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Factors Influencing the Total Inpatient Pharmacy Cost at a Tertiary Hospital in Malaysia: A Retrospective Study

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Abstract

The steady growth of pharmaceutical expenditures is a major concern for health policy makers and health care managers in Malaysia. Our study examined the factors affecting the total inpatient pharmacy cost (TINPC) at the Universiti Kebangsaan Malaysia Medical Centre (UKMMC). In this retrospective study, we used 2011 administration electronic prescriptions records and casemix databases at UKMMC to examine the impact of sociodemographic, diagnostic, and drug variables on the TINPC. Bivariate and multivariate analyses of the factors associated with TINPC were conducted. The mean inpatient pharmacy cost per patient was USD 102.07 (SD = 24.76). In the multivariate analysis, length of stay (LOS; $B = 0.349$, $P < .0005$) and severity level III ($B = 0.253$, $P < .0005$) were the primary factors affecting the TINPC. For each day increase in the LOS and each increase of a case of severity level III, there was an increase of approximately USD 11.97 and USD 171.53 in the TINPC per year, respectively. Moreover, the number of prescribed items of drugs and supplies was positively associated with the TINPC ($B = 0.081$, $P < .0005$). Gender appears to have affected the TINPC; male patients seem to be associated with a higher TINPC than females (mean = 139.55, 95% confidence interval [CI]: 112.97-166.13, $P < .001$). Surgical procedures were associated with higher cost than medical cases (mean = 87.93, 95% CI: 61.00-114.85, $P < .001$). Malay (MYR 242.02, SD = 65.37) and Chinese (MYR 214.66, SD = 27.99) ethnicities contributed to a lower TINPC compared with Indian (MYR 613.93, SD = 98.41) and other ethnicities (MYR 578.47, SD = 144.51). A longer hospitalization period accompanied by major complications and comorbidities had the greatest influence on the TINPC.

Keywords

retrospective study, casemix, inpatients, electronic prescription, comorbidity, pharmacy cost, Malaysia

Introduction

The steady growth of pharmaceutical expenditures is a major concern for health policy makers in Malaysia, where medicine expenditures have grown to represent approximately 11.4 % of the operating budget of the Ministry of Health Malaysia in 2012.[1] The lack of a of national pricing policy has led to escalating medicine prices, significant variation between private and public sectors, and limited accessibility to affordable medicines.[1] Consequently, the Malaysian National Medicine Policy (MNMP) was developed with an agenda that primarily focuses on how to manage medicine and how to reduce unnecessary resource consumption. Methods such as cost containment, cost-effectiveness assessment, generic drug promotion, and international price referencing are being considered.[1] The need for cost and pharmacoeconomics evaluations is well acknowledged.[2-6] In terms of health-policy comparatives and analytic techniques, health economic studies provide important and valuable information that enables health care decision makers to adjust and effectively use of pharmaceuticals.[3] In this article, we used normal linear specifications to test a number of factors (eg, sociodemographic, diagnostic, and drug data) that are thought to impact the total inpatient pharmacy cost (TINPC), and we compared our results with others from literature. To establish these linear relationships, we needed 2 essential sources of individual patient-level data (IPD): pharmaceutical cost data and patient characteristics (ie, diagnosis, procedures, and e-prescriptions data).

IPD captures the details of specific patient (depending on the data source) and serves as a potential tool to analyze pharmaceutical cost.[4] However, many countries including Malaysia are hindered by the lack of the availability of detailed illness costs at IPD, which can reflect negatively on

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the health economic analysis relevant to the local health care system. The National University of Malaysia Medical Center (UKMMC) was a pioneer that adopted and developed its own casemix and Malaysian Diagnosis-Related Groups (MY-DRGs) system in 2002.[7]

DRGs are patient classification systems (PCSs), which are technically and clinically practical systems that facilitate the estimation of patient costs. They classify each patient case according to the diagnosis and other case characteristics, such as the patient's age, gender, case severity, comorbidities, and procedures performed.[8] PCSs have long been recognized as being of great importance in supporting decision makers with resource utilization and helping with budget planning as well.[9] MY-DRGs have been linked to and supported by an effective pharmacy electronic prescribing (e-prescribing) system, which provides information about the medicine prescribed as well as the quantity, dose, and pathology at the individual level.[10]

Considerable research has been performed worldwide to correlate the cost-affecting factors with total hospital costs. A combination of the drug and diagnostic data, rather than either type of data alone, can better estimate total health care costs.[4,9,11] Most research, however, has had to use surrogate data for the cost of individual patient care; some studies have used length of hospital stay,[12-14] severity of illness,[15,16] increase in the number of prescribed items,[3] and demographic structure[17]; and some have modeled drug expenditures based on morbidity data.[18]

This article describes some factors that are likely to influence the TINPC. Our intent is to provide information to aid health policy makers, health-system pharmacists, and other health care managers to determine how future sociodemographic, diagnostic, and drug data will jointly affect pharmacy expenditures in their own organizations.

