Cost Saving and Cost Avoidance of the Pharmacy Automation System

การหาต้นทุนที่ประหยัดและต้นทุนที่หลีกเลี่ยงได้ของระบบจ่ายยาอัตโนมัติ

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The aims of this study were to assess effectiveness of the pharmacy automation system in term of cost saving and cost avoidance, medication filling error reduction; and to suggest a model of cost calculation. Data were collected retrospectively at the inpatient pharmacy department, Bumrungrad International Hospital during 6-month separated period (July-December 2007 and July-December 2008). Cost avoidance concerned costs of medication filling errors and other related costs, while cost saving referred to dispensing labor costs, new staff training costs, and inventory costs. In an overall, the result revealed that the new pharmacy system with an automated drug filling was be able to reduce around 70 percent of medication filling errors. Under traditional dispensing system, the medication error and related costs was 4,940 baht, whereas the new system lost 4,053 baht during the 6-month study period. Cost of claims and compensations could not include in this calculation because of unable to clarify of exact causes and details of such events. Thus, the automated system could avoid 1,687 baht of medication cost and drug filling cost during the study. At the same time, the new automated system was able to save dispensing labor cost around 303,996 baht, training cost saved 176,000 baht, and inventory cost saved up to 1,049,308 baht. So, total cost saving was 1,529,304 baht. In the consideration of cost calculation model, it was concerned that all possible related costs directed to the implementation of the new robot in which; cost avoidance counted from medication filling error cost (calculated depending on levels of severity) and cost of compensation resulting from dispensing deviations; cost saving could be computed fromdispensing labor costs, training costs, and inventory costs.

Keywords: Cost saving, cost avoidance, automation, medication errors

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วัตถุประสงค์ของงานวิจัยนี้ เพื่อประเมินต้นทุนที่ประหยัดและต้นทุนที่หลีกเลี่ยงได้จากการใช้เครื่องจ่ายยาระบบอัตโนมัติที่ใช้ในการจ่ายยาผู้ป่วยในโรงพยาบาลบำรุงราษฎร์ โดยเปรียบเทียบกับระบบการจ่ายยาแบบเดิม และเสนอแบบจำลองของการหาค่าต้นทุนที่ประหยัดและต้นทุนที่หลีกเลี่ยงได้จากการใช้เครื่องดังกล่าว ระยะการวิจัยแบ่งเป็น 2 ช่วง (กรกฎาคม-ธันวาคม พ.ศ. 2550 และ กรกฎาคม-ธันวาคม พ.ศ. 2551) โดยเก็บข้อมูลแบบย้อนหลัง ต้นทุนที่หลีกเลี่ยงได้คำนวณจาก ค่าใช้จ่ายจากการแก้ไขการจ่ายยาที่คลาดเคลื่อน รวมถึงค่าชดเชยอื่นๆ โดยแบ่งความคลาดเคลื่อนและคำนวณค่าใช้จ่ายตามระดับความรุนแรง สำหรับต้นทุนที่สามารถประหยัดได้ คำนวณจาก จำนวนเงินที่ประหยัดไปจาก 3 ส่วน คือ ค่าแรงงานคนที่ใช้การจ่ายยา การฝึกอบรมพนักงาน และค่ายาคงคลัง จากผลการศึกษา พบว่า ความคลาดเคลื่อนจากการจ่ายยาลดลงประมาณร้อยละ 70 ซึ่งความคลาดเคลื่อนส่วนใหญ่เกิดขึ้นที่ระดับต่ำสุด ค่าใช้จ่ายจากความคลาดเคลื่อนจากการจ่ายยาระบบเดิมมีค่า 4,940 บาท ในขณะที่ค่าใช้จ่ายจากความคลาดเคลื่อนในระบบอัตโนมัตินั้นมีค่า 4,053 บาท ซึ่งสามารถหลีกเลี่ยงได้จากค่ายาและค่าจัดยา 1,687 บาท สำหรับค่าชดเชยในกรณีที่เกิดความคลาดเคลื่อนไม่ได้นำมารวมในค่าใช้จ่ายที่เกิดขึ้นในกรณีนี้ เนื่องจากไม่สามารถระบุความคลาดเคลื่อนและสาเหตุที่ชัดเจนได้ ดังนั้น ต้นทุนที่หลีกเลี่ยงได้จึงมีค่า 1,687 บาท ในระยะเวลา 6 เดือน ค่าใช้จ่ายด้านกำลังคนในการจ่ายยาของระบบใหม่เทียบกับระบบเก่า พบว่า ลดลง 303,996 บาท ค่าฝึกอบรมพนังงานใหม่ลดลง 176,000 บาท มูลค่าคลังยาลดลง 1,049,308 บาท เมื่อรวมค่าใช้จ่ายจาก 3 ส่วนดังกล่าว มูลค่าต้นทุนที่สามารถประหยัดในช่วง 6 เดือนที่ทำการศึกษามีมูลค่า 1,529,304 บาท สรุปได้ว่า แบบจำลองที่พัฒนาขึ้นนั้น ทำให้สามารถพิจารณามูลค่าต้นทุนที่สามารถหลีกเลี่ยงได้จากใช้จ่ายที่เกิดจากความคลาดเคลื่อนจากการจ่ายยารวมถึงค่าใช้จ่ายที่เกี่ยวข้อง มูลค่าต้นทุนที่ประหยัดได้จากค่าแรงงานคน ค่าฝึกอบรม และมูลค่าคลังยา

