

Medication errors at intensive care units: nurses' knowledge and attitudes

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Medication errors are among the most frequent causes of adverse events in hospitals. They occur more frequently at intensive care units (ICUs) than other types of hospital departments.

Aim: The main objective of this study was to determine the level of nurses' knowledge about correct use of medications at ICUs.

Methods: A questionnaire regarding high-risk medications was used to evaluate nurses' knowledge, and the experienced administration errors were reported by nurses working at ICUs for adult patients.

Results: A total of 240 respondents participated in the research. As far as their knowledge, in 23 % was found sufficient and in 63 % relatively sufficient. University-educated nurses achieved an average grade of 1.86 while secondary-educated nurses achieved an average mark of 2.02 ($p < 0.05$). Less than 23% of respondents experienced medication error at their workplace and 5 % of the respondents admitted committing such error themselves.

Conclusions: While the knowledge of ICU nurses about medications is good, the reluctance to report medication errors remains apparent.

Key words: medication errors, nurses, questionnaire, pharmacology, knowledge.

Lékové chyby na jednotkách intenzivní péče: znalosti a postoje všeobecných sester

Lékové chyby patří mezi nejčastější příčiny nežádoucích událostí v nemocnicích. Na jednotkách intenzivní péče se vyskytují častěji než na jiných typech oddělení.

Cíle: Hlavním cílem této práce bylo zjistit úroveň znalostí sester o správném používání léčiv na jednotkách intenzivní péče.

Metodika: Ke zjištění znalostí všeobecných sester pracujících na JIP pro dospělé pacienty byl použit dotazník zaměřený na vysoce rizikové léky a dále byly zjišťovány jejich osobní zkušenosti s lékovými chybami.

Výsledky: Výzkumu se zúčastnilo 240 respondentů. Pokud jde o znalosti, u 23 % z nich byly hodnoceny jako dostatečné a u 63 % jako relativně dostatečné. Vysokoškolsky vzdělané sestry dosáhly průměrné hodnocení 1,86, zatímco středoškolsky vzdělané 2,02 ($p < 0,05$). Méně než 23 % respondentů uvedlo zkušenost s lékovou chybou na svém pracovišti a 5 % přiznalo vlastní lékovou chybu.

Závěr: Zatímco znalosti všeobecných sester o používaných lécích jsou dobré, zjevná zůstává neochota k oznamování lékových chyb.

Klíčová slova: lékové chyby, všeobecné sestry, dotazník, farmakologie, znalosti.

Introduction

Medication errors and adverse drug reactions are among the most frequent causes of adverse events in hospitals. These errors may lead to disability and death in up to 6.5 % of hospital admissions (1). Medication errors occur more frequently at intensive care units (ICUs)

than other types of hospital departments. Patients stay there for a longer time and most medications are given to them parenterally (2). Critically ill patients often require life saving treatments and are often exposed to medications with narrow therapeutic index. Therefore, caring for them requires special attention (3).

In the Sentinel Events Evaluation study (SEE), a snapshot of errors recorded on more than 200 ICUs, 10.5 medication errors were identified per 100 patient days, split about equally between prescription errors and administration errors (4). In the Critical Care Safety Study, medication errors counted for almost 78 % of all serious

Tab. 1. Didactic test

Question number	Question	Right answer		Value difficulty (Q)
1.	It is possible to arbitrarily replace an insulin syringe with a standard 2-ml syringe when administering insulin		NO	9.17
2.	Before opening, insulin must be stored in its storage bottle in a refrigerator (at a temperature of 2-8 °C)	YES		4.58
3.	7.5 % KCl can be stored in the pharmacy alongside other commonly available medications		NO	7.50
4.	1 ml of undiluted adrenaline can be administered intravenously for common allergic reaction (itching, redness, urticaria)		NO	7.50
5.	Calcium gluconicum 10 % can be used to replace Calcium chloratum Biotika 10 % in the case of shortage of the latter		NO	22.08
6.	When you dilute Thiopental 0.5 g into a 20-mL syringe, 5 ml will contain 0.1 g		NO	8.75
7.	Nurses can administer opioid analgesics into an epidural catheter		NO	80.83
8.	It is possible to dilute an antibiotic (e.g. gentamicin) in a balanced crystalloid solution for intravenous administration, e.g. Plasmalyte		NO	12.08
9.	Administration of crushed slow-release theophylline tablets into a nasogastric tube is considered the correct procedure		NO	12.50
10.	Unasyn 1.5 g (containing ampicillin and sulbactam) can be administered intravenously to a patient with an allergy to penicillin antibiotics		NO	12.08
11.	Intramuscular injection of FRAXIPARINE is contraindicated	YES		11.67
12.	Dyskinesia (e.g. Parkinson syndrome) can occur after intravenous administration of Degan	YES		25.83
13.	In the preparation of an infusion, furosemide may be mixed with pH-lowering agents, e.g. vitamin B		NO	7.92
14.	VUAB Hydrocortisone 100 mg is diluted for intravenous infusion using 4 mL of sterile water for injection		NO	37.50
15.	Another drug can be added into an infusion containing Helicid 40 mg for infusion		NO	9.17
16.	20 % glucose solution can cause venous irritation following peripheral administration	YES		5.00