Methods

Study Design and Sampling Technique

This study is a secondary analysis of a retrospective study conducted at the University Kebangsaan Malaysia Medical Center (UKMMC) in 2015.[4,19] Briefly, information on all patients admitted in UKMMC from January 1 to December 31, 2011, was collected from the pharmacy e-prescribing and Casemix databases. Outpatient visits and patients who were admitted before or after 2011 were excluded. To produce one set of data, shared variables such as patient medical registration number (MRN), date of admission, and the principle diagnosis were used to join the 2 sets electronically.

Study Outcomes and Definitions

The primary outcome of this study was the TINPC per patient. Figure 1 illustrates the costing approaches used to calculate the TINPC, and the complete estimation methods are described in detail elsewhere.[4]

A number of proposed factors that may have impacted the TINPC are shown in Figure 2. Patient sociodemographics (age, gender, and ethnicity) and diagnostic data (the LOS, type of the cases) were extracted from casemix database, and the drug data (the number of medications and supplies items prescribed in each episode of care) were extracted from the e-prescribing database.

Patient age was defined as age at the last birthday on the day the patient was admitted to UKMMC. Gender was assigned base on sex, male (1) and female (2). The ethnicities of the target population were Malay (1), Chinese (2), Indian (3), and other nationalities (a small minority of Malaysians who do not fit into the broader 3 ethnic groups) (4). Hospital LOS was defined as the duration the patient stayed in the ward from admission until discharge. In the MY-DRG system, the minimum LOS for any patient is 1 day (at least), including patients who were admitted and discharged on the same day. Therefore, the LOS was calculated for each patient / episode using the following equation: (date of discharge – date of admission) + one. The number of drugs and supply items is defined as the number of drugs and supplies prescribed in each e-prescription for each inpatient episode. Patient cases are categorized into 2 case groups: medical and surgical cases. Medical cases are patients who were admitted to a medical-based discipline ward without any major procedures. Surgical cases are patients who were admitted to surgical-based discipline wards and (usually) underwent major surgical procedures. MY-DRG is a casemix system used in Malaysia: it was developed based on an international grouper called United Nations University-Case Based Groups (UNU-CBG) grouper. There are 3 severity levels for acute conditions in MY-DRG: severity level I (no complications or comorbidities), severity level II (minor complications or comorbidities), and severity level III (major complications or comorbidities). The severity levels are determined by the grouper based on the secondary diagnoses and procedures. The severity level is assigned by the grouper software following the algorithm.

Statistical Analysis

Clinical and demographic characteristics were reported for each patient based on the episode of care (admission and discharge). Some missing data were found during the data analysis process; however, the extent to which the data were missing was limited and did not affect the structure of study. The collected data were analyzed using Statistical Package for Social Science (SPSS) program version 16.0 (SPSS Inc, Chicago, Illinois).[20] A normality test (Kolmogorov-Smirnov) was performed and all quantitative data were found to be normally distributed. Descriptive analyses were used to summarize the primary outcome of this study (TINPC per patient) and the affecting factors. Furthermore, bivariate analyses (eg, Pearson's correlation analysis, independent-sample *t* tests, and analysis of

