

Development of a high alert intravenous medication database system (HAIMDS) for health care professionals in Thailand

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Development of a high alert intravenous medication database system (HAIMDS) for health care professionals in Thailand

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บทคัดย่อ:

วัตถุประสงค์: การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อพัฒนาระบบฐานข้อมูลของยาที่มีความเสี่ยงสูง (high alert intravenous medication database system; HAIMDS)

วัสดุและวิธีการ: งานวิจัยครั้งนี้เป็นแบบสำรวจเชิงประยุกต์ ซึ่งการพัฒนาระบบฐานข้อมูลประกอบด้วย 4 ขั้นตอนดังนี้คือ 1) รวบรวมข้อมูลของยาที่มีความเสี่ยงสูงจากแหล่งข้อมูลต่างๆ เช่น ปรจุมภูมิ ทุติยภูมิ ตติยภูมิ และข้อมูลออนไลน์ 2) ออกแบบหน้าจอบทบาทผู้ใช้ของฐานข้อมูล 3) ออกแบบฐานข้อมูล 4) พัฒนาแบบสอบถามทัศนคติเกี่ยวกับระบบฐานข้อมูล HAIMDS ขั้นตอนการพัฒนาฐานข้อมูลที่กล่าวมาทั้งหมดถูกดำเนินการโดยทีมผู้วิจัย ระบบฐานข้อมูลดังกล่าว (HAIMDS) พัฒนาขึ้นสำหรับบุคลากรการแพทย์ เช่น พยาบาลและเภสัชกร ซึ่งเกี่ยวข้องกับขั้นตอนการเตรียม

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และบริหารยาที่มีความเสี่ยงสูง กลุ่มตัวอย่างในการศึกษาเป็นเภสัชกรโรงพยาบาลจำนวน 15 คน จากโรงพยาบาลต่างๆ ในเขตจังหวัดอุบลราชธานี โดยเภสัชกรทดลองใช้ฐานข้อมูลดังกล่าว จากนั้นทำการกรอกแบบสอบถามเกี่ยวกับทัศนคติเกี่ยวกับระบบฐานข้อมูล HAIMDS และจัดส่งแบบสอบถามกลับไปให้ผู้วิจัย ข้อมูลการศึกษาจะถูกนำไปวิเคราะห์เชิงสถิติต่อไป

ผลการศึกษา: ระบบฐานข้อมูล HAIMDS ที่พัฒนาขึ้นประกอบด้วยข้อมูลยาที่มีความเสี่ยงสูง 10 ชนิด ผลการศึกษาพบว่าทัศนคติของกลุ่มตัวอย่างส่วนใหญ่พึงพอใจกับโครงสร้างและหลักการทำงานของระบบฐานข้อมูล HAIMDS นอกจากนี้ยังมีข้อเสนอแนะต่างๆ ที่เป็นประโยชน์ในการนำไปปรับปรุงแก้ไขฐานข้อมูลดังกล่าว

สรุป: ระบบฐานข้อมูลของยาที่มีความเสี่ยงสูงถูกพัฒนาขึ้น ซึ่งการศึกษาดังกล่าวพบว่ากลุ่มตัวอย่างมีทัศนคติด้านบวกเกี่ยวกับ HAIMDS ในด้านเว็บไซต์และฐานข้อมูลยาฉีดที่พัฒนาขึ้นมา อย่างไรก็ตาม ระบบฐานข้อมูลดังกล่าวยังคงต้องได้รับการปรับปรุงในประเด็นสำคัญต่อไป เช่น ผลลัพธ์ของการลดลงของความคลาดเคลื่อนทางยาจากการนำเอาระบบฐานข้อมูล HAIMDS มาใช้จำนวนความคลาดเคลื่อนทางยาที่เกิดขึ้นในขั้นตอนการเตรียมและบริหารยาที่มีความเสี่ยงสูง

คำสำคัญ: การบริหารยา, ข้อผิดพลาดทางยา, บริการสารสนเทศทางยา, ยาฉีดที่ให้ทางหลอดเลือดดำที่มีความเสี่ยงสูง, ระบบฐานข้อมูลยาฉีดที่ให้ทางหลอดเลือดดำที่มีความเสี่ยงสูง

Abstract:

Objective: The study aimed to develop a database system related to high alert intravenous medications (HAIM).

