Songklanakarin J. Sci. Technol.
44 (6), 1532-1538, Nov. – Dec. 2022

http://www.sjst.psu.ac.th

Original Article

The impact of centralized electronic bidding system on procurement prices for generic medicines: A case study from Thailand

Amarawan Pentrakan[1*], Jiun-Yi Wang[2, 3], and Wing-Keung Wong[3, 4]

[1] *Department of Pharmacy Administration, Faculty of Pharmaceutical Sciences, Prince of Songkla University, Hat Yai, Songkla, 90110 Thailand*

[2] *Department of Healthcare Administration, Asia University, Taichung, 413 Taiwan, Republic of China*

[3] *Department of Medical Research, China Medical University Hospital, China Medical University, Taichung, 404 Taiwan, Republic of China*

[4] *Department of Finance, Fintech and Blockchain Research Center, Big Data Research Centre, Asia University, 413 Taiwan, Republic of China*

Received: 7 August 2022; Revised: 7 November 2022; Accepted: 18 November 2022

Abstract

A centralized electronic bidding (e-bidding) system has recently become a key government strategy in developing mechanisms for public drug purchasing systems in Thailand. From the previous literature, e-bidding can be an effective tool for controlling the purchase price of a product in various industries. However, this system is still uncommon in pharmaceutical procurement. Thus, this study aims to determine the impact of the e-bidding system on the pricing of generic medicines. Drug procurement data from Thailand for all generic products of omeprazole injection from 2018 to 2019 were used to analyze drug price changes before and after the adoption of the e-bidding system. The results showed that the effect of the e-bidding system was consistent with a 17.35% drop in the mean prices. In addition, the distribution of purchase prices was greatly reduced compared to the traditional system.

Keywords: pharmaceutical procurement, e-bidding, drug prices, generic medicines

1. Introduction

The costs of pharmaceuticals currently pose a growing burden in many countries. In Thailand also, drug expenditures tend to increase continuously. The proportion of pharmaceutical spending during 2000 to 2015 doubled from 21.2% of health expenditures to 43.9% (Sakulbumrungsil *et al.*, 2020). Therefore, the development of procurement processes has become an important policy issue in the current economic and financial crisis. The appropriate procurement systems can be referred to as a critical connecting procedure to effectively guarantee the best use of the limited government budget for the healthcare system (Ahmadi, Pishvaee, & Torabi, 2018). Accordingly, many governments have attempted to establish effective cost-containment policies and reform their procedures for drug procurement to reach essential savings in the use of public financial resources (Nguyen, Knight, Roughead, Brooks, & Mant, 2015).

In general, innovator medicines (also called brand name medicines) are mostly protected by original patents that limit bargaining power through competition. Generic medicines are off-patent pharmaceuticals (because the original patent expired) and are produced by any company, usually selling at a lower price than those with originator brands. For this reason, the cost-containment policies usually target controlling the prices of these generic medicines (Liberman &

*Corresponding author
Email address: amarawan.p@psu.ac.th

Roebuck, 2010). Several studies have revealed that an encouragement to use generic substitution has become an effective price-related mechanism to reduce the escalating healthcare costs and increase access to essential medicines. Similarly, in Thailand promoting prescription of generics is one way of cost-containment in the healthcare setting (Mohara, Yamabhai, Chaisiri, Tantivess, & Teerawattananon, 2012).

