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Research paper

A longitudinal study of healthcare utilisation and expenditure in people with type 2 diabetes mellitus with and without major depressive disorder



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ABSTRACT

Objective: This study investigated the healthcare service utilisation and expenditure of patients with type 2 diabetes mellitus (T2DM) and major depressive disorder (MDD) and identified associated factors.

Methods: Healthcare service utilisation and expenditure of patients with T2DM with and without MDD during 2002–2013 were examined using Taiwan's population-based National Health Insurance claims database. Healthcare service utilisation included outpatient visits and inpatient admissions, and health expenditure included outpatient, inpatient, and total medical expenditure. Moreover, non-psychiatric health service utilisation and expenditure were distinguished from total health service utilisation and medical expenditure.

Results: Average healthcare service utilisation was significantly higher in those with comorbid MDD (both total and non-psychiatric utilisation). The higher overall costs of the patients with comorbid MDD largely driven by psychiatric costs and non-psychiatric costs between the groups were not significantly different. Gender, age, income, comorbidities and complications, and diabetes complications severity index were significant factors in outpatient visits, medical expenditure, and hospitalisation in those with comorbid MDD.

Conclusions: Type 2 diabetes patients with comorbid MDD were found to have higher costs, and that they appeared to be driven by more visits in the first 6 years and by psychiatric-related costs rather than general medical costs.

1. Introduction

Diabetes mellitus (DM), a chronic and disabling disease, is a major contributor to disability-adjusted life years [1,2]. The global prevalence of DM has recently been estimated to be 8.3% [3]. By 2030, the prevalence of DM is predicted to rise to 9.5% of the adult population [4]. DM and its complications engender considerable morbidity and mortality and are associated with substantial care service utilisation and expenditure; thus, they heavily burden personal and public health globally [5–7]. Similarly, depressive disorders affect worker

productivity through associated high absenteeism and reduced on-the-job output and can lead to disability [8]. Major depressive disorder (MDD) is a leading cause of disability among chronic medical conditions [9,10]. Depression is also expected to be the leading contributor to the burden of global disease by 2030 [5,11]. Both DM and MDD have many economic impacts beyond the health system, including unsatisfactory performance at work, high levels of absenteeism, and premature retirement [12–14].

A recent review reported that people with DM are at greater risk of depression compared with those without DM, and one recent meta-

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analysis reported a 24% increase in the risk of depression in people with type 2 DM (T2DM) [5,15]. Furthermore, the relative risk of DM has been reported to be 1.2–2.6 times greater in people with depression compared with those without depression [5,16]. MDD comorbidity not only increases the risk of nonadherence to self-care practices, such as diet maintenance, regular physical activity, and medication use [5], but it is also associated with a persistent increased risk for premature mortality [17], reported to be up to 38% higher in individuals with DM and depression compared with those with DM alone, regardless of sociodemographic characteristics, lifestyle, or health status [5,18].

However, although much is known about the economic impact and health service utilisation of DM and of depression as separate conditions, less attention has been focused on co-occurrence [19–21]. Furthermore, most studies on the association between depression and DM have been conducted in Western countries [22–25]. Little evidence is available on the aforementioned association in Asian countries, particularly in ethnic Chinese societies, although analyses from other cultures are a critical component of epidemiology. Cultural factors and explanatory disease models may differ in patients from Asian and Western countries, which affects the ability of patients to report the symptoms of mental illnesses and disease presentation, and cultural diversity (can get rid of the rest in between). As stated by Lloyd et al. in a review article, cultural diversity must be considered when assessing patients with mental illnesses [1,26]. Furthermore, most previous studies have investigated the association between depression and DM rather than specifically MDD and T2DM [22–25].

Hence, the present study investigated the healthcare service utilisation (i.e., outpatient visits and hospital admissions) and health expenditure of people with T2DM and MDD in a clinical setting and identified associated factors. The study also sought to distinguish non-psychiatric health utilisation and expenditure from the total health service utilisation and expenditure of patients with T2DM and MDD. Moreover, the study performed the difference between T2DM with and without MDD in health service utilisation and expenditure. We hypothesized that both the total utilisation and total expenditure of patients with T2DM and MDD would be higher than those of patients with T2DM and without MDD. We also hypothesized that non-psychiatric healthcare utilisation and expenditure would not significantly differ between the MDD group and the non-MDD controls. This is the first study to examine these connections in Asian patients, and the first to examine relationships between T2DM diabetes and formal coded MDD diagnoses.

2. Method

2.1. Data sources

The Taiwan National Health Insurance (NHI) program, launched in 1995, is a universal healthcare system that covers 99% of the country's population of 23.3 million. It has one of the largest and most complete population-based healthcare claims datasets, Taiwan's National Health Insurance Research Database (NHIRD), in the world. The NHIRD contains encrypted patient identification numbers, International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes for applied clinical diagnoses and procedures, details of prescribed drugs, dates of admission and discharge, and basic demographic information, including sex and date of birth. Data in this study were obtained from the Longitudinal Cohort of Diabetes Patients (LHDB), a sub-data set of the NHIRD, which contains randomised selected data (120,000 patients per year) from patients with newly diagnosed DM. The definitions of DM in the LHDB are outlined as follows: (a) inpatient: at least one diagnosis of DM (ICD-9-CM 250) or a prescription for antidiabetic medication; and (b) ambulatory care: diagnosis of DM on at least two different visits or diagnosis of DM on at least one visit with a prescription for antidiabetic medication.

