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Original Article

Public Health Section

Economic Consequences of Treating Type-2 Diabetes Mellitus in a Private Hospital: A Fiscal, Analytical Approach (2013-2017)

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ABSTRACT

Introduction: Spread and the costs of Type-2 Diabetes Mellitus (T2DM) treatment are a burden on both Vietnam's nascent economy and its society.

Aim: Cost study with T2DM patients to evaluate the economic-consequence changes in T2DM treatment and strengthen the economic evidence base further.

Materials and Methods: This retrospective study was based on perspectives of patients and third-party payers using ICD 10 code to filter data from the electronic medical records database. It estimated the overall economic impact, accounting for spillovers through the economy at a private hospital from January 2013 to December 2017.

Results: The cases of 120,257 T2DM patients receiving treatment at a private hospital resulted in per patient expenditure of 29.0±11.5 USD (95% CI: 29.0-29.1) and 348.6±137.5 USD every year. The T2DM patients showed a higher prevalence of hypertension (64.1%), disorders of lipoprotein metabolism (42.5%) and gastritis (22.8%). The mean total cost for patients without any comorbidities was almost 27.1±10.8 USD (95% CI: 26.9-27.2) per month, while those having at least one comorbidity spent more (≥28.8 USD per month). The cost of drug and related products were 3,082,452.0 USD (87.4%), in which sulfonylurea (18.2%) and metformin (10.9%) were primarily responsible.

Conclusion: From the results of the present study, it can be concluded that the direct medical costs for T2DM treatment in a private Vietnamese hospital are higher than the corresponding costs for a public hospital and T2DM will continue to be a heavy burden on health budgets.

Keywords: Cost of illness, Diabetes mellitus, Economic burden, Hospital, Vietnam

INTRODUCTION

The International Diabetes Federation (IDF) statistics reveal that in 2015, there were 415 million people with diabetes globally or one in every 11 people, and that more than five million deaths every year could be attributed to diabetes. China and India both has a high incidence of diabetes with 109.6 million and 69.2 million cases, respectively [1]. In Southeast Asia, the incidence of T2DM is 8.5% (78.3 million) and is expected to increase to 10.7% (140.2 million) by 2040 [1]. Research by Pham and Eggleston [2] demonstrated that Vietnam had a high incidence of T2DM with 63,021 new cases and 53,457 deaths from T2DM by the end of 2015. Their study also reported that the incidence of T2DM in Vietnam increased from 2.7% to 5.4% in the period from 2002 to 2012 [2].

Economic analyses of diabetes in various countries have shown that the high cost of treatment is an economic burden on individuals, families and the health system [3]. According to the IDF, global diabetes costs were 673 billion US Dollars (USD) in 2015 and are expected to rise to about 802 billion USD by 2040 [1]. A 2004 study conducted by Ohinmaa A et al., found that Canadian diabetes costs increased 1.7 times from 4.66 billion USD (in 2000) to 8.14 billion USD (in 2016) [4]. Lau R et al., have predicted that Canada's T2DM costs would increase 2.4 times from 673 million USD (in 2008) to 2.27 billion USD (in 2035) [5]. In Australia, a study by Davis W et al., estimated that the country's annual T2DM costs were 636 million USD and were expected to increase 2.5 to 3.5 times between 2000 and 2051 [6]. Diabetes expenditures in the United States in 2010 were estimated at 11,917 USD for each treated patient [7], while in Germany, a 2007 study estimated that a patient spent 1,634 USD in the first year of T2DM treatment, a cost that increased to 4,881 USD in the second year of treatment [8]. In China, a 2016 study by Huang et al., reported that a T2DM patient's annual medical cost was 2,883-2,780 USD, while diabetes mellitus-related costs were an additional 1,655-1,857 USD per patient.

In Vietnam in 2015, the average cost for T2DM treatment is 162.7 USD [9], more than the average monthly per capita income of about 150 USD. At public hospitals in Vietnam, 2017 research by Le NTD et al., reported that the total cost of patient treatment was as high as 246.10 USD, if social costs were factored into the calculation [10]. As the costs of T2DM treatment are a burden on both Vietnam's nascent economy and its society, a study of treatment costs in private hospitals is urgently needed. Only a few studies have assessed the economic impact of T2DM on the Vietnamese private sector. The current study conducted a retrospective cost analysis of T2DM treatment at a private hospital by reviewing electronic patient records and evaluating the economic consequences a T2DM diagnosis. The results were compared to the medical costs for similar treatments at public healthcare facilities.

MATERIALS AND METHODS

Study Design and Study Site

A retrospective cohort study was conducted using an electronic database containing third-party payments and patients records for all outpatient visits and hospitalisations at the Van Hanh Hospital in Ho Chi Minh City, Southern Vietnam during the five-year period from January 2013 to December 2017. This study sought to estimate the overall economic impact of T2DM treatment, accounting for spillovers throughout the economy.

Hospitalisation Data Source and Participant Selection

The present study collected and reviewed the hospital's electronic database that contained records for the period of 2013–2017 of

outpatients who were filtered using the International Classification of Disease, Tenth Revision (ICD-10 code). In addition to major sociodemographic information (age, gender, place of residence, insurance coverage and comorbidity), the database also detailed the drugs that were prescribed, the cost of hospital medical services (medical care, laboratory tests, diagnosis imaging and other hospital expenses) and the payments to providers for a large sample of patients.

This study analysed hospitalisation costs by diagnosis status (primary cost versus secondary costs). Among hospitalisations in which T2DM was the primary diagnosis, the authors examined the frequency of secondary diagnoses. These were hypertension (code I10); disorders of lipoprotein metabolism (code E78); gastritis or duodenitis (code K29); chronic ischemic heart disease (code I25); spondylosis (code M47); varicose veins of the lower extremities (code I83); hypertensive heart disease (code I11); osteoporosis without a current pathological fracture (code M81); disorders of vestibular function (code H81); diseases of the liver (code K70–K77); nerve root and plexus disorders (code G54); chronic kidney disease (code N18); acute pharyngitis (code J02); chronic diseases of the upper respiratory system (code J31–J32); acute sinusitis (code J01); gastro-oesophageal reflux disease (code K21); asthma (code J45); and Parkinson's disease (code G20).

