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Knowledge and Practice of Nurses Regarding Safe Medication Administration in Tertiary Care Hospitals, Bannu

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ABSTRACT

Background: *Medication administration errors remain a major threat to patient safety worldwide, particularly in hospital settings where nurses administer the majority of prescribed medications. As the final checkpoint in the medication-use process, nurses play a critical role in ensuring medications are delivered safely, accurately, and in accordance with established patient safety principles. However, gaps in knowledge, inconsistent adherence to safe medication practices, and limited access to technological safety systems may increase the risk of medication-related harm, especially in resource-limited healthcare settings.* ***Objective:*** *This study aimed to assess the knowledge and self-reported practice of registered nurses regarding safe medication administration in tertiary care hospitals in Bannu District, Khyber Pakhtunkhwa, Pakistan, and to examine the association between nurses' knowledge and their medication administration practices.* ***Methods:*** *A descriptive cross-sectional study was conducted among 157 registered nurses working in inpatient wards of tertiary care hospitals in Bannu between January and June 2026. Participants were selected using simple random sampling. Data were collected using a structured self-administered questionnaire assessing socio-demographic characteristics, medication administration knowledge, and self-reported practices. Descriptive statistics summarized participant characteristics and knowledge/practice scores. Chi-square tests examined associations between demographic variables and knowledge/practice levels, and Pearson correlation assessed the relationship between knowledge and practice scores using SPSS version 25.0.* ***Results:*** *Overall, 68.2% of nurses demonstrated adequate knowledge of safe medication administration, while 72.6% reported adequate practice adherence. Knowledge was highest for identification of the five rights of medication administration (83.4%) and recognition of high-alert medications (78.3%). However, lower knowledge levels were observed for medication error management (37.6%) and technology-supported medication administration systems (47.1%). Education level was significantly associated with knowledge adequacy ($p=0.004$), whereas no demographic factors were significantly associated with practice levels. A moderate positive correlation was observed between knowledge and practice scores ($r=0.54$, $p<0.001$).* ***Conclusion:*** *Although most nurses demonstrated adequate knowledge and practice related to safe medication administration, important gaps remain in medication error management, post-administration monitoring, and technology utilization. Targeted continuing education programs strengthened institutional policies, and improved access to medication safety technologies are recommended to enhance patient safety in tertiary healthcare settings.*

Keywords: *medication administration errors, nursing knowledge, patient safety, safe medication practice, medication safety, tertiary hospitals, Pakistan.*

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INTRODUCTION

Medication administration is one of the most critical and high-risk responsibilities performed by nurses in clinical settings. As the healthcare professionals who most frequently handle and deliver medications to patients, nurses play a central role in ensuring that pharmacological treatments prescribed by physicians are administered safely and accurately. In hospital environments, nurses are responsible for approximately 60–80% of all medication administrations, placing them at the final checkpoint in the medication-use process before drugs reach patients (1). Because this stage represents the last opportunity to detect and

prevent potential errors originating from earlier stages such as prescribing or dispensing, the competence and vigilance of nurses are essential for safeguarding patient safety. Any lapse during the administration phase can lead to medication administration errors (MAEs), which may result in adverse drug events, extended hospitalization, increased healthcare costs, and in severe cases permanent harm or death (1).

Medication errors have been recognized globally as a major patient safety challenge. The World Health Organization has identified medication-related harm as one of the leading causes of preventable injury within healthcare systems worldwide and launched the "Medication Without Harm" initiative aimed at reducing severe avoidable medication-related harm by 50% globally (2). Medication errors can occur at any stage of the medication-use process, including prescribing, transcribing, dispensing, administering, and monitoring. However, the administration stage remains particularly vulnerable because it relies heavily on the individual competence, decision-making, and situational awareness of nurses, often in fast-paced and high-pressure clinical environments (3). Unlike prescribing or dispensing errors, which may be intercepted through pharmacy verification or electronic prescribing systems, administration errors often lack intermediary safeguards and therefore pose a direct risk to patients.

The complexity of modern pharmacotherapy further increases the risk of medication errors in clinical practice. Advances in medical science have introduced a growing number of medications, increasingly complex therapeutic regimens, and high-alert drugs requiring careful monitoring. Nurses must therefore maintain up-to-date knowledge of pharmacology, including dosage calculations, drug interactions, routes of administration, contraindications, and monitoring requirements. High-alert medications such as anticoagulants, insulin, opioids, and chemotherapeutic agents require particular attention because errors involving these drugs can result in serious patient harm (4). Previous studies conducted in different healthcare systems have shown that nurses' knowledge of safe medication administration is often moderate rather than optimal, with reported knowledge levels ranging between approximately 55% and 78% depending on the population studied and the assessment tools used (5,6). These findings highlight the presence of knowledge gaps in critical domains such as dosage calculation, intravenous medication compatibility, and recognition of medication-related adverse events.