Although promoting generic drug use can save a huge amount of government financial resources, some price dispersions are commonly seen in off-patent drug markets (Udomaksorn, Sakulbumrungsil, & Luangruangrong, 2008). Some trade names of generic medicines have continued selling at high prices. This can create problems, as described by Bernstein (Ellison, & Ellison, 2009): a wide range of price dispersion is often present for generic medications in the United States. Some products are threefold more expensive than the lowest priced ones, causing above 43% coefficient of variation (CV, the ratio of the standard deviation to the mean) in drug prices. Theoretically, homogeneous products should be sold at the same price. In the case of buying medicines, if the FDA approves that the products under the same generic name are identical, these generically equivalent products actually should have very little variation in prices. However, the price of the generic drugs often varies greatly, even in an environment convenient for economic competition (Pentrakan, Yang, & Wong, 2021), and the wide price distribution among buyers is often caused by a lack of information (Sorensen, 2000). Many purchasers may buy at higher than the lowest price available because of various reasons, such as information asymmetry, single vendor, higher search costs, and inelastic demand (Jauhar, Sulistyanto, & Laksono, 2018). Furthermore, the limitations of procurement strategies in the market of pharmaceuticals often vary from country to country.

In Thailand, the procurement situation in the pharmaceutical sector is complex and involves various structures, such as monopolies and oligopolies (Suchonwanich *et al.*, 2020). In addition, drug purchasing has related to the agreements of both domestic and international drug markets. The procurement price of each product varies according to the purchasing power of healthcare providers under a decentralized purchasing process (Pentrakan *et al.*, 2021). There was much discussion of inefficient processes and a lack of sufficient information. This has led to inappropriate impacts on the purchasing process, especially by special interest groups. Therefore, Thai policymakers need to develop an efficient procurement system and increase transparency.

In 2018, the Thai government launched an electronic government procurement system (e-GP). One mechanism to improve the efficiency of public drug procurement is the implementation of the electronic bidding (e-bidding) system (Suchonwanich, Laowahutannon, Luangruangrong, Techathawat, & Wongtangprasert, 2020), where there is a central agency handling the procurement activity such as selecting contractors, price negotiation, condition setting, and making a purchasing decision for local units or hospitals who are only required to submit their requests to it. The e-bidding system was issued by the Ministry of Finance and is operated through the Comptroller's Network Information System, namely the e-GP system. Based on review of literature, electronic tendering can be an effective tool in improving public procurement mechanisms for many countries; however, this system is still in its infancy in Thailand, and it remains unclear how much improving the centralized electronic bidding can reduce cost and the distribution of medicine prices, especially in generic medicine market. There is currently no research data to support its efficacy. It can be difficult to assure that implementing an online bidding strategy would greatly benefit governments in curbing generic drug prices.

To inform policymakers about the effectiveness of using the e-bidding system in pharmaceutical procurement, this study aims to determine the effect of this system on drug prices. It was assessed through a sample of all generic products under the same drug category of proton pump inhibitors, namely omeprazole injection (40 milligrams), which accounts for a large magnitude of spending over a given time period and had a wide distribution of purchase prices for equivalent products. This study could be useful to other countries that might consider the e-bidding system in their procurement processes.

2. Materials and Methods

2.1. Participants and data

This study was designed to explore the current situation of the drug market in Thailand assessed through the samples of all generic products under the same drug category of proton pump inhibitors, namely omeprazole injection (40 milligrams). The study data employed nationwide pharmaceutical procurement data of Thailand from 2018 to 2019 in both traditional and e-bidding systems. It consisted of 2,482 transactions in a procurement database from the Ministry of Finance. Data were collected from 1,371 transactions in the year 2018 and 1,111 transactions in the year 2019, as shown in Figure 1.

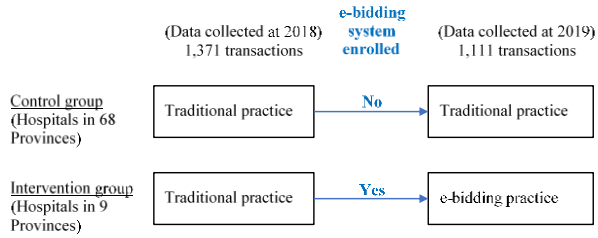

Figure 1. The time frame and intervention of the two groups

2.2. Study design and hypotheses

A retrospective pre-post study design was used in this study. This can be described with the graphic in Figure 1. According to the received data, the hospitals were categorized into two groups: all hospitals in 9 provinces (Sakon Nakhon, Nonthaburi, Trat, Nakhon Phanom, Loei, Nong Khai, Nong Bua Lam Phu, Udon Thani, Bueng Kan) that employed the e-bidding system in 2019 (the intervention group), and all hospitals in the remaining provinces of Thailand that still managed the procurement on their own, not employing the e-bidding in 2019 (the control group). The study determined the year 2018 as a pre-intervention and the year 2019 as post-intervention. Therefore, the following hypotheses were proposed:

Hypothesis 1: The mean price of generic medicines was not significantly different from 2018 to 2019 for those hospitals in the control group.