Additionally, to identify the T2DM patient cohort, two types of inclusion criteria were applied for each year of analysis. To be defined subjects with T2DM, one of the following criteria had to be met: 1) the patient had been assigned an ICD-10 code of E11; or 2) the patient had diabetes-related factors, such as a prescription for anti-diabetic medication. Patients with type-1 diabetes mellitus and women with gestational diabetes were excluded from the study. The patient record was discarded if it lacked any information regarding the demographic characteristics and cost of treatment or if the patient changed treatment facilities or discontinued treatment.

Cost-Of-Illness Data Collection Aspects

The current survey separated costs into five categories: medical care, laboratory tests, diagnosis imaging, drug and related products, and medical supplements. Once the cost for each patient was estimated (including the treatment costs for any comorbidities), the average cost per patient treated in the private hospital was calculated. The unit costs of medical services that were used to estimate the costs of treating T2DM were directly measured from the study facility by standard methods.

Data Management, Analysis and Interpretation

All monetary values were converted and presented in 2017 US dollars using the Vietnamese medical care component of the Consumer Price Index (CPI) and an annual conversion rate between the USD and the Vietnamese Dong (VND Dong) of 1.00 USD = 22,451 VND Dong [11]. Hospital databases were collected and analysed using Microsoft Excel version 2016 and SPSS version 20.0 (SPSS Inc., Chicago, IL, USA) to perform data analysis. Regarding the database, a descriptive analysis was conducted to describe the socioeconomic characteristics of the patients and to assess gender differences. The differences between proportions were tested using the Chi-squared test.

Descriptive statistics (frequency, percentage, mean, median, standard deviation and rankings of the 25^{th}–75^{th} percentile) were used for demographic characteristics, clinical status, cost components and drug utilization. The 95% CIs were computed based on bootstrap resampling with 1,000 replications of the trial data to increase the robustness of the study. To identify the factors affecting the total costs, the study used the Kruskal-Wallis test; the Mann-Whitney test was used to compare costs between two or more groups. Statistical significance was considered when $p<0.05$.

One-Way Sensitivity

To investigate uncertainty in our parameter estimates and the influence of our base-case assumptions on these values, several sensitivity analyses were conducted. First, in one-way sensitivity analyses, we varied the value of several key parameters, including the costs of drugs and related products (sulfonylurea and metformin), and laboratory tests (HbA1c and glucose), one at a time. This allowed us to identify the threshold values for the costs of the varied parameters.

Ethical Considerations

This research protocol was approved by the Van Hanh Hospital in Ho Chi Minh City. Since the study was conducted using the hospital's electronic records database without any patient contact, the written informed consent from the patients was waived. All data was handled confidentially and made anonymous before the analyses were performed.

RESULTS

Demographic Characteristics of the Participants

[Table/Fig-1] From 2013 to 2017, the patients had an average age of 61.6±11.2 years with a higher concentration of patients in the 60- to greater than 70-year-old group (32.6%). Female patients made up 60.5% of the group, while 39.5% of subjects were male. There was a significant difference among the prevalence of the 18 comorbidities recorded for the patients. Hypertension, disorders of lipoprotein metabolism, and gastritis were seen at a high-frequency with an average prevalence of 64.1%, 42.5% and 22.8%, respectively ($p<0.001$).

Both total and per patient costs from 2013 to 2017 increased with total costs being 3,527,530.5 USD and 733,245.3 USD, respectively. The most expensive service was drugs and related products at 3,082,452.0 USD for the total cost.

The average monthly cost for T2DM patients in the 60- to greater than 70-year-old group was the highest among the age groups (29.5 USD), and female patients paid more (29.3±11.3 USD) than their male counterparts (28.7±11.7 USD). The mean total cost for patients without any comorbidities was almost 27.1 USD per month, while those having at least one comorbidity spent more (≥28.8 USD per month). Among those additional disorders and diseases, chronic kidney disease was associated with the highest cost at 31.1 USD for a mean total cost.

Healthcare expenditures for T2DM included drug related products, which were responsible for the majority of total treatment costs (87.4%). Accounting for the highest percentage of total medical costs was sulfonylurea (18.2%), followed by metformin, dipeptidyl peptidase 4, alpha-glucosidase inhibitors, and insulin, which accounted for 10.9%, 8.7%, 5.6% and 0.1%, respectively. The primary laboratory tests were for glucose (20.9%), HbA1C (14.5%), lipid profile (18.0%) and others (36.5%), which were used to monitor glycaemic levels.

The monthly treatment cost for T2DM patients belonging to the 60- to 69-year-old group was the highest among the age groups (29.4 USD), while the youngest group (≤39-year-old) paid an average of 20.1 USD. The treatment cost for the female T2DM patient group was higher than that of the male patient group, with a mean total monthly cost of (29.4 USD) that was 0.4 USD higher than that of their male counterparts (29.0 USD).

Glucose and HbA1c were the independent variables that were primarily responsible for the costs of laboratory tests, while sulfonylurea and metformin played the same role in the costs of related products. The results performed in [Table/Fig-6] were determined by altering the value of glucose and HbA1c (A), or sulfonylurea and metformin (B), to evaluate how those independent variables impacted the total cost.

