SJP Sarawak Journal of Pharmacy
Journal Homepage: http://jknsarawak.moh.gov.my/spj/

A pre- and post-intervention study on the knowledge of High-alert Medications (HAM) among staff nurses in Sarawak General Hospital (SGH)

Lie Jin Pang, Miaw Ling Liap, Wei Wern Khor, Nyuk Tsuey Liew, Wan Jing Pui, Mei Yih Li, Jia Min Long, Yiew Kiong Then, Jessie Wei Wei Ling, Anne Yee Lim, Muhammad Amirrul Mohamad Salleh, Nur Qamarina Abdul Aziz
Department of Pharmacy, Sarawak General Hospital, Sarawak

Corresponding author name and email: Lie Jin Pang (pang.liejin@moh.gov.my)

ABSTRACT

Introduction: Studies had shown that the leading factor contributing to medication administration errors in hospitals was inadequate knowledge. Fortunately, most errors did not cause harm to patients; those that did often involve high alert medications (HAMs). Hence, it is vital for nurses in charge of medication administration to acquire sufficient knowledge about HAMs. This paper aims to evaluate the effectiveness of an educational intervention in strengthening nurses' knowledge towards HAM in SGH.

Methods: We conducted a pre-post intervention study among nurses in SGH. An educational intervention on four main groups of high-alert medications (insulin, anticoagulants, adrenergic agonist agents and injectable Potassium Chloride) given. Their knowledge regarding these medications were assessed using a validated self-developed questionnaire. Participating nurses had to answer a similar set of questionnaire three times: just before the intervention (pre-test), right after the intervention (post-test 1) and four months later (post-test 2). The tests correspond to the measurement of current, immediate retention and long-term retention of knowledge respectively.

Results: A total of 105 staff nurses participated. The mean score difference for pre- and post-test 1 was 5.57 ($p<0.01$). However, the score of post-test 2 was lower as compared to post-test 1, with a significant mean difference of 3.31 ($p<0.01$). Nevertheless, the post-test 2 score was still higher than the pre-intervention score, with a mean difference of 2.26 ($p=0.003$). Years of service, age and educational background did not influence knowledge score. This result suggests that the intervention is useful in improving knowledge about HAM among nurses regardless of seniority nor education level, and improvement in knowledge score is still significantly sustained after four months.

Conclusion: The proposed intervention tool is appropriate and useful in improving knowledge about high alert medication among nurses. However, to ensure proper retention of knowledge, regular update on HAM from time-to-time is needed.

Keywords: High-alert Medications (HAMs), knowledge, nurses

INTRODUCTION

Medication safety is a significant concern and the issue of medication errors has been widely discussed by health professionals due to its potential to cause harm to patients (1-4). Medication error is defined as "any preventable event that may lead to inappropriate medication use or patient harm while the medication is in control of health professional, patient or consumer" (2). A study in 2012 which included 12 Ministry of Health (MOH) primary care clinics in Malaysia showed medication errors were the most common clinical management error, contributing about 41.3% of total errors (5, 6). The high alert medications such as medications for cardiovascular system and central nervous system were responsible for 54.9% of deaths in 496 fatal medication errors (7). In Sarawak General Hospital (SGH), the total number of near-miss medication errors are 569 cases, and the total number of actual medication errors are 89 cases in Year 2017. Thus, more research on medication safety were encouraged (8, 9).

Although the rate of medication errors occurring in hospitals is nearly one in every five doses, most errors do not harm patients (10). Harmful events are mainly due to injection of high-alert medications, and these remain the most problematic drugs associated with medication error (3). The Institute for Safe Medication Practices (ISMP) defines high-alert medications as drugs that bear a heightened risk of causing significant patient harm when used in error (3).

Based on studies from San Diego Patient Safety Council in the United States 2009, 34% to 49% are high alert IV medication administration error. Furthermore, 41% of the drug administration mortalities were associated with dosing errors. Dosing errors were by far the most common type of medication error at 28%. While 70% are ordering errors with only 6% of wrong dose errors occurring in the nurse administration stage. The second most common cause of administration errors was delivery problems and infusion pumps, which contributed 13%. Moreover, based on a study performed in Mangalore, India in 2012, 10-18% of all reported hospital injuries have been said to be caused by medication errors and nurses can be involved in the occurrence of these errors (11).