คำสำคัญ: ต้นทุนประหยัด ต้นทุนที่หลีกเลี่ยงได้ ระบบจ่ายยาอัตโนมัติ ความคลาดเคลื่อนจากการจ่ายยา

Introduction

Patient safety has been relatively one important concern among medical care in many countries. Poor clinical outcomes due to medical errors are associated not only physical conditions but also they do concurrent with excessive expenditures and affect the patient's confidence in the quality of health care system and its personnel[1-3]. With traditional medical management practices, patients experienced with adverse outcome can be seen, even in the best hospitals. Human errors and inappropriate works seem to be involved this circumstance. Overall, those stated problems of health care malpractice have been a challenge of health care organization with respect to improve patient safety with the best managing resource utilization. Together with, consumers in the healthcare system are demanding in higher quality, safety, efficiency and value.

In an era where technologies have been developed rapidly, and many see technologies as a way toward safer. It changes the way hospital pharmacy practices. Several interven-

tions involving information technology has been shown to reduce medication errors considerably. Not only safer patient cares but also save costs on spending extra cares[4-8]. Examples of technology are computerized physician order entry, computerized physician decision support, robot for filling prescriptions, bar coding, or automated dispensing device. Either increase patient safety by minimizing unintended errors, or increase productivity and efficiency in the mean of best utilize optimal resources, several institutions have been recommended the use of technology[9,10]. Wide range of care services can be further served if the right technology is put in place. The automated pharmacy system (Swisslog), in the case, has replaced the traditional medication management process. Three main focal points are to reduce human error, working efficiency, and good inventory control. This filling machine is a multifunction fully automated unit dose packaging, storage, and dispensing system. It also provides simplicity for inventory control. Concerning on costs of health care problems has been deemed in attentions for a period of time. Study on costs of errors could help institutions arising awareness of excessive expenditure from professional practice deviations[1,11-13]. Together with substantial cost of the implementation of the machine, valuation of acquired benefits is intensively concern.

Objectives

The aim of this study were to evaluate cost saving and cost avoidance from the use of the pharmacy automation system, to study effectiveness of the new automation system from the reduction in drugs filling errors, and to create a model of cost saving and cost avoidance from having the pharmacy automation.