Characteristic	2013 n=23,707	2014 n=23,927	2015 n=22,852	2016 n=24,950	2017 n=24,821	2013-2017 N=120,257	p-value
Age in years							
< 40	635 (2.7)	654 (2.7)	569 (2.5)	693 (2.8)	643 (2.6)	3,194 (2.7)	p*
40 - < 50	2,377 (10.0)	2,310 (9.7)	2,131 (9.3)	2,431 (9.7)	2,300 (9.3)	11,549 (9.6)	
50 - < 60	7,945 (33.5)	7,694 (32.2)	7,535 (33.0)	7,703 (30.9)	7,241 (29.1)	38,118 (31.7)	
60 - < 70	7,072 (29.8)	7,419 (31.0)	7,321 (32.0)	8,550 (34.2)	8,882 (35.8)	39,244 (32.6)	
70 - < 80	4,161 (17.6)	4,216 (17.6)	3,882 (17.0)	4,117 (16.5)	4,128 (16.6)	20,504 (17.0)	
≥80	1,517 (6.4)	1,634 (6.8)	1,414 (6.2)	1,456 (5.9)	1,627 (6.6)	7,648 (6.4)	
Mean ± SD[a]	61.3 ± 11.3	61.6 ± 11.2	61.6 ± 11.0	61.5 ± 11.1	61.9 ± 11.1	61.6 ± 11.2	
95% CI[b]	61.2 - 61.5	61.5 - 61.8	61.4 - 61.7	61.4 - 61.7	61.7 - 62.1	61.5 - 61.6	
Median [IQR (Q1 - Q3)][c]	60 (54 - 69)	61 (55 - 61)	61 (55 - 68)	62 (55 - 69)	62 (55 - 69)	61 (55 - 69)	
Gender							
Male	8,633 (36.4)	9,038 (37.8)	9,191 (40.2)	10,364 (41.5)	10,243 (41.3)	47,469 (39.5)	p*
Female	15,074 (63.6)	14,889 (62.2)	13,661 (59.8)	14,586 (58.5)	14,578 (58.7)	72,788 (60.5)	
Health insurance status (%)							
50	4,167 (17.6)	4627 (19.3)	-	-	-	8,794 (7.3)	p*
80	18,259 (77.0)	17310 (72.4)	20,404 (89.3)	22,121 (88.6)	21,909 (88.3)	100,003 (83.1)	
95	543 (2.3)	726 (3.0)	631 (2.8)	990 (4.0)	1,040 (4.2)	3,930 (3.3)	
100	738 (3.1)	1264 (5.3)	1,817 (7.9)	1839 (7.4)	1,872 (7.5)	7,530 (6.3)	
Accommodation							
Urban	23,707 (100.0)	23,927 (100.0)	22,852 (100.0)	24,950 (100.0)	24,821 (100.0)	120,257 (100.0)	
(ICD-10) Comorbidities							
I10	11,637 (49.1)	13,794 (57.7)	16,114 (70.5)	17,200 (68.9)	18,351 (73.9)	77,096 (64.1)	p*
E78	7,627 (32.2)	9,457 (39.5)	10,547 (46.2)	11,258 (45.1)	12,264 (49.4)	51,153 (42.5)	
K29	2,547 (10.7)	4,600 (19.2)	5,747 (25.1)	6,720 (26.9)	7,826 (31.5)	27,440 (22.8)	
I25	2,214 (9.3)	2,938 (12.3)	3,624 (15.9)	3,891 (15.6)	4,522 (18.2)	17,189 (14.3)	
M47	2,910 (12.3)	3,210 (13.4)	3,133 (13.7)	3,090 (12.4)	3,423 (13.8)	15,766 (13.1)	
I83	1,327 (5.6)	2,224 (9.3)	2,909 (12.7)	3,079 (12.3)	3,806 (15.3)	13,345 (11.1)	
I11	1,615 (6.8)	2,091 (8.7)	2,187 (9.6)	2,559 (10.3)	2,474 (10.0)	10,926 (9.1)	
M81	1,534 (6.5)	2,079 (8.7)	2,145 (9.4)	2,055 (8.2)	2,330 (9.4)	10,143 (8.4)	
H81	364 (1.5)	982 (4.1)	1,381 (6.0)	1,512 (6.1)	1,971 (7.9)	6,210 (5.2)	
K70-K77	216 (0.9)	653 (2.7)	862 (3.8)	1,033 (4.1)	1,841 (7.4)	4,605 (3.8)	
G45	563 (2.4)	621 (2.6)	813 (3.6)	1,115 (4.5)	1,375 (5.5)	4,487 (3.7)	
N18	266 (1.1)	647 (2.7)	871 (3.8)	838 (3.4)	1,191 (4.8)	3,813 (3.2)	
J02	137 (0.6)	603 (2.5)	849 (3.7)	795 (3.2)	982 (4.0)	3,366 (2.8)	
J31-J32	869 (3.7)	522 (2.2)	362 (1.6)	271 (1.1)	317 (1.3)	2,341 (1.9)	
J01	102 (0.4)	228 (1.0)	346 (1.5)	346 (1.4)	365 (1.5)	1,387 (1.2)	
K21	33 (0.1)	106 (0.4)	158 (0.7)	223 (0.9)	415 (1.7)	935 (0.8)	
J45	99 (0.4)	135 (0.6)	174 (0.8)	213 (0.9)	291 (1.2)	912 (0.8)	
G20	32 (0.1)	71 (0.3)	105 (0.5)	146 (0.6)	170 (0.7)	524 (0.4)	

[Table/Fig-1]: Baseline characteristics of T2DM patients at private hospital in Vietnam, 2013-2017 {N=120,257, n (%)}.
a: Standard Deviation
b: Bootstrap analysis was conducted based on 1,000 resamples to assess the average costs and the 95% confidence intervals (95% CI)
c: IQR: Interquartile Range (Q1: 25th percentiles - Q3: 75th percentiles)
p*: p< 0.001
ICD: International Classification of Diseases 10;
I10: Hypertension; E78: Disorders of lipoprotein metabolism; K29: Gastritis/duodenitis; I25: Chronic ischemic heart disease; M47: Spondylosis; I83: Varicose veins of lower extremities; I11: Hypertensive heart disease; M81: Osteoporosis without current pathological fracture; H81: Disorders of vestibular function; K70-K77: Diseases of liver; G54: Nerve root and plexus disorders; N18: Chronic kidney disease; J02: Acute pharyngitis; J31–J32: Chronic diseases of upper respiratory system; J01: Acute sinusitis; K21: Gastro-esophageal reflux disease; J45: Asthma; G20: Parkinson's disease