The Institute for Health Care Improvement's Five Million Lives Campaign found that emphasising on a few groups of high-alert medications such as anticoagulants, narcotics, sedatives, insulin and other specific medications have the most significant impact due to

their high volume of use coupled with inherent risks. Thus, they are responsible for most of the harm due to all high-alert medications (1). A review of medical event reports from the US national database showed that potassium chloride, heparin, xylocaine, and epinephrine (adrenaline) were the drugs most commonly involved in critical incidents (12).

Medication errors can occur at any stage (i.e., prescription, transcription, filling, dispensing and administering, monitoring the effects of a medication), but the administration stage accounts for the significant portion, and nurses have therefore been held responsible for a substantial number of errors (13, 14). It is mainly because medication administration is part of nurses' responsibility to ensure that patients receive the correct medication (9). Studies had shown that the leading factor contributing to administration errors was insufficient knowledge, which was about 44% (3, 15-17). Among the medication errors, the administration of an intravenous (IV) bolus push of a high-alert medication is one of the most significant factors contributing towards patient harm (2). A study on ten wards in two UK hospitals indicated that 95% of these administration technique errors were due to the dose being administered too quickly, leading to moderately severe harm to patients (18). According to a study about "Critical Care Nurses' Knowledge and Practice Regarding Administration of Selected Positive Inotropes at Cairo University Hospitals", the majority of critical care nurses had unsatisfactory knowledge level (87.1%), and unsatisfactory practice level (98.6%) regarding selected positive inotropic medications (11).

In a cross-sectional study done by Hsiao et al. at Taiwan in 2006, out of 305 nurse participants, only 3.6% of nurses considered themselves to have sufficient knowledge about high-alert medications, and 84.6% of them hoped to gain more training. Out of 184, the most prominent medication errors are wrong drug (33.7%) and wrong dose (32.6%). The leading obstacle for medication errors was still insufficient knowledge (75.4%) (19).

In order to assess the knowledge and practices of nurses concerning intravenous administration of potassium, a study in Turkey shows 61.9 of the 105 nurses did not know all the elements of a correct potassium order (20). The mean knowledge score was 9.48 (3.21), while the mean practice score was 10.85 (2.04), which was relatively low compared to the highest scores of both knowledge and practice about intravenous potassium administration (21). Intravenously administered potassium chloride and potassium phosphate are considered as high alert medication as they can cause ventricular tachycardia,

ectopic beats and ventricular fibrillation if administered erroneously. They suggested to develop protocols regarding intravenous potassium administration and adding this to the nursing curriculum or in-service training programs.

In short, there is a need to create awareness about the risk of high alert medications and develop comprehensive strategies to provide the latest knowledge about these medications to reduce medication error rate among all healthcare providers including nurses. The general aim of this research is to evaluate the effectiveness of an educational intervention in improving nurses' knowledge about high-alert medications in SGH. This research also aims to assess the current level of knowledge of nurses in SGH regarding HAM. On top of that, this study also intends to ascertain whether intervention effects would decay with the passage of a specific period.

METHODS

Study participants

We applied quantitative research method in this study (17). The study design was one sample group pre-test/post-test design. The population of this study was all registered nurses (including head nurses, matron and sisters) working in SGH wards; sample was those purposively chosen by their matrons to participate in our educational intervention. However, we excluded the nurses who were unwilling to consent participation in pre- and post-tests. Subject's participation in this study was voluntary. There were no replacements for the withdrawn subjects, but we included the data before their withdrawal.

Sample size determination

The total number of respondents was determined using power & sample size software (22). Prior data indicate that the difference in the response of matched pairs was normally distributed with a standard deviation of five. We believe that an average increase of five points out of a maximum of 30 per respondents (16.7% improvement) will be meaningful. Based on PS programme software, if the true difference in the mean response of matched pairs is five, we need to study ten pairs of subjects to be able to reject the null hypothesis that this response difference is zero with probability (power) 0.8. The Type 1 error probability associated with this test of this null hypothesis is 0.05. Our target was 100 nurses with the anticipation that some non-responses and losses to follow up was likely, especially during the second post-test.