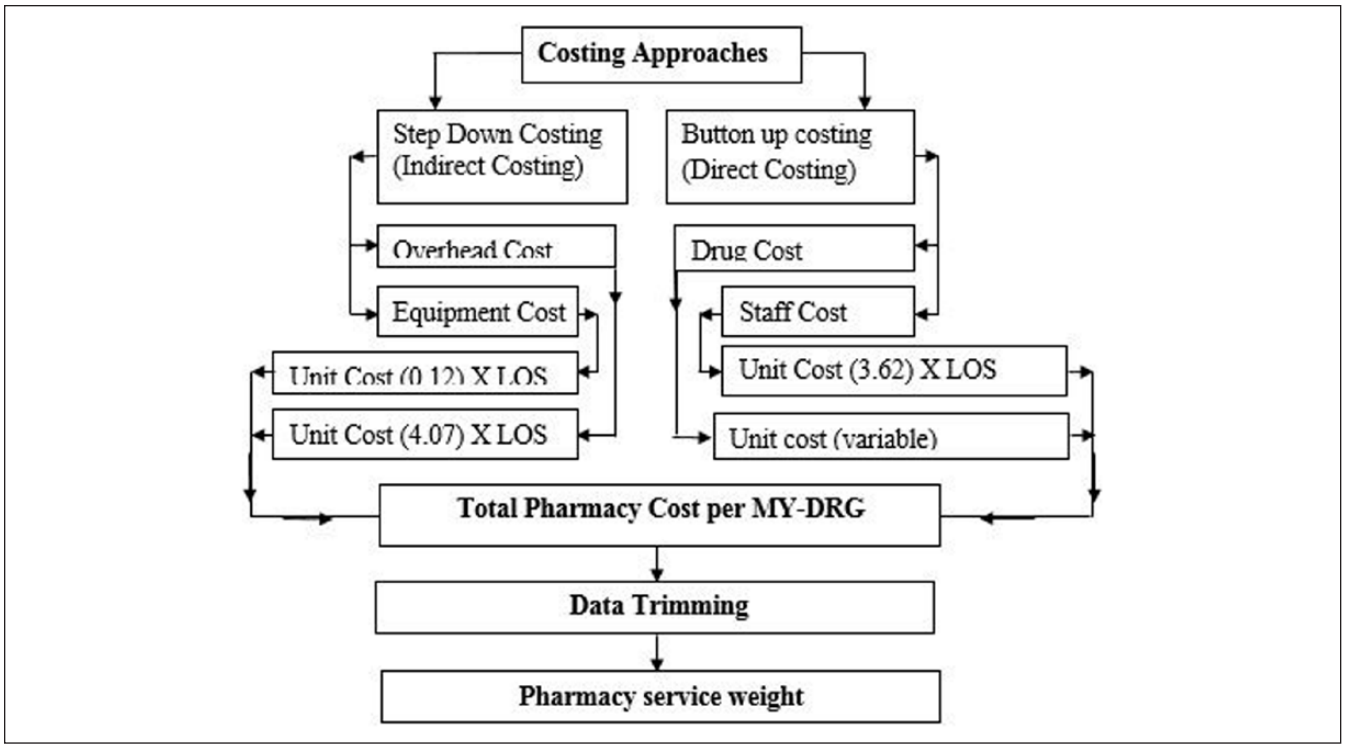

Figure 1. Study costing strategy.[4]
Note. LOS = length of stay; MY-DRG = Malaysian Diagnosis-Related Groups.

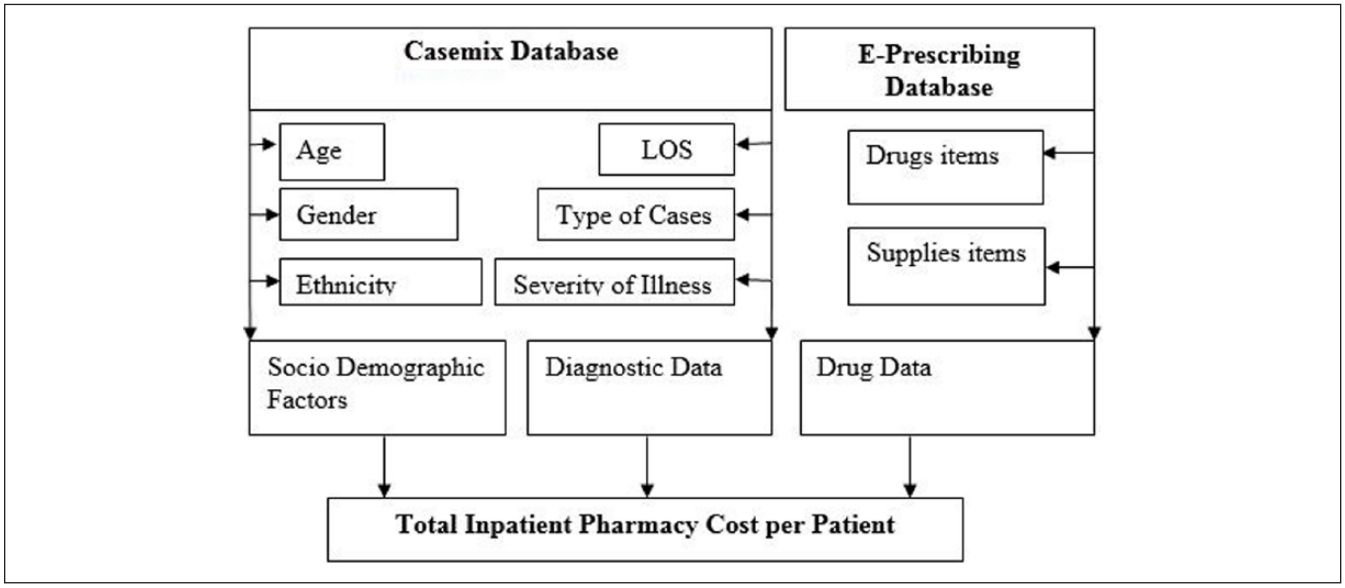

Figure 2. Factors affecting total inpatient pharmacy cost per patient.
Note. LOS = length of stay.