DISCUSSION

A clear understanding of the current patterns of resource use and costs associated with T2DM identifies management and research priorities and assists with health service planning. The current study sample size of 120,257 T2DM cases receiving treatment at a private hospital resulted in an average age of 61.6 years (95% CI, 61.5-61.6), the age group of 60- to greater than 70-year-old had the highest number of patients, accounting for 32.6%, the ≥80 age group and ≤39 age group represented 6.4% and 2.7% of patients, respectively. The average age is lower than that seen by Shuyu CN et al., in Singapore study with 500 patients (69.0±9.4 years) [12] and higher than the 2011, Riewpaiboon A et al., [13] study that reported on 475 patients in a Thai public district hospital (59.34±11.40 years). In comparison, the proportion of T2DM patients in 60- to greater than 70, ≥80 age group and ≤39 age group in the 2011 research conducted by Javanbakht M et al., in Iran was 19.9%, 8%, 11.5%, respectively [14]. In a study from Iran, the proportion of patients in 50- to greater than 60 age group was the highest at 35.8% [14], while this age group had the second highest percentage of patients with 31.7%.

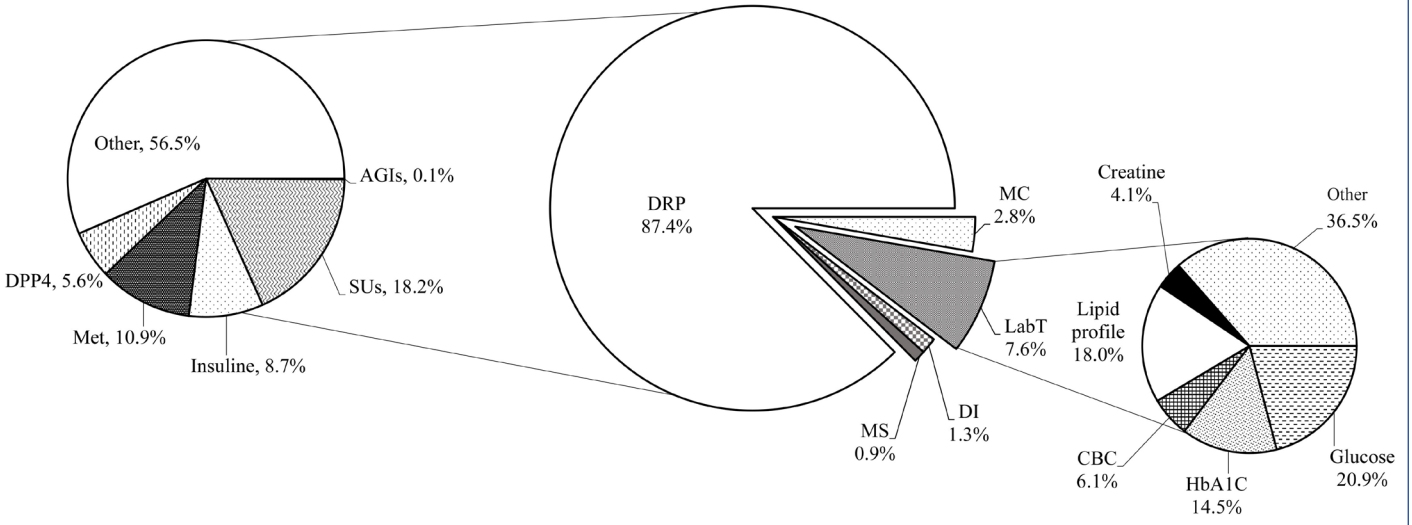
In general, the T2DM patients in the current study showed a higher prevalence of hypertension (64.1%), disorders of lipoprotein metabolism (42.5%) and gastritis (22.8%). The difference between the increase in comorbidities and the treatment cost was statistically significant. According to Khue NT, this result can be explained by the life style of the Vietnamese people [15]. This is in line with the 2017 Italian results of Marcellusi A et al., who reported that treatment costs increased from 437 Euros for patients with T2DM alone to 7,574 Euros for patients with T2DM plus four comorbidities [16].