mistakes. Nearly two-thirds of serious medical errors in ICUs occurred during the ordering or execution of treatments, especially medications (5). The consequences of medication error in critical care are often serious: according to Osmond et al., 9.8 % of medication errors require life-sustaining treatment (6).

Nurses play a key role in the prevention of the medication errors. Therefore, it is important to provide them sufficient information about the issue and adequate training in its prevention and reporting. They should be motivated to report medication errors without fear of any negative consequences (7, 8).

Currently, there are nurses with three different levels of education in the Czech Republic. The first level of education includes secondary nursing school. Nurses were educated at secondary nursing schools from 1950 s until 2004. Since then, only higher nursing schools or universities graduate general nurses. The second level of education is represented studying at higher nursing schools. Graduates of this type of education are awarded a certified specialist and entitled to use the designation nurse and allowed to work without supervision. The third level of education is the university degree in nursing. University graduates are receiving a Bachelor's or Master degree and are allowed to work without supervision.

Besides these educational levels, specialization courses for general nurses are also available at the National Centre of Nursing and Non-medical Health Professions. For the nurses' work at an ICU, it is recommended (but not absolutely necessary) to undergo specialization course in intensive care nursing.

Hitherto, many studies using the method of questionnaire survey to ascertain the knowledge of nurses about proper handling of medicines were published. Their methodology is of varying quality and often is focused on single type of medications or nurses of specific medical specialization. Also, these studies rarely compare the knowledge of nurses with different level of education. We believe that of high-quality methodology is the study by Lan et al., performed at the cohort of pediatric nurses (9). Therefore, we have considered useful to adapt methodology of this study for the survey focused on nurses working at ICUs for adult patients.

The main objective of this study was to determine the level of nurses' knowledge about correct use of medications at ICUs. The other objectives were to compare the differences of nurses' knowledge according to their education level and experience in the field, to determine the factors contributing to errors occurrence during the use of medications at IUCs and find out the prevalence of

these errors at IUCs at selected hospitals in the Czech Republic.

Methods

Sample of respondents

The research was conducted in selected hospitals in Olomouc, Zlín, South Moravia, Moravia-Silesia and Prague Regions. The research sample consisted of nurses working at hospital IUCs. Their highest education level was secondary nursing school, higher nursing school or university. Some respondents also have completed specialization course in intensive care nursing.

Questionnaire

Development and validation

A combination of quantitative and qualitative research was used for this study. Both types of research were performed by a questionnaire. The modified questionnaire published by Lan et al. (9) was used after adjustment to the field of intensive care nursing. This questionnaire was pilot tested and several items were adjusted based on the results of this preliminary research. Content and construct validity were applied to examine whether the 30 questions were appropriate and sensitive enough to differentiate knowledge levels.

In order to examine the importance, relevance and appropriateness of the questionnaire and to understand the reactions when answering questions, face validity was applied. Then the questionnaire was distributed in printed or electronic form through the staff and head nurses.

Part 1

The first part of the questionnaire, which included 7 items, was focused on demographic and factual data about the respondents. This part of the questionnaire examined the age, sex, length of experience, the highest education level, finished school/ university, completed specialization course in intensive care nursing, current position at the ICU (registered nurse, staff nurse or head nurse) and the type of the ICU.

Part 2

The second part of questionnaire consisted of the didactic test including 16 questions, focused to information about the level of nurses' knowledge on high-alert medications frequently used in critical care. List of High-Alert Medications that created ISMP was used for constructing questions (10). Results were evaluated using a standardized four-point grading scale. For each question, the value of difficulty (Q) was calculated. This value indicates the percentage of respondents who answered the question incorrectly or missed it. The question of high difficulty is defined by the Q greater than eighty. On the contrary, questions are considered easy when the Q value is lower than twenty. Didactic test is shown in Table 1.