variance [ANOVA]) were performed to test the association between the factors and the study outcome. Significant factors affecting the TINPC in the bivariate analysis (P value $< .05$) were included in the multivariate analysis. Multivariate linear regression analysis (backward technique) was performed to identify the significant factors affecting TINPC. In "backward elimination," all independent variables are entered into the equation first and the variables that are not significant are removed one by one until a satisfactory model is obtained.

Table 1. Descriptive and Bivariate Association Between the Related Factors and the Total Inpatient Pharmacy Cost (n = 13 673).

Characteristics	N (%)	Mean ± SD	*r* value and *P* value, according to Pearson correlation analysis, *t* test, and ANOVA
Age		43.53 ± 22.27 (years)	$r = 0.147$, $P < .0001$
Length of stay		6.76 ± 7.16 (days)	$r = 0.502$, $P < .0001$
Number of items		8.18 ± 5.81	$r = 0.376$, $P < .0001$
Gender			
Male	5767 (42.2)	397.11 ± 84.50 (MYR)	$t = 10.292$, $P < .001$
Female	7906 (57.8)	257.56 ± 68.89 (MYR)	
Type of cases			
Surgical	5204 (38.1)	349.89 ± 72.89 (MYR)	$t = 6.402$, $P < .001$
Medical	8469 (61.9)	261.96 ± 80.95 (MYR)	
Ethnicity			
Malay	6738 (49.3)	242.02 ± 65.37 (MYR)	$F = 179.320$, $P < .0001$
Chinese	3801 (27.8)	214.66 ± 27.95 (MYR)	
Indian	1887 (13.8)	613.93 ± 98.41 (MYR)	
Others	1247 (9.1)	578.47 ± 144.51(MYR)	
Severity of cases			
Severity level I	7329 (53.6)	126,05 ± 21.81 (MYR)	$F = 1327.693$, $P < .0001$
Severity level II	4210 (30.8)	269.98 ±49.28 (MYR)	
Severity level III	2134 (15.6)	1008.59 ± 157.23 (MYR)	

Note. Data are the mean ± standard deviation; *P* values were calculated based on Pearson correlation analysis, an independent-sample *t* test, and ANOVA. ANOVA = analysis of variance; MYR = Malaysian Ringgit.

Odds ratios and 95% confidence interval were calculated. An alpha level of $P < .05$ was considered to be statistically significant.

Results

Descriptive Analyses

The average patient ages was 43.53 years (SD = 22.28 years) (range: 0-107), and 7906 (57.8%) were females. Approximately half of the patients were Malay (6738, 49.3%), diagnosed as medical cases (8469, 61.9%), with severity level I (53.6%). The LOS ranged from 1 to 69 days with an average LOS of 6.76 (SD = 7.16) days and a median of 4 days. In total, more 111 794 items (ie, the number of drugs and supplies) were prescribed for all 13 673 patients with an average of 8.18 (SD = 5.81; range, 1 to 25 items; median, 6 items). The TINPC calculated for all 13 673 patients was Malaysia Ringgit (MYR) 4 326 458.36, which is equivalent to USD 1 395 631.73 (based on the exchange rate from August 27, 2014). The mean cost for each patient was MYR 316.42 (SD = MYR 76.75), which is equivalent to USD102.07 (SD = USD24.76), and a median cost of MYR 109.65, which is equivalent to USD 35.37 (Table 1).

Bivariate Analysis

A Pearson product moment correlation was performed to determine the relationship between the patient age, LOS, number of items of drugs and supplies, and TINPC. As shown in Table 1, there was a positive correlation between the patient age, LOS, number of items of drugs and supplies, and TINPC. The correlation was statistically significant for age ($r = 0.147$, n = 13673, $P < .0001$), LOS ($r = 0.502$, n = 13 673, $P < .0001$) and number of items of drugs and supplies ($r = 0.376$, n = 13 673, $P < .0001$).

