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Cost-effectiveness analysis of an unit dose dispensing robot in Thailand

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Background

- Medication errors (MEs) can lead to serious consequences, including adverse drug events and even death. To reduce MEs, many hospitals are implementing technologies like the Unit Dose Dispensing Robot (UDRs).
- However, no studies in Thailand have evaluated the costs and MEs associated with UDRs.
- This study aimed to analyze the cost-effectiveness of drug dispensing through UDRs compared to traditional pharmacist dispensing in Thailand.

Method

Cost measurement:

- Cost data were divided into direct and indirect categories. Direct costs included labor, materials, and capital costs. Indirect costs were assumed as overhead, estimated at approximately 20% of direct costs.
- Costs were adjusted for inflation using the Consumer Price Index (CPI).
- All expenses were converted from Thai Baht (THB) to US Dollars (USD).
- The conversion used the 2024 average exchange rate from the Bank of Thailand: 35.97 THB per USD.

Outcome measurement:

- Outcome evaluation was based on pre-dispensing errors identified by pharmacists, comparing UDRs dispensing to traditional manual dispensing.
- Errors classified as: wrong drug, where the medication did not match the prescription; wrong dose, involving a dosage that was too high or too low; and mixed-up medications, where drugs were placed in the wrong sachets.

Data Collection:

- Conducted a retrospective study collecting cost and outcome data from 2017 to 2022 (total of 6 years).
- Cost and outcomes were sourced from Nopparat Rajathanee Hospital (tertiary care hospital).

Study Outcome:

- The outcome is represented by the Incremental Cost-Effectiveness Ratio (ICER).
- ICER is calculated as:

$$\frac{\text{Cost of dispensing drugs with UDRs - Cost of dispensing drugs without UDRs}}{\text{difference in the number of avoidable MEs}}$$

Results

The traditional manual dispensing methods resulted in 451, 488, and 455 medication errors in 2017, 2018, and 2019, respectively, as shown in Table 1.

Table 1 Annual Number of Medication Errors by Type from Drug Dispensing without and with UDRs

Type of medication errors	Annual medication errors without UDRs			Annual medication errors with UDRs		
	2017	2018	2019	2020	2021	2022
Wrong drug	316.00	342.00	329.00	135.00	99.00	150.00
Wrong dose	124.00	141.00	120.00	93.00	56.00	50.00
Medication mix-up	11.00	5.00	6.00	1.00	0.00	2.00
All MEs	451.00	488.00	455.00	229.00	155.00	202.00

UDRs, Unit Dose Dispensing Robot

The implementation of UDRs with pharmacists reduced annual medication errors from 464.67 to 195.33 events, preventing a total of 269.34 errors, as presented in Table 2.

Table 2 Frequency of medication errors in each type from drug dispensing without UDRs and with UDRs, avoidable medication errors.

Type of medication errors	The average number of medication errors without UDRs per year (%)	The average number of medication errors with UDRs per year (%)	The average number of avoided medication errors per year (%)
Wrong drug	329.00 (70.80%)	128.00 (65.53%)	201.00 (74.63%)
Wrong dose	128.33 (27.62%)	66.33 (33.96%)	62.00 (23.02%)
Medication mix-up	7.33 (1.58%)	1.00 (0.51%)	6.33 (2.35%)
All MEs	464.67	195.33	269.34

UDRs, Unit Dose Dispensing Robot; MEs, Medication errors

The definition of practices before and after the implementation of the UDRs in the medication dispensing process is shown in Table 3.

Table 3 Operational definition of drug dispensing without UDRs and with UDRs, based on an incremental costing approach.

Resource type	Resource drug dispensing by pharmacists alone	Resource for drug dispensing by UDRs
Labor cost		
Pharmacist salary	Performing medication-related tasks during regular work hours.	
Pharmacist Technician salary		
Pharmacist Assistant salary		
OT Pharmacist salary	Performing medication-related tasks during nonstandard work hours, encompassing both day and night shifts.	
OT Pharmacist Technician salary		
OT Pharmacist Assistant salary		
Material cost		
Medicine package cost	The cost of medicine packets is separated based on the type of medicine for each inpatient.	
Medication cost	The medication costs for inpatients.	
Capital cost		
Unit Dose Dispensing Robot (UDRs)	-	Investment cost for the entire automatic medicine dispenser and software installation cost.
Maintenance cost	-	Maintenance costs of automatic medicine dispensers

UDRs, Unit Dose Dispensing Robot; OT, Overtime costs

After the implementation of the UDRs in the medication dispensing process, the overall total cost, increased by $64,883.10 per year, as shown in Table 4.

Table 4 Annual dispensing cost without UDRs and with UDRs.