Year		Medical care (MC)	Laboratory tests (LabT)	Diagnosis imaging (DI)	Drugs and related products (DRP)	Medical Supplement (MS)	Total	Mean ± SD (95% CI)*	Median (Q1 - Q3)**	Mean of year
2013	Patient	1,032.7 (0.6)	13,481.4 (8.2)	1,868.2 (1.1)	148,085.6 (89.9)	304.4 (0.2)	164,772.2	6.9±4.4 (6.9-7.0)	6.0 (4.8-7.0)	83.3±53.4
	Third payer	3,215.8 (0.6)	35,585.6 (7.1)	4,338.8 (0.9)	454,048.0 (91.1)	1,253.6 (0.3)	498,441.9	21.0±7.5 (20.9-21.1)	22.4 (15.8-25.0)	252.0±89.7
	Total cost	4,248.5 (0.6)	49,067.0 (7.4)	6,207.0 (0.9)	602,133.6 (90.8)	1,558.0 (0.3)	663,214.1	27.9±9.2 (27.8-28.1)	29.5 (23.4-32.0)	335.3±109.8
2014	Patient	1,297.1 (0.8)	12,931.8 (8.3)	3,217.3 (2.1)	139,079.3 (88.8)	4.6 (<0.1)	156,530.0	6.6±4.7 (6.5-6.6)	5.7 (4.1-6.9)	78.8±56.2
	Third payer	4,003.8 (0.9)	31,777.3 (6.9)	6,818.6 (1.5)	417,863.1 (90.2)	2,931.7 (0.5)	463,394.6	19.4±7.8 (19.3-19.5)	19.9 (14.0-24.3)	233.3±94.1
	Total cost	5,301.1 (0.9)	44,700.5 (7.2)	10,032.3 (1.6)	556,950.5 (89.8)	2,940.2 (0.5)	619,924.6	26.0±10.0 (25.9-26.1)	27.2 (19.8-31.3)	312.1±119.4
2015	Patient	2,501.1 (2.0)	9,940.5 (7.8)	1,428.5 (1.1)	112,698.5 (88.1)	1,301.6 (1.1)	127,870.2	5.6±2.7 (5.6-5.6)	5.9 (4.2-7.0)	67.1±32.8
	Third payer	11,393.0 (2.0)	43,402.1 (7.7)	6,291.0 (1.1)	495,591.9 (88.1)	5,655.2 (1.1)	562,333.2	24.6±9.5 (24.5-24.7)	24.5 (19.1-29.3)	295.3±113.6
	Total cost	13,894.1 (2.0)	53,342.5 (7.7)	7,719.5 (1.1)	608,290.4 (88.1)	6,956.8 (1.1)	690,203.4	30.2±11.6 (30.0-30.3)	30.3 (23.7-35.8)	362.4±138.8
2016	Patient	6,346.4 (4.6)	10,828.5 (7.9)	2,067.0 (1.5)	115,810.3 (84.8)	1,573.1 (1.2)	136,625.4	5.5±2.9 (5.4-5.5)	5.6 (3.7-7.3)	65.7±34.4