Beyond knowledge deficits, a substantial body of research has highlighted a discrepancy between what nurses know and how consistently safe medication practices are implemented in real clinical settings. The fundamental principles guiding medication administration are commonly described as the "five rights": the right patient, right medication, right dose, right route, and right time. These principles serve as a foundational safety framework intended to minimize medication-related harm during administration (7). Despite widespread awareness of these principles among nursing professionals, studies have shown that adherence to medication safety protocols is not always consistent. Observational and survey-based studies report that compliance with critical safety steps—such as verifying patient identity using two identifiers, checking medication labels multiple times, assessing allergies, and documenting administration—can vary widely across clinical settings (3,8). Interruptions during medication preparation and administration, high workload, and time pressures have been identified as key contributors to deviations from standard safety procedures (9).

Several individual and organizational factors may contribute to the gap between knowledge and practice in medication administration. At the individual level, clinical experience, professional training, and confidence influence nurses' ability to implement safe medication practices effectively. Newly graduated nurses may lack sufficient experience to manage

complex medication regimens, whereas more experienced nurses may occasionally rely on routine-based shortcuts in busy clinical environments (4). Continuous professional development and in-service training programs are therefore essential to maintain competency in medication safety practices. At the organizational level, staffing shortages, high nurse-to-patient ratios, and heavy workloads have been consistently associated with increased risk of medication errors. In high-acuity environments such as emergency departments and intensive care units, nurses frequently administer medications under conditions characterized by interruptions, multitasking, and urgent decision-making, all of which may increase cognitive load and error risk (3,9).

Technological systems have been introduced in many healthcare settings to mitigate medication errors and strengthen safety during the medication administration process. Electronic prescribing systems, computerized physician order entry (CPOE), and barcode medication administration (BCMA) technologies provide additional safeguards by verifying medication orders, ensuring correct patient identification, and reducing transcription errors (10). BCMA systems in particular require nurses to scan both the patient's identification band and the medication barcode before administration, thereby confirming the essential elements of safe medication practice. Studies conducted in high-income countries have demonstrated that such technologies can significantly reduce medication administration errors and improve adherence to safety protocols (10). However, the availability and utilization of these systems remain limited in many low- and middle-income countries, where resource constraints, inadequate technological infrastructure, and insufficient training may hinder widespread adoption.

In addition to technological factors, the organizational culture of healthcare institutions plays a critical role in medication safety. Healthcare environments that encourage open communication, interprofessional collaboration, and non-punitive reporting of errors are more likely to foster a culture of patient safety. Conversely, environments characterized by blame and punitive responses to mistakes may discourage healthcare professionals from reporting medication errors or near misses, thereby limiting opportunities for system-level learning and improvement (8). Underreporting of medication errors is widely documented and can obscure the true magnitude of medication safety problems within healthcare institutions.

These challenges may be particularly pronounced in low- and middle-income healthcare systems where resources are limited and healthcare demand is high. Hospitals in such settings often face shortages of trained personnel, limited access to technological support systems, and insufficient opportunities for continuing professional education. Pakistan's healthcare system reflects many of these structural challenges, including high patient volumes, limited funding, and workforce shortages. Public hospitals in particular frequently operate under conditions of overcrowding and resource constraints, which can place additional pressure on nursing staff responsible for delivering direct patient care. Nurses working in tertiary care hospitals must often manage large patient loads while simultaneously performing complex clinical tasks, including medication administration, documentation, patient education, and monitoring of treatment outcomes.

Within the province of Khyber Pakhtunkhwa, tertiary care hospitals serve as referral centers for large populations, including patients from rural and semi-urban districts such as Bannu. In such contexts, nurses may face substantial workload demands and limited access to advanced medication safety technologies or structured continuing education programs. Despite the potential implications for patient safety, empirical research examining nurses' knowledge and practices related to safe medication administration in these settings remains

limited. Most available studies in Pakistan have been conducted in large metropolitan areas, leaving smaller districts and peripheral healthcare facilities underrepresented in the literature. This lack of localized evidence restricts the ability of policymakers and hospital administrators to design context-specific interventions aimed at improving medication safety.

Furthermore, cultural and systemic factors within healthcare environments may also influence medication safety practices in South Asian settings. Hierarchical relationships between healthcare professionals can sometimes limit open communication, potentially discouraging nurses from questioning medication orders or reporting errors. Communication barriers between physicians, pharmacists, and nurses may further complicate the medication administration process, particularly in high-pressure clinical environments. In addition, documentation systems in many hospitals remain paper-based, which may increase the risk of transcription errors and reduce the efficiency of medication monitoring processes.