2.2. Research design

In this longitudinal retrospective cohort study, only patients with newly diagnosed T2DM (ICD9-CM 250.x0 and 250.x2) in the LHDB between 1 January 2002 and 31 December 2002 were selected and defined as the study population. Patients with type 1 DM (ICD9-CM 250.x1 and 250.x3) were excluded. For the case group, subjects were defined as having MDD if they were newly diagnosed as having a mental illness (ICD-9-CM296.2x and 296.3x) during ambulatory or inpatient care in 2002 [9,27]. Patients who were newly diagnosed as having MDD after 2002 were excluded. We included only those with MDD diagnosed in 2002 because the effects of newly-diagnosed MDD on expenditures likely differs over time, with initial costs related to depression treatment early on and potentially lower costs with depression treatment in subsequent years.

The non-MDD controls were patients who were not diagnosed as having MDD between 1 January 2002 and 31 December 2002. For each patient with MDD, 10 controls were matched by sex, age, urbanisation, income, the DM complications severity index (DCSI), and comorbidities and complications by using propensity scores. DCSI reflects DM severity. A higher severity may reflect more hospitalisation and healthcare utilisation [28]. Propensity score matching was used to reduce selection bias because it can combine many confounding covariates that may be present in an observational study. An SAS matching macro '%OneToManyMTCH' proposed during the proceedings of the 29th SAS Users Group International was used in this study. After propensity score matching, 12,090 controls were selected.

2.3. Age, income, time, and covariates

Demographic data included sex, age, urbanisation, and income, and clinical characteristics included comorbidities and complications and the DCSI. Patients were classified into the following age groups: < 45, 45–64, and ≥ 65 years. Urbanisation was defined as urban or rural. Income level (per month) was classified into the following categories: dependent (family dependents, students and the unemployed), < NT\$20,000 (US\$666), NT\$20,000–39,999 (US \$666–1332), and ≥ NT\$40,000 (≥ US\$1333). We included individual comorbidities and complications (neurological, peripheral vascular, cardiovascular, renal, endocrine/metabolic, ophthalmic, and generalised anxiety disorder (GAD)) to provide information on specific clinical characteristics among patients with T2DM with and without MDD [27,29–31]. The DCSI included seven categories of complications. Each complication was rated from 0 to 2 [28]. The DCSI was categorised into three levels (no abnormality = 0, some abnormality = 1–2, and severe abnormality = 3) in our study, depending on the presence and severity of the complication. We counted these comorbid conditions if they occurred either in the inpatient setting or in three or more ambulatory care claims incidents coded 12 months before the date of T2DM diagnosis. Patients were followed from 2002 to the date of death or 31 December 2013, the end of the database period. Enrollment in the NHI program is mandatory for all citizens and other legal residents of Taiwan, and disenrollment must occur within 30 days after an individual's death. Therefore, those patients recorded as deceased in an inpatient claim or as disenrolling from the NHI system within 30 days after being discharged from their last hospitalisation were presumed dead, and the discharge date was designated as the date of death.

2.4. Healthcare utilisation and expenditure

Data on healthcare service utilisation and expenditure were available for 3-year periods (2002–2004, 2005–2007, 2008–2010, and 2011–2013). Healthcare service utilisation included the following: (i) outpatient visits per person per period was defined as those who visited doctors' clinics and hospital outpatient departments (including accident and emergency presentation) and (ii) hospital admission per person per

period was defined as the number of hospitalisations. Healthcare expenditure included outpatient, hospitalisation, and total medical expenditure (total health care costs) per person per period. Outpatient expenditure included payments for office-based provider visits and hospital outpatient visits. The items paid for included physician fees, medication, laboratory exams, and others. Inpatient expenditure involved 14 items, including medication, room/ward fees, procedure, imaging, and others [29,32]. To determine the impact of MDD on healthcare service utilisation and expenditure in patients with T2DM, healthcare service utilisation and expenditure were stratified by psychiatric and non-psychiatric care. For service claims, visits made for ambulatory or inpatient care not in psychiatry departments were defined as non-psychiatric visits.

2.5. Statistical analysis

Descriptive statistical analyses were conducted using the Chi-square tests were used to compare the differences between the groups with and without MDD in terms of sociodemographic and clinical characteristics. Healthcare service utilisation and expenditure was ascertained by taking log-transformation due to the right-skewed distribution. Subsequently, the transformed differences in healthcare service utilisation and expenditure per person per period among patients with T2DM with and without MDD from 2002 to 2012 were tested using the *t*-test for continuous variables. General estimation equations (GEEs) were used to analyse the differences between the MDD group and non-MDD control group in outpatient visits and total medical expenditure for each 3-year period after controlling for confounding covariates. Moreover, the factors of interest associated with T2DM and MDD in outpatient visits and total medical expenditure were investigated using GEEs. Multiple logistic regression with GEE analysis was also applied to investigate the associations between the factors of interest and hospitalisation of patients with T2DM and MDD. SAS 9.4 for Windows (SAS Institute, Cary, NC, USA) was used for all analyses. Significance was set at $p < 0.05$.

This study was conducted according to the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Kaohsiung Medical University Hospital. The IRB waived the need for informed consent (written and oral) from the patients because the dataset used in this study comprised nationwide, unidentifiable, secondary data released to the public for research purposes.