Study intervention and instrument

The educational intervention was a Microsoft PowerPoint presentation prepared by study investigators and validated by five clinical pharmacists. Information used to prepare the presentation were from highly reliable tertiary source of references, including Micromedex, Lexicomp Drug Information and Medscape, as well as local Ministry of Health (MOH) guidelines such as Clinical Practice Guideline on Management of Type 2 Diabetes Mellitus (5th Edition), Guideline on safe use of High Alert Medications, Guideline of Handling Look-Alike, Sound-Alike Medications and Dilution Guide of High Alert Medications. Our educational intervention focused on four main groups of the high-alert medications: Insulin, Anticoagulants, adrenergic agonist agents and Injectable Potassium Chloride.

The presentation was given by a neutral presenter who had a bachelor degree in Pharmacy and five years of working experience in the clinical setting to reduce bias. The whole oral presentation took around one hour. Additional referral notes were not provided to the nurses to reduce bias while answering the questionnaire. Questionnaires on HAM based on the presentation were distributed to the nurses before the teaching session, right after the teaching session, and four months after the teaching session.

The questionnaire used is a self-developed questionnaire prepared by study investigators and validated by the same five clinical pharmacists. The questionnaires have two sections. The first section regarding personal information of the nurses participating in this study consisted of seven questions. The second section on the knowledge of high-alert medications consisted of 30 questions. This section aims to examine and assess the knowledge and understanding of nurses toward high-alert medications. The questions covered some of the standard practices (focuses on the medications' administration stage) and calculations regarding high-alert medications in the wards. Both pre- and post-test questionnaires were the same. We used close-ended and objective questions and awarded "1" mark for each correct response and "0" mark for incorrect response. The total score was determined by dividing the number of correct responses obtained by each subject by the total number of questions and expressed as a percentage (%). There was no passing or failing scores; however, HAMs are classified as an unacceptable level of knowledge if <50%, 50-79% as moderate, >80% as good.

As noted earlier, a pre-test was conducted immediately before the teaching session, and the first post-test (post-test 1) was conducted right after the session. The second post-test (post-test 2) was conducted four months post-intervention to study the long-term retention of knowledge. We collected contact number of nurses to minimise loss due to follow-up for the second post-test.

Statistical analysis

Data gathered was analysed using SSPS software version 22.0. Paired t-test was to assess the educational effectiveness by determining the statistically significant differences between the results of pre-, first and second post-test. Pearson Correlation was used to observe the correlation between years of service and age with the improvement of knowledge after intervention whereas Kruskal-Wallis test for the association between educational background and knowledge improvement after intervention.

Ethical consideration

Each questionnaire included a cover letter which explains the purpose of the study, the voluntary nature of the study, the anonymity of the response as well as the informed consent form. Respondent's confidentiality was assured, and we emphasised that they could withdraw at any stage of the study. We provide contact and address to allow further enquiries concerning the study (if any). We registered the current study with the National Medical Research Register (NMRR-17-965-35133) and ethical approval for this study was obtained from the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia.

RESULTS

A total of 105 staff nurses participated in this study. However, 66 participants were lost to follow up due to various reasons (maternity, further studies and transfer out of SGH) and unreachable contact numbers. The nurses were from various departments (Medical, Paediatric, Urology, Intensive Care, Psychiatric, Surgical, Emergency, and Obstetrics & Gynaecology) in SGH, with an average age of 32 ± 8 years and total year of service of 9 ± 8 years. Most of the participants are female (94.3%). Regarding the level of education, most of them completed high school (76.2%) and only a few obtained their degree (3.8%) and post-basic qualification (1.9%) (Table 1).

Table 1: Demographic characteristics (n=105)

Variables	n (%)	Mean (SD)
Age		32.92 (7.61)
Total year of service		9.46 (7.36)
Gender		-
Male	6 (5.7)	
Female	99 (94.3)	
Highest level of education		
Diploma	80 (76.2)	
Degree	4 (3.8)	
Masters	2 (1.9)	
Others	19 (18.1)	

SD=Standard deviation

Table 2: Mean and standard deviation for pre-test, post-test 1 and post-test 2

Variables	Pre-test, Mean (SD) n=105	Post-test 1, Mean (SD) n=41	Post-test 2, Mean (SD) n=41
Knowledge Score	19.24 (3.24)	24.84 (2.45)	21.26 (4.08)

