ORIGINAL ARTICLE

Comparative assessment of high-risk cardiovascular medication knowledge between practising and student nurses: a descriptive multi-centre study

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ABSTRACT

Aim To examine unexplored knowledge of cardiovascular high-risk medications and perception thereof among practising nurses and students in the Kingdom of Saudi Arabia (KSA).

Methods The multicentre cross-sectional quantitative study used an online survey dichotomised into a knowledge test (true/false and multiple choice questions) and a perception assessment (closed-ended questions). Four hundred and eighteen nurses participated in the study.

Results In the knowledge test, 19 (4.5%) participants scored high ($\geq71\%$), while 83 (19.8%) and 316 (75.5%) demonstrated moderate (score ≥51-70%) and poor performance (score $\leq50\%$), respectively. In a comparative analysis, the knowledge level of staff nurses was significantly higher than the students but not the other nurses' cohort. Nurses' specialty and region of KSA were strongly associated with the knowledge level. Emergency room nurses and those belonging to the eastern region of KSA exhibited higher knowledge levels than other subgroups. A vast majority of nurses, 128 (30.6 %), rated their knowledge of medicines as somewhat sufficient, while quoting insufficient knowledge 226 (54.1%) as the major cause of medication errors. Three hundred and sixteen (75%) nurses expressed interest in undergoing specialised training in high-alert medication-based therapy preferably in a classroom setting by 279 (66.7%).

Conclusion This study revealed a marked knowledge deficit in high-risk cardiovascular drugs among nurses. The pharmacological curriculum in nursing schools should be tailored to be clinically oriented and reinforced with problem-based learning. Continued pharmacology education focusing on high-risk drugs should be implemented among nurses to safeguard patient lives by mitigating the risks of medication error.

Key words: cardiovascular drugs, curriculum, Kingdom of Saudi Arabia, nurses knowledge, nursing students

INTRODUCTION

Medication error (ME) is an extensively studied and serious patient safety concern in the contemporary healthcare system (1, 2). With the emergence of newer medications, polypharmacy, and multidisciplinary approaches to acute and chronic diseases, the hazard of ME has risen to disturbing levels (3,4). Despite its underreporting, especially in developing or underdeveloped countries, ME is estimated to be the most significant cause of preventable mortality, accounting for 2–5% of hospital admissions worldwide (5-8).

Studies have indicated that besides several environmental factors, such as inadequate staffing and unsuitable work conditions, human factors are the leading cause of ME, accounting for 65.2% (9-15). Among human factors (fatigue, distraction, and poor protocol adherence), deficits in the medication knowledge of healthcare professionals have also been repeatedly implicated as a major contributing factor for ME (6). Of all healthcare professionals, nurses are mostly held accountable for the ME because of their intimate involvement in medication management and time spent in direct patient care (16).

Numerous studies have demonstrated that deficiency in nurses' knowledge directly correlates with the high incidence of ME (17-20). Furthermore, the nurses' role in managing high-risk parenteral therapeutic agents in hospitalized patients is vital. High-risk drugs carry a considerable risk of adverse or even fatal consequences because of their narrow therapeutic margin (21). Cardiovascular drugs encompass a broad spectrum of high-risk medications, including inotropes, sympatholytics, diuretics, antiarrhythmics, vasodilators, and vasoconstrictors, and are reported to be the category of drugs most frequently involved in ME (22). According to the Adverse Drug Event Prevention Study Group, the odds ratio of adverse drug events with cardiovascular drugs is 2.4 times higher than that of other drugs (23). The high prevalence of cardiovascular diseases and concomitantly higher use of cardiovascular drugs account for the substantially higher proportion of ME associated with their use (24,25).

Like elsewhere, cardiovascular diseases are a leading cause of mortality (an estimated 42% of overall deaths) and have the highest disability burden in the Kingdom of Saudi Arabia (KSA) (25). A significant proportion of ME is related to cardiovascular and diabetic drugs, and 41.2% of ME diagnoses lead to hospitalisation in the country (26). Several researchers in the past have addressed ME issues and attempted to underscore their importance in patient safety matters (27-29). However, none, to our knowledge has evaluated the knowledge and competency of the hospital nurses in pharmacotherapy management. Neither did we find research addressing the quality of the pharmacology curriculum delivered to nursing students during their academic years. Hence, we intended this study to fill the research gap.