Method

This study presented had been using the Bumrungrad International Hospital as a research setting. It is a 480-bed tertiary hospital where the pharmacy robot was first implemented in Thailand since April 2008, within the inpatient pharmacy department. The general workflow is individual unit doses automatically first packaged, bar-coded, labeled, and then stored for future retrieval and dispended to patient. Drugs are packed for a specific patient, 24 hours supply grouped together orderly. This study was targeting toward 3 main benefits expected to obtain from the automated system; medication errors, staff benefits, and inventory control, in term of cost avoidance and cost saving. Costs calculated by using charge price. Effectiveness of the robot was also monitored in comparison with the manual system. The objective data was investigated retrospectively. Study period was divided into two separated time frames; 1st July-31st December 2007 (the manual dispensing system) and 1st July-31st December 2008 (the pharmacy automation system). Both dispensing practices were the same, except the part of filling drugs changed according to the intervention. Patients care units included the general care units 6-11,

the intensive care units (ICU) 1-3, and the critical care unit (CCU).

Cost avoidance was defined as money that would have to spend by the pharmacy department but do not spend because of the use of pharmacy dispensing machine, classified as costs of medication errors in the relation to the drug dispensing system, including costs of accusation as a result of dispensing deviations. Data were retrieved from the inpatient department (IPD) predispensing errors record and incident reports, only filling errors were selected. All errors were then classified into level of severity, graded from 0 to 6 according to hospital's medication errors level of severity, classifying as:

Level 0: Non medication error occurred (potential errors would be classified here)

Level 1: An error occurred that did not result in patient harm.

Level 2: An error occurred that result in the need for increased patient monitoring but no change in vital signs and no patient harm.

Level 3: An error occurred resulted in the need for increased patient monitoring with a change in vital signs but no ultimate patient harm or any error that resulted in the need for increased laboratory monitoring.

Level 4: An error occurred that resulted in need for treatment with another drug or an increased length of stay or that affected patient participation in an investigational drug study.

Level 5: An error occurred that resulted in permanent patient harm.

Level 6: An error occurred that resulted in patient death.

Data collection included descriptions, details of events, and cost information. Other data included compensation claims from wrongful acts as a result from IPD dispensing provided by the pharmacy director.

Cost savings referred to money that was previously spent but no longer spent due to the robot implementation. Cost savings included money saved from cost of 3 sources. First, IPD dispensing labor costs were computed by using information of total time for dispensing medication to admitted patients and average pharmacists' and technicians' payments. Second, pharmacy staff training cost was a cost of individual teaching for new staff required one experienced staff to train the new comer for 4 months duration. That staffs had to devote themselves taking care of new employees though partially relinquishing foregoes duties. This cost was assumed from double new staff's salary without benefits. Third, inventory costs included drug inventory cost supplied for IPD as believing that the robot could provide better control of drug uses. Cost can be assumed from drug inventory cost at the end of each study period and then compared in order to examine stock volume controlling capability of the automation.

To finish, cost avoidance from implementing the pharmacy automation system can be concluded from the different medication errors costs between the two study periods. Whereas, cost saving computed by the different of the sum of dispensing labor costs, training

expenditure, and inventory costs between the two systems.

Results and Discussions

During July-December 2007, the numbers of patient were around 10,000 patient-days per month, and total dispensed drugs in 2007 were 808,594 items. During the same period in 2008, the amount of patient-day was slightly lower by 8 percent but dispensed items had 13 percent higher. Smaller figure of patient-days admitted in 2008 was reasoned by some parts of patient care units were closed because of renovation.

1. Cost Avoidance from the Use of Inpatient Pharmacy Automation System

1.1 The Incidence of Medication Filling Errors. In an overview, the incidence medication filling errors occurred at an average 8.91 errors/10,000 items dispensed during the 6 months in 2007, while the later 6 month intervals in 2008 an average rate was 2.37 errors/10,000 items dispensed. Around 70 percent of errors had been reduced (Figure 1). Other researches could produce the similar outcomes in which the machine provided accuracy and handful to the dispensing routine, and the filling drugs accuracy might high up to 88 percent of total items dispensed[14-18]. However, dispensing errors in this presenting study had very low figures at baseline.