Given these complexities, a comprehensive assessment of both knowledge and clinical practice is necessary to understand the factors influencing medication safety among nurses. Evaluating knowledge alone may not accurately reflect real-world behavior, while assessing practice without examining underlying knowledge gaps may fail to identify educational needs. A combined analysis of knowledge and practice therefore provides a more complete understanding of medication administration safety within clinical environments. Such assessments can identify specific domains where nurses may require additional training, including recognition of high-alert medications, appropriate post-administration monitoring, medication error management, and the safe use of medication-related technologies.

In light of the limited evidence available from smaller districts in Pakistan and the critical role nurses play in medication safety, it is important to generate context-specific data that can inform targeted interventions and policy development. Understanding the current level of knowledge and adherence to safe medication administration practices among nurses working in tertiary care hospitals in Bannu District may help identify gaps in education, training, and institutional support systems. The findings may also guide the development of evidence-based educational programs, strengthen institutional policies related to medication safety, and promote a culture of patient safety within healthcare facilities in the region.

Therefore, the present study aimed to assess the level of knowledge and self-reported practice of registered nurses regarding safe medication administration in tertiary care hospitals in Bannu District, Khyber Pakhtunkhwa, Pakistan, and to examine the association between nurses' knowledge and their medication administration practices.

METHODS

This study employed a descriptive cross-sectional observational design to evaluate the knowledge and self-reported practices of registered nurses regarding safe medication administration in tertiary care hospitals. A cross-sectional design was selected because it allows the measurement of knowledge levels, clinical practices, and their associations within a defined population at a single point in time without manipulating variables, making it appropriate for baseline assessments of healthcare practices and workforce competencies (11). Such designs are widely used in healthcare services research to identify gaps in professional knowledge and clinical practice that may inform future interventions and policy development.

The study was conducted in tertiary care hospitals located in Bannu District in the province of Khyber Pakhtunkhwa, Pakistan. These hospitals provide secondary and tertiary healthcare services to a large catchment population from Bannu and surrounding rural districts. Clinical services in these hospitals include inpatient medical wards, surgical units, pediatric wards, gynecology and obstetrics units, emergency departments, and intensive care units. The study was carried out over a six-month period from January 2026 to June 2026, which included the stages of study preparation, ethical approval, instrument validation, data collection, data analysis, and interpretation of findings.

The study population consisted of registered nurses working in inpatient clinical wards of tertiary care hospitals in Bannu District. The target population included nurses who were directly involved in medication preparation and administration as part of routine patient care. Nurses were eligible for participation if they held a valid license from the Pakistan Nursing Council, were currently employed in inpatient clinical wards, and had at least six months of experience in medication administration in hospital settings. Nurses working exclusively in outpatient departments, administrative positions, or non-clinical roles were excluded to ensure that the study population consisted of healthcare professionals actively engaged in medication administration. Nursing students, trainee nurses, and interns were also excluded to avoid potential bias related to limited clinical experience.

Participants were selected using simple random sampling to ensure that each eligible nurse had an equal probability of being included in the study. Lists of eligible nurses working in inpatient wards were obtained from hospital administrative records and ward registers. A sampling frame was constructed from these lists, and participants were randomly selected using a random number table. Selected nurses were approached during non-clinical hours or break periods to minimize disruption of patient care activities. The purpose of the study was explained to potential participants, and written informed consent was obtained before enrollment. Participation was voluntary, and nurses were informed that they could withdraw from the study at any stage without any consequences.

The required sample size was determined using the finite population correction formula for cross-sectional studies, taking into account the estimated population of registered nurses working in inpatient wards of tertiary hospitals in the district. A confidence level of 95%, an assumed proportion of 50% to maximize variability, and a margin of error of 5% were applied. The calculated minimum sample size was increased by an additional allowance to compensate for potential non-response. A total of 157 completed questionnaires were obtained, representing a response rate exceeding the minimum required sample for adequate statistical precision.

Data were collected using a structured, self-administered questionnaire developed based on previously published medication safety research instruments and international medication administration guidelines (3,7,10). The questionnaire consisted of three sections: socio-demographic characteristics, knowledge of safe medication administration, and self-reported medication administration practices. The socio-demographic section collected information on variables including gender, age group, educational qualification, ward type, and hospital type. These variables were included to explore potential associations between professional characteristics and medication safety knowledge and practices.