The aim of this study was to determine the current knowledge status of nurses in KSA in the administration, regulation, and monitoring of high-risk cardiovascular drugs, to evaluate the adequacy of the pharmacological curriculum offered in academic institutions, to identify nurse-reported factors leading to ME, to determine nurses' perception of and engagement in medication knowledge, and to identify the nurses' preferred method of continuing education.

PARTICIPANTS AND METHODS

Participants and study design

A web-based cross-sectional quantitative study was conducted among 292 working and 126 student nurses at eight different locations across KSA. The study was initiated in November 2020 and conducted for about a month. During this period only 83 responses were collected. However, owing to the outbreak of the coronavirus pandemic and the high work stress on working nurses, the study was paused. In October 2022, the study was launched again and conducted through May 2023. In total, 418 participants took part in this study.

The current total nursing population in KSA was 186,565, with 147,386 (79%) constituting Saudi nationals (30). The estimated sample size was obtained using the online Raosoft sample size calculator (31). A minimum of 385 participants were required at a margin of error of 5 with a 95% confidence interval at a 50% response distribution.

Head nurses in the major Ministry of Health Hospitals (MOH) in Al-Baha, Jeddah, Dammam, and Jizan areas were contacted with the purpose of the study. Head nurses distributed the participation request and the survey link via WhatsApp texts

among all eligible nurses. Nurses with a temporary contract (< 6 months) with the hospitals were excluded. To accelerate data collection, one text message reminder was sent to participants every 2 weeks. Responders were also requested to forward the link to their peer nurses in other hospitals. Student nurses in the universities of Imam Abdulrahman bin Faisal, Princess Noura, Rahman, and Jazan were contacted through their pharmacology course coordinators and were requested to fill out the survey after obtaining consent. Only final-year nursing students or those who had completed pharmacology courses were allowed to participate in the study. The survey took 12 minutes to complete.

A human subject ethical approval was received through the central institutional review board at the MOH (Reference no. 2019-0093E). All voluntary participants were verbally informed of the nature and purpose of the study and a written consent was obtained before test-taking. Responses were anonymous and no identifiable personal information was solicited or retained from the participants.

The questionnaire-based study model incorporated three sections besides the disclosure and the consent-seeking section: the demographic section, the knowledge section, and the perception-evaluating section.

The knowledge section consisted of a total of 34 questions; 18 true/false (T/F) questions (Q 1-18) adapted from an already published validated questionnaire (30). The original questionnaire was reinforced by an additional 16 multiple choice questions (MCQ) (Q 19-34), which were created and validated by our research team consisting of a pharmacologist, pharmacist, nursing supervisor, statistician, and a critical care physician. The perception questions from Hsaiso et al. (16) were modified to incorporate into this study.

The knowledge questions were formulated to test students' competency in high-risk drugs and electrolyte solutions commonly used in cardiovascular diseases. Specifically, the questions tested participants' knowledge of drug administration (Q 1-7), electrolyte uses (Q 8-11), storage/ regulation (Q 12-18), drug use (Q 19-24), contra-indications (Q 25-28) and side effect/drug monitoring (Q 29-34). High-risk cardiovascular agents included in the study were inotropes, sympatholytics, vasodilators, vasopressors, antiarrhythmics, and electrolyte solutions of pota-

ssium and calcium salts. Every correct answer was equal to one point, whereas an incorrect or "I don't know" response earned zero points. The percentage knowledge score was calculated as:

Because there was no prior data or predefined basal level of knowledge of the recently graduated or experienced nursing staff in KSA, the researcher used their judgement and expert opinion to classify the knowledge levels into three categories: low level ($\leq 50\%$); moderate ($\geq 51–70$ %) and high ($\geq 71\%$).

The second part of the study or nurses' perception was evaluated by a questionnaire containing four closed-ended questions. The questions were designed to assess nurses' self-perceived possible causes of ME (item 1), their knowledge status (item 2), their need for training in high-risk drugs (item 3), and nurses' preference for a mode of training (item 4). The research instrument was piloted with 25 respondents. The English language survey was created in an online Google form and an access link was generated for dissemination to participants.

Statistical analysis

Descriptive statistical methods were applied to summarize data on socio-demographic and knowledge tests. The demographic items and knowledge results were described by frequencies and/or percentages. Means and standard deviations (SD) were used to understand the dispersion or variability in the data. Cronbach's alpha for the instrument was calculated at 0.778 which is a good measure of internal consistency. In the perception section, Likert type scale (Sufficient, Somewhat sufficient, Fair, Insufficient, Extremely insufficient was used to estimate the nurses' self-rated knowledge of high-risk medications (32). Associations between socio-demographic and knowledge levels were evaluated by Pearson bivariate analysis. Knowledge difference among nurse subgroups was evaluated by one-way ANOVA. The knowledge level across various nurses' cohorts, one-way ANOVA with a 95% confidence interval and 5% marginal error was utilized. The level of statistical significance was set at $p < 0.05$.