Part 3

The third part of questionnaire, consisting of 7 items, focused on nurses' experience with the medication errors and self-assessment of their knowledge in this field. University graduated respondents were asked whether pharmacology courses, which they completed during nursing undergraduate curriculum, have provided a benefit for their practice.

Ethical considerations

The study design provided autonomy, giving nurses the freedom to decide whether to participate and provide information. A cover letter attached to each questionnaire explained that participation was voluntary and returned questionnaire signified consent. Participants were asked

not to place individual identifiers on the questionnaire to secure confidentiality. This research was approved by the deputy or managers of nursing care of each participating hospital.

Data processing

Data obtained from the questionnaires was processed in Excel tables and then imported into SPSS statistical software version 20.0. The differences in the occurrence of observed phenomena in nominal variables were tested using the chi-square test. The difference in test results between different education levels was tested using the independent sample t-test with Levene's test for equality of variances. Pivot tables were used for testing of qualitative data. The strength of the dependence of those variables was also tested using the chi-square test.

Results

A total of 240 respondents participated in the research. Nearly half of respondents (49.17 %) were older than 36 years of age. Respondents were predominantly female (92.92 %). All respondents general nurses at ICUs. Respondents with the working experience of 11 or more years were the most represented (45.00 %) in the sample. According to the level of education, the secondary nursing school graduates were most prevalent (40.83 %). A total of 55 % of respondents passed the specialization course in intensive care nursing at the National Centre of Nursing and Non-medical Health Professions. More detailed demographic and factual data are shown in Table 2.

The second part of the questionnaire consisted of didactic test with 16 questions. Four-point grading scale was used to evaluate the test. Each level of this classification had set-point margin. Respondent was awarded 1 point for each correct answer always. A total of 23 % of respondents received the best classification level (grade 1). The largest group of respondents passed the test with the classification grade 2 (almost 63 %). Less than 14 % of respondents obtained a classification grade 3. Only one respondent failed. Results of the didactic test are shown in Figure 1.

We also focused on diversity of results by highest educational attainment in assessing the didactic test. It was found that the results of graduates of secondary or higher nursing schools differs from that of university educated nurses. University-educated nurses achieved an

Tab. 2. Background and characteristics of nurses

Characteristics	n	%
Age (years)		
≤ 25	26	10.83
26–30	62	25.83
31–35	34	14.17
≥ 36	118	49.17
Sex		
Female	223	7.08
Male	17	92.92
Intensive care nursing practice (years)		
≤ 2	32	13.33
3–5	49	20.42
6–10	51	21.25
≥ 11	108	45.00
Education		
Secondary	98	40.83
Higher	56	23.33
University	86	35.83
Specialized education (PSS ARIP)		
Yes	133	55.42
No	107	44.58
Position		
Registered nurse	224	93.33
Staff nurse	13	5.42
Head nurse	3	1.25
Department		
Anesthesiology and Resuscitation Department	102	42.50
Internal medicine IUCs*	74	30.83
Surgical IUCs**	64	26.67

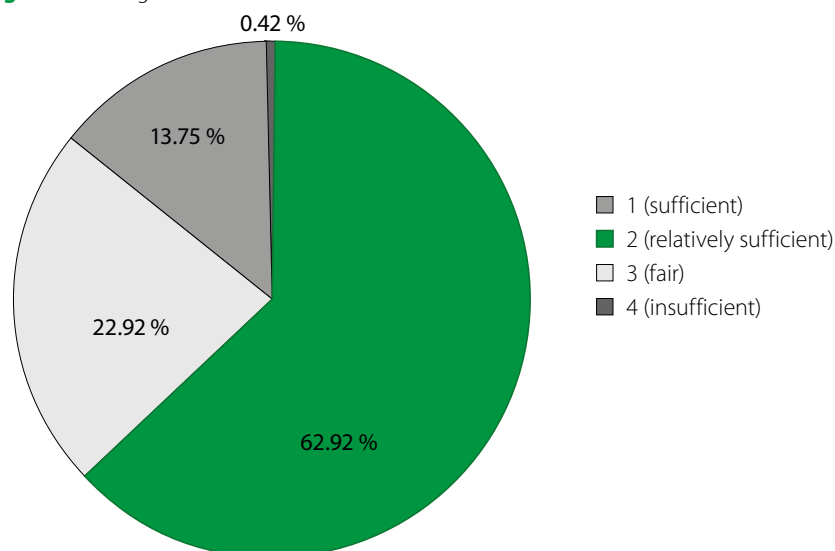
*Internal IUCs included: Hematology IUCs, Internal IUCs, Cardiology IUCs, Metabolic IUCs, Neurological IUCs, Department of Intensive Medicine

**Surgical IUCs included: Surgical IUCs, Cardiac IUCs, Neurosurgical IUCs, Obstetric-Gynecological IUCs, Trauma IUCs

average grade of 1.86 while secondary-educated nurses achieved an average mark of 2.02 ($p < 0.05$). More detailed results from a comparison of respondent groups among them are shown in Table 3. On the contrary, undergoing of the specialization course in intensive care nursing didn't affect the results of this test (1.93 and 1.90 for those with and without the specialization course, respectively, non-significant).