3. Results

In total, 1209 patients with T2DM and MDD (the case group) and 12,090 matched controls with T2DM without MDD (the control group) were included. The demographic and clinical characteristics of the two groups are provided in Table 1. No significant differences in sex, age, urbanisation, income, comorbidities and complications, or DCSI were observed between the two groups.

3.1. Healthcare utilisation and expenditure of patients with T2DM with and without MDD

Healthcare service utilisation and expenditure were compared for the two cohorts for each study period (2002–2004, 2005–2007, 2008–2010, 2011–2013, Table 2). The average total number of outpatient visits of the MDD group was 134.22 in 2002–2004 and 128.73 in 2011–2013, whereas that of the non-MDD control group was 85.63 in 2002–2004 and 94.95 in 2011–2013. The average total number of non-psychiatric outpatient visits of the MDD group was 113.98 in 2002–2004 and 112.83 in 2011–2013, whereas that of the non-MDD control group was 84.79 in 2002–2004 and 93.67 in 2011–2013. The average total outpatient expenditure of the MDD group was NT\$158,688.96 in 2002–2004 and NT\$161,915.98 in 2011–2013, whereas that of the non-MDD control group was NT\$100,004.58 in

Table 1
Demographic data and clinical characteristics of persons with T2DM with and without MDD in year 2002.

Variables	T2DM with MDD (n = 1209)		T2DM without MDD (n = 12,090)		p-Value
	N	%	n	%	
Gender					
Female	711	58.81	7156	59.19	0.823
Male	498	41.19	4934	40.81	
Age					
< 45 years	261	21.59	2647	21.89	0.404
45–64 years	571	47.23	5478	45.31	
≥ 65	377	31.18	3965	32.80	
Urbanisation					
Urban	664	54.92	6633	45.14	0.993
Rural	545	45.08	5457	44.86	
Income					
≥ NT\$40,000 (≥ US\$1333)	85	7.03	836	6.91	0.995
NT\$20,000–39,999 (US \$666–1332)	285	23.57	2876	23.79	
< NT\$20,000 (US\$666)	409	33.83	4063	33.61	
Dependents	430	35.57	4315	35.69	
Comorbidity/complication					
Neurological	224	18.53	2208	18.26	0.850
Peripheral vascular	41	3.39	427	3.53	0.864
Cardiovascular	526	43.51	5212	43.11	0.814
Renal	211	17.45	2104	17.40	0.997
Endocrine/metabolic	126	10.42	1237	10.23	0.874
Ophthalmic	109	9.02	1111	9.19	0.882
GAD	25	2.07	223	1.84	0.663
DCSI					
0	421	34.82	4117	34.05	0.700
1–2	526	43.51	5413	44.77	
≥ 3	262	21.67	2560	21.17	

Note: Dependents include family dependents, students and the unemployed.

Exchange rate of US\$1 to NT\$30.

T2DM: type II diabetes mellitus.

MDD: major depressive disorder.

GAD: generalized anxiety disorder.

DCSI: diabetes complications severity index.

2002–2004 and NT\$138,807.55 in 2011–2013. The average total non-psychiatric outpatient expenditure of the MDD group was NT\$119,925.65 in 2002–2004 and NT\$132,014.42 in 2011–2013, whereas that of the non-MDD control group was NT\$98,544.93 in 2002–2004 and NT\$136,701.81 in 2011–2013. The average total inpatient expenditure of the MDD group was NT\$128,086.51 in 2002–2004 and NT\$100,029.80 in 2011–2013, whereas that of the non-MDD control group was NT\$102,066.91 in 2002–2004 and NT\$70,590.96 in 2011–2013. The average total non-psychiatric inpatient expenditure of the MDD group was NT\$104,567.16 in 2002–2004 and NT\$79,698.03 in 2011–2013, whereas that of the non-MDD control group was NT\$99,643.93 in 2002–2004 and NT\$68,964.09 in 2011–2013. After log transformation, in healthcare utilisation, the number of outpatient visits (total and non-psychiatric), and hospital admissions (total and non-psychiatric) was significantly higher for the case group than for the control group in every period, except for non-psychiatric hospital admission in 2005–2007 ($p = 0.087$). Regarding health expenditure, total average outpatient expenditure, total inpatient expenditure, and total medical expenditure were also significantly higher for the case group than for the control group in every period, except for total inpatient expenditure in 2005–2007 ($p = 0.132$). Total non-psychiatric outpatient expenditure and non-psychiatric medical expenditure were also significantly higher for the case group than for the control group in every period. However, non-psychiatric inpatient expenditures did not significantly differ between the case and control groups.

Table 2
Health care utilisation and expenditure between T2DM with and without MDD.

