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Nurses' knowledge of high-alert medications in a large-size university hospital

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Abstract

Objective: The objective of this study was to characterize the knowledge about high alert medications (HAMs) among nurses who work in an Intensive Care Unit (ICU). **Methods**: A cross-sectional study was carried out in February 2019. We included 100 ICU nurses and nursing technicians from an ICU of a large university hospital working at three works shifts through convenience sampling. The participants answered a self-reported questionnaire about self-assessment and experience with HAMs, obstacles when administering HAMs, administration knowledge, and clinical procedures involving HAMs. **Knowledge** was scored by correct answers (less than 70 points, from 70-89 and above 90). Descriptive analyzes were performed using relative frequency, mean and standard deviation, or median and interquartile range. Fisher's Exact Test was used to verify the associations between the score obtained and sociodemographic and labor variables, considering a significance level of 5%. The analyzes were performed using SPSS version 18.0.0. **Results**: The mean knowledge score for HAMs was 73.2 (±16.4); 36% of participants had a score of less than 70, 54% from 70 to 89, and 10% above 90. The main obstacles were oral order (50%), confused prescription (39%), and insufficient knowledge (35%). **Conclusion**: Only one in 10 professionals scored above 90 points, suggesting a fragile ICU care practice situation involving HAMS.

Keywords: potentially inappropriate medication list; medication errors; patient safety; knowledge; nursing; intensive care units.

Conhecimento de profissionais de enfermagem sobre medicamentos de alta vigilância em hospital universitário de grande porte

Resumo

Objetivos: O objetivo deste estudo foi caracterizar o conhecimento sobre medicamentos de alta vigilância (MAV's) entre profissionais da enfermagem que atuam em uma unidade de terapia intensiva (UTI). **Métodos:** Foi realizado um estudo transversal em fevereiro de 2019. Por meio de amostragem por conveniência, foram incluídos 100 enfermeiros e técnicos de enfermagem atuando na UTI de um hospital universitário de grande porte, nos três turnos de trabalho. Os participantes responderam questionário de autopreenchimento sobre auto avaliação e experiência com MAV's, obstáculos encontrados no processo de utilização, conhecimento sobre administração e procedimentos clínicos envolvendo MAV's. O conhecimento foi pontuado por meio de escores de acerto (menor que 70 pontos, de 70-89 e acima de 90). Foram realizadas análises descritivas por meio de frequência relativa, media e desvio padrão, ou mediana e intervalo interquartílico. O teste Exato de Fisher foi utilizado para verificar as associações entre o escore obtido e variáveis sociodemográficas e laborais, considerando um nível de significância de 5%. As análises foram realizadas no SPSS versão 18.0.0. **Resultados:** O escore médio de conhecimento de MAV'S foi de 73,2 (+16,4); 36% dos participantes apresentaram escore abaixo de 70, 54% de 70 a 89, e 10% acima de 90. Os principais obstáculos foram prescrição verbal (50%), prescrição médica confusa (39%) e conhecimento insuficiente (35%). **Conclusão:** Apenas um em cada 10 profissionais apresentaram escore acima de 90 pontos, sugerindo uma situação de fragilidade na prática assistencial na UTI envolvendo MAV's.

Palavras-chave: lista de medicamentos potencialmente inapropriados, erros de medicação, segurança do paciente, conhecimento, enfermagem, unidades de terapia intensiva.

Introduction

High-alert medications (HAMs), also described as high-risk or potentially dangerous drugs, are at greater risk of causing significant harms to the patient due to failures during use. The errors with these medications are not the most frequent ones, but their consequences tend to be more severe, with the possibility of causing permanent lesions or even death.[1-3]

Nearly 60% of the medication-related harms in hospitals is associated with HAMs, according to the Institute of Health Care Improvement (IHI) in the USA.[4] HAMs are distributed in different therapeutic classes, such as high concentration electrolytes, intravenous antiarrhythmic agents, oral and injectable hypoglycemic agents, antithrombotic agents, sedatives, anesthetics, agonists and adrenergic antagonists and neuromuscular blockers.[6] HAMs are especially important in ICUs and in emergency services, since their use is more frequent in these places;[7] in addition, errors involving medications in general tend to be more frequent in ICUs.[16-17] In the ICUs, the patients have different levels of severity, generally high, receive complex drug therapies (with a significant number of HAMs), undergo numerous procedures and have clinical instability. In these patients, the errors involving medications can imply more severe harms than in other hospitalization units.