The third part of the questionnaire was focused on medication errors and nurses attitude to the benefits and needs of education in pharmacology. Respondents were asked whether any medication error occurred at their ICU and whether they made such an error themselves during the last 3 months at their workplace. Less than 23 % of respondents experienced medication error at their workplace and 5 % of the respondents committed the error themselves. We also investigated the relationship

Fig. 1. Knowledge level based on results of the didactic test



Tab. 3. Results of the didactic test by educational attainment

Education level			Grade of didactic test				Total
			1	2	3	4	
secondary education	Number		26	59	12	1	98
	% of category		26.53	60.20	12.24	1.02	100.00
	% of total		10.83	24.58	5.00	0.42	40.83
higher education	Number		15	35	6	0	56
	% of category		26.80	62.50	10.70	0.00	100.00
	% of total		6.20	14.60	2.50	0.00	23.33
university education	Number		14	57	15	0	86
	% of category		16.28	66.28	17.44	0.00	100.00
	% of total		5.83	23.75	6.25	0.00	35.83
Total	Number		55	151	33	1	240
	% of total		22.92	62.92	13.75	0.42	100.00

between the length of working experience and making medication errors. It was found that the length of work experience didn't play a role in the self-reported incidence of making medication errors (4.3 % vs 6.5 % incidence for those with less than 10 years of experience and those with 10 or more, non-significant). Furthermore, respondents had to choose three factors most contributing to the medication errors from the 9 proposed answers. The factors were most represented: inattention (27 %), increased workload (20 %) and inexperienced / new staff (16 %). Finally, university graduated respondents were asked whether pharmacology courses, which they completed during nursing undergraduate curriculum, have provided a benefit for their practice. Absolute majority (99.00 %) of responses were positive.

Discussion

The study „Medication errors in pediatric nursing: Assessment of nurses' knowledge

and analysis of the Consequences of errors" was the model on the methodology of this research (9). However, the model study examined the knowledge and the incidence of medication errors in pediatric intensive care. Our study examined the same issue in adult patients.

A total of 240 respondents participated in the research. Respondents were predominantly female (92.92 %). The age range was from 25 years to 36 years or more. Nearly half of respondents (49.17 %) were older than 36 years of age. The study also focused on the respondents' education level in nursing. Most respondents had secondary education. Nearly a quarter (23.33 %) had higher education and 36 % had a university degree, compared with 39 % in the study by Lan et al. (9). Nurses in the Czech Republic could also have a specialization course in intensive care nursing. There were 55 % nurses in our study which have had finished the course. Also some pediatric nurses (40.50 %) in

the abovementioned model study had similar specialization course (2014).

Most respondents had 11 years and more of experience (45.00 %). The least proportion of respondents had experience up to 2 years (13.33 %). Surprisingly, a previous study from Japan has revealed reverse dependence of error making on the length of practice (11). Experienced nurses made more errors than less-experienced nurses in that study. Authors of the study stated that there is the possibility that some medication errors occur due to preoccupation that nurses feel it is less necessary to explain and confirm everything related to medication administrations as their length of service increase. On the contrary, in our study nurses with longer experience didn't make the errors more often than less experienced nurses.

The didactic test was focused on the respondents' knowledge of the high-alert medications used frequently in the intensive care. The List of High-Alert Medications, guidelines issued by World Health Organization (Control of Concentrated electrolyte solutions) and the Summaries of Product Characteristics were used for formulating questions regarding high-alert medication used in critical care. Questions on antibiotics, vasopressors, glucocorticoids sedatives, anticoagulants, anti-ulcer drugs and solutions used for the fluid resuscitation were asked in the test. Most of these drugs are parenterally administered (12).