RESULTS

Out of the 418 participants, 340 (81.3%) were females followed by their male counterparts, 78 (18.7%). Most of the participants, 178 (42.6%) be-

Table 1. Demographical data of 418 participants

Variables	No (%) of participants
Age (years)	
<25	178 (42.6)
26-30	106 (25.4)
31-35	75 (17.9)
≥36	59 (14.1)
Gender	
Female	340 (81.3)
Male	78 (18.7)
Education	
Diploma	58 (13.9)
Baccalaureate	323 (77.3)
Master and above	37 (8.9)
Experience (years)	
<1	126 (30.1)
1-5	105 (25.1)
6-10	89 (21.3)
11-15	60 (14.4)
≥16	38 (9.1)
Citizenship	
Saudi	306 (73.2)
Philippines	34 (8.1)
India	48 (11.5)
Egypt & Jordan	5 (1.2)
Pakistan	2 (0.5)
Other	18 (4.3)
Region	
Western area	54 (12.9)
Eastern area	139 (33.3)
Northern area	23 (5.5)
Southern area	116 (27.8)
Middle area	86 (20.6)
Hospital	
MOH	222 (53.1)
Teaching	13 (3.1)
Military	18 (4.3)
Private	39 (9.3)
I am a student- do not work	126 (30.1)
Position	
Staff Nurse	239 (57.2)
Head nurse	33 (7.9)
Clinical instructor	12 (2.9)
Student	134 (32.1)
Specialist area of work	
Adult ICU	119 (28.5)
Adult Medical & Surgical ward	38 (9.1)
ER	113 (27)
OB/GYN	17 (4.1)
None – I am a student	131 (31.3)
In the last 3 years have you taken any continuing education, or attended a conference or training event on medication therapy or high-alert medicine?	
Yes	230 (55.5)
No	188 (45)
Does your workplace offer training program in pharmacology, pharmacotherapy, safe medication administration or prevention of medication errors?	
Yes, and I attend them	156 (37.3)
Yes, but I don't attend them	53 (12.7)
No	87 (20.8)
I don't know	30 (7.2)
I am a student	92 (22)

MOH, Ministry of Health; ICU, Intensive Care Unit; ER, Emergency Room; OB/GYN, Obstetrics and Gynaecology.

longed to the age group of ≤ 25 years followed by the age group of 26-30 years, 106 (25.4%). Respondents held the highest degree of baccalaureate, 323 (77.3%) in nursing education alongside the highest experience of up to 5 years, 105 (25.1%) followed by 6-10 years, 89 (21.3%). Students were represented with 126 (30%) (Table 1).

Most participants were Saudi nationals, 306 (73.2%), followed by the Philippines. The greatest proportion of respondents, 139 (33.3%) participated from the eastern area, followed by the southern area with 116 (27.8%). In terms of the hospital, the majority, 222 (53.1%), belonged to MOH.

The largest population of our nurses were staff nurses, 239 (57.2%), followed by head nurses, 33 (7.9%). The most common specialty areas were intensive care units (ICU) accounting for 119 (28.5%), and emergency room (ER) for 113 (27.0%) (Table 2).

Table 2. Knowledge test results

Question type*	Question Goal	Correct (%)	Incorrect (%)	Knowledge level
Q1	Drug administration	40.4	59.6	41.5
Q2		36.4	63.6	
Q3		43.5	56.5	
Q4		49.8	50.2	
Q5		34.9	65.1	
Q6		53.8	46.2	
Q7		31.3	68.7	
Q8	Electrolyte use	33.7	66.3	41.7
Q9		43.3	56.7	
Q10		46.7	53.3	
Q11		43.1	56.9	
Q12	Storage/regulation	54.1	45.9	47.6
Q13		45.9	54.1	
Q14		40.0	60.0	
Q15		58.9	41.1	
Q16		38.8	61.2	
Q17		45.0	55.0	
Q18		50.5	49.5	
Q19	Drug use	23.9	76.1	34.3
Q20		53.3	46.7	
Q21		32.8	67.2	
Q22		19.6	80.4	
Q23		36.4	63.6	
Q24		40.2	59.8	
Q25	Contraindication	33.7	66.3	33.3
Q26		32.8	67.2	
Q27		30.4	69.6	
Q28		36.4	63.6	
Q29	Side effect/monitoring	34.9	65.1	26.2
Q30		25.6	74.4	
Q31		20.6	79.4	
Q32		37.3	62.7	
Q33		12.2	87.8	
Q34		26.8	73.2	