Hypothesis 2: The mean price of generic medicines was significantly different from 2018 to 2019 for those hospitals in the intervention group.

Hypothesis 3: The mean price of generic medicines showed a significantly larger decrease from 2018 to 2019 in the intervention group compared with that in the control group.

2.3. Variables and analyses

The continuous variable was examined for normality using the Shapiro-Wilk test. In descriptive statistics, the mean prices of medicine between subgroups of variables were compared using an independent *t*-test and one-way analysis of variance. We identified the maximum, minimum, average price, and median price, comparing the traditional system and the e-bidding systems. Price dispersion measures included the maximum price to the minimum price (high-to-low) ratio, the maximum to the median price (high-to-median) ratio, and coefficient of variation (CV) (Ellison, & Ellison, 2009). More specifically, the study employed a difference-in-differences (DID) analysis (Saeed, Moodie, Strumpf, & Klein, 2019) to estimate the effect of an e-bidding system on the price of medicine products. The analysis was calculated as an interaction term in a regression model between participant groups and time dummy variables, after adjustment for the covariate variables.

From our design, the main independent variables were the time dummy variable (pre-and post-intervention), the participant groups (intervention and control groups), and the interaction term of the participant groups and time variables. Four factors associated with prices of medicine were controlled in the analysis. These covariates included procurement quantities (Lewis-Faupel, Neggers, Olken, & Pande, 2016), regions of buyers (Liao, & Cheung, 2002), owners of the facilities (Liberman, & Roebuck, 2010), and the manufacturer's countries (Mackey & Cuomo, 2020). The DID was considered as an interaction term in a general linear model (GLM) between the group and time dummy variables, after controlling for potentially confounding factors (Martin, 2007). This can provide the following equation:

$$Y = \beta_0 + \beta_1[time\ periods] + \beta_2[participant\ groups] + \beta_3[time\ periods * participant\ groups] + \sum_{i=1}^{4} \beta_i [Covariate]_i + \varepsilon$$

Here Y indicates the e-bidding performance measured by drug prices; *[time periods]* indicates a dummy variable of time periods, specified with a value of 1 for the year 2019 (post-intervention) and 0 for the year 2018 (pre-intervention); *[participant groups]* indicates a dummy variable of participant groups, specified with a value of 1 for the intervention group and 0 for the control group; *[time periods * participant groups]* indicates an interaction term of time and participant groups to determine price changes in the time trend of both groups; *[Covariates]* indicates a vector of control variables which may influence Y; and ε indicates an error term.

Regarding the coefficients in the model, $\beta 1$ and $\beta 2$ represent effects with fixed time periods and fixed participant groups, respectively. $\beta 3$ represents an interaction effect between time periods and participant groups, indicating the change in procurement prices of medicines for the intervention group, comparing between post-intervention and pre-intervention. This study considered a significance level of 0.05 (2-sided test) and used IBM SPSS (version 21) to perform the analysis.

3. Results

In the study, three types of analysis results were assessed, including (1) descriptive statistics that pointed out the comparisons of the mean prices of medicine products between subgroups of main factors in the study, (2) price dispersion analysis classified by procurement practices between the e-bidding system and the traditional system, and (3) price reduction analysis with DID estimate of the price for these two groups, before and after program intervention.