Results of the test were evaluated using a standardized four-point grading scale: grade 1 (sufficient) reached 22.92 % of respondents, 62.92 % reached grade 2 (relatively sufficient), 13.75 % grade 3 (fair) and 0.42 % grade 4 (insufficient). Pediatric nurses in a study of Lan et al. also achieved similar results (2014). The most difficult question in our questionnaire appeared to be if nurses can apply opioid analgesics into the epidural catheter. In this issue, the rate of incorrect answers was 80.83 %. A possible explanation is that some hospitals have created standards that intensify the competence of personnel, although the national regulations generally reserve this type of administration to medical doctors. Another two items with highest occurrence of errors were focused on the numerical abilities of respondents. In these issues, errors occurred in 8.75 % and 37.50 %, respectively. This type of mistake might have serious consequences during administration of parenteral drugs requiring dilution prior to administration with variable dosage according to the weight of the patient (13).

Tab. 4. Results of Part 3 of the questionnaire: nurses' experience with medication errors and self-assessment of their knowledge

Items	n	%
Self-estimated knowledge of pharmacology		
Inadequate	19	7.92
Satisfying	212	88.33
Great	9	3.75
Experience of medication error in the workplace		
Yes	69	28.75
No	171	71.25
Factors contributing to medication errors		
Inattention	172	26.88
Increased workload	130	20.31
Inexperienced (new) staff	103	16.09
Lack of knowledge	90	14.06
Understanding physicians' prescription	64	10.00
Other*	80	12.5
Experience of one's own error		
Yes	13	5.42
No	227	94.58
Benefit of a university course of pharmacology for intensive care practise		
Yes	58	67.44
No	28	32.56
Need for further education in the field of pharmacotherapy in intensive care		
Positive	231	95.25
Negative	9	3.75

*other factors included: lack of staff, complicated prescription, frequent staff changes, missing dose of the drug, changing work shifts, incorrectly written prescription

Differences of results of the didactic test between graduates of different levels of nursing education were also tested. As expected, it was found that the results of secondary or higher nursing schools graduates were significantly worse than that of university educated nurses. On the contrary, finishing the specialization course in intensive care nursing didn't affect the results of this test. Recent study by Bülbül et al. (14), focused on knowledge related with drug administration and drug administration errors, unexpectedly showed that undergraduate nurses were more successful in calculating doses. This may indicate that level of education might be less important factor than individual attitude or abilities of nurses.

In questions focused on medication errors, respondents were asked whether any such error occurred at their ICU and whether they made such an error themselves during the last 3 months at their workplace. Less than 23 % of respondents experienced medication error at their workplace and 5 % of the respondents made the error themselves. When we com-

pare the results with those from the study by Kim et al. (15), in which the misconduct admitted 63.6 % of respondents, our result is substantially lower. Unfortunately, it is not possible to ensure that respondents truly accountable to the items in the survey. Nurses are often afraid to report their own mistakes, because of potential consequences (16). Fear of punishment, reputational risk medical devices or nescience in the field of medication errors are the cause of the low number of reported errors in most cases. The solution might be the direct observation, which is the most objective method for error detection. However, this method of data collection was found difficult and costly (17, 18).

Furthermore, the respondents had to choose three factors most contributing to the medication errors from the 9 proposed possibilities. The most frequently reported causes were: inattention (26.88%), increased workload (20.31 %) and inexperienced or new staff (16.09 %). In the study by Tang et al. the same issues were found in the same

order - inattention was reported in 86.10 %, increased workload 37.50 % and new staff in 37.50 % (19).

The major limiting factor of this research was just its focus on the nurses' errors. Establishing cooperation with nurses was not easy; they generally did not feel comfortable with testing on their knowledge. They also did not admit that they could make a mistake that could harm the patient or believed that the reporting of such errors could result in a disciplinary action.

We believe that prevention of medication errors must be implemented in every part of the process of drug use. Registering and publishing cases of medication errors is not enough. It is necessary to discover the cause and determine the severity of these errors (20, 21). Primarily, it is necessary to uncover any risk behavior of the medical staff. Education of nurses in the pharmacology and/or clinical pharmacology is also an important intervention to prevent medication errors. This basic knowledge must be also strengthened by practical training (22). It is advisable to apply a multidisciplinary approach and involve pharmacists in preventing medication errors. Involvement of clinical pharmacists at hospital wards can reduce substantially the incidence of medication errors (23). Good undergraduate and continuous postgraduate education of nurses plays the most important role in preventing of medication errors.

Conclusion

Results of the research were quite satisfactory. Nearly 86 % of nurses achieved sufficient or relatively sufficient rating in the evaluation of their knowledge by the didactic test. The level of knowledge of university-educated nurses was significantly higher than that with secondary or higher education. On the other hand, the results of the didactic test were not different between respondents with or without a specialization in the field of intensive care nursing. The most effective way to avoid medication errors is prevention at all stages of the process of dealing with drugs, from their prescription to the monitoring of the patient's condition after their administration.

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