The knowledge assessment component consisted of six multiple-choice questions designed to evaluate core domains of medication administration safety. These domains included identification of the five rights of medication administration, essential safety checks prior to medication administration, required actions following medication administration, appropriate management of medication errors, recognition of high-alert medications, and

awareness of barcode medication administration systems. Each item had one correct response and was scored as one point for a correct answer and zero for an incorrect answer. The total knowledge score therefore ranged from 0 to 6. Adequate knowledge was operationally defined as a score of four or higher (≥60%), reflecting correct responses to the majority of knowledge items.

Self-reported practice of safe medication administration was assessed using six items measuring the frequency of key safety behaviors in clinical practice. These included verification of patient identity prior to medication administration, documentation of medications after administration, provision of medication-related information to patients, use of technological systems supporting medication safety, participation in training related to medication administration safety, and appropriate response actions following medication errors. Responses were recorded using a four-point Likert scale indicating frequency of behavior: always, often, sometimes, or never. For scoring purposes, responses indicating consistent adherence to safe practice behaviors were assigned one point, while other responses were assigned zero. The total practice score therefore ranged from 0 to 6. Adequate practice adherence was defined as a score of four or higher.

Content validity of the questionnaire was evaluated through review by three senior nurse educators and clinical experts with experience in medication safety and nursing research. The instrument was subsequently pilot tested among a small group of nurses representing approximately ten percent of the target population to assess clarity, comprehension, and feasibility. Feedback obtained during pilot testing was used to refine the wording of several items to ensure cultural and contextual relevance. Data collected during the pilot phase were not included in the final analysis.

To minimize potential sources of bias, several methodological precautions were implemented. Self-administered questionnaires were completed anonymously to reduce social desirability bias and encourage honest responses. Participants were instructed not to consult reference materials or discuss answers with colleagues while completing the questionnaire. Data collection was conducted during non-clinical hours to reduce time pressure and minimize interruptions that might affect responses. Random sampling of participants from multiple clinical wards was used to reduce selection bias and enhance representativeness of the nursing workforce in the participating hospitals.

Completed questionnaires were coded and entered into a statistical database using Statistical Package for the Social Sciences (SPSS) version 25.0 for analysis. Data cleaning procedures were performed prior to statistical analysis to identify inconsistencies, missing values, and outliers. Descriptive statistics including frequencies, percentages, means, and standard deviations were used to summarize socio-demographic characteristics, knowledge scores, and practice scores. Associations between categorical variables and levels of knowledge or practice were assessed using chi-square tests. The relationship between total knowledge scores and total practice scores was examined using correlation analysis to determine whether higher knowledge levels were associated with improved medication administration practices. The significance level of $p < 0.05$ was considered statistically significant.

Missing data were assessed prior to analysis, and cases with incomplete responses for key variables were excluded from specific analyses using pairwise deletion to preserve available data while minimizing bias. Subgroup analyses were conducted to explore potential differences in knowledge and practice according to educational level, gender, and clinical ward type. The statistical analysis plan was defined prior to data analysis to ensure methodological transparency and reproducibility.

Ethical approval for the study was obtained from the Institutional Review Committee of the Government College of Nursing in Bannu prior to commencement of data collection. All participants received written information describing the purpose of the study, procedures involved, and their rights as research participants. Written informed consent was obtained from all participants before questionnaire administration. Confidentiality and anonymity were maintained by assigning unique identification codes to questionnaires and by avoiding collection of personally identifiable information. Data were stored securely and were accessible only to the research team.

Several measures were implemented to ensure data integrity and reproducibility of the study procedures. Standardized instructions were provided to all participants during questionnaire administration to ensure consistent data collection conditions. Data entry was independently verified to reduce transcription errors, and statistical analyses were conducted according to a predefined analysis protocol. These procedures were implemented to maintain methodological rigor and to enable replication of the study in similar healthcare settings.

RESULTS

Across the sample of 157 registered nurses (Table 1), females comprised 63.7% (n=100) and males 35.0% (n=55), with 1.3% not specifying gender (n=2). Most participants were young adults, with 51.0% aged 25–29 years (n=80) and 43.3% aged 20–24 years (n=68); only 4.5% were ≥30 years (n=7). Educationally, the cohort was predominantly degree-prepared: 79.6% held a BScN (n=125) and 1.9% an MScN (n=3), while 16.6% had a diploma (n=26). Regarding clinical placement, 54.1% worked in general wards (n=85), 24.2% in emergency units (n=38), and 19.7% in ICU (n=31). Most nurses were employed in general hospitals (80.9%, n=127) compared with specialized hospitals (17.2%, n=27).