*participants' knowledge of drug administration (Q 1-7), electrolyte uses (Q 8-11), storage/ regulation (Q 12-18), drug use (Q 19-24), contra-indications (Q 25-28) and side effect/drug monitoring (Q 29-34)

The knowledge test analysis showed that overall 316 (75.5%) of our participants obtained a score <50% reflecting a low knowledge level, while 83 (19.8%) scored between 51-69 % and only 19 (4.5%) received a score of 70% or above, indicating, moderate and high knowledge, respectively.

The knowledge level of our participants in a specific domain was calculated by averaging all correct questions related to that domain. On average, the knowledge level was 41.4% in questions related to drug administration, 41.7% in electrolyte use, 47.6% in storage and regulation, 34.3% in drug use, 33.3 % in contraindications, and 26.2 % in side effects and monitoring. Overall, results demonstrate a low drug knowledge in all areas of pharmacology (Table 3).

Table 3. Overall knowledge level and significance according to the position

Position	No (%) of participants with knowledge level			Total	Mean (SD)	p
	Low	Moderate	High			
Staff Nurse	164 (68.6)	60 (25.1)	15 (6.2)	239	1.38 (0.601)	
Head nurse	25 (75.7)	8 (24.2)	0	33	1.24 (0.435)	
Clinical instructor	8 (66.7)	3 (25)	1 (8.3)	12	1.42 (0.669)	0.0001
Student	119 (88.7)	12 (8.9)	3 (2.2)	134	1.13 (0.403)	
Total	316 (75.7)	83 (19.8.7)	19 (4.5)	418	1.29 (0.545)	

The results showed a significant difference in knowledge level among different positions (p<0.001). A vast proportion of our participants depicted poor or low knowledge including students, 119 (88.8%), staff nurses, 164 (68.6%), head nurses, 25 (75.7%), and clinical instructors, eight (66.6%). Furthermore, multiple comparisons analysis showed that the knowledge levels of staff nurses, head nurses, and clinical instructors, were not statistically significantly different from each other. However, a significant knowledge gap with mean difference of 0.242 existed between staff nurses and students (Table 3).

Our analysis revealed that only three variables, age, specialty, and region of KSA were significantly associated with the knowledge level.

As for the region, 189 (6.5%) of respondents from the Eastern region demonstrated a high knowledge level and 105 (75%) showed low levels. Overall, the performance of respondents was superior compared to other regions of KSA

(Table 4). The corresponding asymptotic significance was reported as p=0.004, indicating a statistically significant association between the region and knowledge level at the conventional level of significance (p<0.05).

In specialised areas of work, ER nurses exhibited the highest knowledge score of nine (8%), followed by medical and surgical nurses, two (5.3%). The corresponding asymptotic significance was reported as p<0.001, indicating a significant association between specialized areas of work and knowledge level (approaching the conventional level of significance with a p<0.05) (Table 4).

Table 4. Association of knowledge and demographic characteristics

| Region	No (%) of participants with knowledge level			Total	p
	Low (Up to 50%)	Moderate (51-70%)	High (≥71%)		
Western area	49 (90.7)	3 (5.56)	2 (3.7)	54	
Eastern area	105 (17.5)	51 (17.5)	189 (64.9)	139	
Northern area	19 (21)	17 (17)	62 (62)	23	0.004
Southern area	74 (14.2)	31 (14.6)	151 (71.2)	116	
Middle area	69 (9)	7 (10.4)	54 (80.6)	86	
Total	316	83	19	418	
Specialist area of work					
ICU	107 (90)	10 (8.4)	2 (1.6)	119	
ER	72 (63.7)	32 (28.3)	9 (8)	113	
Medical & Surgical word	24 (63.1)	12 (31.5)	2 (5.2)	38	0.001
OB/GYN	14 (82.4)	3 (17.6)	0 (0)	17	
None-I am a student	99 (75.6)	26 (19.8)	6 (4.6)	131	
Total	316	83	19	418	

MOH, Ministry of Health; ICU, Intensive Care Unit; ER, Emergency Room; OB/GYN, Obstetrics and Gynaecology.