3.1. Descriptive statistics

Descriptive statistics for all variables used in this study are described in Table 1. We apply the comparison analysis for the mean prices of the omeprazole drug between/among subgroups and find that all variables have a significant difference in the mean prices between subgroups. All variables were statistically significantly different in the mean price between the subgroups of each variable. Specifically, the findings indicated higher drug average price differences between the control and intervention groups in 2019 with e-bidding implemented, compared to 2018 without e-bidding.

3.2. Price dispersion analysis

The results in Table 2 suggest that the prices of generic medicines for omeprazole products had high price dispersions. The overall average coefficient of variation (CV) was 18.81%. The study found that the various products were procured in the traditional system and had high price dispersion. The average CV of drug prices was 23.18%. Specifically, the products manufactured from India, Thailand, and Mexico had high average CV ratio, approximately 32.43%, 37.40%, and 34.38%, respectively. The price dispersion was substantially lower when using the e-bidding system. It showed that there was the high-to-low ratio ranging from 1.16 to 5.10 and the high-to-median ranged from 1.10 to 3.24. In contrast, for the e-bidding system, only Indian product was procured and represented a CV of 0.92%. It also presented a smaller ratio of the high-to-low and the high-to-median than the traditional system at 1.11 and 1.03, respectively.

3.3. Difference-in-differences (DID) analysis

As shown in Table 3, purchasing the medicine product after implementing the e-bidding system was significantly associated with a 4.347 baht (95% CI, 2.229 - 6.466 baht) or a 22.32% decrease in the unit prices when compared with before implementing the system. Further, the

Table 1. Comparison of the mean prices of medicine between subgroups

Variables	n	%	Mean	SD	*p*-value [a]
1. Data collected at 2018					<0.001
Control group	1,106	83.98	20.48	10.29	
Intervention group	265	16.02	17.54	8.00	
2. Data collected at 2019					<0.001
Control group	1,039	93.52	20.61	12.13	
Intervention group	72	6.48	12.34	0.11	
3. Regions of buyers					<0.001
North	428	17.24	18.51	10.2	
Central	522	21.03	22.46	13.99	
East	1,124	45.29	19.21	9.80	
South	408	16.44	20.51	9.16	
4. Manufacturer's countries					<0.001
From India	1,930	77.76	17.51	5.95	
From others	552	22.24	28.64	17.65	
5. Owners of facilities					<0.001
MOPH agencies	2,347	94.56	18.47	8.28	
Non-MOPH agencies	135	5.44	46.29	15.80	
6. Purchased Quantities					<0.001
Less than 100 vials	46	1.85	36.28	21.51	
100-499 vials	684	27.56	19.86	9.53	
500 vials and more	1,752	70.59	19.61	10.63	

Abbreviations: MOPH, Ministry of Public Health

[a] Independent *t*-test for two-samples comparison and 1-way ANOVA for multiple-samples comparison.

Table 2. Drug price dispersion parameters, classified by procurement systems

Systems	Manufacturers Countries	n (%)	Min.	Max.	Median	Mean	High to low ratio	High to median ratio	%CV
1. E-bidding system	INDIA (1 trade name)	72 (100%)	11.47	12.74	12.35	12.34	1.11	1.03	0.92
2. Traditional system	INDIA (13 trade names)	2,113 (87.68%)	12.10	50.29	15.51	17.58	4.16	3.24	32.43
	THAILAND (3 trade names)	206 (8.55%)	12.35	63.00	53.00	45.19	5.10	1.19	37.40
	MEXICO (2 trade names)	65 (2.70%)	12.35	35.00	16.00	18.10	2.83	2.19	34.38
	TAIWAN (1 trade name)	22 (0.91%)	41.00	52.00	46.90	46.69	1.27	1.11	5.24
	COLOMBIA (1 trade name)	4 (0.17%)	13.37	15.51	14.05	14.24	1.16	1.10	6.43