Safety in the processes involving medications is a major global concern. Medication care encompasses a complex system of processes, involving multiple professionals; in this context, insufficient nursing knowledge about medications is considered one of the factors that contribute to the error, since this professional has a fundamental role in the medication administration process.[8]

Some research studies dealing with nurses' knowledge about HAMs has included professionals working in ICUs.[7,10,14] Zyoud *et al.*[7] verified higher knowledge scores among ICU nurses, compared to emergency, medical and pediatric units.[7] In opposition, Salman *et al.*[14] did not find significant differences in the scores across hospitalization units.[14]

Studies evaluating the knowledge, experience and other aspects related to HAMs by nurses are necessary to establish intervention measures aimed at preventing errors with HAMs, and to monitor the effectiveness of these measures. Few studies have specifically addressed the nurses' knowledge about this category of medications.[2,7,9-10,15]

The objective of this study was to characterize the knowledge about HAMs among Nursing professionals who work in an Intensive Care Unit (ICU).

Methods

A cross-sectional study was carried out in the Intensive Care Unit (ICU) of a tertiary-level hospital in southern Brazil with 100% public care. Of its 848 beds, 59 belong to the ICU for adults, one of the largest public networks in Brazil. At the time the study was conducted, 65 nurses and 210 nursing technicians were working in this unit.

Nursing technicians and ICU nurses from the three work shifts (morning, afternoon and night) from February 11th to February 28th, 2019, were invited to participate in the research. Sampling was by convenience.

Through self-completion, the participants answered a questionnaire freely adapted from Hsaio *et al.*[10] and Engels and Ciarkowsk,[2] which was tested on 5 professionals, before the final version. The questionnaire consisted of 16 questions to assess knowledge, experience and self-assessment related to HAMs, divided into three parts.

The first part contained 4 questions of self-assessment and experience of the professional with HAMs, containing multiple-choice questions about the obstacles encountered in the use process, the level of knowledge ("In your opinion, what is your level of knowledge about the high-alert medications?"), the importance of conducting training ("Do you think that it is important and necessary to carry out training on high-alert medications?") and participation in some error involving the HAMs ("Have you ever witnessed any type of medication error involving high-alert medications (either in this or in another institution?"). The answer options presented were the following: sufficient, relatively sufficient, reasonable, insufficient and extremely insufficient; subsequently, the sufficient and relatively sufficient alternatives were categorized as sufficient, and the others as insufficient.

The second part ("medication administration") had 6 questions about medication administration, with 'true', 'false' and 'I don't know' alternatives about daily situations involving prescription and storage of HAMs in a hospital inpatient unit.

The third part ("clinical procedures") contained 5 questions about effects on the organism resulting from the wrong administration of a HAM (containing 4 answer alternatives, only one being true), and a question about the relationship of a HAM with its antidote, totaling 5 HAMs.

A score of 6.25 was attributed to each of the 6 questions in the second part and each of the 10 questions in the third part, totaling 100 points. It is worth noting that the last question about HAMs and antidotes (belonging to the third stage) was broken down into 5 questions. The knowledge score was categorized as below 70, between 70 and 89 and equal to or above 90 points, according to Hsaio *et al.*[10]

The professionals' characterization was based on the following questions: work shift (morning, afternoon or night), gender (female and male), age (in years old), profession (nursing technician or nurse), time of experience in the profession (in years), profession practiced in the institution (nursing technician or nurse), time working in the institution (months and years) and if they worked in another institution (yes or no).

The data collected were entered into an Excel spreadsheet by two different typists, and the discrepancies were resolved after consulting the printed questionnaires. The analyses were performed in SPSS, version 18.0.0, and tabulated by means of descriptive analyses. The data were expressed by means of relative frequency, mean and standard deviation, or as median an interquartile range. Fisher's Exact test was used to verify the associations between the score obtained and sociodemographic and work variables, considering a significance level of 5%.