Perception data

In the perception section, nurses were asked four questions and their responses to the respective questions are as follows:

1. How do you rate your knowledge of high-alert medications

The results showed that 128 (30.6%) of the respondents rated their knowledge as "Somewhat sufficient," followed by 86 (20.6%) respondents who rated their knowledge of high-alert medications as "Sufficient" ; 103 (24.6%) rated their knowledge as "Fair.", and 65 (15.6%) considered their knowledge of high-risk medications as "Insufficient" and 36 (8.6%) rated their knowledge as "Extremely insufficient," indicating that they perceived their knowledge to be significantly lacking in the area of high-alert medications.
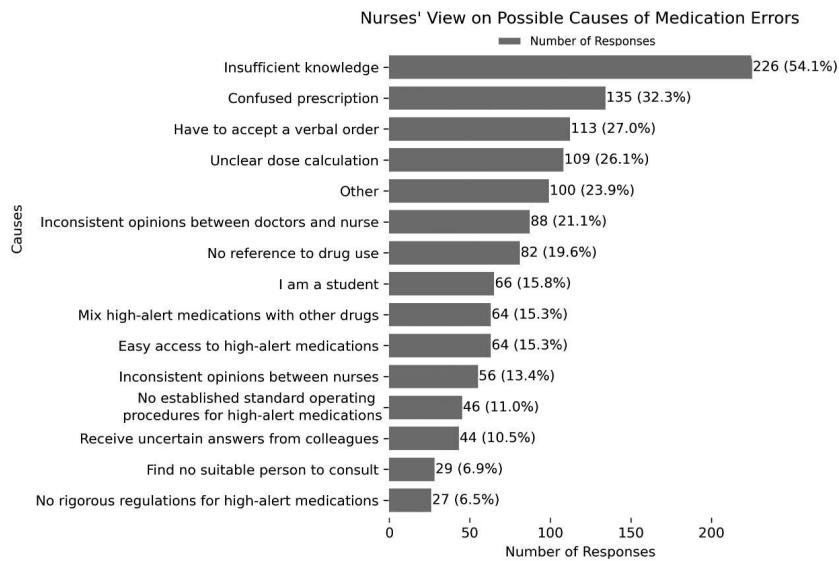
Figure 1. Nurses' views on possible causes of medication errors

2. What do you think is the most common cause for errors in high alert medication (HAM)?

Figure 1 provides insights into the respondents' perceptions of the most common causes of errors in high-risk medication. The figure lists different statements related to potential causes of errors, along with the corresponding number of responses and percentages.

Results showed that the most frequently cited cause of errors is "Insufficient knowledge," with 226 (54.1%) responses, followed by "Confused prescription," with 135 (32.3%) responses. Other notable causes included "Have to accept verbal order", 113 (27.0%), "Unclear dose calculation", 109 (26.1%), and "Other", 100 responses (23.9%). It is important to note that respondents could select multiple causes from the given options, which is why the percentages do not add up to 100%.

3. Do you think you need training in high-risk medication usage?

Individuals were questioned regarding the need for training in high-alert medication usage. A significant number of individuals, 316 (75.6%) responded affirmatively, stating that they believed they needed training in high-alert medication usage. In contrast, 53 (12.7%) responded with "No," indicating that they did not believe they required training in high-alert medication usage. Furthermore, 49 (11.7%) individuals responded with "I don't know," indicating uncertainty regarding their need for training in high-alert medication usage.

4. Which method of learning pharmacology would you prefer?

Participants of this study were inquired about the preferred method of learning. The respondents were asked to select multiple responses (that is why the response exceeded 100%). The findings revealed that the majority of the respondents valued the traditional approach to learning- that is classroom lectures (66.7%) – over online lectures (43.3%) and self-learning coaching (35.6%).

DISCUSSION

This multi-purpose study was primarily designed to investigate for the first time the existing knowledge and competency levels of hospital nurses in the pharmacological management of cardiovascular high-risk drugs as well as to identify nurses-perceived factors that may lead to ME in the developing healthcare system of KSA. Furthermore, the adequacy of the pharmacology curriculum taught during academic training was also evaluated by comparative data analysis of knowledge scores between students and working nurses.