Item-level knowledge performance (Table 2) showed strong recognition of the foundational “five rights” of medication administration, with 83.4% answering correctly (n=131) and 16.6% incorrectly (n=26). Knowledge of high-alert medications was similarly high at 78.3% correct (n=123), and 74.5% (n=117) correctly identified essential requirements to be completed before administering medication. In contrast, knowledge gaps were prominent in domains requiring downstream clinical judgment and systems thinking: only 50.3% correctly identified all required post-administration actions (n=79), 47.1% correctly identified the benefits of barcode medication administration systems (n=74), and the weakest domain was medication error management, with only 37.6% selecting the complete correct response (n=59), leaving 62.4% incorrect (n=98).

When knowledge items were aggregated (Table 3), the mean total knowledge score was 3.71 (SD 1.18) out of 6. Using the prespecified adequacy threshold (≥4/6), 68.2% of nurses demonstrated adequate knowledge (n=107), while 31.8% were categorized as having inadequate knowledge (n=50). This distribution indicates that roughly two-thirds met the minimum competency benchmark, but nearly one-third did not, which is clinically meaningful given the risk profile of medication administration.

Self-reported practice adherence (Table 4) was strongest for documentation: 86.6% reported they always documented after administration (n=136), with small proportions reporting often (1.9%, n=3), sometimes (7.6%, n=12), or never (2.5%, n=4). Patient engagement behaviors were also reported at relatively high levels: 75.8% always informed patients about medications (n=119) and 73.9% always checked patient identity prior to administration (n=116). However, technology use was markedly lower and more variable, with only 35.0% reporting always using technology (n=55), while 19.7% reported often (n=31), 34.4% sometimes (n=54), and 9.6% never (n=15), indicating a substantial implementation gap in

technology-supported safety practices. Training exposure was moderate: 56.1% reported they always received training (n=88), 14.0% often (n=22), 22.3% sometimes (n=35), and 7.0% never (n=11). Medication error management behavior was assessed separately in the dataset narrative: 34.4% reported taking all recommended actions (inform physician, inform patient, and document) (n=54), whereas 54.1% reported informing only the physician (n=85), underscoring a practical shortfall consistent with the low knowledge performance observed for error management.

At the composite level (Table 5), the mean total practice score was 3.96 (SD 1.12) out of 6, and 72.6% met the adequacy threshold of ≥4/6 (n=114), compared with 27.4% categorized as inadequate (n=43). Notably, the adequate practice proportion (72.6%) exceeded the adequate knowledge proportion (68.2%), suggesting that some safety behaviors may be routinized institutionally even when underlying conceptual knowledge is incomplete—though this must be interpreted cautiously given self-reporting.

In bivariate association testing for knowledge adequacy (Table 6), educational qualification was the only variable demonstrating a statistically significant relationship. Degree-prepared nurses (BScN/MScN) had 71.1% adequate knowledge (n=91/128), compared with 61.5% among diploma-prepared nurses (n=16/26), and this difference was statistically significant (χ^2=8.34, p=0.004). By contrast, knowledge adequacy did not differ significantly by gender (female adequate 70.0% vs male adequate 67.3%; χ^2=0.21, p=0.644) or by ward grouping (ICU/Emergency adequate 71.0% vs general ward adequate 68.2%; χ^2=0.78, p=0.377), indicating broadly similar knowledge levels across these subgroups.

Table 1. Socio-demographic characteristics of participating nurses (n = 157)

Variable	Category	n	%
Gender	Female	100	63.7
	Male	55	35.0
	Not specified	2	1.3
Age group	20–24 years	68	43.3
	25–29 years	80	51.0
	≥30 years	7	4.5
	Not specified	2	1.3
Education	Diploma in Nursing	26	16.6
	BScN	125	79.6
	MScN	3	1.9
	Not specified	3	1.9
Ward type	General ward	85	54.1
	Intensive Care Unit	31	19.7
	Emergency	38	24.2
	Not specified	3	1.9
Hospital type	General hospital	127	80.9
	Specialized hospital	27	17.2
	Not specified	3	1.9

Table 2. Knowledge of nurses regarding safe medication administration (n = 157)

Knowledge domain	Correct response n (%)	Incorrect response n (%)
Identification of five rights of medication administration	131 (83.4)	26 (16.6)
Essential requirements before medication administration	117 (74.5)	40 (25.5)
Required actions after medication administration	79 (50.3)	78 (49.7)
Correct management of medication errors	59 (37.6)	98 (62.4)
Definition of high-alert medications	123 (78.3)	34 (21.7)
Benefits of barcode medication administration system	74 (47.1)	83 (52.9)

Table 3. Overall knowledge level of nurses (n = 157)