Variables	Before log transformation		After log transformation		p-Value ^a
	T2DM with MDD, mean (S.D.)	T2DM with non-MDD, mean (S.D.)	T2DM with MDD, mean (S.D.)	T2DM with non-MDD, mean (S.D.)	
2002–2004					
Health utilisation					
Total outpatient visits	134.22 ± 87.27	85.63 ± 61.32	4.68 ± 0.70	4.20 ± 0.79	< 0.001
Psychiatry	20.24 ± 21.85	0.84 ± 5.30			
Non_Psychiatry	113.98 ± 81.68	84.79 ± 60.80	4.48 ± 0.78	4.19 ± 0.79	< 0.001
Total hospital admission	2.42 ± 3.85	1.45 ± 2.61	0.91 ± 0.83	0.69 ± 0.74	< 0.001
Psychiatry	0.34 ± 1.32	0.01 ± 0.27			
Non_Psychiatry	2.08 ± 3.48	1.44 ± 2.59	0.83 ± 0.81	0.69 ± 0.74	< 0.001
Health expenditure (NT\$)					
Total outpatient expenditure	158,688.93 ± 151,276.02	100,004.58 ± 165,039.91	11.68 ± 0.80	11.03 ± 0.96	< 0.001
Psychiatry	38,763.28 ± 50,296.84	1459.65 ± 12,489.36			
Non_Psychiatry	119,925.65 ± 140,539.39	98,544.93 ± 164,564.63	11.31 ± 0.89	11.01 ± 0.96	< 0.001
Total inpatient expenditure	128,086.51 ± 304,690.91	102,066.91 ± 376,197.49	11.26 ± 1.37	11.11 ± 1.41	0.003
Psychiatry	23,519.35 ± 117,838.47	2422.98 ± 56,537.49			
Non_Psychiatry	104,567.16 ± 282,567.40	99,643.93 ± 372,124.47	11.10 ± 1.35	11.10 ± 1.40	0.865
Total medical expenditure	286,775.44 ± 347,902.26	202,071.49 ± 425,016.32	12.13 ± 0.93	11.50 ± 1.12	< 0.001
Psychiatry	62,282.63 ± 134,669.54	3882.64 ± 60,243.54			
Non_Psychiatry	224,492.81 ± 327,277.73	198,188.86 ± 421,357.62	11.77 ± 1.04	11.48 ± 1.12	< 0.001
2005–2007					
Health utilisation					
Total outpatient visits	128.96 ± 93.16	86.58 ± 62.56	4.57 ± 0.88	4.17 ± 0.87	< 0.001
Psychiatry	17.47 ± 22.63	0.94 ± 5.79			
Non_Psychiatry	111.49 ± 86.76	85.64 ± 61.92	4.38 ± 0.94	4.16 ± 0.87	< 0.001
Total hospital admission	1.63 ± 3.10	0.99 ± 2.16	0.74 ± 0.82	0.62 ± 0.73	0.001
Psychiatry	0.25 ± 1.22	0.01 ± 0.23			
Non_Psychiatry	1.38 ± 2.72	0.98 ± 2.15	0.67 ± 0.77	0.61 ± 0.73	0.087
Health expenditure (NT\$)					
Total outpatient expenditure	159,034.89 ± 186,076.55	109,447.83 ± 196,166.83	11.54 ± 1.05	11.03 ± 1.09	< 0.001
Psychiatry	34,173.91 ± 54,322.52	1668.77 ± 14,998.86			
Non_Psychiatry	124,860.98 ± 175,419.71	107,779.06 ± 195,593.76	11.22 ± 1.11	11.01 ± 1.10	< 0.001
Total inpatient expenditure	102,448.03 ± 293,667.83	68,863.67 ± 261,463.47	11.24 ± 1.36	11.15 ± 1.33	0.132
Psychiatry	21,425.19 ± 115,406.39	3438.36 ± 72,086.03			
Non_Psychiatry	81,022.84 ± 269,833.14	65,425.30 ± 251,817.08	11.07 ± 1.31	11.12 ± 1.32	0.374
Total medical expenditure	261,482.92 ± 368,955.88	178,311.50 ± 346,614.64	11.90 ± 1.16	11.33 ± 1.23	< 0.001
Psychiatry	55,599.10 ± 136,012.18	5107.13 ± 75,893.59			
Non_Psychiatry	205,883.82 ± 346,381.64	173,204.37 ± 339,259.42	11.56 ± 1.23	11.31 ± 1.23	< 0.001
2008–2010					
Health utilisation					
Total outpatient visits	128.29 ± 91.51	90.73 ± 63.55	4.58 ± 0.85	4.23 ± 0.85	< 0.001
Psychiatry	16.09 ± 21.25	1.06 ± 6.04			
Non_Psychiatry	112.20 ± 85.98	89.67 ± 62.85	4.40 ± 0.92	4.22 ± 0.86	< 0.001
Total hospital admission	1.54 ± 2.98	0.94 ± 2.06	0.77 ± 0.81	0.61 ± 0.71	< 0.001
Psychiatry	0.20 ± 1.07	0.01 ± 0.23			
Non_Psychiatry	1.34 ± 2.72	0.93 ± 2.04	0.70 ± 0.78	0.61 ± 0.71	0.013
Health expenditure (NT\$)					
Total outpatient expenditure	158,052.73 ± 193,826.51	125,210.01 ± 234,414.40	11.56 ± 0.98	11.14 ± 1.09	< 0.001
Psychiatry	30,798.29 ± 53,794.42	1964.08 ± 17,744.63			
Non_Psychiatry	127,254.44 ± 183,591.68	123,245.93 ± 233,840.67	11.28 ± 1.04	11.12 ± 1.10	< 0.001
Total inpatient expenditure	96,152.48 ± 236,695.04	70,166.57 ± 261,936.55	11.36 ± 1.30	11.21 ± 1.32	0.016
Psychiatry	22,386.20 ± 147,968.43	2552.84 ± 55,256.18			
Non_Psychiatry	73,766.28 ± 187,693.13	67,613.73 ± 256,213.20	11.21 ± 1.23	11.19 ± 1.31	0.795
Total medical expenditure	254,205.21 ± 339,279.11	195,376.58 ± 375,852.86	11.88 ± 1.12	11.42 ± 1.23	< 0.001
Psychiatry	53,184.49 ± 163,065.04	4516.93 ± 60,081.44			
Non_Psychiatry	201,020.71 ± 298,348.21	190,859.65 ± 371,724.78	11.59 ± 1.18	11.39 ± 1.23	< 0.001
2011–2013					
Health utilisation					
Total outpatient visits	128.73 ± 86.71	94.95 ± 64.81	4.60 ± 0.84	4.29 ± 0.83	< 0.001
Psychiatry	15.90 ± 20.30	1.28 ± 6.38			
Non_Psychiatry	112.83 ± 81.29	93.67 ± 64.10	4.43 ± 0.90	4.27 ± 0.84	< 0.001
Total hospital admission	1.48 ± 3.24	0.98 ± 2.11	0.75 ± 0.79	0.60 ± 0.70	< 0.001
Psychiatry	0.18 ± 1.05	0.01 ± 0.24			
Non_Psychiatry	1.30 ± 2.83	0.97 ± 2.09	0.72 ± 0.76	0.60 ± 0.70	0.003
Health expenditure (NT\$)					
Total outpatient expenditure	161,915.98 ± 200,765.21	138,807.55 ± 267,043.62	11.57 ± 0.99	11.24 ± 1.07	< 0.001
Psychiatry	29,901.56 ± 59,815.57	2105.75 ± 17,949.17			
Non_Psychiatry	132,014.42 ± 190,910.40	136,701.81 ± 266,581.26	11.31 ± 1.05	11.22 ± 1.08	0.013