Most of filling errors occurred at level 0, and a very few errors found in level 1. The majority of harmless incidences occurred from medical dispensing practice had likely experiences by other settings.[19-21]. It was found that 0.33 error/10,000 patient-day was potential to harm patients in 2007, and the rate of 0.18 error/10,000 patient-day was obtained in the later period. However, errors were found after dispensing had increased such as dispensing wrong amount of drugs increased by 4 times. Many of occurred incidences resulted from robot errors, such as, over filled drugs, filled more than one drugs in a bag, no drug in a bag, and drug deterioration. These incidences

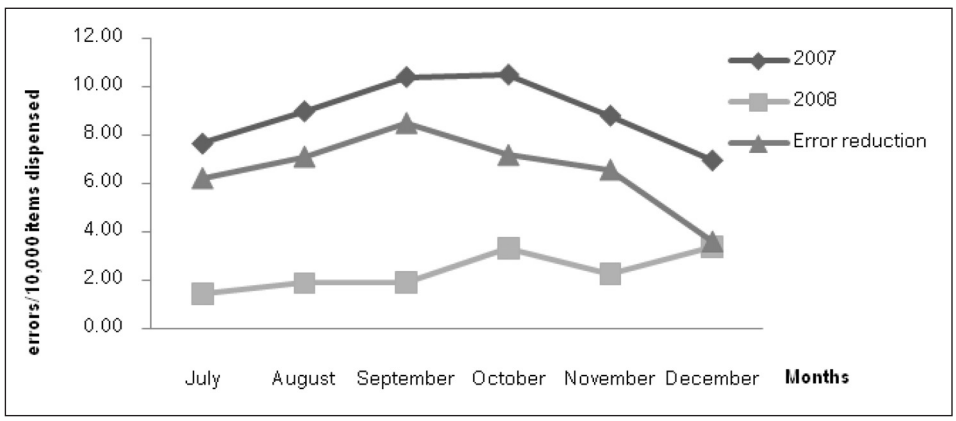

Figure 1. Rates of errors per 10,000 items dispensed during 6 months in 2007 and 2008, and rates of error reduction

could happen because drugs dispensed by the robot have no re-checked routine before sending out from pharmacy. Several errors were turned out mainly from overload dispensed items in an hour and down-time of the robot system. This reason could be supported by a study of Bond and Raehl[22] in which indicated a significant relationship between the risk of dispensing errors and the number of filling items per hour. In general, dispensing wrong drugs and wrong quantity were the most frequency types of errors of the two periods, take into account of around 40 percent and 30 percent of total filling errors. Obtained results varied and were different from others[17,19-21,23]. These variations might result from identified definitions, populations, observation methods, and differences in drug distribution systems.

1.2 Costs of Medication Filling Errors Calculating error costs were given details in Table 1 and 2. On the whole, costs of medical errors of the manual dispensing system were toted up to obtained the entire costs of medication filling errors occurred during July-December 2007. The cost was 4,940 baht as can be seen in Table 1.

Table 2 explained medication filling errors cost calculation during 6-month period after implementing the automation. Estimation procedure of this cost had identical to the earlier period. Therefore, obtained cost of medication filling error at level 0 was 3,676 baht and at level 1 was 377 baht. Following, total cost of medication errors during July-December 2008 was 4,053 baht.