	Third payer	29,084.0 (4.8)	48,350.4 (7.9)	9,024.4 (1.5)	516,201.2 (84.7)	6,678.6 (1.2)	609,338.6	24.4±10.2 (24.3-24.6)	24 (17.5-30.4)	293.1±121.8
	Total cost	35,430.4 (4.7)	59,178.9 (7.9)	11,091.4 (1.5)	632,011.5 (84.7)	8,251.7 (1.1)	745,964.0	29.9±12.3 (29.8-30.1)	29.4 (21.6-37.3)	358.8±148.1
2017	Patient	6,774.1 (4.6)	11,245.5 (7.6)	2,275.3 (1.5)	124,731.0 (84.6)	2,421.6 (1.6)	147,447.5	5.9±3.2 (5.9-6.0)	6.1 (3.9-8.0)	71.3±38.1
	Third payer	31,169.6 (4.7)	50,342.3 (7.6)	10,195.3 (1.5)	558,335.0 (84.5)	10,734.7 (1.7)	660,777.0	26.6±11.3 (26.4-26.8)	26.2 (18.8-33.6)	319.5±135.5
	Total cost	37,943.7 (4.7)	61,587.8 (7.6)	12,470.6 (1.5)	683,066.0 (84.5)	13,156.3 (1.7)	808,224.5	32.6±13.7 (32.3-32.8)	32.2 (23.0-41.2)	390.7±164.6
2013-2017	Patient	17,951.4 (2.4)	58,427.6 (8.0)	10,856.2 (1.5)	640,404.7 (87.3)	5,605.4 (0.8)	733,245.3	6.1±3.8 (6.1-6.1)	5.9 (4.1-7.2)	73.4±45.1
	Third payer	78,866.3 (2.8)	209,457.6 (7.5)	36,668.1 (1.3)	2,442,039.2 (87.4)	27,253.9 (1.0)	2,794,285.1	22.9±9.5 (22.9-23.0)	23.0 (16.4-27.5)	275.2±114.3
	Total cost	96,817.9 (2.7)	267,876.7 (7.6)	47,520.8 (1.3)	3,082,452.0 (87.4)	32,863.1 (1.0)	3,527,530.5	29.0±11.5 (29.0-29.1)	29.3 (22.1-34.3)	348.6±137.5

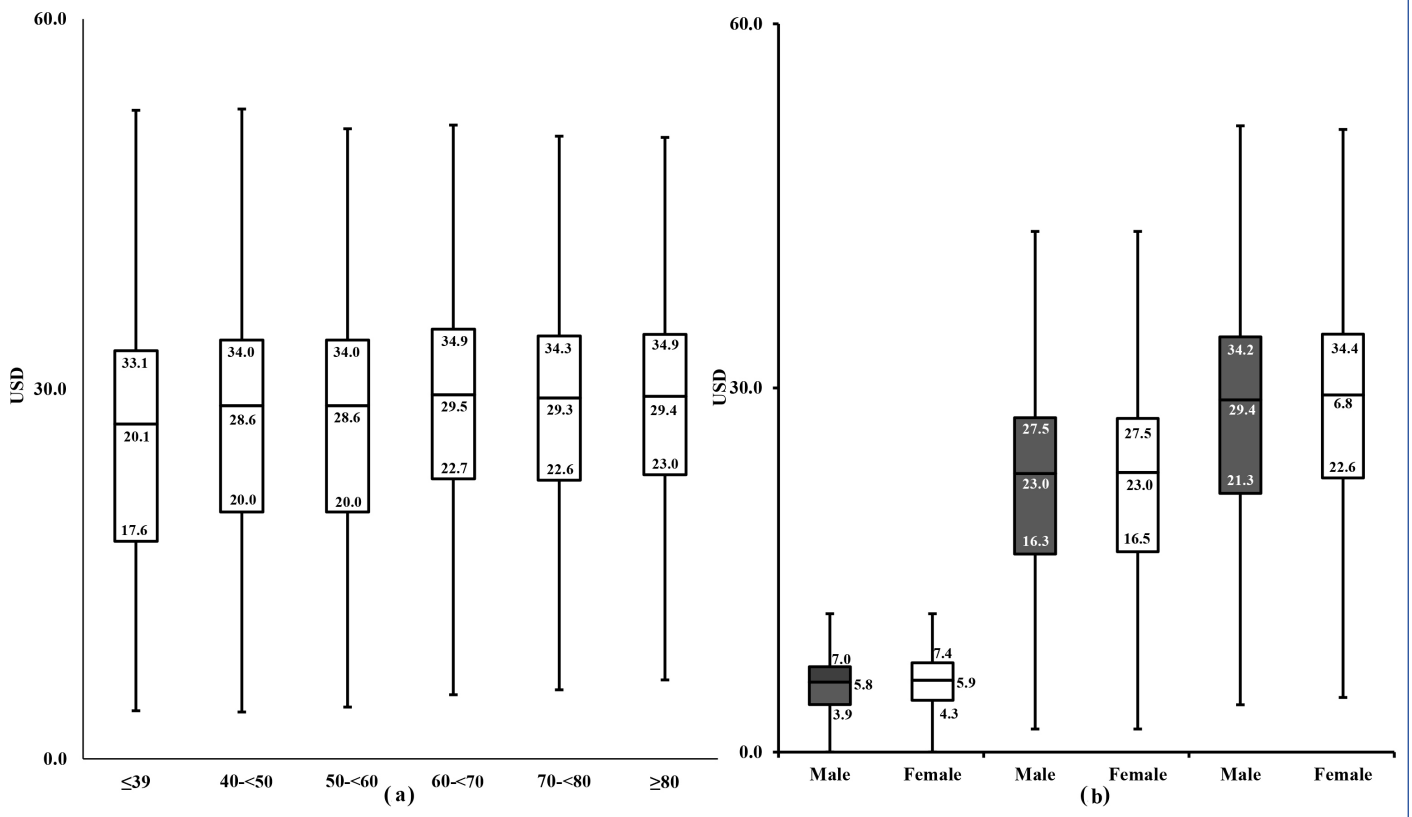
[Table/Fig-2]: Total and per patient costs, split by category service in period 2013-2017. {2017; cost (%)}
* Bootstrap analysis was conducted based on 1,000 resamples to assess the average costs and the 95% confidence intervals (95% CI)
**Interquartile Range (Q1: 25th percentiles - Q3: 75th percentiles)
SD: Standard Deviation