An independent-sample *t* test was performed to determine whether there were differences in the TINPC between males and females and between medical and surgical cases separately. There were differences in the TINPC between males and females. The TINPC was higher among males (m = MYR 397.11, SD = 84.50) than among females (m = MYR 257.56, SD = 68.89), and this difference was statistically significant, m = 139.55, 95% CI = 112.97-166.13, $t(10851.317) = 10.292$, $P < .001$. Surgical procedures incurred a much higher TINPC compared with medical cases, and this difference was statistically significant, m = 87.93, 95% CI = 61.00-114.85, $t(10132.631) = 6.402$, $P < .001$ (Table 1). A 1-way between-groups ANOVA was conducted to explore the impact of ethnicity and case severity on the TINPC. A statistically significant difference was observed between ethnic groups as determined by 1-way ANOVA, $F(3, 13669) = 197.320$, $P < .0001$. The Tukey post hoc test revealed that the TINPC was statistically significantly higher among patients of Indian ethnicity (MYR 613.93, SD = 98.41, $P < .0001$) and other ethnicities (MYR 578.47, SD = 144.51, $P < .0001$) compared with Malay ethnicity (MYR 242.02, SD = 65.37, $P < .0001$) and Chinese ethnicity (MYR 214.66, SD = 27.99, $P < .0001$), respectively. There was a statistically significant difference between the severity of cases groups, as determined by 1-way

Table 2. Multivariate Linear Regression Analysis for the Total Inpatient Pharmacy Cost (n = 13 673).

Model	Unstandardized coefficients		Standardized coefficients		
	B	SE	Beta	*t*	Significance
(Constant)	1.381	16.112	—	0.086	0.932
Length of stay	37.118	0.998	**0.349**	37.199	0.000
No. of items	10.553	1.188	0.081	8.879	0.000
Surgical cases	31.432	11.253	0.020	2.793	0.005
Gender (males)	28.378	10.954	0.018	2.591	0.010
Severity level II	82.778	12.246	0.050	6.760	0.000
Severity level III	531.750	16.861	**0.253**	31.536	0.000
Malay ethnicity	−193.938	13.714	−0.127	−14.141	0.000
Chinese ethnicity	−212.117	15.260	−0.125	−13.901	0.000

ANOVA, $F(2, 13670) = 1327.693$, $P < .0001$. The Tukey post hoc test revealed that the TINPC was statistically significantly higher among patients with severity level III (MYR 1008.59, SD = 157.23, $P < .0001$) and patients with severity level II (MYR 296.98, SD = 49.28, $P < .0001$) compared with patients with severity level I (MYR 126.05, SD = 21.81, $P < .0001$) (Table 1).

Multivariate Linear Regression Analysis

In backward elimination (or backward deletion), the variables of age and Indian ethnicity did not contribute to the regression equation because their coefficients were statistically insignificant ($P = .789$, $P = .162$), respectively. The multivariate linear regression analysis (after excluding of age and Indian ethnicity) was statistically significant, and overall, explained 32.7% of the variance in the TINPC, $F(8, 13664) = 829.328$, $P < .0005$.

The LOS and severity level III appeared to be the strongest factors affecting the TINPC; followed by the number of items of drugs and supplies and severity level II (Table 2).

Patients with a longer LOS in the hospital were more likely to have high a TINPC ($B = 0.349$, $P < .0005$). Patients with severity level III were more likely to have high TINPC ($B = 0.253$, $P < .0005$). Patients with more items of prescribed drugs and supplies were more likely to have a high TINPC ($B = 0.081$, $P < .0005$). Patients with severity level II were more likely to have high TINPC ($B = 0.050$, $P < .0005$). Patients who had have undergone more complex procedures (surgical case) were more likely to have a high TINPC ($B = 0.020$, $P = .005$). Male patients were more likely to have a high TINPC than female patients ($B = 0.018$, $P = 0.010$). Malay and Chinese ethnicities were more likely to have lower TINPC compared with other ethnic groups ($B = -14.141$, $P < .0005$), ($B = -13.901$, $P < .0005$), respectively (Table 2).

Discussion

It was an interesting exercise to examine factors that may have impacted on the TINPC at UKMMC. However, it was not possible to capture all possible factors. Only 32.7% of the variation was explained; 67.3% of the variation remained unexplained. Clearly, other factors may affect the TINPC.

In the multivariate regression analysis, LOS and severity level III showed the strongest impact on the TINPC. These factors appeared to have a significant and positive linear association with the TINPC. After controlling for other factors, for each 1-day increase in LOS, there was an increase approximately MYR 37.118 (equivalent to USD 11.97) increase in TINPC per year; and for each increase in one case of severity level III, there was an increase approximately MYR 531.75 (equivalent to USD 171.53) in the TINPC per year.