Therefore, cost of medication errors reduction from using the pharmacy automation at the Bumrungrad International Hospital was 4,940 - 4,053 = 887 baht. It is obvious that when errors occurred at the patient care floors, high expenses were inevitable in which, the

Table 1. Calculating error costs before robot implementation

	Levels of Severity			Average Cost of Drug Filling	Total Cost of Filling Error (Baht)		Cost of Drugs	Monthly Nurse Labor Costs (Baht)	
	Level 0								
Months	Within Rx	On Wards	Level 1	(Baht)	Level 0	Level 1	(Baht)	Level 0	Level 1
July-07	104	7	0	3.27	363			467	
Aug-07	123	4	1	3.42	434	3	100	267	67
Sep-07	135	5	0	3.48	487			333	
Oct-07	130	5	0	3.58	483			333	
Nov-07	108	6	0	3.78	431			400	
Dec-07	85	5	1	4.00	360	4	8	333	67
Total	**685**	**32**	**2**		**2,558**	**7**	**108**	**2,133**	**134**
Grand Total	**Drug and filling cost + Nurse cost = 2,673 + 2,267 = 4,940 baht**								

Note: Rx = Pharmacy department

Table 2. Calculating error costs after robot implementation

Months	Levels of Severity: Level 0 Within Rx	Level 0 On Wards	Level 1	Average Cost of Drug Filling (Baht)	Total Cost of Filling Error (Baht): Level 0	Total Cost of Filling Error (Baht): Level 1	Cost of Drugs (Baht)	Monthly Nurse Labor Costs (Baht): Level 0	Monthly Nurse Labor Costs (Baht): Level 1
July-08	20	4	0	3.06	73			267	
Aug-08	24	7	0	3.12	97			467	
Sep-08	22	4	0	3.49	91			267	
Oct-08	36	13	1	3.15	154	3	307	867	67
Nov-08	28	7	0	3.27	115			467	
Dec-08	39	10	0	2.97	146			667	
Total	**169**	**45**	**1**		**676**	**3**	**307**	**3,000**	**67**
Grand Total	**Drug and filling cost + Nurse cost = 986 + 3,067 = 4,053 baht**								

Note: Rx = Pharmacy department

robot has not reduced nurse cost but reduced cost of medications and cost of drug filling. The reduced cost of drug and filling error was 1,687 baht.

1.3 Cost of Compensation Resulting from Medication Filling Wrongful Acts. There were reports of claims and compensations consequent to drugs and drugs used but they could not clarify of fundamental causes, specified details, and whose responsibility. Thus, it was unable to generate accurate amounts and would not include into cost avoidance here. Nevertheless, this cost aspect is likely relevant to extra spending of wrong filling drugs and important to comprise in the cost avoidance calculation in general.

1.4 Cost Avoidance of the Inpatient Pharmacy Automation System. From above obtained information, it could present in term of cost avoidance. The related cost of medical error of the traditional pharmacy system (4,940 baht) weighted against the related cost of medical error of the new Spharmacy dispensing system with the drugs filling robot (4,053 baht), it shown that the use of inpatient pharmacy automation could avoided 887 baht along 6 months in practice (Table 3). Published reports about costs of medication error were rarely available. Many had focused on the

Table 3. Calculating cost avoidance of the inpatient pharmacy automation system

Cost Elements	Tradition Dispensing System (Baht)	New System with Filling Robot (Baht)
Medication filling errors	4,940	4,053
Claims and compensation	-	-
Total	**4,940**	**4,053**
Cost avoidance	**4,940-4,053 = 887 baht**	

value of the health lost as a result of adverse drug events (ADEs) or adverse drug reactions (ADRs). Costs of medication error might approximate from costs for potential ADEs in which producing the most likely economic outcome possibility. Costs of medical avoided were range from $7.33 per patient day to $2595 for individual events.[3,4,7,12] The differences were depending upon case criteria, study period or investigational durations.

2. Cost Saving from the Use of Inpatient Pharmacy Automation System

2.1 Cost of Pharmacy Staff. In general, there were approximately 35 IPD pharmacists and 53 IPD pharmacist assistances. Two pharmacists worked for IPD reduction after applied the automation system, mean while 6 technicians had obvious lower than in the year 2007. Some change within the department was typically about transferring staff to other section such as outpatient pharmacy, or changing job positions. Other studies[18,24] observed the impact of the automation systems revealed same tendentious outcomes in which minimizing mechanical works while expanding other work areas with the same number of staff. Additionally, IPD overtime working hours had been declining right through the new system.