Knowledge level	n	%	Mean score ± SD
Adequate (≥4/6)	107	68.2	3.71 ± 1.18
Inadequate (<4/6)	50	31.8	—

Table 4. Self-reported safe medication administration practices (n = 157)

Practice domain	Always n (%)	Often n (%)	Sometimes n (%)	Never n (%)
Check patient identity before administration	116 (73.9)	16 (10.2)	14 (8.9)	9 (5.7)
Document medication after administration	136 (86.6)	3 (1.9)	12 (7.6)	4 (2.5)
Inform patient about medication	119 (75.8)	16 (10.2)	17 (10.8)	4 (2.5)
Use technology during medication administration	55 (35.0)	31 (19.7)	54 (34.4)	15 (9.6)
Receive training on safe medication administration	88 (56.1)	22 (14.0)	35 (22.3)	11 (7.0)

Table 5. Overall practice level of nurses (n = 157)

Practice level	n	%	Mean score ± SD
Adequate (≥4/6)	114	72.6	3.96 ± 1.12
Inadequate (<4/6)	43	27.4	—

Table 6. Association between demographic characteristics and knowledge level

Variable	Category	Adequate knowledge n (%)	Inadequate knowledge n (%)	χ^2	p-value
Education	BScN/MScN	91 (71.1)	37 (28.9)	8.34	0.004*
	Diploma	16 (61.5)	10 (38.5)		
Gender	Female	70 (70.0)	30 (30.0)	0.21	0.644
	Male	37 (67.3)	18 (32.7)		
Ward type	ICU/Emergency	49 (71.0)	20 (29.0)	0.78	0.377
	General ward	58 (68.2)	27 (31.8)		

Table 7. Association between demographic characteristics and practice level

Variable	Category	Adequate practice n (%)	Inadequate practice n (%)	χ^2	p-value
Education	**BScN/MScN**	95 (74.2)	33 (25.8)	1.12	0.290
	Diploma	19 (73.1)	7 (26.9)		
Ward type	**ICU/Emergency**	51 (73.9)	18 (26.1)	0.03	0.862
	General ward	63 (74.1)	22 (25.9)		
Hospital type	**General hospital**	92 (72.4)	35 (27.6)	0.16	0.692
	Specialized hospital	20 (74.1)	7 (25.9)		

For practice adequacy (Table 7), no examined demographic or workplace variable showed a statistically significant association. Adequate practice was similar by education (BScN/MScN 74.2% vs diploma 73.1%; χ^2=1.12, p=0.290), ward type (ICU/Emergency 73.9% vs general ward 74.1%; χ^2=0.03, p=0.862), and hospital type (general 72.4% vs specialized 74.1%; χ^2=0.16, p=0.692). These findings suggest that self-reported practice adherence is relatively homogeneous across the assessed strata, despite differences observed in knowledge by education.

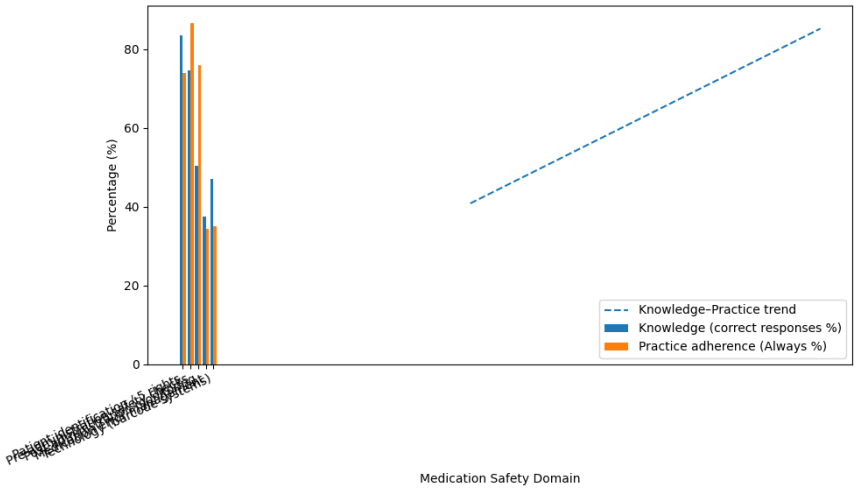

Figure 1 Knowledge–Practice Gradient Across Medication Safety Domains Among Nurses (N=157)