Table 3: Change of knowledge scores (related to HAM) after intervention among 105 respondents

Comparison	Mean of score difference between Pre-test and Post-test 1 (95% CI)	*t*- statistics (df)	*p* value[a]
Post-test 1 - Pre-test	5.57 (6.14, 5.00)	19.28 (105)	< 0.01
Post-test 2 - Pre-test	2.26 (3.69, 0.83)	3.19 (41)	0.003
Post-test 2 - Post-test 1	-3.31 (-1.96, -4.66)	-4.97 (41)	< 0.01

a. Paired t-test

The knowledge score changed significantly from pre-intervention to both post-intervention ($p < 0.05$). We observed that Post-test 1 and Post-test 2 score are significantly higher than Pre-test score. However, we noted that the Post-test 2 score is significantly lower than Post-test 1.

Table 4: Influence of years of service over knowledge score differences

Variables	**n**	**Correlation Coefficient, *r***	***p* value[a]**
Pre-test - Post-test 1	105	- 0.125	0.208
Pre-test - Post-test 2	41	0.020	0.899
Post-test 1- Post-test 2	41	0.104	0.519

a. Pearson Correlation

There is no significant correlation between years of service of nurses and knowledge score differences over time ($p > 0.05$).

Table 5: Influence of age over knowledge score differences

Variables	**n**	**Correlation Coefficient, *r***	***p* value[a]**
Pre-test - Post-test 1	105	- 0.100	0.314
Pre-test - Post-test 2	41	0.021	0.896
Post-test 1- Post-test 2	41	0.091	0.569

a. Pearson Correlation

There is no significant correlation between age of nurses and knowledge score differences over time ($p > 0.05$).

Table 6: Comparing the influence of education level over knowledge score differences

Variable		n	Median (IQR)	x^2 statistics (df)[a]	p value[a]
Pre-test - Post-test 1	High School Degree Post-graduate Others	105	6 (4) 5.5 (-) - 6 (2)	0.611 (3)	0.894
Pre-test - Post-test 2	High School Degree Post-graduate Others	41	3(7) -1.5 (-) - -0.5 (6.75)	1.865 (2)	0.393
Post-test 1- Post-test 2	High School Degree Post-graduate Others	41	-2 (3) -7 (-) - -	3.672 (2)	0.159

a. Kruskal- Wallis Test

The medians of score difference is not significantly different ($p > 0.05$) for all education level. Hence, education level is not associated with the understanding and retention of knowledge for High Alert Medication.

DISCUSSION

In recent years, nurses in SGH have exposure to knowledge about HAM via a printed list of latest HAM. Good practices such as putting high alert stickers on HAM and separating look-alike sound-alike (LASA) medications using Tallman letterings were also enforced and further monitored by the Pharmacy Department during routine ward checks that were carried out every three months in various wards. However, as the turnover rate of nurses was high, it was unknown whether all nurses exposed regarding HAM as well as their knowledge levels regarding these medications. Thus, this study aims to emphasise the importance of HAM among nurses in SGH in order to reduce medication errors.

Based on the pre-test findings, the average score was 19, which showed that the nurses had moderate knowledge regarding HAM. After the teaching session, the average score of first post-test improved to 24 which indicated that the educational intervention tool was informative and effective. Even four months after the pre-test, the average score of second post-test was still higher than pre-test, which was 21. We expected the score of

the second post-test to be lower than the first post-test, as the nurses might not be able to retain the knowledge. Thus, we recommend teaching session as regular as every four months in order to enhance the knowledge. However, there were no studies on knowledge retention that we could find to make a comparison. Hence, more studies on knowledge retention are needed.

Years of service

Our result showed that the year of service does not significantly correlate with pre-interventional and first post and second post interventional test score among nurses in SGH after three months (p=0.208, p=0.899). In contrast, a randomised controlled trial done in Taiwan in 2009 (3) found that total nursing year significantly affect the pre-interventional score, this discrepancy might be due to the knowledge regarding high alert medication is not up to date or many related knowledge forgotten over the years. Most importantly, nurses did not attend any training in HAM before unlike those study in Min et al. in 2011, 25.9% of the nurses had undergone training for HAM. On top of that, this also expressed that the years of service do not affect the retention of post-intervention knowledge after three months, thus suggesting educational tool can be beneficial for all nurses even for those with more experiences. Therefore, we proposed to use the educational tools on a periodical basis to provide training for HAM for nurses or even staffs in SGH to ensure the knowledge is always up to date.