The study revealed a marked knowledge deficit in all tested domains of pharmacology, drug administration, drug and electrolyte use, storage, regulation, drug monitoring, and side effects of high-risk cardiovascular drugs among nurses. The findings of this study correlated with other international studies that also showed a deficiency of medication knowledge among working

nurses (33-35). In a recent study at a tertiary hospital in Spain, critical care nurses earned an average score of 47% in a medication knowledge test involving commonly used drugs (29,33). Similarly, authors of a study from Pakistan reported mediocre performance on knowledge tests among registered nurses with 84% of nurses scoring below 70% (34). Previously, a United Kingdom-based study had also revealed a 34% score on insulin-related knowledge among nurses in a large teaching hospital (36). Altogether, theses studies showed nurses' lack of medication knowledge is a universal issue and KSA is not much different from the rest of the World. Nurses' poor competency in medication management and its serious implications as regards patient safety have been well documented and discussed in the literature for more than a decade. Surprisingly, despite raised alarms the global mortality rate secondary to ME continues to rise, possibly due to insufficient reporting by healthcare professionals (5-8, 37).

As far as the comparative knowledge analysis between working and student nurses is concerned, these data showed that nursing students' knowledge was markedly lower than that of the working nurses reflecting a gap in academic education. The literature review shows that all around the world nurses' academic education and training in pharmacotherapy have been called into question by clinical experts (38-39). In most nursing schools throughout the world, pharmacology is taught in a traditional lecture room setting (40). Students learn a plethora of drugs and their uses, mechanisms, side effects, contraindications, monitoring, and so on in a short span of two semesters. Logically, students are unable to retain the overwhelming amount of information by the time they graduate.

The latest academic research has proven the inefficacy of such a pedagogy method (41). Current education and learning models emphasize interactive, hands-on, collaborative, and experiential learning styles. Nursing students should be exposed to clinical problems and pharmacotherapy skills during their undergraduate years. The coursework should entail scenario-based practice sessions to allow the assimilation of pharmacology concepts and should also be tailored to cover therapy-related topics on high-risk drugs (42-44). Our data reiterate the need for an upgrade in the pharmacology curriculum in nursing schools.

Although working nurses performed better than students in this study, perhaps due to hands-on work experience, they also exhibited suboptimal performance. This knowledge deficit serves to indicate the immediate need for on-the-job educational intervention. Based on our study findings, we recommend that specialised pharmacotherapy educational programs or training workshops should be offered to hospital nurses to broaden their expertise in this area.

Given the nurses' exclusive role in patient care and the growing complexities of drug regimens, recently, there has been a growing demand to expand nurses' roles and responsibilities and integrate them into clinical decision-making as regards to patient pharmacotherapy care (38, 45). Nurses' antibiotic stewardship program has already been revised and implemented in many hospitals around the world (46). Nurses are empowered with specialised education and training in medication utilisation to cater to this expanded role (45, 47-48). Cardiovascular diseases are the number one cause of mortality worldwide (23-24). Thus, strong knowledge of the correct use of cardiovascular medicines among healthcare professionals, especially nurses, is imperative to ensure positive patient outcomes.

The Saudi healthcare system is ranked 26th in the world by the World Health Organization (49). Saudi health services have improved substantially in the past few years and continue to improve. A major challenge for Saudi healthcare has been a shortage of local health professionals. Up until recently, a bulk of the healthcare force constituted foreign nationals with tremendous variability in education level and experience. Under the Saudi Vision 2030 (50), local nurses are being hired to bring stability and improvement to the current system. The Saudi Joint Commission for Nurses has implemented international standards for the education and training of its nurses (51). At present, the commission does not offer any pharmacology-based continuing education courses, which explains the poor performance in the pharmacology test (52). The findings from this study will spark attention in this direction not only in the country but internationally.

This study has addressed a critical issue impacting patients' lives all around the World. Our data

consistent with other studies, emphasize a need to initiate on-the-job pharmacology training courses for nurses to enhance patient safety. An upgrade in pharmacology education in nursing colleges is also necessary based on our findings. For the first time in KSA, we have practically measured and reported a medication knowledge gap in the nurse community. The study was, however, limited to the nursing profession only. The overall safety of the health care system counts on knowledge and contribution by other professionals as well, and they should be invited to participate in future studies.

In conclusion, the outcomes from the current study revealed a knowledge deficit in high-risk cardiovascular drugs among students and nurses. Compared to student nurses, the responding staff nurses performed better. Based on these data, we recommend that interactive, problem-based teaching should be incorporated into pharmacology pedagogy courses at nursing colleges to improve student learning and retention. Nurses working with high-risk medications should be mandated to do specialised continuing education courses in pharmacotherapy to reduce the risk of ME and maintain patient safety.

TRANSPARENCY DECLARATION

Conflict of interest: None to declare.

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