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The effect of pay for performance on risk incidence of hip fracture in type 2 diabetic patients: a nationwide population-based cohort study

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Abstract

Objectives: Diabetes mellitus (DM) increases the risk of hip fracture. The literature rarely discusses the importance of pay-for-performance (P4P) programs for the incidence of hip fractures in patients with type 2 DM (T2DM). This study aimed to examine the impact of the P4P program on hip fracture risk in patients with T2DM.

Methods: This retrospective cohort study focused on data from T2DM patients aged 45 and older between 2001 and 2012. We continued to track these data until 2013. The data were collected from the National Health Insurance Research Database in Taiwan. To minimize selection bias, T2DM patients were divided into P4P enrollees and non-enrollees. Propensity score matching by greedy matching technique (1:1 ratio) was used to include 252,266 participants. A Cox proportional hazard model was performed to examine the impact of the P4P program on hip fracture risk. We used the bootstrap method to perform sensitivity analysis by random sampling with replacement.

Results: Our results showed that the risk of hip fracture in P4P enrollees was 0.92 times that of non-enrollees. (hazards ratio [HR] = 0.92; 95% confidence interval [CI]: 0.85–0.99). P4P enrollees who received regular treatment had lower risk in the first 4 years (HR = 0.90; 95%CI: 0.84–0.96) but no statistically significant difference after 4-year enrollment (HR = 0.99; 95%CI: 0.93–1.06). There was no statistically significant difference in the effect of hip fractures between P4P non-enrollees and P4P enrollees with irregular treatment (HR = 0.94, 95%CI: 0.87–1.03). Through sensitivity analysis, the results also showed P4P enrollees had a lower risk of hip fracture compared to P4P non-enrollees (mean HR = 0.919; 95% CI: 0.912–0.926). Stratified analysis showed that patients without DM complications (DCSI = 0) who enrolled in P4P had lower risks of hip fractures than the non-enrollees (HR = 0.90; 95% CI: 0.82–0.98).

Conclusion: T2DM patients enrolled in P4P program can reduce the risks of hip fracture incidence. Early inclusion of patients without DM complications in the P4P program can effectively reduce hip fractures.

Abbreviations: CCI = Charlson's Comorbidity Index, CI = confidence interval, DCSI = diabetes complications severity index, DM = diabetes mellitus, HR = hazards ratio, NHIRD = National Health Insurance Research Database, P4P = pay for performance, PSM = propensity score matching, T2DM = type 2 diabetes mellitus.

Keywords: diabetes mellitus, hip fracture, pay for performance, Type II diabetes mellitus

1. Introduction

According to the 2016 statistics of causes of death by the Ministry of Health and Welfare and Statistics Department, diabetes mellitus (DM) was ranked fifth in 2016.[1] From 2000 to 2009, diabetic patients in Taiwan increased by 70%, reaching 1.2 million, equivalent to an adult incidence of 6.4%.[2] Research shows that 450 out of every 100,000 people in Taiwan sustained hip fractures. Taiwan's prevalence of hip fracture follows only Denmark, Sweden, Norway, the United States, and Austria, ranked 7th worldwide, and is the highest among Asian nations.[3]

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Hip fractures often require hospitalized surgical treatment, and exhibit high rates of complications and mortality; mortality is 8.4% to 36% each year.[4]

Many studies have previously investigated the relationship between medications and hip fractures. Among these, common drugs that increase the risks of fracture include: glucocorticoids,[5,6] anticonvulsants;[7] drugs that reduce the risk of fracture include: calcium,[8] vitamin D,[9] and bisphosphonates;[10] and loop diuretics may either increase or reduce the risk of fracture.[11]

Diabetic patients exhibit relatively higher risk of hip fractures than non-diabetic patients, with a relative risk (RR) of 1.8.[12] Chinese diabetic patients in Singapore have an RR of 1.98 for hip fracture; longer durations of diagnosed DM led to higher risks of hip fracture. Compared to non-DM patients, patients diagnosed with DM for less than 5 years have an RR of 1.8, whereas those diagnosed for longer than 15 years have an RR of 2.66.[13] 1997 – 2002 National Health Insurance Research Database (NHIRD) research also showed that the incidence of hip fracture in diabetic patients was higher to those of non-diabetic patients in varying genders and ages.[14]

In November 2001, the National Health Insurance Administration of the Ministry of Health and Welfare started the diabetic pay for performance (P4P) program and introduced the concept of shared care and inclusion of administrative procedures within disease care management. The program is a method of insurance payment based on a disease management program. The program objectives are as follows:

(1) Establish a patient-centered, shared care model.
(2) Increase compliance to diabetes treatment guidelines.
(3) Construct a quality-oriented payment system.