Table 4 indicated IPD dispensing labor expenditures during the study periods. In the last half year of 2007, the total cost was 7,831,742 baht and 7,527,746 baht in the same period of 2008, so that 303,996 baht could be

Table 4. Expenditures of the inpatient pharmacy dispensing in 2008

Months	Pharmacists' Dispensing Hour (Hours)	Total Pharmacist Payment (Baht)	Pharmacist Assistances' Dispensing Hour (Hours)	Total Pharmacist Assistance Payment (Baht)
July 2007	4,466	687,764	9,967	637,248
August 2007	4,455	686,070	10,053	643,392
September 2007	4,429	651,266	9,842	629,888
October 2007	4,356	670,824	10,146	649,344
November 2007	4,326	666,204	9,736	623,104
December 2007	4,275	658,350	9,817	628,288
Total	**26,107**	**4,020,478**	**59,551**	**3,811,264**
Grand Total	**4,020,478 + 3,811,264 = 7,831,742**			
July 2008	4,590	706,860	9,761	624,704
August 2008	4,649	715,946	8,927	571,328
September 2008	4,357	670,978	8,502	544,128
October 2008	4,565	703,010	8,843	565,952
November 2008	4,373	673,442	8,528	545,792
December 2008	4,223	650,342	8,676	555,264
Total	**26,757**	**4,120,578**	**53,237**	**3,407,168**
Grand Total	**4,120,578 + 3,407,168 = 7,527,746**			

saved. Previous investigations[14,16,25] had disclosed similar evidence in which hand-help machines could save pharmacy personal's time on proceeding works.

2.2 Pharmacy Staff Training Cost. There was no formal training course for a new staff of pharmacy department at the Bumrungrad International Hospital. The only training program was individual teaching by an experienced staff. There was 1 new pharmacist had been employed during 6 months in 2007. Pharmacist's turnover rate was 3 percent and 4 percent for pharmacist assistances. Hence, personnel teaching cost calculated from experienced staff salary who trained the new staff which equaled to 176,000 baht. Staff turnover data in July till December 2008 was lower than the previous year (3 percent and 2 percent for pharmacists and technicians). There was no new employee was recruited through the period, so no such of cost incurred.

2.3 Inventory Cost. Drug cost of IPD store of the first study period (October 2007-March 2008) was 14,596,703 baht, whilst, the later period (October 2008-March 2009) stock volume of drugs for in-patient was 13,547,395 baht (Table 5). Thus, the machine could save 1,529,304 baht over 6 months.

When compared inventory costs at the end point of each study period, stock volume cost in 2008 was proper controlled than the drugs stock in 2007 because of the lower cost of inventory. It is interesting that even implementing the robot, it did not cause extra expenditure in order to managing drugs. However, inventory system is still requiring system adjustment and improvement, including the amounts of drugs supply to the machine or recurring materials used for operation. It is likely to refer to a study of inventory management system named "Artima" operating in the similar way to "Swisslog". It produced an impressive return after 10 years implementation and inventory decreased by 70 percent along with the continuous improvement of the system[26]. Artima could reflect to this study which anticipated to increased hospital revenue by reducing drug inventory expense soon after settle system stability.

Table 5. Drug inventory acquisition costs during the two study periods

Months (The Manual System)	Drug Inventory Costs (Baht)	Months (The New System with Automation)	Drug Inventory Costs (Baht)		
			Pharmacy IPD	Pharmacy Pill	Total
October 2007	12,221,057.60	October 2008	13,206,221.96	2,081,390.81	15,287,612.87
November 2007	12,296,317.67	November 2008	15,047,680.60	2,271,426.56	17,319,107.16
December 2007	14,056,182.63	December 2008	14,427,858.99	1,877,624.72	16,305,483.71
January 2008	15,606,490.73	January 2009	12,989,901.91	1,748,416.68	14,738,318.59
February 2008	12,465,633.87	February 2009	12,739,027.50	1,995,647.44	14,734,674.94
March 2008	14,596,702.89	March 2009	11,589,757.33	1,957,638.10	13,547,395.43