(continued on next page)

Table 2 (continued)

Variables	Before log transformation		After log transformation		p-Value ^a
	T2DM with MDD, mean (S.D.)	T2DM with non-MDD, mean (S.D.)	T2DM with MDD, mean (S.D.)	T2DM with non-MDD, mean (S.D.)	
Total inpatient expenditure	100,029.80 ± 269,876.55	70,590.96 ± 214,970.25	11.45 ± 1.29	11.26 ± 1.28	0.004
Psychiatry	20,331.77 ± 120,822.62	1626.87 ± 40,233.09			
Non_Psychiatry	79,698.03 ± 238,325.53	68,964.09 ± 211,157.23	11.31 ± 1.25	11.25 ± 1.27	0.331
Total medical expenditure	261,945.78 ± 363,516.04	209,398.51 ± 372,420.55	11.90 ± 1.13	11.52 ± 1.20	< 0.001
Psychiatry	50,233.33 ± 146,968.15	3732.62 ± 47,544.02			
Non_Psychiatry	211,712.45 ± 330,669.99	205,665.90 ± 369,787.99	11.62 ± 1.18	11.50 ± 1.21	0.003

Exchange rate of US\$1 to NT\$30.

T2DM: type II diabetes mellitus.

MDD: major depressive disorder.

Total = psychiatry + non-psychiatry.

Total = inpatient + outpatient.

^a The log transformation wasn't taken since the value of healthcare service utilisation and expenditure would become negative infinity for those patients who are not diagnosed with psychiatry.

Table 3

Results from the Multivariate regression models for analysing health care utilisation and expenditure between T2DM with and without MDD.

	T2DM with MDD vs T2DM with non-MDD		p-Value
	Beta	95% CI	
Health utilisation			
Total outpatient visits	39.43	(35.01, 43.84)	< 0.0001
Non_Psychiatry	23.43	(19.34, 27.52)	< 0.0001
Total hospital admission	0.68	(0.52, 0.83)	< 0.0001
Non_Psychiatry	0.44	(0.30, 0.58)	< 0.0001
Health expenditure (NT\$)			
Total outpatient expenditure	39,075.73	(29,895.79, 48,255.66)	< 0.0001
Non_Psychiatry	8066.58	(- 565.76, 16,698.92)	0.0670
Total inpatient expenditure	26,199.39	(14,606.50, 37,792.29)	< 0.0001
Non_Psychiatry	6852.95	(- 2903.01, 16,608.92)	0.1686
Total medical expenditure	64,887.56	(48,201.19, 81,573.93)	< 0.0001
Non_Psychiatry	14,174.21	(- 936.56, 29,284.99)	0.0660

Multivariate regression model was adjusted by gender, age group, urbanisation, income, comorbidity, DCSI, and year period (three year period).

T2DM: type II diabetes mellitus.

MDD: major depressive disorder.

CI: confidence interval.

3.2. Association between T2DM with and without MDD in health care utilisation and expenditure

The association between T2DM with and without MDD in health care utilisation and expenditure after controlling for T2DM severity and complications and year period (3-year period) is detailed in Table 3. The results for total outpatient visits, non-psychiatric outpatient visits, total hospital admissions, and non-psychiatric hospital admissions indicated that the MDD group had 39.43, 23.43, 0.68, and 0.44 (95% confidence interval [CI], 35.01–43.84, 19.34–27.52, 0.52–0.83, 0.30–0.58) times more visits, respectively, than did the non-MDD control group in every 3-year period. Total average outpatient expenditure, total inpatient expenditure, and total expenditure were also significantly higher for the case group than for the control group. Nevertheless, the non-psychiatric outpatient expenditure, non-psychiatric inpatient expenditure, and non-psychiatric medical expenditure were not significantly higher for the case group than for the control group.