Method: It is an applied survey research. There were four steps in the development of the high alert intravenous medication database system (HAIMDS) including; collecting data from primary, secondary, tertiary, and online resources, designing the system, developing the system, and developing a questionnaire to assess attitudes to the system. All four steps were conducted via a research team. This system targeted health workers involved in HAIM preparation and administration. Fifteen clinical pharmacists from various hospital in Ubon Ratchathani participated in a study. Each pharmacist completed a questionnaire about their use of and attitudes to the system. All data were analyzed via descriptive statistical analysis.

Results: The database system involved ten medications. The clinical pharmacists' attitudes to the system were generally positive and valuable suggestions were made.

Conclusion: A new database system; HAIMDS was developed. Some positive attitudes toward HAIMDS both website and database system were addressed. It is also suggested that further evaluations address the effects of the implementation of such a database system on changes in the number and/or nature of errors made by hospital staff during preparation.

Key words: administration, drug information service (DIS), high alert intravenous medications (HAIM), medication database system (HAIMDS), medication error

Introduction

High alert intravenous medications (HAIM) are drugs that have a high risk of causing significant harm to patients when used incorrectly. They have a narrow therapeutic range that could possibly lead to unexpected adverse reactions for the patient if giving high doses. High alert categories of medications that may be administered in the peri-operative setting include intravenous adrenergic agonists such as phenylephrine, intravenous beta-blockers (e.g., esmolol, metoprolol), anesthetic agents (e.g., inhaled propofol, ketamine), anticoagulants including heparin, moderate sedative agents (e.g., midazolam), neuromuscular blocking agents (e.g., succinylcholine), intravenous promethazine, and insulin.^{1,2} According to the American Society of Health System of Pharmacists, high alert medications can cause severe adverse effects in patients and may lead to charges of medical malpractice. Problems resulting from the incorrect use of HAIM can significantly undermine patients' health and well-being and in many cases require substantial efforts and resources for correction.^{3,4} In the United States alone, the cost of clinical drug-related problems amounted to \$76.6 billion in 1995⁵ and was expected to exceed \$177.4 billion within a few years.⁶ Other studies have noted the serious dangers of medication errors. Bruce, et al.⁷ evaluated medication errors during intravenous drug administration by registered nurses at an acute medical admission ward and found some medication errors related to intravenous admixture process (88 percent) out of the overall medication errors (107 times). Significant findings of medication errors included

inappropriate dissolved solutions, incompatible medication administrations, unstable medication, and incorrect durations of intravenous admixture medication.⁸

In 2007, Ministry of Public Health of Thailand collaborated with the World Health Organization (WHO) launched a project called "First Global Patient Safety Challenge: Clean Care is Safer Care." This aimed to develop the network to enhance the hospitals to develop a drug system for safety and efficacy. The project focused on four different aspects including; HAIM, look alike/sound alike medications, adverse drug reactions (ADR), and ADR management.⁹ The project identified the personnel involved in the intravenous medication admixture process were primarily clinical pharmacists and registered nurses, and it emphasized that these workers should have adequate knowledge and appropriate skills concerning IV medication admixture, including knowledge of drug compatibility, stability, and appropriate types of dissolved solutions. A previous survey revealed there were some limitations during the IV admixture process such as limited time, lack of data resources (textbooks, manuals, guidelines), and lack of well-recognized references.¹⁰ Although the use of Internet online services in Thailand for data-searching is increasing, accessibility is still difficult due to poor availability of hardware and software, lack of experienced drug information staff, inadequate knowledge and skills of staff, service charges, and membership requirements.¹⁰ To assist in overcoming these difficulties, the authors developed a HAIM Database System (HAIMDS) that was added to a previously produced web-based intravenous admixture database focused on frequently-used