The research was approved by Research Ethics Committee of the Hospital (report 3.12.7.530). Each of the professionals who participated in the research received informed consent form in two copies, one of which was filed by the researchers. The questionnaires did not include information regarding the participants' names, thus precluding their identification.

Results

Of the 124 professionals approached in their workplace, 100 returned the completed questionnaire, 22 did not return it, and 2 refused to participate (response rate of 80.6%). The participants accounted for 36.4% of all the Nursing professionals working in the hospital's ICU.

The main characteristics of the sample are presented in Table 1. Most of the professionals were female (74.7%), belonging to the age group of 31 to 40 years old (55.7%) (36.78 ± 7.3), predominantly nursing technicians (62%) and with up to 10 years in the profession (55%) (11.0 ± 5.8).

The knowledge of HAMs score presented a mean of 73.2 (+16.4) and a median of 75.0 (interquartile range: 62.5-81.2). The minority of the respondents obtained a score of correct answers equal to or above 90 (10% of respondents); 54% obtained a score of correct answers from 70 to 89 and 36%, below 70. There were no statistically significant differences between the sociodemographic or work characteristics assessed and the knowledge score, with the exception of the profession. Among the interviewees who obtained scores equal to or above 90 points, 80% were nurses (p=0.001) (Table 1).

Table 1. Sociodemographic and labor characteristics and knowledge about HAMs scores of ICU Nursing professionals in a Brazilian public hospital (n=100).

		Score in three categories			
		<70	70-89	≥90	p-value**
Characteristic	**N (%)***	**N (%)**	**N (%)**	**N (%)**	
Gender					0.79
Female	74 (74.7)	25 (71.4)	41 (75.9)	8 (80.0)	
Male	25 (25.3)	10 (28.6)	13 (24.1)	2 (20.0)	
Age (years old)					0.739
20-30	18 (18.6)	7 (20.6)	8 (15.1)	3 (30.0)	
31-40	54 (55.7)	20 (58.8)	28 (52.8)	6 (60.0)	
41-50	20 (20.6)	5 (14.7)	14 (26.4)	1 (10.0)	
51-60	5 (5.2)	2 (5.9)	3 (5.7)	0 (0.0)	
Work Shift					0.956
Morning	35 (35.0)	11 (30.6)	20 (37.0)	4 (40.0)	
Afternoon	37 (37.0)	14 (38.9)	20 (37.0)	3 (30.0)	
Night	28 (28.0)	11 (30.6)	14 (25.9)	3 (30.0)	
Profession					0.001
Nursing technician	62 (62.0)	30 (83.3)	30 (55.6)	2 (20.0)	
Nurse	38 (38.0)	6 (16.7)	24 (44.4)	8 (80.0)	
Years in the Profession					0.677
Up to 10 years	55 (55.0)	19 (52.8)	29 (53.7)	7 (70.0)	
More than 10 years	45 (45.0)	17 (47.2)	25 (46.3)	3 (30.0)	
Working time in the institution					0.853
Less than 5 years	34 (34.3)	14 (40.0)	17 (31.5)	3 (30.0)	
5-10 years	47 (47.5)	14 (40.0)	28 (51.9)	5 (50.0)	
More than 10 years	18 (18.2)	7 (20.0)	9 (16.7)	2 (20.0)	

Note. HAMs = High-Alert Medications; ICU = Intensive Care Unit; * The variation in the total number of participants in the categories results from missing data related to each variable in question; ** p-value obtained in Fisher's Exact test

Table 2. Obstacles encountered by Nursing professionals in the administration of HAMs in the ICU of a Brazilian public hospital (n=100).

Obstacle	**%***
Reception of verbal prescription of medications	50
Confusing medical prescription	39
Insufficient knowledge	35
Absence of a defined standard operating procedure for high-alert medications	27
Incoherencies among health professionals	24
Lack of suitable professionals for any queries in case of doubts	20
Absence of strict control for high-alert medications	18
Ease of access to high-alert medications	18
Storing high-alert medications along with other drugs	15
Lack of bibliographic references for using the medication	13
Others	11

Note. HAMs = High-Alert Medications; ICU = Intensive Care Unit; *The total exceeds 100% because each professional could select more than one obstacle.