Characteristic	Patient		Third-payer		Total		p-value
Age	**Mean±SD (95% CI)[a]**	**Median (IQR)**	**Mean±SD (95% CI)[a]**	**Median (IQR)**	**Mean ± SD[b] (95% CI)[a]**	**Median (Q1-Q3)[c]**	
< 40	6.1±3.9 (5.9-6.2)	5.7 (3.8-7.2)	20.4±9.7 (20.0-20.8)	20.3 (13.2-26.0)	26.4±11.9 (26.0-27.0)	27.1 (17.6-33.1)	p<0.001
40 - < 50	6.1±3.8 (6.1-6.2)	5.8 (4.0-7.1)	21.8±9.4 (21.6-22.0)	22.1 (15.1-26.7)	27.9±11.7 (27.7-28.1)	28.6 (20.0-34.0)	
50 - < 60	6.1±3.5 (6.1-6.1)	5.9 (4.2-7.1)	22.7±9.3 (22.6-22.8)	22.9 (16.4-27.2)	28.8±11.4 (28.6-28.9)	29.2 (21.8-34.0)	
60 - < 70	6.2±3.6 (6.1-6.2)	5.9 (4.3-7.3)	23.4±9.3 (23.3-23.5)	23.3 (17.1-28.0)	29.5±11.4 (29.4-29.6)	29.5 (22.7-34.9)	
70 - < 80	6.3±3.7 (6.3-6.4)	5.9 (4.4-7.3)	23.0±9.5 (22.8-23.1)	22.9 (16.6-27.3)	29.3±11.5 (29.1-29.5)	29.3 (22.6-34.3)	
≥80	5.5±5.0 (5.4-5.6)	5.3 (1.2-7.3)	24.0±10.6 (23.8-24.3)	23.6 (16.0-29.5)	29.5±11.1 (29.2-29.7)	29.4 (23.0-34.4)	
Gender							
Male	5.9±3.5 (5.8-5.9)	5.8 (3.9-7.0)	22.8±9.6 (22.7-22.9)	23.0 (16.3-27.5)	28.7±11.7 (28.6-28.8)	29.0 (21.3-34.2)	p <0.001
Female	6.3±3.9 (6.3-6.3)	5.9 (4.3-7.4)	23.0±9.4 (22.9-23.1)	23.0 (16.5-27.5)	29.3±11.3 (29.2-29.4)	29.4 (22.6-34.4)	
Number of Comorbidities							
None	7.0±7.0 (6.4-6.5)	7.0 (7.0-7.0)	20.7±8.7 (20.5-20.8)	21.4 (14.7-25.5)	27.1±10.8 (26.9-27.2)	28.6 (20.5-32.4)	p <0.001
1	7.3±7.3 (6.1-6.3)	7.3 (7.3-7.3)	22.6±9.5 (22.5-22.7)	22.8 (16.0-27.2)	28.8±11.5 (28.6-28.9)	29.2 (21.7-34.1)	
2	7.4±7.4 (6.1-6.2)	7.4 (7.4-7.4)	23.6±9.9 (27.9-23.7)	23.3 (17.0-28.3)	29.8±11.9 (29.6-29.9)	29.5 (22.7-35.2)	
3	7.2±7.2 (6.0-6.1)	7.2 (7.2-7.2)	23.5±9.4 (23.4-23.7)	23.5 (17.3-28.3)	29.6±11.2 (29.5-29.7)	29.6 (22.8-35.1)	
≥ 4	7.1±7.1 (5.6-5.7)	7.1 (7.1-7.1)	23.9±9.5 (23.8-24.0)	23.5 (17.6-28.9)	29.6±11.3 (29.4-29.8)	29.4 (22.4-35.5)	
ICD Comorbidities							
I10	5.9±3.5 (5.9-6.0)	5.8 (4.1-7.2)	23.3±9.5 (23.2-23.4)	23.2 (16.9-28.1)	29.3±11.4 (29.1-29.3)	29.2 (22.2-34.8)	
E78	5.9±3.3 (5.8-6.0)	5.9 (4.2-7.2)	23.7±9.7 (23.4-23.9)	23.5 (17.2-28.6)	29.6±11.7 (29.3-29.9)	29.5 (22.2-35.5)	
K29	6.1±3.5 (6.1-6.1)	5.9 (4.3-7.3)	23.8±9.6 (23.7-23.8)	23.6 (17.4-28.6)	29.8±11.5 (29.8-29.9)	29.7 (23.0-35.5)	
I25	6.2±3.9 (6.0-6.4)	5.9 (4.2-6.9)	22.7±9.7 (22.3-23.1)	23.0 (16.4-26.8)	28.9±11.6 (28.4-29.4)	29.5 (22.2-33.5)	
M47	6.2±4.1 (5.9-6.5)	5.9 (3.9-7.6)	24.8±10.6 (24.0-25.5)	23.9 (17.0-30.3)	31.0±11.8 (30.1-31.8)	30.4 (23.5-37.8)	
I83	6.0±3.5 (5.9-6.0)	5.9 (4.1-7.3)	23.8±9.7 (23.7-23.9)	23.6 (17.3-29.0)	29.8±11.6 (29.6-29.9)	29.6 (22.4-36.0)	
I11	5.7±3.5 (5.6-5.8)	5.6 (3.6-7.1)	22.7±9.8 (22.4-23.0)	22.4 (15.8-28.1)	28.4±12.0 (28.0-28.7)	28.2 (20.5-35.1)	
M81	6.0±3.7 (5.9-6.1)	5.8 (4.1-7.2)	29.2±11.3 (29.0-29.4)	29.0 (22.4-34.5)	29.2±11.3 (29.0-29.4)	29.0 (22.4-34.5)	
H81	5.6±3.4 (5.6-5.7)	5.6 (3.8-6.8)	28.2±11.1 (28.0-28.4)	28.4 (21.1-33.6)	28.2±11.1 (28.0-28.4)	28.4 (21.1-33.6)	
K70-K77	5.5±3.5 (5.5-5.6)	5.6 (3.7-6.7)	28.3±10.9 (28.1-28.5)	28.5 (21.4-33.5)	28.3±10.9 (28.1-28.5)	28.5 (21.4-33.5)	
G45	5.9±3.3 (5.8-6.0)	5.9 (4.3-7.2)	30.4±11.4 (30.0-30.8)	30.1 (23.7-36.2)	30.4±11.4 (30.0-30.8)	30.1 (23.7-36.2)	
N18	6.0±3.2 (5.8-6.2)	6.0 (4.3-7.4)	31.1±11.8 (30.4-31.7)	30.6 (24.5-37.1)	31.1±11.8 (30.4-31.7)	30.6 (24.5-37.1)	
J02	5.7±3.1 (5.6-5.7)	5.8 (4.0-7.0)	29.6±10.8 (29.4-29.8)	29.5 (22.8-35.3)	29.6±10.8 (29.4-29.8)	29.5 (22.8-35.3)	
J31-J32	6.0±3.5 (5.9-6.0)	5.9 (4.2-7.3)	30.2±11.3 (30.1-30.4)	30.0 (23.8-35.8)	30.2±11.3 (30.1-30.4)	30.0 (23.8-35.8)	
J01	6.0±2.7 (5.8-6.2)	6.1 (4.6-7.4)	30.7±11.8 (29.9-31.5)	30.7 (24.4-37.2)	30.7±11.8 (29.9-31.5)	30.7 (24.4-37.2)	
K21	6.5±3.8 (6.4-6.6)	6.2 (4.3-8.6)	34.0±14.1 (33.5-34.4)	31.8 (25.5-42.4)	34.0±14.1 (33.5-34.4)	31.8 (25.5-42.4)	
J45	5.7±3.5 (5.6-5.8)	5.6 (3.9-6.9)	28.4±11.3 (28.0-28.7)	28.2 (21.2-33.8)	28.4±11.3 (28.0-28.7)	28.2 (21.2-33.8)	
G20	5.7±3.8 (5.4-6.1)	5.7 (3.7-7.0)	27.9±11.1 (26.8-28.9)	28.3 (20.0-33.8)	27.9±11.1 (26.8-28.9)	28.3 (20.0-33.8)	