antibiotics such as penicillins, cephalosporins, aminoglycosides, etc.¹¹ Currently, we added ten more high alert intravenous medications (HAIM) surveyed from the peri-operative setting at the hospitals, Ubon Ratchathani province. This additional section aimed to provide HAIM information for health care professionals including doctors, nurses, and pharmacists, as well as enhancing the Drug Information Service (DIS) Units in hospitals in Thailand and providing support for the Drug Information Unit in the Department of Pharmaceutical Sciences at Ubon Ratchathani University.

Materials and methods

Design: The study was of an applied descriptive survey research.

Research materials: The HAIMDS contains website and database system including four sections:

1. Intravenous medication admixture resources

- a. American Hospital Formulary Service 2007 (AHFS 2007)¹²
- b. Drug Facts and Comparisons 2007¹³
- c. Trissel's Handbook on Injectable Drugs 2007¹⁴
- d. Drug Information Handbook 2007¹⁵
- e. Micromedex[®]
- f. Drug manufacturing brochures
- g. National and international Internet online resources:

- <http://www.md.kku.ac.th/pharmshop>¹⁶

- <http://www.ismp.org/MSAarticles/HighAlertDrug.html>¹⁷

- http://www.si.mahidol.ac.th/office_h/pharmacy/HighAlertDrug.html¹⁸

- <http://www.ihl.org/IHI/Topics/PatientsSafety/MedicationSystem/Tools>¹⁹

- http://www.pha.nu.ac.th/apirukw/dis/uploads/ABBCC_HighAlertDrugs.pdf²⁰

- [http://www.sanpatonghos\[pital.go.th?document/High%20Alert%20Drug1.html](http://www.sanpatonghos[pital.go.th?document/High%20Alert%20Drug1.html)²¹

2. Web-designs

- a. Macromedia Flash MX[®]
- b. Macromedia Firework MX[®]
- c. Adobe Photoshop 7.0[®]
- d. Webstyle 4.0[®]
- e. Dreamwaver MX 204[®]

3. Database structures

a. Hardware: CPU (Intel[®] Core[™] 2 Duo Processor T5500 (1.6 GHz), memory (1.49 GB, HDD (120 GB)

b. Software: Java script, appserv-win 32-2.3

c. php MyAdmin Database Manager version

2.5.4

Note: all softwares used are licensed programs

4. Questionnaires to collect:

- a. Demographic data
- b. Attitudes to the design of the HAIMDS
- c. Attitudes to the contents of the HAIMDS

Participants

Fifteen pharmacists from various hospitals in Ubon Ratchathani province participated in the study. A condition of selection was that they worked in the DIS Unit at the hospital.

Process

1. Ten HAIM were selected from the drug lists used by central, community, and general hospitals with DIS Units. Drug items selection was priori-

tized on the most frequently-used medications at peri-operative setting of each hospital. These were:

- a. Digoxin
- b. Dopamine
- c. Adrenaline
- d. Calcium gluconate
- e. Morphine
- f. Pethidine
- g. Heparin
- h. Atropine
- i. Phenytoin
- j. Streptokinase

2. Information for each drug was collected from primary, secondary, and tertiary resources, and electronic sources (see Research Materials 1) and evaluated for content validation by three experts including; two chiefs of Pharmacy DIS Units, and one clinical pharmacy lecturer, Pharmacy Practice Unit, Ubon Ratchathani University. Changes were made prior to the launch of the final version of the database system in consideration of the comments of these experts.

3. A HAIMDS webpage was designed using the web design software noted above.

4. A HAIMDS database system was constructed using php MyAdmin Database Manager[®] version 2.5.4, Java script[®], appserv-win 32-2.3[®]

5. A questionnaire was developed to collect demographic data and information about attitudes to the design and content of the HAIMDS from the participants after exposure to the use of the database system. The contents of each questionnaire items were implemented via High Alert Drug Protocols, Drug Information Center, Pharmacy Practice Unit, Ubon Ratchathani University.