In the part of the questionnaire on self-assessment and experience, each professional selected an mean of 2.6 ± 1.9 answers among 10 obstacles listed for the administration of HAMs. Prescription-related obstacles accounted for 89% of the answers, followed by "insufficient knowledge" (35%) (Table 2).

Regarding self-perception about the level of knowledge about HAMs, 53% of the interviewees considered they had sufficient knowledge. Regarding the conduction of training on HAMs, 99% answered that they considered it important and necessary and 68.1% stated that they had already witnessed some type of medication error involving this category of medications.

In the questions about medication administration, the mean of correct answers was 3.3 ± 1.2, from a total of 6 questions. The rate of correct answers varied from 20% to 95%, as shown in Table 3.

Regarding the clinical procedures, the mean of correct answers was 8.4 ± 1.9, from a total of 10 questions. The rate of correct answers varied from 65% to 96%, as shown in Table 4.

Table 3. Knowledge of Nursing professionals about the management of HAMs in the ICU of a Brazilian public hospital (n=100).

Question	Answer	% Correct	% Incorrect
Using the terms "ampoules" or "vials" in the medical prescriptions	F	72	28
Using "IU" to substitute the word "unit" in the medical prescriptions	F	32	68
Storing heparin and insulin together to ease use	F	95	5
Warfarin has different concentrations to allow choice	F	20	80
10% Potassium Chloride must be stored in an easy-to-access place	F	83	17
Neuromuscular blockers should be stored in an easily accessible location for use in emergencies	F	33	67

Note. HAMs = High-Alert Medications; ICU = Intensive Care Unit; IU = International Unit; F = False

Table 4. Knowledge of Nursing professionals about clinical procedures involving HAMs in the ICU of a Brazilian public hospital (n=100).

Question	Correct answer	% Correct	% Incorrect
Consequence of insulin overdose	Diabetic coma	76	24
Consequence of opioid overdose	Respiratory depression	93	7
Consequence of anticoagulant overdose	Bleeding	94	6
Consequence of chemotherapy drug overdose	Bone marrow suppression	86	14
Consequence of intravenous electrolyte overdose	Cardiac arrhythmias	93	7
Antidote for insulin	50% glucose	96	4
Antidote for opioids	Malona	84	16
Antidote for neuromuscular blockers	Neostigmine	65	35
Antidote for anticoagulants	Vitamin K	79	21
Antidote for chemotherapy drugs	Filgrastima	71	29

Note. HAMs = High-Alert Medications; ICU = Intensive Care Unit

Discussion

This research addresses a little explored theme in Brazil and in the world, presenting data on the knowledge of nurses and nursing technicians about HAMs. These data, which demonstrate the weaknesses of the professionals, may contribute to changes in the hospital environment and encourage discussions on the subject matter in the academic and hospital environments.

The questions involving obstacles related to the prescription (verbal prescription and confusing medical prescription) and insufficient knowledge were the most highlighted by the participants. In a qualitative study conducted in the United States, the nurses interviewed reported that lack of knowledge is an important barrier to the safe use of HAMs. Of 18 nurses assessed, only 10 correctly described what HAMs are. Other barriers cited by nurses who contributed to errors were excessive workload and distractions, such as interruptions by family members and other health professionals.[11] According to Trbovich *et al.*,[12] the highest rate of interruptions referred to nursing colleagues (35.2%), followed by patients (29.6%) and, lastly, infusion pump alarms (20.4%).[12] In a systematic review by Queres *et al.*,[13] 13 of the 58 studies evaluated pointed out that minor mistakes and lapses at the time of prescription were frequent (53.7%), compromising the health status of the team due to stress, sleep deprivation, illness and fatigue.[13]

Although the institution under study has an electronic prescription system, the obstacles related to the reception of verbal prescription of medications were pointed out by 50% of the participants, similarly to what was verified by Hsaio *et al.*[10] (46.2%) and Salman *et al.*[14] (55,6%), but almost twice as much as that found by Zyoud *et al.*[7] (26.8%). The ANVISA recommends that, in urgent situations, verbal prescription can be made by the prescriber with name, dose and administration route of the medication. Whoever receives the verbal order must repeat what was requested and the prescriber must confirm. After the medication is administered, it must be prescribed to the patient immediately, and the double-check method for administration by verbal order must be used.[18] In the routine of an ICU, verbal prescription can be an important obstacle for the professionals who administer the medication due to the urgency in certain situations, where the patient has to be medicated quickly, and to the insecurity of the professional, resulting in delays in the administration of medications and management of incorrect doses to the patients.