3.3. Associated factors of outpatient visits and total medical expenditure among patients with T2DM with MDD

Among the patients with T2DM with MDD, the associations between outpatient visits (total and non-psychiatric) and associated factors analysed using the GEE model are presented in Table 4. Sex, age, urbanisation, income, comorbidities and complications, and DCSI were significant factors for outpatient visits for the case group (total and non-psychiatric). The results for total outpatient visits, after adjustment for other covariates, indicated that women had 9.54 times more visits (95% [CI], 7.58–11.49) than men. Those aged 45–64 and ≥65 years had 15.72 and 10.56 times more visits, respectively, than did those aged < 45 years. Urban dwellers had fewer visits than did rural dwellers. Those in the NT\$20,000–39,999 (US \$666–1332), < NT\$20,000 (US\$666), and dependent income categories had 8.59, 4.57, and 7.10 times more visits, respectively, than did those in the ≥NT\$40,000 (US\$1333) category. Compared with patients without comorbidities or complications, those with cardiovascular, renal, endocrinal/metabolic, ophthalmic, and GAD comorbidities had more visits. The relatively high DCSI scores also indicated more visits. Significant factors for and the patterns of non-psychiatric outpatient visits were similar to the factors for and patterns of total outpatient visits.

The factors associated with the total medical expenditure of patients with T2DM and MDD were analysed using the GEE model (Table 4). Sex, age, income, comorbidities and complications, and DCSI were significant factors for the medical expenditure of the case group (total and non-psychiatric). After adjustment for other covariates, women had NT\$41,749 less in total medical expenditure than did men. Older age indicated relatively high medical expenditure. Those in the NT\$20,000–39,999 (US\$666–1332), < NT\$20,000 (US\$666), and dependent income categories had NT\$32,445, NT\$89,798, and NT\$77,288 more in total medical expenditure, respectively, than did those in the ≥NT\$40,000 (US\$1333) category. Compared with patients without comorbidities or complications, those with neurological, peripheral vascular, cardiovascular, and renal comorbidities had higher medical expenditure. The relatively high DCSI scores also indicated higher medical expenditure. Significant factors for and patterns of non-psychiatric medical expenditure were similar to the factors for and patterns of total medical expenditure.

3.4. Risk factors for hospitalisation among patients with T2DM and MDD

The risk of hospitalisation in the observation period was analysed using logistic regression models (Table 5). Sex, age, urbanisation, income, comorbidities and complications, and DCSI were significant factors for the hospitalisation of the case group (total and non-

Table 4

Results from the multivariate regression models for analysing outpatient visits and total medical expenditure among T2DM with MDD during 2002–2013 (n = 1209).

Variables	Outpatient visits				Total medical expenditure			
	Total (psychiatry + non-psychiatry)		Non_Psychiatry		Total (psychiatry + non-psychiatry)		Non_Psychiatry	
	Beta	95% CI	Beta	95% CI	Beta	95% CI	Beta	95% CI
Constant	51.79	(48.56, 55.03)**	49.74	(46.66, 52.82)**	68,602	(55,584, 81,620)**	58,941	(46,385, 71,497)**
Gender								
Male (reference)								
Female	9.54	(7.58, 11.49)**	9.47	(7.59, 11.35)**	-41,749	(-52,419, -31,079)**	-37,739	(-48,106, -27,372)**
Age								
< 45 years								
45–64 years	15.72	(13.25, 18.20)**	16.76	(14.44, 19.08)**	13,803	(1540, 26,067)*	26,008	(14,477, 37,539)**
≥ 65	10.56	(7.35, 13.77)**	12.47	(9.43, 15.51)**	50,404	(33,212, 67,595)**	67,452	(50,897, 84,007)**
Urbanisation								
Rural (reference)								
Urban	-2.36	(-4.30, -0.41)*	-2.56	(-4.43, -0.68)*	-5157	(-15,374, 5061)	-5959	(-15,914, 3996)
Income								
≥ NT\$40,000 (≥ US\$1333) (reference)								
NT\$20,000–39,999 (US \$666–1332)	8.59	(5.41, 11.78)**	7.87	(4.84, 10.91)**	32,445	(20,451, 44,438)**	24,401	(12,805, 35,996)**
NT\$20,000 (US\$666)	4.57	(1.35, 7.79)*	3.01	(-0.05, 6.08)	89,798	(76,560, 103,035)**	72,376	(59,847, 84,904)**
Dependents	7.10	(3.90, 10.30)**	6.12	(3.07, 9.18)**	77,288	(64,476, 90,099)**	66,505	(54,117, 78,892)**
Comorbidity/complication								
Neurological	-1.08	(-4.38, 2.21)	-0.95	(-4.14, 2.24)	24,202	(4021, 44,383)*	23,053	(3119, 42,987)*
Peripheral vascular	0.36	(-7.22, 7.93)	0.80	(-6.62, 8.22)	76,549	(24,990, 128,108)*	77,006	(25,933, 128,080)*
Cardiovascular	12.06	(9.75, 14.36)**	11.79	(9.57, 14.01)**	35,350	(23,321, 47,379)**	34,096	(22,314, 45,877)**
Renal	6.25	(3.03, 9.46)**	5.84	(2.74, 8.94)*	146,352	(125,451, 167,254)**	142,167	(121,553, 162,782)**
Endocrine/metabolic	11.69	(8.07, 15.31)**	11.39	(7.88, 14.89)**	-11,514	(-28,946, 5917)	-9597	(-26,703, 7509)
Ophthalmic	24.63	(20.64, 28.63)**	24.24	(20.35, 28.13)**	5604	(-14,434, 25,642)	5678	(-13,994, 25,350)
GAD	23.99	(16.03, 31.95)**	20.13	(12.48, 27.78)**	-664	(-27,985, 26,657)	-14,054	(-37,268, 9160)
DCSI								
0 (reference)								
1–2	11.05	(8.97, 13.14)**	11.08	(9.08, 13.07)**	39,575	(30,204, 48,947)**	39,574	(30,627, 48,521)**
≥ 3	15.11	(11.75, 18.47)**	15.32	(12.08, 18.56)**	161,868	(140,765, 182,972)**	164,528	(143,636, 185,420)**

Note: Dependents include family dependents, students and the unemployed.