A questionnaire paper contains three sections including;

- a. Demographic data (9 items)
- b. Attitudes to the design of the HAIMDS (8 items)
- c. Attitudes to the contents of the HAIMDS (4 items)

Volunteers can select the answer via multiple choices as well as priority setting. Each questionnaire item used a 5 (strongly agree) >>>>1 (strongly disagree) Likert rating scale.

6. Fifteen pharmacists from various hospitals, Ubon Ratchathani province, Thailand participated in the study. Five were from central, six from community, and four from general hospitals, and each was required to work in the DIS Unit at their workplace. Before the data collection, the participants were allowed to undergo a HAIMDS session within two weeks. HAIMDS training session, during which they were allowed unlimited access to the HAIMDS. At the completion of the study period all participants completed the questionnaire (see 5 above) and returned it to the researchers immediately.

7. Demographic data, attitudes toward both design and contents of HAIMDS were analyzed statistically.

Statistical analysis

Descriptive analyses; frequencies, percentages, means.

Results

The HAIMDS contains 2 components including; website and database system. The webpage

contains; home, definition, acknowledgement, editors, introduce, search, administrator, links. When access into the database system, the users were required to login with their username and password. They can type the name of HAIM into the box, then press “enter” key. The medication information will be shown including; general data, compatibility, incompatibility, recommendation, and self-exam (Figure 1, 2). Each section contains essential information for health workers to use the HAIM safely and effectively (Figure 3).

There were fifteen clinical pharmacists enrolled into the study; seven males and eight females. Most of them had graduated from university with a bachelor’s degree (n=11) and had approximately between one to five years of working experience (n=9). A majority had approximately three years experience in DIS Unit (n=9) with a high alert intravenous medication service via typical guidelines provision. Those involved with HAIM routine service at work implemented HAIM data via tertiary resource such as textbooks, followed by internet searching (n=12, and 5) (see more details in Table 1).

After the completion of the HAIMDS sessions, those participants were asked to fill out a form regarding the attitudes toward the new HAIMDS. The assessments were divided into 2 categories including; web designs and the HAIMDS content. Regarding the web designs the overall results were favorably positive, and they also generally agreed with the functional structure and design of the database system, as well as the possibility of the HAIMDS implementation in their DIS Units. (see more details in Table 2). Most

of the participants also felt positive about the appropriateness of the database system, as well as the content correction, cited references, etc. (see more details in Table 3).

Other comments

A number of other comments were made by the participants regarding the new HAIMDS. These included:

- “there should be a web-board space to exchange ideas among users”
- “contents should be written in both Thai and English”
- “the pregnancy category should have options to select such as Categories; A, B, C, D, or X for convenience”
- “lactation and breast-feeding topics should be mentioned”
- “details of adverse drug reaction should be adequately provided”
- “pharmacokinetic properties of HAIM are essential”
- “the letters should be larger as they are quite difficult to read”
- “some multimedia interactive video clips might be an alternative for a better understanding”
- “the website should be less complicated for users unfamiliar with computer”
- “should add more self-assessment questions. For example, each section should have at least five questions”
- “sometimes, presentation with figures, tables, or graphs might be a good idea”