The mean knowledge of HAMs score obtained in this study (73.2 + 16.4) was higher than in a pilot study conducted in São Paulo (63.6%),[9] in Korea (65%)[19] and in Pakistan (60%).[14] However, the mean presented in the São Paulo study refers to nurses and pharmacy students. In this study, 36% of the professionals obtained knowledge scores below 70 points, contrasting with results from previous studies.[7,10] In a study carried out in Taiwan hospitals, with a sample of 305 nurses, 70.5% obtained a score below 70,[10] similarly to the study carried out in Pakistan, in which 84% obtained scores below 70, from a sample of 2,363 nurses.[14] In the study by Zyoud *et al.*,[7] the percentage was 67.1%, verified in a sample of 280 hospital nurses in Palestine.[7] These differences can be partially explained by the fact that in the studies by Hsaio *et al.* (2010)[10] and by Zyoud *et al.* (2019),[7] only 15.1% and 25.4% of the nurses worked in ICUs, respectively. The others worked in inpatient, surgical, obstetrics and pediatric units, among others.[7,10] On the other hand, in a study on knowledge about HAMs carried out with 300 health professionals in three general hospitals in China, 72% of the participants (physicians, nurses, pharmacists and administrative staff) scored above 60; in this study, the nurses obtained a mean score slightly lower than that of the physicians and pharmacists.[15]

Despite the relatively high score found in our study, only 10% of the sample had high knowledge (score above 90 points), which is a cause for concern, especially due to the characteristics of the hospital where these professionals work. Bearing in mind that drug therapy in an ICU is complex, with the use of several HAMs, associated with the severity and clinical instability of the patients, the consequences of the incorrect administration of a HAM can be more serious.[16-17]

The questions that assessed the knowledge about HAM administration were related to medication prescriptions and storage. Among the questions that evaluated prescription knowledge, those that had the highest percentage of errors, the questions that stood out were those about the use of IU to replace the word unit (68%) and the question that the same medication (for example, warfarin) must have different concentrations to enable the choice (80%). In previous studies, the percentage of incorrect answers for the question about insulin ranged from 22.6% to 62.3%[7,9-10] and, for the question of multiple concentrations, it ranged from 11.9% to 43.6%.[7,9-10]

According to ISMP Brasil,[20] medication errors involving insulin, one of the top ten HAMs worldwide, can be associated with failure to interpret abbreviations; therefore, it is recommended not to use "U" or "IU" in the prescriptions. The abbreviation "U" can be mistaken by the number "0". The word "units" should be spelled out and computerized prescriptions should be preferred.[20] In Queres *et al.*,[13] the incorrect reading of labels, prescription and other documents also proved to be common, involving misunderstandings between names of medications, names of patients and packaging of medicines.[13] As for the same drug having different concentrations to choose from, the recommendation is to reduce to the necessary minimum the number of pharmaceutical alternatives (concentrations and volumes) of the same medication available in an institution.[6]

Among the questions that evaluated the storage of HAMs in the inpatient unit, the one that had the highest percentage of correct answers (95%) was the question about vials of heparin and insulin, both with doses prescribed in "units" and that should not be stored side by side. In previous studies that included the same question, the percentage of correct answers was 61.3%[10] and 65%.[7] The high rate of correct answers for this question can be explained by the identification of insulins in the hospital under study, which are labeled with the phrase "keep refrigerated", unlike heparin. In addition to that, these medications have been an important target of studies and recommendations related to patient safety worldwide.[6]