Abbreviations: CV, Coefficient of Variation

Table 3. Regression results

Parameters	B	95% CI	*t*	*p*-value
Main Effect				
Group: intervention (e-bidding)	-4.480	(-6.481, -2.478)	-4.389	<0.001
Time: post-intervention	-4.347	(-6.466, -2.229)	-4.024	<0.001
Interaction Effect				
E-bidding System*Time	-3.176	(-5.405, -0.946)	-2.793	0.005
Control variables				
1. Hospital Regions (Reference: Central region)				
North Region	-2.093	(-3.136, -1.050)	-3.934	<0.001
East Region	0.740	(-0.147, 1.626)	1.636	0.10
South Region	2.232	(1.151, 3.314)	4.048	<0.001
2. Sources of Manufacturers (Reference: Not manufactured in India)				
Indian Manufacturers	-7.550	(-8.361, -6.739)	-18.257	<0.001

Table 3. Continued.

Parameters	B	95% CI	*t*	*p*-value
3.Purchased Quantity (Reference: High volume: equal or more than 500 vials)				
Low volume (less than 100 vials)	6.943	(4.521, 9.364)	5.622	<0.001
Medium volume (100-499 vials)	0.179	(-0.548, 0.906)	0.482	0.63
4. Owners of facilities (Reference: Non-MOPH agencies)				
Ministry of Public Health (MOPH) agencies	-24.214	(-25.735, -22.693)	-31.218	<0.001

R-square = 0.449 (Adjusted R-square = 0.447)

mean price for medicine products purchased in the intervention group was significantly cheaper compared to the control group, which was 4.480 baht (95% CI, 2.478 - 6.481 baht) or a 22.85% decrease in the unit prices.

In DID estimate, the analysis involved the control group to provide an estimate of the counterfactual, and time-varying confounders are controlled by design, as shown in Figure 2. The estimated marginal means of the prices for these two groups, before and after program intervention are demonstrated in Table 4. The results showed that there was no significant difference from 2018 to 2019 for those hospitals in the control group, while there was significant difference for hospitals in the intervention group. Furthermore, Figure 2 also presents the mean price of generic medicines that showed a significantly larger decrease from 2018 to 2019 in the intervention group compared with that in the control group.

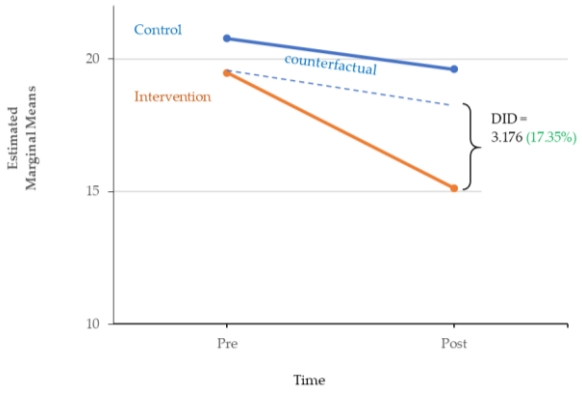

Figure 2. Illustration of the two-group two-period DID estimate

4. Discussion

This analysis used Thai procurement data from 2018 to 2019 in both traditional and e-bidding systems and was designed to sample all generic products under the same drug category of proton pump inhibitors, namely omeprazole injection (40 milligrams), which incurred a large magnitude of spending over the given time period.

Our results showed large price dispersions among generic medicine products in the current market, as seen in Table 2. This can suggest that some hospitals still purchased medicine at an expensive price. Some prior literature dealing with pharmaceutical procurement mentioned that different public hospitals purchase the exact same product at different prices, and this is caused by many factors (Pentrakan *et al.*, 2021; Songthung *et al.*, 2012) such as different bargaining power of buyers, the relationship with suppliers, volume discounts, differences in manufacturer's countries or distributors, etc.