The figure illustrates the comparative gradient between knowledge correctness and corresponding practice adherence across five medication safety domains. Knowledge performance was highest for identification of the five rights of medication administration (83.4%), while the associated practice behavior—checking patient identity—was reported as consistently performed by 73.9% of nurses, indicating a 9.5 percentage-point knowledge–practice gap. Pre-administration safety knowledge was correctly identified by 74.5% of participants, while documentation after administration showed the highest practice adherence at 86.6%, suggesting that institutional routines may reinforce documentation behaviors beyond conceptual knowledge levels. In contrast, domains involving higher-order clinical judgment demonstrated marked deficits. Only 50.3% of nurses correctly identified required post-administration monitoring actions, although 75.8% reported consistently informing patients about medications, indicating a 25.5-point discrepancy between knowledge and communication behavior. The largest alignment between knowledge and practice deficits occurred in medication error management, where only 37.6% correctly identified the full error response protocol and 34.4% reported performing all recommended actions, reflecting a narrow but critically low safety margin. Technology-related competencies showed similarly low performance, with 47.1% demonstrating knowledge of

barcode medication administration systems and only 35.0% reporting consistent technological use. The overall domain-level trend demonstrates a positive knowledge–practice gradient consistent with the study's correlation findings (r = 0.54) but also reveals domain-specific asymmetry where institutional workflow behaviors (documentation, patient communication) outperform conceptual understanding, while system-dependent safety domains (technology use and error disclosure) remain consistently underdeveloped.

DISCUSSION

The present study examined the knowledge and self-reported practices of registered nurses regarding safe medication administration in tertiary care hospitals in Bannu District and explored the relationship between these two domains. Overall, the findings indicate that a moderate proportion of nurses demonstrated adequate knowledge (68.2%) and practice adherence (72.6%) related to medication safety. These findings align with previous studies conducted in comparable healthcare settings where nurses demonstrated moderate but not optimal levels of medication administration knowledge. For example, studies conducted in Kenya and Saudi Arabia reported adequate knowledge levels ranging from approximately 65% to 72% among hospital nurses, indicating that medication safety knowledge gaps remain a persistent concern in many healthcare systems (12,13). The findings of the present study therefore support the broader literature suggesting that while nurses possess foundational understanding of medication administration principles, significant gaps remain in more complex domains of medication safety.

A particularly encouraging finding of this study was the high level of awareness regarding the fundamental principles of medication administration. A large majority of nurses (83.4%) correctly identified the five rights of medication administration, indicating that core patient safety principles are well integrated into nursing education and clinical training in the study setting. Similar levels of awareness have been reported in studies conducted in other healthcare contexts, where knowledge of the five rights among nurses often exceeds 80% (14). This consistency across studies suggests that the five rights framework remains a widely taught and recognized cornerstone of medication safety practice. In addition, recognition of high-alert medications was relatively strong (78.3%), indicating that nurses are generally aware of medications associated with elevated patient safety risks.

Despite these strengths, the study revealed important knowledge deficits in areas that are critical for preventing and managing medication-related harm. Only 50.3% of nurses correctly identified the complete set of actions required after medication administration, and an even smaller proportion (37.6%) correctly identified the full protocol for medication error management. These findings are consistent with previous research indicating that nurses often have limited knowledge regarding post-administration monitoring and error disclosure procedures (3,8). Effective medication administration extends beyond the act of delivering medication to the patient and includes monitoring for adverse reactions, documenting outcomes, and responding appropriately when errors occur. Insufficient knowledge in these domains may increase the risk that medication-related complications are not detected promptly or that errors are inadequately managed.

Another notable finding was the relatively low level of knowledge regarding technological safety tools such as barcode medication administration systems. Less than half of the participants (47.1%) correctly identified the benefits of barcode medication administration. This result likely reflects the limited implementation of such technologies in many public hospitals in low- and middle-income countries, where financial and infrastructural constraints restrict adoption of digital health systems (15). Previous studies have shown that

when barcode medication administration and computerized prescribing systems are implemented effectively, they can significantly reduce medication administration errors by ensuring correct patient identification and verifying medication orders (10). However, the benefits of these technologies depend on both their availability and the competency of healthcare professionals using them.

The practice findings of the present study showed somewhat higher levels of adherence compared with knowledge scores. Approximately three-quarters of the nurses reported consistently following key medication safety practices such as verifying patient identity (73.9%), documenting medication administration (86.6%), and informing patients about medications (75.8%). The high adherence to documentation practices observed in this study may reflect institutional expectations and accountability systems that emphasize accurate clinical documentation. Documentation is a routine clinical requirement in most healthcare institutions and may therefore be more consistently practiced even when other safety behaviors are less consistently implemented. Similar findings have been reported in other studies where nurses demonstrated higher compliance with routine tasks such as documentation compared with more complex safety procedures (16).