Figure 1 <http://www.sappasit.net/pharmacy/did/index.php>

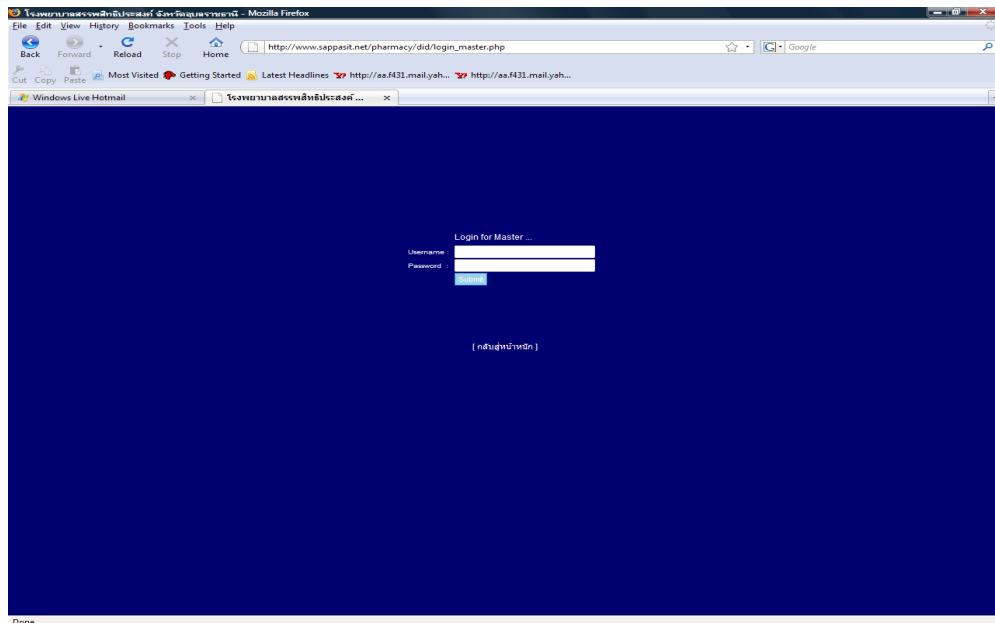


Figure 2 Login to the HAIMDS



ค้นหาตาม : Generic Name ▼

ค้นหา

General Data

Compatibility Data

Incompatibility Data

Recommendation

Exam

- › ชื่อยาสามัญ [Generic name] Heparin
- › ชื่อการค้า [Trade name] Heparin LEO ® vial[LEO Pharma]
- › กลุ่มยา [Class] Anticoagulant
- › Pregnancy category C
- › ขนาดบรรจุ [Preparation]

Heparin LEO ®® vial(LEO Pharma); 5000iu/1mL x 5 mL x 1, DBL
 Heparin ® amp (Mayne Pharma); 5000iu/1mL x 1, Heparin Sodium
 Kamada ® vial (Kamada); 5000iu/1mL x 5 mL x 1

- › ข้อบ่งใช้ [Indication]

Prophylaxis and treatment of thromboembolic disorders(1)

- › วิธีบริหารยา [Administration]

SC, IV infusion and Intermittently ห้ามฉีด IM เพราะจะทำให้มีเลือด กระจายเคือง หรือเกิด haematoma (1)

- › ขนาดยา [Dose]

Children:
Intermittent IV: Initial 50-100 unit/kg then 50-100 unit/kg every 4 hr IV infusion: Initial 50 unit/kg then 15-25 unit/kg /hr;Increase dose by 2-4 unit/kg/hr every 6-8 hr as required

Adult:
Prophylaxis(low-dose heparin):SC 5000 unit every 8-12 hr Intermittent IV: Initial 10,000 units then 50-70 unit/kg (5,000-10,000 units) every 4-6 hr



Figure 3 General data

Table 1 Demographic data of participants (n=15)

Questionnaire items	Numbers (n)
1. Gender	
Male	7
Female	8
2. Age	
20-30	9
31-40	5
>40	1
3. Education level	
Bachelor	11
Master	4
PhD	0
4. Work experience (years)	
1-5	9
6-10	4
>10	2
5. Experience in DIS Unit (years)	
0-3	9
4-6	6
>6	0

Table 1 (Continued)