Exchange rate of US\$1 to NT\$30.

T2DM: type II diabetes mellitus.

MDD: major depressive disorder.

GAD: general anxiety disorder.

DCSI: diabetes complications severity index.

CI: confidence interval.

* p value < 0.05.

** p value < 0.001.

psychiatric). After adjustment for other covariates, women had 0.82 times fewer total hospitalisations than did men. Those aged ≥ 65 years had 1.84 times more hospitalisations than did those < 45 years. Urban dwellers had 0.86 times fewer hospitalisations than did rural dwellers. Those in the NT\$20,000–39,999 (US\$666–1332), < NT\$20,000 (US\$666), and dependent income categories had 1.35, 1.90 and 1.60 times more hospitalisations, respectively, than did those in the ≥ NT\$40,000 (US\$1333) category. Compared with patients without comorbidities or complications, those with neurological, peripheral vascular, cardiovascular, and renal comorbidities had 1.36, 1.39, 1.21, and 1.73 times more hospitalisations, respectively. Those with DCSI scores of 1–2 and ≥ 3 had 1.30 and 2.36 times more hospitalisations, respectively, than did those with a DCSI score of 0. Again, significant factors for and the patterns of non-psychiatric hospitalisations were similar to the factors for and patterns of total hospitalisations.

4. Discussion

This study had several key findings. First, healthcare service utilisation, including outpatient visits and hospital admissions, was significantly higher in those with comorbid MDD than in the control group (both total and non-psychiatric parts). Second, the average outpatient expenditure (total), inpatient expenditure (total), and total expenditure were significantly higher in those with comorbid MDD than in the control group. Nevertheless, the average outpatient expenditure (non-psychiatric), inpatient expenditure (non-psychiatric), were not significantly higher for the case group than for the control group. Third, sex, age, income, comorbidities and complications, and DCSI were significant factors for outpatient visits, medical expenditure, and hospitalisation in those with comorbid MDD (in both total and non-psychiatric). However, urban living status was a significant factor for only

Table 5
Multivariate results from the logistic regression models for the likelihood of hospitalisation among T2DM with MDD during 2002–2013 (n = 1209).

Variables	Hospitalisation					
	Total (psychiatry + non-psychiatry)			Non-psychiatry		
	OR	95% CI	p value	OR	95% CI	p value
Gender						
Male (reference)						
Female	0.82	(0.78, 0.86)	< 0.001	0.83	(0.79, 0.87)	< 0.001
Age						
< 45 years (reference)						
45–64 years	1.00	(0.94, 1.07)	0.938	1.04	(0.98, 1.11)	0.202
≥ 65	1.84	(1.71, 1.99)	< 0.001	1.95	(1.80, 2.10)	< 0.001
Urbanisation						
Rural (reference)						
Urban	0.86	(0.82, 0.90)	< 0.001	0.86	(0.82, 0.90)	< 0.001
Income						
≥ NT\$40,000 (≥ US\$1333) (reference)						
NT\$20,000–39,999 (US\$666–1332)	1.35	(1.22, 1.50)	< 0.001	1.32	(1.19, 1.46)	< 0.001
< NT\$20,000 (US\$666)	1.90	(1.71, 2.11)	< 0.001	1.82	(1.64, 2.01)	< 0.001
Dependents	1.60	(1.44, 1.78)	< 0.001	1.55	(1.40, 1.72)	< 0.001
Comorbidity/complication						
Neurological	1.36	(1.27, 1.47)	< 0.001	1.36	(1.26, 1.46)	< 0.001
Peripheral vascular	1.39	(1.19, 1.62)	< 0.001	1.38	(1.18, 1.61)	< 0.001
Cardiovascular	1.21	(1.15, 1.28)	< 0.001	1.21	(1.15, 1.28)	< 0.001
Renal	1.73	(1.61, 1.86)	< 0.001	1.72	(1.60, 1.85)	< 0.001
Endocrine/metabolic	0.93	(0.86, 1.01)	0.092	0.94	(0.87, 1.02)	0.157
Ophthalmic	1.05	(0.97, 1.15)	0.231	1.06	(0.97, 1.16)	0.166
GAD	0.88	(0.73, 1.05)	0.163	0.88	(0.73, 1.05)	0.156
DCSI						
0 (reference)						
1–2	1.30	(1.23, 1.38)	< 0.001	1.31	(1.24, 1.38)	< 0.001
≥ 3	2.36	(2.17, 2.56)	< 0.001	2.38	(2.19, 2.58)	< 0.001

OR: odds ratio.

Note: Dependents include family dependents, students and the unemployed.

Exchange rate of US\$1 to NT\$30.

T2DM: type II diabetes mellitus.

MDD: major depressive disorder.

GAD: general anxiety disorder.

