0 ± 18.9		

DISCUSSION

The findings of the present research revealed that the largest proportion of respondents was BSN (47.1%), followed by Post-RN (40.3%), as has been the case with other studies conducted in Pakistan, which have reported a consistent increase in the degree of formal education of nurses [1, 12]. On work experience, most of the respondents (61%) had an experience of 2-5 years- this is a good proportion of information that the majority of respondents are middle career practitioners who are newly trained yet already clinically practicing HAM administration. This finding aligns with [13], who also noted that younger and moderately experienced nurses can attain improved medication safety assessment results. The administration knowledge (75.13 ± 18.37) is overall impressive, as it signifies that critical care nurses are well aware of safe HAM administration practices. This result is in line with the results of [14] in Karachi. Instead of using the insulin syringe, a 1ml syringe [69.9% correct score] can be used (approximately 70% correct score), which is similar to KPK study results [15]. Precise labeling of look-alike/sound-alike drugs (73 %). This good reaction indicates that nurses are aware of the danger of look-alike drugs. The same outcome was cited in Palestine (70%) [2] and Saudi Arabia [16]. Store heparin and insulin in the refrigerator, correct score (69.9%). The insulin and heparin should be stored at room temperature but not in combination since they are lookalike drugs once they are opened. This unsafe storage practice was rejected by the majority of the respondents with better storage awareness, similar to [17]. To nurses, 15% KCl must be readily available (81.75% correct response). Some of the nurses were not aware of this. The previous studies have indicated that the Potassium Chloride 15% must not be stored in the nursing stations, so nurses should not have unregulated access to this drug. This was the correct rate, which was the highest in the current study and a reflection of [2] (80%) and the ISMP (2024) guidelines [18]. The issue of nurses lacking the necessary good knowledge regarding HAMs, the three leading obstacles were found to be the lack of stringent institutional regulations (46%), absence of reference materials (45.3%), and non-existent standard operating procedures (42.6%). Same results as [19], which stated inconsistency in policy implementation and absence of decision-support tools as an obstacle to medication safety. Similar research in Saudi Arabia [20] also mentioned inconsistency in policy implementation and lack of decision-support tools as barriers to medication safety.

The study is limited to two tertiary care hospitals within the public sector, restricting the generalizability of this study to other areas of healthcare, such as Outpatient Departments, private hospitals, or rural healthcare centers. Future studies should focus on conducting longitudinal and interventional studies to assess changes in nurses' knowledge and practices over time.

CONCLUSIONS

The study provides a comprehensive assessment of nurses' moderate knowledge regarding the administration, regulation, and perceived obstacles to HAM in tertiary care Hospitals in Karachi, Pakistan. In general, and according to results, nurses are moderately knowledgeable with significant gaps in knowledge about dosage calculation, compliance with regulations, and institutional procedures. Age (p=0.030) and work experience (p=0.021) were significantly associated with knowledge levels, suggesting exposure and professional maturity contribute to safer medication administration. The results highlight the fact that in order to reduce medication-related errors in critical care units, there is a need for organized training, institutional standard operating procedures, and frequent competency assessments.

Authors' Contribution

Conceptualization: DA, RMH
Methodology: RMH
Formal analysis: MS
Writing and Drafting: DA, MY, TA
Review and Editing: DA, RMH, MS, MY, TA

All authors approved the final manuscript and take responsibility for the integrity of the work

DOI: https://doi.org/10.54393/pbmj.v9i6.1371

Conflicts of Interest

The authors declare no conflict of interest.

Source of Funding

The authors received no financial support for the research, authorship and/or publication of this article.

REFERENCES

[1] Aziz T, Khan AN, Sial JA, Jaseem MN, Adnan M, Ur Rehman Z. Enhancing Nurses Knowledge of High-Alert Medications: The Impact of Educational Intervention in a Tertiary Care Cardiac Hospital, Karachi. Pakistan Heart Journal. 2024 Jun; 57(2): 148-52. doi: 10.47144/phj.v57i2.2698.

[2] Zyoud SE, Khaled SM, Kawasmi BM, Habeba AM, Hamadneh AT, Anabosi HH *et al.* Knowledge About the Administration and Regulation of High Alert Medications among Nurses in Palestine: A Cross-Sectional Study. BioMed Central Nursing. 2019 Mar; 18(1): 11. doi: 10.1186/s12912-019-0336-0.

[3] Sessions LC, Nemeth LS, Catchpole K, Kelechi TJ. Nurses' Perceptions of High-Alert Medication Administration Safety: A Qualitative Descriptive Study. Journal of Advanced Nursing. 2019 Dec; 75(12): 3654-67. doi: 10.1111/jan.14173.

[4] Kuitunen S, Saksa M, Tuomisto J, Holmström AR. Medication Errors Related to High-Alert Medications in a Pediatric University Hospital–A Cross-Sectional Study Analyzing Error Reporting System Data. BioMed Central Pediatrics. 2023 Oct; 23(1): 548. doi: 10.1186/s12887-023-04333-2.

[5] Kuitunen S, Saksa M, Holmström AR. Medication Errors and Error Chains Involving High-Alert Medications in a Pediatric Hospital Setting: A Qualitative Analysis of Self-Reported Medication Safety Incidents. Drugs: Real-World Outcomes. 2025 Mar; 12(1): 45-61. doi: 10.1007/s40801-024-00469-4.