A study on HAMs prescription errors carried out in a Brazilian hospital, showed that 90% of the errors with HAMs were concentrated in nine medications, with heparin being the one that caused the most errors. The most frequent errors for heparin were omission of the pharmaceutical form and concentration, poor readability and incomplete concentration.[21] In a review of unfractionated heparin, Nicolai *et al.*[22] pointed out that this HAM is associated with high error rates and is among the ten medications with the highest number of errors reported with harms caused in patients in the United States.[22] In a study carried out in an emergency unit, Cabila *et al.*[5] found that the highest percentage of errors occurred with narcotics and sedatives, followed by antibiotics, anticoagulants, insulin, potassium chloride and other electrolytes, in addition to infusion pumps and immunosuppressants.[5]

The second question that obtained the highest percentage of correct answers (83%) concerned 10% potassium chloride, which must be identified with a label and must not be stored in an easily accessible place. The incorrect administration of concentrated potassium chloride solutions intravenously is one of the most frequent and addressed errors in the area of patient safety, whether in courses, training and in the work routine itself.[23] Concentrated solution packs are available in Brazil in the form of 10 ml and 20 ml ampoules and can be easily confused with ampoules of other electrolytes, water for injection, other solutions for reconstituting medications and even other injectable medications. Therefore, some special care measures are recommended in the storage and administration of this medication, such as defining which Nursing stations can store it and establishing special conditions such as differentiating and signaling the storage location of these ampoules, separating them from other hydroelectrolytic replacement ampoules. At the time of preparation and administration, double-check must be carried out, in addition to reading the labels before preparing the injectable solutions.[23]

The nurses obtained better scores than the nursing technicians. This result was expected, as professionals with more years of study and more qualified are expected to have more knowledge in their area of expertise and perform technical activities better.

As a limitation of this study, we highlight the self-administered questionnaire model, which does not allow questions to be answered with the interviewer when filling out the questionnaire. In addition to that, the participants may have asked for help from colleagues or sought information from other sources such as material available in the unit or on the Internet, although this type of conduct also occurs in real situations involving the issues addressed in the questionnaire. Finally, it is necessary to highlight that structural, cultural and professional training differences between the sample studied and that of other studies, in addition to methodological differences, may have influenced the results. The use of specific HAMs can differ between countries, hospitals and inpatient units, and may affect, to a greater or lesser extent, the knowledge scores obtained.

Conclusion

The knowledge presented by the professionals suggests a situation of fragility for patient care, especially if we consider that patients admitted to the ICU have severe clinical conditions and use of several medications, many of them being HAMs. Both training and the difficulty in participating in training courses for nursing technicians may have contributed to the lower rates of correct answers in this professional category. The risks are high, but may not be adequately addressed in the technical school courses and the overload in the workplace of this professional category, restricting the time for participation in training.

In consonance with other authors, we recommend the following actions to be implemented in the hospitals, in order to prevent errors with HAMs: 1) updating and disseminating the hospital's list of HAMs; 2) developing and implementing guidelines and protocols aimed at preventing and minimizing harms to patients affected by errors in the entire process of using HAMs, including prescription, dispensing, preparation, administration and storage; 3) improving the skills and means of communication between physicians, pharmacists, nurses and nursing technicians; 4) identifying HAMs in a different way, with alerts on the packaging; 5) performing double-checks on the dispensing, preparation and administration of HAMs; 6) including training on HAMs in Nursing schools; 7) promoting continuing education for professionals regarding HAMs. We also highlight the need for integrated multidisciplinary action among the professionals involved in the chain, specifically physicians, pharmacists and nursing professionals, in order to discuss best practices and ensure safety in the assistance provided to the patients.

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Collaborators

LNP participated in the conception of the project, data collection, data analysis and interpretation, and writing of the article. SC participated in the conception of the project and in the critical review of the intellectual content. ANP participated in the conception of the project, data collection and critical review of the intellectual content. FHM participated in the conception of the project and in the critical review of the intellectual content. TSS participated in the analysis and interpretation of the results and in the critical review of the intellectual content. TSDP participated in the conception of the project, analysis and interpretation of the results, and in the critical review of the intellectual content. The authors approved the final version of the manuscript and are responsible for all the information presented in the paper, ensuring the accuracy and integrity of any of its parts.

Conflict of interest statement

The authors declare that there are no conflicts of interest regarding this article

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