DCSI: diabetes complications severity index.

CI: confidence interval.

outpatient visits and hospitalisation in those with comorbid MDD (both total and non-psychiatric). Fourth, the factors for total and non-psychiatric outpatient visits, hospital admissions, and medical expenditure did not differ.

Compared with the control group, those with comorbid MDD availed themselves of more healthcare services and incurred a higher expenditure during the study period. These results are consistent with those of previous studies on patients with DM and depression [22–25], although the current study specified patients with T2DM and MDD rather than patients with DM and depression. Moreover, the increased total healthcare service utilisation, including outpatient visits and hospital admissions, did not occur solely because the patients used additional psychiatric resources. Furthermore, the expenditure increased, including total outpatient expenditure, total inpatient expenditure, and total expenditure, during our study period (2002–2013). Overall total expenditures were higher in the patients with comorbid MDD, and that this seems largely driven by higher psychiatric costs, which were very different between the two groups, while non-psychiatric costs did not significantly differ. Although total non-psychiatric outpatient expenditure and total non-psychiatric medical expenditure were significantly higher in those with comorbid MDD than in the control group in the unadjusted log-transformation comparison (Table 2), after controlling for diabetes severity and complications and year period (Table 3), no significant difference was recorded in non-psychiatric expenditure, including total outpatient expenditure, total inpatient expenditure, and total non-psychiatric expenditure.

One of the study findings was that women availed themselves both of more total and non-psychiatric outpatient visits than did men. This finding is consistent with that of a previous study; this study reported that women, to a greater extent than men, can identify depressive symptoms and are more willing to seek help [33]. Because women are more willing to seek help, their medical problems can be treated earlier. These factors may explain why women had fewer hospitalisations and lower medical expenditure (including total and non-psychiatric) than do men. Men were significantly associated with higher healthcare costs in a Thai study [34]. Overall, we found that the results were pointing out that the group with comorbid MDD had a vastly larger number of visits in the first two time periods, and actually fewer in the next two periods. Women had more outpatient visits but less total expenditure due to lower inpatient costs, suggesting potentially greater preventive/maintenance treatment in the group with comorbid MDD.

Age was another key factor in healthcare utilisation and expenditure. Older patients had more outpatient visits, medical expenditure, and hospitalisation (both total and non-psychiatric). The findings on healthcare utilisation and expenditure are similar to those of previous studies on DM [23,34]. Those who lived in urban areas had fewer outpatient visits and hospitalisations (both total and non-psychiatric) than did rural dwellers. A previous study determined that rural patients with depression were likely to be hospitalised for physical and mental illnesses [35].

In this study, patients in the NT\$20,000–39,999 (US \$666–1332), < NT\$20,000 (US\$666), and dependent income categories were associated with higher healthcare service utilisation and

expenditure than those in the \geq NT\$40,000 (US\$1333) category, including more outpatient visits, total medical expenditure, and hospitalisation (both total and non-psychiatric). In prior work, a low income level was associated only with increased outpatient expenditure rather than direct medical costs and outpatient visits for patients with T2DM in a Chinese study [36,37].

In addition to the aforementioned factors, comorbidities and complications and DCSI were other significant factors for outpatient visits, medical expenditure, and hospitalisations of patients with T2DM and MDD (both total and non-psychiatric). This finding is consistent with those of previous studies on patients with DM that have reported more healthcare service utilisation, hospitalisations, and expenditure of patients with DM comorbid with physical complications [19–21,23,34,36]. The number of DM complications was also significantly related to total cost [23,36]. Apart from the physical complications, the present study revealed that GAD was another significant factor for outpatient visits, medical expenditure, and hospitalisations of patients with T2DM with MDD (both total and non-psychiatric). An understanding of the factors affecting healthcare utilisation and expenditure may help healthcare providers intervene to improve patient management and possibly reduce the healthcare costs burden in the future.

4.1. Strengths and limitations

Investigating healthcare service utilisation and expenditure of patients with T2DM and MDD by using an insurance database has many advantages, including a large sample size, fewer resources required for psychiatric assessments, and the availability of longitudinal data for detecting incidence and risk factors [27,29,30]. However, this study has some limitations. The diagnoses of T2DM and MDD could not be validated. Furthermore, the reliability and validity of the secondary data, a crucial factor [27,29,38], as well as the presence of dual diagnoses, the existence of overdiagnoses and underdiagnoses, and the presence of primary or secondary diagnoses cannot be ensured [29–31,39]. Some demographic variables, including education, occupation, marital status, lifestyle, physical activity, blood sugar control, and body weight, were also unavailable in the claims database. Additionally, no global income scale was available. Next, because patients who were newly diagnosed as having MDD after 2002 were excluded, the results may have been underestimated. Additionally, patients with T2DM and MDD are usually younger and have numerous complications. Although we used propensity matching between the two groups, overadjustment may have occurred and led to underestimation [40].

5. Conclusion

In conclusion, in this large-scale, population-based study, we revealed the healthcare service utilisation and expenditure of patients with T2DM and MDD. To date, scant research has been conducted for clinical practice with respect to the healthcare service utilisation and expenditures of patients with T2DM and MDD in Asia, particularly for ethnic Chinese populations. We had found that patients with comorbid MDD were found to have higher costs, and that they appeared to be driven by more visits in the first 6 years and by psychiatric-related costs rather than general medical costs.

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Conflict of interests

We declare that none of the authors has a conflict of interest with regard to this manuscript.

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