Age of nurses

According to our result, there is no significant difference between the age of nurses and pre- interventional and first post and second post interventional test score ($p > 0.05$) in SGH. Age does not influence the knowledge on high alert medication. Therefore, periodical training or education program on high alert medication is needed for all ages of healthcare personnel to improve patient medication safety. This finding concurred those of Loo et al. in 2016, where age of the nurses is not one of the factors affecting the knowledge of nurses on high alert medication in Hospital Kanowit, Sarawak as both age and year of service were highly collated after the multicollinearity test (23).

Furthermore, we found that there is no significant correlation between age and retention of knowledge across the three months, which indicates that this educational tool can be beneficial across all ages and it is understandable regardless different level of age

groups. Thus, it is essential to implement this educational tool into the training programs in all age groups to ensure their knowledge on high alert medications are always up-to-date in order to prevent medications error related to high alert situations which in turn, improving patient's quality of life.

Education background

Based on our results, we found that previous education level does not affect the pre- and post-interventional test score (refer table 6, $p>0.05$). This result was similar to the study done by Min et al. in 2011, which showed that there are insignificant differences between different education degree ($p=0.179$) (3). Besides, based on another study done by Lan et al. in 2014, nurses with higher nursing degrees (bachelor) were not more knowledgeable about pharmacology than nurses with lower nursing degrees (associate degrees) ($p=0.52$). Thus, based on our studies, regardless of the education background, continuous provision of in-service training for all nurses to maintain the required level of knowledge regarding HAM is necessary. HAM knowledge benefits from previous high-school learning may not apply to the practical working experience.

Based on studies done by Ahmed et al. in 2015, implementation of a comprehensive educational program as well as individual nurse training of preparation and administration procedures could reduce the medication administration errors by 37%. Wrong administration rate reduced by 23% and 12% for both minor and moderate harm, respectively (24).

LIMITATIONS

There are a few limitations in this study. Firstly, the sampling method applied was purposive sampling. Therefore, not all nurses had equal opportunity to be part of the research, study findings may not be as representative of the population. Second, many participants dropped out during the second post-test. Upon investigation, some of the participants were on maternity leave, and some transferred out of the hospital. Other participants did not have a specific reason but were not cooperative. Many participants achieved a lower score during the second post-test, thus reflect the knowledge retention of nurses over time that can be used as a guide to improve the study.

CONCLUSION

Overall, the educational intervention on high alert medication is effective; however, retention of knowledge decreases with time. Multiple refresher course on HAM is required to ensure nurse's knowledge on HAM is updated.

CONFLICT OF INTEREST

The investigators declare no conflict of interest. No external sponsorship is involved in this study.

ACKNOWLEDGEMENT

We would like to thank the Director-General of Health Malaysia for his permission to publish this article. We thanked Mr Kho Boon Phiaw and Clinical Research Centre SGH for assistance with this write-up and for comments that improved the manuscript.

REFERENCES

1. U.S. Department of Health & Human Services partnership for patients. Implementation guide to reducing harm from high-alert medications.
2. Tsai-Feng Lo. Shu Yu. I-Ju Chen. Kai Wei K. Wang. Fu-In Tang. Faculties' and nurses' perspectives regarding knowledge of high-alert medications. Nurse education today. 33 (2013) 214-221.
3. Min-Chin Lu. Shu Yu. I-Ju Chen, Kai Wei K. Wang, Hsiang-Feng Wu, Fu-In Tang. Nurses' knowledge of high alert medications: A randomized controlled trial. Nurse Education Today 33 (2013) 24-30.
4. Benjamin DM (2003) Reducing Medication Errors And Increasing Patient Safety: A Case Studies In Clinical Pharmacology. Journal of Clinical Pharmacology 43, 768-783.
5. Teoh BC. Alrasheedy AA. Hassali MA. Tew MM. Samsudin MA. Perceptions of Doctors and Pharmacists towards medication error reporting and prevention in Kedah, Malaysia: A Rasch Model Analysis. Advances in Pharmacoepidemiology & drug safety.
6. Ee Ming Khoo. Wai Khew Lee. Sondi Sararaks. Azah Abdul Samad. Su May Liew. Ai Theng Cheong. Medication errors in Primary care clinics - a cross sectional study. BMC family practice 2012.