These outcomes are expected in a tertiary hospital such UKMMC because the more severe cases are referred or admitted. Most of these cases will be seen by the specialists and consultants, who are more likely to prescribe high cost and new generation drugs, as opposed to the first line or generic drugs that are often prescribed for less severe cases (level I and II).[3,21] Moreover, patients with worse conditions are likely to need longer hospitalization stays because they must be transferred to the high dependency health service. Consequently, they tend to consume more resources. These patients usually presented with severe complications and comorbidities.

Public health care continues to be the most popular choice among Malaysians when seeking medical treatment, with a significant increase in hospital admission (ie, 1.53% from 2010 to 2014). The percentage of total allocation to the Ministry of Health Malaysia in the national budget has increased from 8.02% in 2010 to 8.39% in 2014.[22,23]

In this study, the number of prescribed drugs and supplies averaged of 8.18 (SD = 5.81), which is comparable to the 7.56 (SD = 3.37) items reported in an earlier study conducted by Al-Junid et al (2007) at UKMMC.[3] However, the number is higher than the average number of 1.4 to 3.8 in South-East Asian countries.[24,25] Indeed, similarities and differences in prescribing patterns and number of items have been reported across different type of health organization.[25] Various reasons such as financial incentives, lack of therapeutic training, and

availability of drugs, result in prescribers increasing the number of drugs.[24]

The study results showed that the prescribed number of drugs and supplies has a significant and positive association with the TINPC; for each increase in an item of prescribed drugs and supplies, there was an increase of approximately MYR 10.553 (equivalent to USD 3.40) in the TINPC per year. Al-Junid et al (2007) and his team found that higher drug costs are related to an LOS of 6 or more days, severity level II and III, and an increased number of prescribed generic drugs (ie, 7 or more items).[3]

Demographic structure is undoubtedly one of the most influential factors affecting the TINPC. Our study showed that the patient's age has a significant and positive correlation with the TINPC. More resources are used for older patients, and more drugs are prescribed to them. This finding could also result from the increasing health care demands attributed to steady increase in life expectancy as well as an aging population and wide spread chronic diseases in Malaysia.[1] Moreover, gender appears to affect the TINPC; male patients seem to be associated with a higher TINPC than female patients. For each increase in the number of males, there was an increase of approximately MYR 28.378 (equivalent to USD 9.15) increase in the TINPC per year. Note that the prescribed number of medications was higher in male patients 60 years of age and older, with an average LOS of more than 7 days.[3]

Surgical procedures may also increase the LOS and contribute to high cost. UKMMC provides a tertiary referral services at the primary emergency reception center. In this study, surgical cases were significantly and positively related to the TINPC compared with medical cases. For each increase in the number of surgical procedure cases; there was an increase of approximately MYR 31.432 (equivalent to USD 10.14) in the TINPC per year.

Malay and Chinese ethnicities constituted up to 77.1% of our total sample population. However, in the multivariate regression analysis, these ethnicities unexpectedly contributed to a lower TINPC compared with Indian and other ethnicities; for each increase in cases of Malay and Chinese patients, there was a decrease of approximately MYR 193.938 (equivalent to USD 62.56) and MYR 212.117 (equivalent to USD 68.42) in the TINPC per year, respectively. Statistical differences have been reported in the incidence of noncommunicable diseases (NCDs) among the multiethnic Malaysians.[26] Teh et al (2011) found that the rates of arthritis, diabetes, and ischemic heart diseases among Malaysian Indians were higher than Malay and Chinese people.[27] Moreover, study conducted by Tan et al (2011) revealed that Malaysian Indians experienced poor health with high prevalence of metabolic syndrome than Malays and Chinese.[28] Patients with NCDs impose economic burden on governments and households, because they need recurrent use of medical services and long-term medications.[29]

In fact, comparison with similar findings was difficult and restricted because most studies tend to correlate the predicting factors with total hospital cost or drug cost rather than the total pharmacy cost alone. However, most of these studies reported that drugs and supplies constituted the highest percent of total hospital cost,[4,12-14,16] and LOS and severity of cases are the primary drivers for health care cost.[3,12-14,16]

It is not clear what the implications of testing factors against the TINPC are for policy makers in Malaysia. However, any discussion of new strategies to address the issues of pricing and even reimbursement policies should consider the results of relevant pharmacoeconomic evaluations. The findings of this study should be interpreted in light of a number of limitations. Because of limited time and resource constraints, this study was not designed to cover a representative number of hospitals in Malaysia. A limited number of factors were tested against the TINPC. Therefore, our findings may not be generalizable to all medical settings. However, we think that results of this study will contribute greatly toward the establishment of baseline data to service and advance policy makers and health care providers to optimize and refine existing medicine policies.