[6] He M, Huang Q, Lu H, Gu Y, Hu Y, Zhang X. Call for Decision Support for High-Alert Medication Administration among Pediatric Nurses: Findings from a Large, Multicenter, Cross-Sectional Survey in China. Frontiers in Pharmacology. 2022 Jul; 13: 860438. doi: 10.3389/fphar.2022.860438.

[7] Alothmany HN, Bannan DF, Bannan D. Implementation Status and Challenges Associated with Implementation of the Targeted Medication Safety Best Practices in a Tertiary Hospital. Cureus. 2023 Sep; 15(9). doi: 10.7759/cureus.45552.

[8] Yousef A, Mohamed W, Ali F, Ali E. Effect of nursing education guidelines about high alert medications on critical care nurses' knowledge and practices. IOSR Journal of Nursing and Health Science. 2018; 7(1): 47-54.

[9] Labib JR, Labib-Youssef MR, Fatah S. High Alert Medications Administration Errors in Neonatal Intensive Care Unit: A Pediatric Tertiary Hospital Experience. The Turkish Journal of Pediatrics. 2018 Jun 25; 60(3): 277-85. doi: 10.24953/turkjped.2018.03.007.

[10] Naheed S and Arif S. Assessment of Knowledge Regarding High Alert Medications Administration and Regulation among Nurses. Journal of Nurses and Midwives Pakistan. 2024 Jul; 4(1): 54-61.

[11] Salman M, Mustafa ZU, Shehzadi N, Mallhi TH, Asif N, Khan YH *et al.* Evaluation of Knowledge and Practices About Administration and Regulations of High Alert Medications among Hospital Pharmacists in Pakistan: Findings and Implications. Current Medical Research and Opinion. 2022 Nov; 38(11): 1967-75. doi: 10.1080/03007995.2022.2124063.

[12] Aziz S, Saddique H, Tasneem SS. Knowledge about Administration and Regulation of High Alert Medication among Nurses in Oncology Department. Journal of Health and Rehabilitation Research. 2024 May; 4(2): 509-13. doi: 10.61919/jhrr.v4i2.893.

[13] Younis I, Shaheen N, Bano S. Knowledge and Practice About Administration of High Alert Medication in the Tertiary Care Hospital in Lahore. International Journal of Health, Medicine and Nursing Practice [Internet]. 2021; 3(4): 1-6. doi: 10.47941/ijhmnp.644.

[14] Ahmad A, Khan D, Bibi A, Khan MI, Kauser M, Hasan M, Ishaq M, Ullah S. Assess the Knowledge and Attitude of Nurses Regarding High Alert Medication in Tertiary Care Hospital in Karachi: Knowledge and Attitude of Nurses on High Alert Medications. NURSEARCHER (Journal of Nursing and Midwifery Sciences). 2024 Jun: 23-7. doi: 10.54393/nrs.v4i02.90.

[15] Bibi S, Ihsan A, Nisa NU, Begum H, Parveen N, Rehman AU *et al.* Knowledge Regarding the Administration and Regulation of High Alert Medications among Nurses in Tertiary Care Hospitals, Bannu KPK: Administration and Regulation of High Alert Medications among Nurses. Pakistan Journal of Health Sciences. 2025 Apr: 221-6. doi: 10.54393/pjhs.v6i4.2828.

[16] Alghamdi AA. Medication Safety in Saudi Arabia: Evaluating the Current Situation and Identifying the Areas for Improvement. Pharmacy. 2025 Apr; 13(2): 50. doi: 10.3390/pharmacy13020050.

[17] Härkänen M, Turunen H, Vehviläinen-Julkunen K. Differences Between Methods of Detecting Medication Errors: A Secondary Analysis of Medication Administration Errors Using Incident Reports, the Global Trigger Tool Method, and Observations. Journal of Patient Safety. 2020 Jun;

DOI: https://doi.org/10.54393/pbmj.v9i6.1371

16(2): 168-76. doi: 10.1097/PTS.0000000000000261.

[18] Kassaw AT, Teferi ET, Tarekegn GY, Zerihun TE, Wondm SA, Moges TA *et al.* Five-Year Survival and Determinants of Diffuse Large B-cell Lymphoma in Resource-Limited Settings: The Impact of HIV/AIDS in a Multi-Center Cohort Study. Cancer Control. 2026 Mar; 33: 10732748261434396. doi: 10.1177/10732748261434396.

[19] Syam Y, Sjattar EL, Tombong AB, Latif AI, Najib A. Are There Obstacles Faced by Nurses in Administering High Alert Medication (HAM) Safely? A Scoping Review. Pakistan Journal of Life and Social Sciences. 2024 Jul; 22(2). doi: 10.57239/PJLSS-2024-22.2.00127.

[20] Al-Zaagi IA, Al-Dossari DS, Salem SO, Qureshi NA. Medication Safety Unit Programs in King Saud Medical City, 2012-2013: Safe Medication Management and Use with a Focus on Patient Safety. British Journal of Medicine and Medical Research. 2015; 8(5): 384-407. doi: 10.9734/BJMMR/2015/17221.