Questionnaire items	Numbers (n)
6. Type(s) of HAIM service at your DIS Unit (choose more than 1 if necessary)	
Guidelines/manual provision	12
On-line service	5
Software package	7
7. Question answering service related to HAIM	
1-10 questions per month	9
11-20 questions per month	2
More than 20 questions per month	0
Not at all	4
8. Usage of high alert IV medication resource (s)	
Yes (if "yes" please answer Q.9)	15
No (if "no" skip Q.9)	0
Not sure	0
9. Type(s) of resources (can choose more than 1 choice)	
Primary (e.g., original articles)	6
Secondary (e.g., database, CD-ROM)	5
Tertiary (e.g., textbooks)	12
Internet searching	7

Table 2 Attitudes to web design of the new HAIMDS (n=15)

Survey item	Number of participants (percentage)				
	Strongly agree	Agree	No comment	Disagree	Strongly disagree
1. It is an appropriate database system	-	12 (80.0)	3 (20.0)	-	-
2. The design is interesting	1 (6.8)	10 (66.6)	2 (13.3)	2 (13.3)	-
3. All buttons are easy to use	1 (6.7)	11 (73.3)	3 (20.0)	-	-
4. The website is well-designed	-	9 (60.0)	4 (26.7)	2 (13.3)	-
5. The website is useful	-	13 (86.6)	2 (13.4)	-	-
6. The website instructions are clear	2 (13.3)	10 (66.6)	3 (20.1)	-	-
7. It is practical for health workers to apply in their DIS Unit routine work	-	8 (53.2)	6 (40.0)	1 (6.8)	-
8. Adequate information about HAIM can be found in the website	1 (6.8)	9 (60.0)	3 (20.0)	2 (13.2)	-

Table 3 Attitudes to content of the new HAIMDS (n=15)

Questionnaire item(s)	Number of volunteers				
	Strongly agree	Agree	No comment	Disagree	Strongly disagree
Appropriateness of the database					
<i>Section 1 (General data)</i>					
- Generic name	1	12	2	0	0
- Trade name	0	15	0	0	0
- Class	0	14	1	0	0
- Pregnancy category	0	14	0	1	0
- Indication	1	13	1	0	0
- Administration	0	15	0	0	0
- Dose	0	13	1	1	0
- Precaution	1	12	0	2	0
- Adverse drug reaction	0	11	1	3	0
- Drug interaction	0	12	3	0	0
- Monitoring parameters	0	13	2	0	0
- Dissolved solution	0	13	2	0	0
- IV admixture	0	13	2	0	0
- Stability	1	14	0	0	0
- Preparation	1	13	0	1	0
<i>Section 2 (Compatibility)</i>					
- IV admixture-compatible	1	12	2	0	0
- IV admixture given by Y-site	0	13	2	0	0
- IV admixture given by syringe	2	13	0	0	0
<i>Section 3 (Incompatibility)</i>					
- IV admixture-incompatible	2	12	0	1	0
- Prohibited dissolved solution by Y-site	2	12	1	0	0
- Prohibited IV admixture given by syringe	0	12	1	2	0
- Source of reference(s)	0	12	1	2	0
Appropriateness of the database					
<i>Section 4 (Recommendation)</i>					
- Medication prescription	1	10	3	1	0
- An example of doctor prescription order	0	12	0	0	0
- Taking doctor prescription	2	12	1	0	0
- Drug-related problem finding	2	11	2	1	0
- Medication administration	0	13	2	0	0
The correction of contents	0	13	0	2	0
The up-dating of database	2	13	0	0	0
The appropriateness of reference(s)	2	12	1	0	0

Discussion

The HAIMDS was similarly developed from a previous web-based intravenous admixture databased.¹¹ Thus, the difficulty of database construction was minor. Additionally, some limitations from a previous works were corrected this time. More data sections were included into the system, therefore, adequate, ease-to-use medication information was provided. The demographic data gave an overall impression of younger, more inexperienced workers working in this specific area. Nine of the 15 study participants were under the age of 30 and 11 had an education only to a bachelor's level. There was generally a low level of experience in both routine work and drug information service with 9 of them having between 1 and 6 years' work experience and 9 having between 0 and 3 years' involvement in a DIS Unit. Twelve relied on the use of manuals, guidelines, and texts for medication data searching when dealing with HAIM situations with patients. Five participants had experience of using an online drug information service and 4 stated they had no familiarity in answering questions regarding HAIM.