This can be confirmed by our findings, which are described in Table 1. The study found that the mean prices of generic medicines had significant differences among subgroups of participants, regions of buyers, manufacturer's countries, owners of the facilities, and procurement quantities. Specifically, when comparing the price dispersions between the e-bidding system and the traditional system, we found that purchasing drugs in the e-bidding system presented less price dispersions. Only one generic trade name from India was selected as the winner product for all transactions in the e-bidding system with the lowest mean price and the percentage of coefficient of variation (CV) for drug prices in the e-bidding system was only 0.92%, whereas those purchasing by the traditional system had higher prices and larger variations from various trade names, both domestic and imports. The average CV of drug prices in the traditional system was 23.18%. Specifically, the products manufactured from India, Thailand, and Mexico had an average CV ratio in excess of 30%, often suggesting that existing procedures might not be appropriate enough (Bernstein *et al.*, 2019). These results suggested that the distribution of drug prices in the e-bidding system was substantially lower than that in the traditional system. From previous literature, the study of Arslan *et al.* (2006) also supported this phenomenon, namely that the electronic technology can improve the efficiency and accuracy of the bidding procedure, since the entirely online procurement system can enable the government to control the bidders and obtain eligibility winners.

Table 4. Estimated marginal means of price in model for two groups, before and after program intervention

Groups	Time Periods	Mean (95% CI)	Standard Error	*P*-value
Control group	Pre-intervention	20.780 (20.300-21.160)	0.245	0.795
	Post-intervention	19.609 (19.111-20.106)	0.254	
Intervention group	Pre-intervention	19.476 (18.452-20.500)	0.522	<0.001
	Post-intervention	15.129 (13.205-17.053)	0.981	

In this study, the effect of the e-bidding system on procurement prices was measured by comparing the differences in outcomes, before and after an intervention, between two groups after controlling for potentially confounding factors. As shown in Table 3, we found that the main effects both in the different groups and different time periods were significantly associated with the changes in mean prices of medicines. The mean price of omeprazole products purchased by the intervention group was significantly cheaper than in the control group, approximately by 4.480 baht/vial (95% CI, 2.478 – 6.481 baht) or a 22.85% decrease in mean price for each vial. Furthermore, the mean price of medicines significantly decreased after introducing the e-bidding system, approximately by 4.347 baht/vial (95% CI, 2.229 – 6.466 baht) or a 22.32% decrease in mean price for each vial.

Furthermore, the results in Table 4 fully support all the hypotheses, which can be easier to see from the graphic in Figure 2. There was no significant difference from 2018 to 2019 for those hospitals in the control group, while there was significant difference for hospitals in the intervention group. This clearly supports our hypotheses 1 and 2. Moreover, the results also supported hypothesis 3 because the mean price of generic medicines showed a significantly larger decrease from 2018 to 2019 in the intervention group compared with that in the control group. The DID estimate clearly indicates that lowering generic drug prices during given time periods was strongly associated with the adoption of e-bidding system, incurring a 3.176 baht (95% CI, 0.9462 - 5.405 baht) or 17.35% decrease in the mean price of each vial.

The findings corroborate the study of Lenin (2011), that is, only eligible suppliers who provided quality drug at the best prices can be winners in the e-bidding system because the system can inform of data on transactions for procurement between the client and bidders. The circulation of information can be monitored, as bidding documentation and outcomes of any transactions were automatically recorded online (winning suppliers, rankings, final offers). Some studies have also explained that the e-bidding system could lead to increasing transparency, mitigating the corruption risks by avoiding direct contact between suppliers and purchasers (Zuba-Ciszewska *et al.*, 2022). Further, our findings point out that the prices of generic medicines were significantly associated with procurement quantities, manufacturers' countries, regions, and owners of facilities. We found that the hospitals registered under the Ministry of Public Health (MoPH) can purchase medicines at a much lower price (statistically significantly) than those registered under other agencies. This may be due to some previous policies and indirect measures of MoPH to control the drug prices, such as the implementation of the National List of Essential Medicines and encouraging pooled procurement at provincial levels for high volume bargaining (Suchonwanich *et al.*, 2020).