7. Phillips, J., Beam, S., Brinker, A., Holquist, C., Honig, P., Lee, L.Y., Pamer, C., 2001. Retrospective analysis of mortalities associated with medication errors. American Journal of Health-System Pharmacy 58, 1835–1841.
8. Institute for Health Systems Research (2008) August 19th 2008. Available from: http://www.ihsr.gov.my/evipnet_on.php#ssub7
9. Hariati Johari. Fatihah Shamsuddin. Norziyana Idris. Ahla Hussin. Medication errors among nurses in government hospital. IOSR Journal of Nursing and Health Science (IOSR-JNHS). ISSN: 2320-1959. ISBN: 2320-1940 Volume 1, Issue 2 (Jan-Feb. 2013).
10. Barker, K. N. Flynn, E. A. Bates, D.W. Mikeal, R. L, 2002. Medication errors observed in 36 health care facilities. Archives of Internal Medicin 162 (16). 1897-1903.
11. Amr Zaher Rady Y, Warda Yousef M, Fatma Shoeib A, Essam Fouad A. Effect of Nursing Education Guidelines about High Alert Medications on Critical Care Nurses Knowledge and Practices. ISOR Journal Of Nursing and Health Science. 7(1), 47-54.
12. Edgar. T.A, Lee, D. S., Cousinsm D. D. 1994. Experience with a national medication error reporting program. American Journal of Hospital Pharmacy 51, 1335-1338.
13. Santell, J.P., Hicks, R.W., McMeekin, J., Cousins, D.D., 2003. Medication errors: experience of the United States Pharmacopeia (USP) MEDMARX reporting system. Journal of Clinical Pharmacology 43, 760–767.
14. Goeckner, B.,Gladu, M., Bradley, J., Garmon, S.C., Hicks, R.W., 2006. Differences in perioperative medication errors with regard to organization characteristics. AORN Journal 83, 351–352, 355–362, 365–368.
15. Philips, J., Beam, S., Brinker, A Holquist. C., Honig. P., Lee, L.Y. Pamer, C., 2001. Retrospective analysis of mortalities associated with medication errors. American Journal of Health-System Pharmacy 58. 1835-1841.
16. Tang, F.I., Sheu, S.J., Yu, S., Wei, I.L., Chen, C.H., 2007. Nurses relate the contributing factors involved in medication errors. Journal of Clinical Nursing 16, 447-457.
17. Winterstein. A.g., Johns, T.E. Rosenberg, E. I. Hatton, R.C., Gonzalez-Rothi, R., Kanjanarat, P., 2004. Nature and causes of clinically significant medication errors

in a tertiary care hospital. American Journal of Health-System Pharmacy 61(18), 1908-1916.

18. Taxis. K., Barber, N., 2003b. Ethnographic study of incidence and severity of intravenous drug errors. British Medical Journal 326 (7391), 684.
19. Ghi-Yin, I-Ju Chen, Shu Yu, Len-Lan Wei, et al., Nurses' knowledge of high Alert medications: instrument development and validation. Journal of Advanced Nursing, Feb 2010:177-190.
20. Ayşegül, A. and Senol Celik, S. Knowledge and practices of nurses concerning intravenous potassium administration in a Turkish hospital. Australian Journal of Advanced Nursing.
21. Creswell, J. (2003). Research design: Qualitative, quantitative and mixed methods approaches (2nd ed.). Thousand Oaks, CA: SAGE Publications.
22. PS: Power and Sample Size Calculation software. Available from: https://en.freedownloadmanager.org/Windows-PC/PS-Power-and-Sample-Size-Calculation-FREE.html
23. Loo, S. (2016). Assess the effectiveness of interventions on Knowledge of Nurses towards High Alert Medications (HAMs) in Hospital Kanowit. Sarawak Journal of Pharmacy, pp.79-101.
24. Ahmed A, Soraya D, Mark J, Maisoon G. Systematic Literature Review of Hospital Medication Administration Errors in Children. Integrated Pharmacy Research and Practice. *2015*(4), 153-165.