Conclusion

Pharmaceutical expenditures have generally been viewed as a potentially driver of total health care expenditures. Therefore, decision makers and pharmacy leaders are encouraged to stay appraised of important developments in research methodology and health care policy to be effectively prepared to address changes that might impact pharmacy spending. The analyses provided in this study focus on factors that are more likely to influence inpatient pharmacy cost. However, health care managers and pharmacy leaders should also carefully monitor other factors that are related to outpatient visits and patient day care and that are likely to impact total pharmacy cost and, consequently total hospital costs. Our study results suggest that more complicated cases result in longer LOSs and that as more drugs and supplies are prescribed, the TINPC increases.

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Author Contributions

SAAJ conceived the study; collected, coded, and analyzed the data; and wrote the first and final draft of the article. SMA advised and contributed to the study design, conducted the data analysis, and revised the first and final draft of the article. All authors have read and approved the final manuscript.

Availability of Data and Materials

Data and materials for this study are kept at the International Center for Casemix and Clinical Coding, Universiti Kebangsaan Malaysia. These data and materials can be accessed by writing to the Dean, Faculty of Medicine, Universiti Kebangsaan Malaysia, Jalan Yaacob Latiff, 56000 Cheras, Kuala Lumpur, Malaysia.

Consent for Publications

We received approval from The Research and Ethics Committee of Faculty of Medicine, Universiti Kebangsaan Malaysia to publish this study.

Ethics Approval

This study was approved by the Research and Ethics Committee of the Faculty of Medicine, Universiti Kebangsaan Malaysia (Approval Code: UKM 1.5.3.5/244/UNU-002-2013)

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

1. Director General of Health. Balancing access, quality, affordability & sustainability. Keynote address at the 7th Asia Pacific Future Trends Forum. https://kpkesihatan.com/2014/09/20/medicine-expenditure-accounted-for-11-4-of-the-operating-budget-of-the-ministry-in-2012/. Published September 20, 2014. Accessed October 23, 2016.
2. Lublóy Á. Factors affecting the uptake of new medicines: a systematic literature review. *BMC Health Serv Res*. 2014;14:469. doi:10.1186/1472-6963-14-469.
3. Al-Junid SM, Sharifa Ezat WP, Surianti S. Prescribing patterns and drug cost among cardiovascular patients in Hospital Universiti Kebangsaan Malaysia. *Med J Malaysia*. 2007;62(1):59-65.
4. Ali Jadoo SA, Aljunid SM, Nur AM, Ahmed Z, Van Dort D. Development of MY-DRG casemix pharmacy service weights in UKM Medical Centre in Malaysia. *Daru*. 2015;23(1):14. doi:10.1186/s40199-014.
5. Hughes D, Reynolds DJ. Pharmacoeconomics: principles and relevance to the activities of drug and therapeutics committees. *Clin Med (Lond)*. 2009;9(5):490-492. doi:10.7861/clinmedicine.9-5.
6. Ellis CN, Teiter KL, Wheeler JR, Fendrick AM. Economic analysis in dermatology. *J Am Acad Dermatol*. 2002;46(2):271-283. doi:10.1067/mjd.2002.119566.
7. Saperi BS, Amrizal MN, Rohaizat BY, Zafar A, Syed A. Implementation of case-mix in hospital UKM: the progress. *Malaysian J Public Health Med*. 2005(5)(Suppl 2):45-53.
8. Kobel C, Thuilliez J, Bellanger M, Pfeiffer KP. DRG systems and similar patient classification systems in Europe. In: Busse R, Geissler A, Quentin W, Wiley M, eds. *Diagnosis Related Groups in Europe: Moving Towards Transparency, Efficiency and Quality in Hospitals*. New York, NY: McGraw-Hill; 2011: 37-45.
9. Aguado A, Guinó E, Mukherjee B, et al. Variability in prescription drug expenditures explained by adjusted clinical groups (ACG) case-mix: a cross-sectional study of patient electronic records in primary care. *BMC Health Serv Res*. 2008;8:53. doi:10.1186/1472-6963.
10. Odukoya OK, Chui MA. E-prescribing: a focused review and new approach to addressing safety in pharmacies and primary care. *Res Social Adm Pharm*. 2013;9:996-1003. doi:10.1016/j.sapharm.2012.09.004.
11. Zhao Y, Ash AS, Ellis RP, et al. Predicting pharmacy costs and other medical costs using diagnoses and drug claims. *Med Care*. 2005;43(1):34-43.
12. Chow WL, Tin AS, Meyyappan A. Factors influencing costs of inpatient ischaemic stroke care in Singapore. *Proc Singapore Healthc*. 2010;19(4):283-291. doi:10.1177/201010581001900402.
13. Cortoos PJ, Gilissen C, Laekeman G, et al. Length of stay after reaching clinical stability drives hospital costs associated with adult community-acquired pneumonia. *Scand J Infect Dis*. 2013;45(3):219-226. doi:10.3109/00365548.2012.726737.
14. Wang XJ, Wong M, Hsu LY, Chan A. Costs associated with febrile neutropenia in solid tumor and lymphoma patients—an observational study in Singapore. *BMC Health Serv Res*. 2014;14:434. doi:10.1186/1472-6963.
15. Gordon SC, Pockros PJ, Terrault NA, et al. Impact of disease severity on healthcare costs in patients with chronic hepatitis C (CHC) virus infection. *Hepatology*. 2012;56(5):1651-1660. doi:10.1002/hep.25842.
16. Nor Azlin MN, Syed Aljunid SJ, Noor Azahz A, Amrizal MN, Saperi S. Direct medical cost of stroke: findings from a tertiary hospital in Malaysia. *Med J Malaysia*. 2012;67(5):473-477.
17. Bramkamp M, Radovanovic D, Erne P, Szucs TD. Determinants of costs and the length of stay in acute coronary syndromes: a real life analysis of more than 10,000 patients. *Cardiovasc Drugs Ther*. 2007;21(5):389-398. doi:10.1007/s10557-007.
18. García-Goñi M, Ibern MP. Predictability of drug expenditures: an application using morbidity data. *Health Econ*. 2008;17(1):119-126. doi:10.1002/hec.1238.
19. Aljunid SM, Ali Jadoo SA. *Development of Pharmacy Service Weights in the Implementation of Casemix System for Provider Payment: Concept, Methods and Applications*. Singapore: Partridge Publishing Singapore; 2017.
20. SPSS Inc. *SPSS 16.0 for Windows*. Chicago, IL: SPSS Inc; 2008.
21. Aravamuthan A, Arputhavanan M, Subramaniam K, Udaya Chander SJ. Assessment of current prescribing practices using World Health Organization core drug use and complementary indicators in selected rural community pharmacies in Southern India. *J Pharm Policy Pract*. 2017;10:1. doi:10.1186/s40545-016.
22. Ministry of Health Malaysia, Health Informatics Centre, Planning and Development Division. Health facts 2010. http://www.slideshare.net/ArefizApit/health-facts-2010. Published October 30, 2011. Accessed September 29, 2016.