Table 6. Table for calculating cost saving of the inpatient pharmacy automation system

Cost Elements	Traditional Dispensing System (Baht)	New System with Filling Robot (Baht)
Cost of Rx staff	7,831,742	7,527,746
Rx training cost	176,000	-
Inventory cost	14,596,703	13,547,395
Total	**22,604,445**	**21,075,141**
Cost saving	**22,604,445 – 21,075,141 = 1,529,304 baht**	

Note: Rx = Pharmacy department

Since July to December 2007 cost from 3 dimensions was 22,604,445 baht, while the later half year in 2008 was 21,075,141 baht, the cost loss was saved 1,529,304 baht (Table 6). However, as a result that this study evaluated the machine in the very beginning years, it is possible to be able to produce cost saved when fully operation to other automated system or take into account of other advantages in the next operating years, such as more staff benefits of growing clinical works or other benefits best gain from people.

3. **A Model of Cost Saving and Cost Avoidance from having the Pharmacy Automation**. This cost analysis study had suggested a model of cost saving and cost avoidance from having the filling robot. The model was established as a following of the investigator's and expert's consideration mutually with corresponding evidence bases of cost analysis. Each of cost averted was demonstrated below;

Cost avoidance = Cost of traditional dispensing system - cost of pharmacy automation system.

While:

Cost of traditional dispensing system = (cost of medication errors$_T$) + (related costs of compensation)

Cost of pharmacy automation system = (cost of medication errors$_R$) + (related costs of compensation$_R$)

Cost of medication errors can be analyzed as illustrated in Table 7.

Cost saving = cost traditional dispensing system - cost of pharmacy automation system

While:

Cost traditional dispensing system = (dispensing labor costs$_T$) + (training cost$_T$) + (drug inventory costsT)

Cost of pharmacy automation system = (dispensing labor costs$_R$) + (training cost$_R$) + (drug inventory costs$_R$)

To be conclude, this presenting study had investigated effectiveness and to provide cost information of the pharmacy automation system. Overall illustration of obtained results revealed the new dispensing system was be able to reduce just around 70 percent of medication filling errors. In the consideration of medication error and related costs, the automated system could avoid 1,687 baht during 6-month interval. At the same time 1,529,304 baht had saved from labor costs including

Table 7. Cost components for calculating medication error costs divided according to error stages

Error Stages	Cost Elements
Dispensing errors within the pharmacy dept.	1. Cost of prescription
Dispensing errors outside the pharmacy dept. (classified into 6 levels)	
Level 0	1. Cost of prescription
	2. Nurse labor cost (one shift)
Level 1	1. Cost of prescription
	2. Nurse labor cost (one shift)
	3. Cost of administered drugs
Level 2:	1. Cost of prescription
	2. Nurse labor cost (one working day)
	3. Cost of administered drugs
	4. Cost of additional drugs
Level 3	1. Cost of prescription
	2. Nurse labor cost (one working day)
	3. Cost of administered drugs
	4. Cost of additional drugs
	5. Additional physician /specialist fee
Level 4	Same as level 3, costs are estimated since patients received therapy of adverse conditions resulting from pharmacy dispensing deviations, including prolonged hospital stay days from those incidences.
Level 5,6	These two most harm stages are not included in the cost consideration because there has been no error occurred at these levels ever since. However, if such an error takes place, costs would determine according to details specified in the incident report.

Note: dept = department

training expenditure and inventory costs. The autorobot is believed to gain trustiness, create confidence, and credibility needed by the consumers. However, the implementation of this robot is being in the initial phase. It somehow takes years of continuing improving the system until achieving the highest expected benefits. Information from the study was proposed to put forward decision making on investment such the automation in Thailand, and to be an informative data for improving patient safety and resource allocation for health investors.

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