Moreover, we found that almost 98% of the total purchase quantity was manufactured by Indian pharmaceutical companies and the mean price also was cheaper than of equivalent products from other countries. This may be not only evident for Thailand, since India also showed as the largest provider of generic pharmaceuticals globally (Kale & Little, 2007). For domestic pharmaceutical manufacturers, there was no doubt that they had the highest median price and largest dispersion due to the limited capacity of the manufacturers in Thailand to produce the active ingredients, so most raw materials have been imported. Thus, further actions are necessary to contain the risk of inhibiting innovation and limiting supplier participation, especially for domestic manufacturers.

5. Conclusions

In conclusion, our analysis has revealed that by implementing the centralized e-bidding system in the government procurement of pharmaceuticals, Thailand has achieved the goal of reducing the prices of generic medicine products, specifically of the omeprazole injection drug. By adopting the e-bidding system, hospitals can respond to the challenge of generic medicine prices by receiving unbiased market information on the product availability and on fair comparative prices to select the eligible winners, which will reduce the drug prices for each medicine and narrow price dispersion significantly. Our reported study has some limitations. First, it was designed to examine exactly the generic products for omeprazole injection. Using a different selection of medicines could yield different findings. Second, the result in the study was based on the accuracy of purchasing data and the identification of the twenty-one trade products for the given generic name. More data and more trade products would be a better sampling. Nevertheless, the demonstration of price dispersion and the changes in the drug price here can be treated as an example of the impact of a centralized e-bidding system on the price changes of generic pharmaceuticals.

Future research is needed to profoundly analyze hospitals' willingness to use the e-bidding system. The difficulty of using data networks through electronic platforms is discussed, and it should be explored to make the system more user-friendly. As shown in our study, although the driving force for the adoption of e-bidding systems is increasing, a significant proportion of current purchasing transactions in Thailand still represent a high level of traditional system use. Therefore, the willingness of hospitals to implement e-bidding systems needs to be analyzed regarding hospital outcomes in terms of both the benefits and challenges of implementing e-bidding.

Acknowledgements

We are thankful to Dr. Boonchai Kijsanayotin, Manager, the Thai Health Information Standards Development Center for providing the updated report of Thai Medicine Terminology and the Comptroller General's Department, Ministry of Finance in Thailand for providing access to the pharmaceutical procurement database.

References

Ahmadi, A., Pishvaee, M. S., & Torabi, S. A. (2018). Procurement management in healthcare systems. In C. Kahraman, & Y. I. Topcu (Eds.), *Operations research applications in health care management* (pp. 569-598). Cham, Switzerland: Springer.

Arslan, G., Tuncan, M., Birgonul, M. T., & Dikmen, I. (2006). E-bidding proposal preparation system for construction projects. *Building and Environment,*

41, 1406-1413.

Bernstein, J. J. J., Holt, G. B., & Bernstein, J. (2019). Price dispersion of generic medications. *PLoS One, 14*(11), e0225280. doi:10.1371/journal.pone.0225280

Dimitri, N., Dini, F., & Piga, G. (2006). When should procurement be centralized? In G. Spagnolo, G. Piga, & N. Dimitri (Eds.), *Handbook of procurement* (pp. 47-81). Cambridge, England: Cambridge University Press.

Ellison, G., & Ellison, S. F. (2009). Search, obfuscation, and price elasticities on the internet. *Econometrica*, *77*(2), 427-452. doi:10.3982/ECTA5708

Jauhari, W. A., Sulistyanto, R., & Laksono, P. W. (2018). Coordinating a two-level supply chain with defective items, inspection errors and price-sensitive demand. *Songklanakarin Journal of Science and Technology*, *40*(1), 135–145.

Kale, D., & Little, S. (2007). From imitation to innovation: The evolution of r&d capabilities and learning processes in the Indian pharmaceutical industry. *Technology Analysis and Strategic Management*, *19*(5), 589–609.

Lenin, J. N. (2011). Integrated e-bidding framework for construction. *International Journal of Construction Education and Research*, *7*(4), 243–258.