However, the study also revealed substantial variation in practice behaviors related to medication safety systems. Only 35.0% of nurses reported consistently using technological tools during medication administration. This low level of technology utilization likely reflects structural limitations within the healthcare system rather than solely individual nurse behavior. In many resource-limited hospital settings, technological infrastructure supporting medication safety—such as barcode scanning systems or electronic medication administration records—may not be widely available or fully implemented. Previous research has shown that technology adoption in healthcare requires not only infrastructure investment but also training and organizational support to ensure successful implementation (15).

Medication error management practices also revealed concerning patterns. Only 34.4% of nurses reported taking all recommended actions when a medication error occurs, including informing the physician, informing the patient, and documenting the incident. In contrast, more than half of the nurses (54.1%) reported informing only the physician. This pattern suggests that open disclosure and documentation of medication errors may not be consistently practiced. Similar findings have been reported in other healthcare settings where fear of blame, lack of training in error disclosure, and hierarchical organizational cultures discourage comprehensive reporting of medication errors (8,17). A culture of patient safety requires the establishment of non-punitive reporting systems that encourage healthcare professionals to report errors and near-misses without fear of disciplinary consequences.

The results of this study also demonstrated a statistically significant positive correlation between knowledge and practice scores ($r = 0.54$, $p < 0.001$), indicating that nurses with higher levels of medication safety knowledge were more likely to report consistent adherence to safe medication administration practices. This finding is consistent with theoretical models of clinical competence that emphasize the role of knowledge as a foundation for safe clinical practice. Previous studies have similarly reported moderate correlations between knowledge and practice in medication safety research, reinforcing the importance of continuing education programs to strengthen nursing competencies (18). While knowledge alone cannot guarantee safe clinical behavior, adequate knowledge provides the cognitive framework necessary for informed decision-making during medication administration.

The analysis of demographic variables revealed that educational level was the only factor significantly associated with knowledge adequacy. Nurses with bachelor's or master's degrees demonstrated significantly higher knowledge levels compared with diploma-trained nurses. This finding aligns with existing evidence showing that higher levels of nursing education are associated with improved patient safety knowledge and better clinical decision-making (19). Degree-based nursing education programs typically include more extensive training in pharmacology, patient safety principles, and evidence-based practice, which may contribute to stronger knowledge of medication safety protocols. However, practice adherence did not differ significantly across educational groups or clinical wards, suggesting that institutional routines and workplace culture may standardize medication administration behaviors across staff regardless of educational background.

Several strengths of this study should be acknowledged. The study employed a systematic random sampling approach and achieved a high response rate, which enhances the representativeness of the findings for nurses working in tertiary care hospitals within the district. The use of structured assessment tools based on established medication safety principles also allowed for standardized measurement of knowledge and practice. However, several limitations must also be considered when interpreting the results. First, the assessment of practice behaviors relied on self-reported responses rather than direct observation, which may introduce social desirability bias. Nurses may report higher adherence to safety practices than what occurs in actual clinical practice. Second, the cross-sectional design limits the ability to establish causal relationships between knowledge and practice. Third, the study was conducted in a specific geographic region, which may limit generalizability to other healthcare settings in Pakistan or internationally.

Despite these limitations, the findings provide important insights into medication safety practices among nurses working in tertiary care hospitals in Bannu District. The results highlight both strengths and areas requiring improvement within the medication administration process. While foundational knowledge and routine safety practices appear reasonably well established, deficiencies remain in domains such as medication error management, post-administration monitoring, and technology-supported medication safety. Addressing these gaps will require a combination of educational interventions, institutional policy improvements, and investments in healthcare infrastructure to strengthen medication safety systems.

CONCLUSION

This study evaluated the knowledge and self-reported practices of registered nurses regarding safe medication administration in tertiary care hospitals in Bannu District, Khyber Pakhtunkhwa, Pakistan. The findings indicate that while a majority of nurses demonstrated adequate levels of knowledge (68.2%) and practice adherence (72.6%), important gaps remain in critical areas of medication safety. Nurses showed strong understanding of fundamental concepts such as the five rights of medication administration and recognition of high-alert medications; however, deficiencies were observed in knowledge and practice related to post-administration monitoring, medication error management, and the use of technology-supported medication administration systems. The study also identified a statistically significant positive relationship between knowledge and practice, indicating that improved knowledge levels are associated with better adherence to safe medication administration behaviors. Educational level was the only demographic factor significantly associated with knowledge adequacy, suggesting that higher levels of nursing education may contribute to improved medication safety competency. These findings highlight the need for targeted continuing education programs, simulation-based medication safety training, and

institutional policies that promote error reporting and safe medication practices. Strengthening medication safety systems, particularly through improved training and technological support, may contribute to reducing preventable medication errors and improving patient safety outcomes in tertiary healthcare settings..

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DECLARATIONS

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