Cost Type		Cost without UDRs (USD)	Cost with UDRs (USD)	Difference cost (USD)
Labor cost	Pharmacist salary	2,891.27	2,114.22	- 777.05
	Pharmacist Technician salary	1,923.66	1,379.52	- 544.14
	Pharmacist Assistant salary	1,375.10	952.83	- 422.27
	Total salary	6,190.02	4,446.56	-1,743.46
	OT Pharmacist salary	6,797.97	6,176.07	-621.90
	OT Pharmacist Technician salary	4,078.78	3,705.64	-373.14
	OT Pharmacist Assistant salary	3,059.08	2,779.23	-279.85
	Total OT	13,935.83	12,660.94	-1,274.89
Material cost	Medicine package cost	5,267.98	16,290.15	+11,022.17
	Medication cost	128,426.48	144,466.87	+16,040.39
	Total Material cost	133,694.46	160,757.02	+27,062.57
Capital cost	Unit Dose Dispensing Robot (UDRs)	-	27,800.95	+27,800.95
	Maintenance cost	-	2,224.08	+ 2,224.08
	Total capital cost	-	30,025.03	+30,025.03
Total cost (excluding overhead cost)		153,820.31	207,889.56	+54,069.25
Overhead cost 20%		30,764.07	41,577.91	+10,813.85
Total cost		184,584.38	249,467.47	+64,883.10

UDRs, Unit Dose Dispensing Robot; OT, Overtime; USD, the United States Dollars

Implementing UDRs increased annual costs by 64,883.10 USD but reduced medication errors from 464.67 to 195.33 events, avoiding 269.34 errors. The ICER was 240.90 USD per avoided medication error. Details are presented in Table 5.

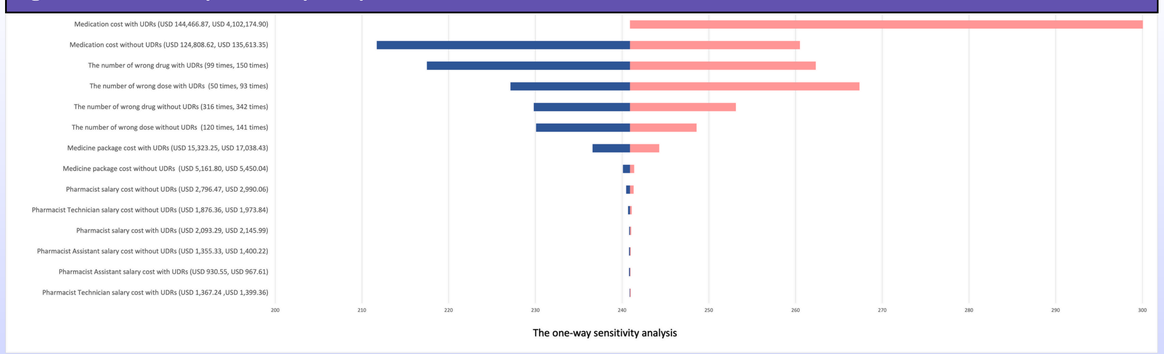
Table 5 The frequency of medication errors, costs, and cost-effectiveness ratio of implementing UDRs.

	Cost (USD)	The number of medication errors	Cost per avoided medication administration error (USD)
Without UDRs	184,584.38	464.67	240.9
with UDRs	249,467.47	195.33	
Incremental comparison (annually)	64,883.10	269.34	

UDRs, Unit Dose Dispensing Robot; USD, the United States Dollars

The one-way sensitivity analysis in Figure 1 indicates that the cost of medications after the implementation of UDRs shows the highest variability, leading to an ICER of $18,116.41 per avoided medication error, compared to the actual ICER of $240.90 per event, which is 75.2 times lower. The second most variable factors are the costs of medications and the number of avoided medication errors, while staff labor costs have the least impact on ICER variability.

Figure 1 The one-way sensitivity analysis.



Discussion

The use of UDRs with a pharmacist added an annual cost of 64,883.1 USD while reducing 269.90 medication errors, resulting in an ICER of 240.4 USD per error avoided. Sensitivity analysis showed medication cost had the highest variance.

Comparison with Previous Studies:

- To our understanding, no previous study has assessed the cost of avoiding medication errors in Thailand.
- Medication Error Reduction: Our findings aligned with studies from Taiwan, Denmark, and Austria, which showed that automated dispensers significantly reduced medication errors, supported by systematic reviews that emphasized their effectiveness over manual dispensing.
- Cost Analysis: Our results matched a Thai study, which showed that although automated dispensers had higher initial costs, their long-term benefits in reducing errors and improving safety justified the investment.

Limitations:

- Medication costs rose in 2021–2022 during the COVID-19 pandemic due to increased admissions and new drug procurements. Threfore, data in 2020 was used for base-case cost calculations, while 2021–2022 data were included in one-way sensitivity analysis to assess variability.
- Data from 2020 was used for cost calculations, with 2021-2022 analyzed via one-way sensitivity.
- A single pharmacist collected data, which may introduce potential bias or human error.
- Only wrong dose, wrong drug, and mix-ups were recorded; other errors were excluded.
- Overhead costs were estimated at 20% due to data collection challenges.

Conclusions

In summary, this study found that the implementation of an Unit Dose Dispensing Robot has a higher cost but can help reduce the number of medication errors. The incremental cost-effectiveness ratio of the implementation of the automatic medication dispenser is 240.40 USD per avoided medication error. Therefore, the use of automatic drug dispensers may be considered a worthwhile investment to increase patient safety and improve the efficiency of hospital drug dispensing.

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