The study revealed that textbooks (tertiary) were the most frequently-used resource for searching for information about medications followed by use of the Internet, and finally secondary and primary sources (Table 1). This indicated most of DIS Unit personnel rely heavily on text-based resources. However, there are a number of limitations associated with text-based resources, notably the lengthy amount of time it can take for a search, lack of up-dated information, and restricted range of data sources.

These limitations may lead to medication searches inefficient and unreliable.

The results showed that the participants' attitudes to the design and content of the HAIMDS were generally favorable. There was some concern expressed about the infrastructure of the website, while the real benefits of the HAIMDS were either reluctant or uncertain (Table 2, items 4 and 7). These less favorable comments may have been due to the participants' lack of skill and experience in a DIS Unit and that they were not familiar with a web-based IV medication service. As a result, they might have anticipated difficulties in using the website and implementing the HAIMDS into their routine work. Nevertheless, the feasible benefits of HAIMDS were noticeably found via both attitudes of design and contents of HAIMDS. Some comments were made suggesting additional information should be included, for example the effects of HAIM on lactation and breast-feeding, adequate information regarding ADR, and the pharmacokinetic properties of HAIMs. They felt that such information could be of assistance to hospital staff in the correct administration and/or preparation of HAIMs. Additional comments were also offered about the web-design, which the researchers used to make some changes to the functions and appearance of the HAIMDS.

Regarding the benefits of HAIMDS to the hospital routine works, the medication errors may be made by health workers during drug distribution and administration.²² The implementation of an easy-to-use and reliable HAIMDS may be a means to minimizing some of these errors.^{8,23,24} The possibility of encouraging any health care workers including; nurse, pharmacist, or even

doctor to be able to work together in HAIMDS, is to provide an essential information and training, as well as share knowledge and skills in data-base searching. Also, they should provide and together evaluate feedback after the completion of a medical HAIM situation to help improve the procedure as well as the staff performances in HAIMDS situation. Further evaluation of the usability of the system and the effectiveness of the system is required involving an assessment of the levels of medication errors of hospital workers after the implementation of the HAIMDS. This evaluation should include:

1. Numbers of medication errors during HAIM preparation and administration
2. Comparison of the medication errors among different groups of health care personnel
3. Severity of medication errors
4. Internal and external factors related to medication errors concerning HAIM
5. Effects of the implementation of the HAIMDS on medication errors made by hospital personnel.

Additionally, the implementation of HAIMDS among bachelor pharmacy students should be addressed. The evaluation of students' performances of the use of HAIMDS between B.Pharm and Pharm.D students is also recommended. Thus, we can improve HAIMDS into DIS clerkship training.

Study limitations

1. The number of participants (15) in the study was relatively small. The involvement and collaboration of health workers from other hospitals would increase this number and strengthen the findings of a future study.
2. A further usefulness should be tested in a bigger size despite a pilot project in nature.

3. The study was performed as part of a senior study project for university pharmacy students. As a result, it was limited to a 4 month period during which the students had to attend lectures as part of their degree course which restricted the involvement of the students and the duration of the study.

4. An evaluation of the effectiveness of the system is required prior to its public release. This proved impossible due to the limitations imposed by the study's status as a university project.

Conclusion

Research indicates a high incidence of errors in prescription, preparation, and/or administration of intravenous medications, especially HAIM.^{25,26} To attempt to reduce the incidence of such errors, a new database system, the HAIMDS, was developed by students at the Department of Pharmaceutical Sciences at Ubon Ratchathani University and pharmaceutical personnel from Sapasithprasong Hospital. The database system provides health workers with essential information of HAIM preparation and administration presented in a free, accessible, easy-to-use web-based service.

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