Lewis-Faupel, S., Neggers, Y., Olken, B. A., & Pande, R. (2016). Can electronic procurement improve infrastructure provision? Evidence from public works in India and Indonesia. *American Economic Journal: Economic Policy*, *8*(3), 258-283. doi:10.1257/pol.20140258

Liao, Z., & Cheung, M. T. (2002). Internet-based e-banking and consumer attitudes: An empirical study. *Information and Management*, *39*(4), 283–295. doi:10.1016/s0378- 7206(01)00097-0

Liberman, J. N., & Roebuck, M. C. (2010). Prescription drug costs and the generic dispensing ratio. *Journal of Managed Care Pharmacy*, *16*(7), 502-506. doi:10.18553/jmcp.2010.16.7.502

Mackey, T. K., & Cuomo, R. E. (2020). An interdisciplinary review of digital technologies to facilitate anti-corruption, transparency and accountability in medicines procurement. *Global Health Action, 13*(Supplement 1), 1695241. doi:10.1080/16549716.2019.1695241

Martin, J. L. N. (2007). E-bidding for building contracts in the UK. *AACE International Transactions*, RI21-RI24.

Mohara, A., Yamabhai, I., Chaisiri, K., Tantivess, S., & Teerawattananon, Y. (2012). Impact of the introduction of government use licenses on the drug expenditure on seven medicines in Thailand. *Value Health*, *15*(1), S95-S99.

Nguyen, T. A., Knight, R., Roughead, E. E., Brooks, G., & Mant, A. (2015). Policy options for pharmaceutical pricing and purchasing: Issues for low- and middle-income countries. *Health Policy and Planning, 30*(2), 267-280. doi:10.1093/heapol/czt105

Pentrakan, A., Yang, C. C., & Wong, W. K. (2021). How well does a sequential minimal optimization model perform in predicting medicine prices for procurement system? *International Journal of Environmental Research and Public Health*, *18*(11), 5523. doi:10.3390/ijerph18115523

Saeed, S., Moodie, E. E. M., Strumpf, E. C., & Klein, M. B. (2019). Evaluating the impact of health policies: Using a difference-in-differences approach. *International Journal of Public Health*, *64*(4), 637-642. doi:10.1007/s00038-018-1195-2

Sakulbumrungsil, R., Kessomboon, N., Kanchanapibool, I., Manomayitthikan, T., Thathong, T., Patikorn, C., Vanichayakorn, T., & Udomaksorn, K. (2020). The impact of drug financing system under Thailand universal health coverage (UHC) on the performances of drug system. *Journal of Health Science*, *29*, 59-71.

Songthung, P., Sripanidkulchai, K., Luangruangrong, P., Sakulbumrungsil, R. C., Udomaksorn, S., Kessomboon, N., & Kanchanaphibool, I. (2012, 24-27 July 2012). *An innovative decision support service for improving pharmaceutical acquisition capabilities.* Paper presented at the 2012 Annual SRII Global Conference.

Sorensen, A. T. (2000). Equilibrium price dispersion in retail markets for prescription drugs. *Journal of Political Economy*, *108*(4), 833-850. doi:10.1086/316103

Suchonwanich, N., Laowahutannon, T., Luangruangrong, P., Techathawat, S., & Wongtangprasert, S. (2020). Drug procurement and distribution. *Journal of Health Science*, *29*, S45-S58. Retrieved from https://thaidj.org/index.php/JHS/article/view/8412.

Udomaksorn, S., Sakulbumrungsil, R. C., & Luangruangrong, P. (2008). The investigation of pharmaceutical price discrimination among public hospitals in Thailand: A case study of agent acting on the renin angiotensin system (ACE) inhibitors. *Thai Journal of Pharmaceutical Sciences*, *18*(2), 128-138.

Zuba-Ciszewska, M., Brodziak, A., Manning, L., Kijek, T. (2022). Lactose-free products: A study of young Polish consumers' knowledge and purchase behaviour. *Songklanakarin Journal of Science and Technology. 44* (3), 619-626.