[Table/Fig-3]: Cost per type 2 diabetes mellitus patient-month by patient's characteristic 2013–2017 [2017, Arithmetic mean (bootstrap 95% CI), USD)
[a] Bootstrap analysis was conducted based on 1,000 resamples to assess the average costs and the 95% confidence intervals (95% CI)
[b] SD: Standard Deviation
[c] Interquartile Range (Q1: 25th percentiles - Q3: 75th percentiles)
Exchange rate: 1USD = 22,451 VNĐ, Source MOF (December 31, 2017)
ICD: International Classification of Diseases;
I10: Hypertension; E78: Disorders of lipoprotein metabolism; K29: Gastritis/duodenitis; I25: Chronic ischemic heart disease; M47: Spondylosis; I83: Varicose veins of lower extremities; I11: Hypertensive heart disease; M81: Osteoporosis without current pathological fracture; H81: Disorders of vestibular function; K70-K77: Diseases of liver; G54: Nerve root and plexus disorders; N18: Chronic kidney disease; J02: Acute pharyngitis; J31-J32: Chronic diseases of upper respiratory system; J01: Acute sinusitis; K21: Gastro-esophageal reflux disease; J45: Asthma; G20: Parkinson's disease

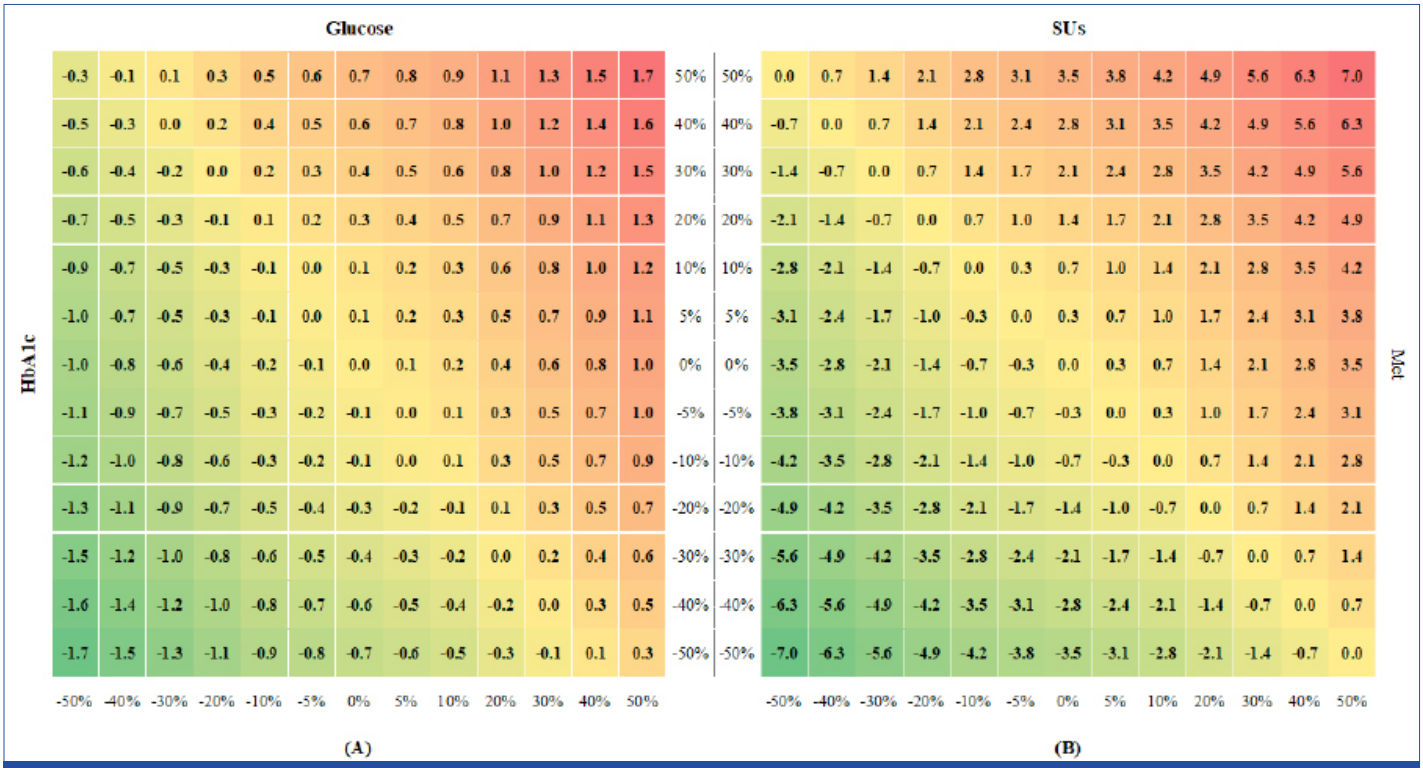


[Table/Fig-4]: Percentage of healthcare expenditures of type-2 diabetes mellitus in period 2013-2017.
Lipid profile: LDL-Cholesterol, HDL-Cholesterol, Triglyceride, Cholesterol
HbA1C: Glycosylated hemoglobin A1c
CBC: Complete Blood Count
Met: Metformin
DPP4: Dipeptidyl peptidase 4
AGIs: Alpha-Glucosidase Inhibitors
SUs: Sulphonyl urea's



[Table/Fig-5]: Treatment cost per type-2 diabetes mellitus patient-month by patient's group age (a) and gender (b).

Per patient cost estimate in the present study was 348.6 USD. Hospital costs reported in the European continents were also much higher than those obtained in this study [17-19]. A 2010 comparison of five countries (Germany, France, Italy, Spain and United Kingdom) by Kanavos P et al., estimated that the direct costs for T2DM treatment ranged from 1,708 to 5,899 Euros [20]. Notably, the treatment costs reported in the current study are lower than those in other Asia countries. An estimate of 1,575.6 USD per patient was reported in Singapore for 2015, and 842.6 USD was reported in Iran for 2011 [14]. A Chinese study conducted by Huang et al., reported per patient costs for the period of 2009 to 2011of 1,655 to 1,857 USD for the management of T2DM [21]. However, the current results are 3.2 times higher (127.3 USD) than the direct medical costs reported in a 2017 study conducted by Le NTD et al., for a Vietnamese public hospital that included data from 392 patients [10]. Our results are also higher than those reported in a 2011 Thai study that included 475 patients treated in a public hospital that reported an average treatment cost of 199.7 USD [13]. There is a clear difference between the T2DM treatment costs at private and public hospitals.



[Table/Fig-6]: Sensitivity analysis results {laboratory test (A), drugs and related products cost (B)}.

Our results are similar to a 2016 study conducted in China that showed that medications were responsible for 90% of direct medical costs [21]. In contrast, in the Singapore study, the most expensive component of total outpatient costs were physician costs; medication was the second component (64%, 23% respectively). Several explanations can account for these differences. First, the price of physician services in Singapore is higher than in Vietnam. Secondly, in our study, insulin prescriptions (8.7% of the total cost of drugs and related products) were responsible for most of the cost increase (about 53.2% was attributable to insulin alone), whereas in Singapore, the combined cost of other glucose-lowering drugs and insulin increased only slightly (about 17.3%) [12]. Our results are consistent with a German study covering the period of 2000 to 2007, where the treatment costs of patients treated with insulin increased 54.7% [18].

Regarding the costs of laboratory tests, the current results conform with those of national and international studies, with laboratory test costs (10%) accounting for a smaller proportion of total costs than medication costs. In the study from Iran [14], the costs for laboratory tests was 9% of the total direct cost; in the Singapore study, it was 10.6% [12]; and in the Vietnam study, it was 4.9% [10].

This study used an electronic medical database instead of reported or surveyed data. Despite this strength, there were still some limitations. First, the diagnosed cases of T2DM with the ICD-10 code E11 did not include the costs of monitoring HbA1c levels [22]. Second, the treatment cost was defined as all costs associated with the E11 code, so the costs of diseases unrelated to T2DM were not excluded. Third, retrospective data from a single private hospital cannot be used to make generalisations for the entire southern portion of the country. Finally, there is always the possibility that the hospital database contained mistakes in the raw data that could have caused study errors.

CONCLUSION

This study found that the direct medical costs for T2DM treatment in a private Vietnamese hospital were higher than the corresponding costs for a public hospital. These results indicate that the most important factor affecting the higher direct cost was related to the cost of drugs and related products. T2DM will continue to be a heavy burden on health budgets. Therefore, it is important to improve the prevention and treatment of T2DM to contribute to the sustainability of the Vietnamese healthcare system.

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