23. Ministry of Health Malaysia, Health Informatics Centre, Planning and Development Division. Health facts 2014. http://www.moh.gov.my/images/gallery/publications/HEALTH%20FACTS%202014.pdf. Published June 30, 2014. Accessed September 29, 2016.
24. Nguyen HT, Wirtz VJ, Haaijer-Ruskamp FM, Taxis K. Indicators of quality use of medicines in South-East Asian countries: a systematic review. *Trop Med Int Health*. 2012;17:1552-1566. doi:10.1111/j.1365-3156.2012.03081.x.
25. World Health Organization (WHO). Medicines Use in Primary Care in Developing and Transitional Countries—Fact Book Summarizing Results From Studies Reported Between1990 And 2006. Geneva, Switzerland: World Health Organization. http://www.who.int/medicines/publications/primary_care_8April09.pdf?ua=1. Published April 8, 2009. Accessed September 4, 2017.
26. National Cancer Registry Report: Malaysia Cancer Statistic, Data and Figures. 2007. http://www.care.upm.edu.my/dokumen/13603_NCR2007.pdf. Accessed October 16, 2017.
27. Teh JK, Tey NP, Ng ST. Ethnic and gender differentials in non-communicable diseases and self-rated health in Malaysia. *PLOS ONE*. 2014;9(3):e91328. doi:10.1371/journal.pone.0091328.
28. Tan AK, Dunn RA, Yen ST. Ethnic disparities in metabolic syndrome in Malaysia: an analysis by risk factors. *Metab Syndr Relat Disord*. 2011;9(6):441-451. doi:10.1089/met.2011.0031.
29. Kankeu HT, Saksena P, Xu K, Evans DB. The financial burden from non-communicable diseases in low- and middle-income countries: a literature review. *Health Res Policy Syst*. 2013;11:31. doi:10.1186/1478-4505.