Physicians, nurses, case managers, nutritionists, and other medical professional personnel are teamed to provide diabetic patients with regular inspections, exams, health education, and outpatient tracking. Many studies have indicated that implementing P4P increases quality and satisfaction of medical care for diabetic patients, and reduces diabetes complications.[15,16] Diabetic patients who participated in P4P programs receive more continuing care than do non-P4P enrollees.[17] In medical resource consumption, research shows that after diabetic patients join P4P programs, outpatient visits, laboratory measurement items, and test frequency increase. However, annual admission days and total medical cost are lower in P4P groups.[18]

There are presently few studies exploring whether type 2 DM (T2DM) patients' participation in pay for P4P programs has a significant influence on their incidence of hip fractures. This study investigated whether the P4P enrollment of T2DM patients had an influence on their incidence of hip fracture.

2. Materials and methods

2.1. Study design

This study adopted a retrospective cohort study methodology and focused on data from T2DM patients aged 45 and older between 2001 and 2012. We continue to track these data until 2013. The research data were retrieved from the NHIRD. All data had been fully anonymized before we accessed them and personal privacy was under protection from using these data. The study was passed by the Institutional Review Board of China Medical University (CMU). The approval number is CMUH103-REC-003.

2.2. Patient selection

In this study, diabetic patients are defined as those who have been hospitalized once within 365 days or who have at least 3 primary or secondary outpatient diagnoses of DM (International Classification of Diseases, Ninth Revision, Clinical Modification of 250.XX). This study focused solely on T2DM patients and thus did not include patients with type 1 diabetes, neonatal diabetes, gestational diabetes, or impaired oral glucose tolerance. T2DM patients who were diagnosed with T2DM for more than 1 year before participating in the P4P program, died within 3 months after diagnosed with T2DM, had hip fractures before they were diagnosed with T2DM, had hip fractures within 3 months after they had been diagnosed with T2DM, had missing data, and were under 45 years of age were excluded. The hip fracture patients in this study are defined as patients who sustained femoral neck fracture, intertrochanteric fracture, or subtrochanteric fracture and required hospitalization and surgical treatment; and whose primary or secondary International Classification of Diseases, Ninth Revision, Clinical Modification diagnoses are 820.XX. The surgical codes were hemiarthroplasty (International Classification of Diseases [ICD] 81.52), open reduction and internal fixation (ICD 79.35), and close reduction and internal fixation (ICD 79.15).

The P4P enrollees and non-enrollees exhibited numerous inherent differences in basic characteristics. To minimize selection bias, they were divided into P4P enrollees and non-enrollees. The propensity score matching (PSM) was applied by using a 1:1 matching ratio. The way to form a subject matching set was through greedy matching by digit without replacement.[19]

2.3. Study variables

In this study, the independent variable was whether or not the T2DM patients enrolled in a P4P program. The P4P enrollees were divided according to Yu et al (2014) into regular treatment patients, who received medical treatment at least once every 3 months and 4 times each year, and irregular treatment patients.[20] The controlled variables were demographics (age, gender, monthly salary, and urbanization of residence area); health status (comorbidity, severity of diabetes complications, and presence or absence of catastrophic illness); characteristics of healthcare organization (physician's annual service volume, level of healthcare organization, and ownership of organization); and medication status (steroids, anticonvulsants, diuretics, calcium, vitamin D, or bisphosphonates). The dependent variable was the hip fracture incidence of the diabetic patients and follow-up time.

Monthly salaries were used to measure the patient's socioeconomic status. The income levels are divided into 7 levels: low-income households; < NT$17,800, NT$17,281-22,800, NT $22,801-28,000, NT$28,801-36,300, NT$36,301-45,800, and >NT$45,801. The degree of urbanization of the residence areas was divided into 7 ranks: 1st rank represents the highest degree of urbanization, and 7th rank refers to the lowest degree of urban development.[21] Catastrophic illnesses/injuries consist of 30 kinds of disease or injury such as cancers, leukemia, stroke, end-stage renal disease, acquired immune deficiency syndrome (AIDS), rare diseases, coma, and so on., which were defined by the National Health Insurance Administration.

Comorbidity is measured by Deyo's Charlson Comorbidity Index (CCI), which is the CCI modified by Deyo, in which the CCI score and postoperative complications, mortality rates, and duration and cost of hospitalization are significantly correlated.[22] Therefore, Deyo's CCI is the method most commonly adopted in topics related to comorbidity.[23] CCI scores were divided into the 2 levels of 0 and ≧1. The diabetes complications severity index (DCSI) was adopted based on the 7 diabetes complications classified by Young et al: retinopathy, nephropathy, neuropathy, cerebral vascular disease, cardiovascular disease, peripheral vascular disease, and metabolic disease.[24] DCSI scores are divided into the 2 levels of 0 and ≧1.

The main medical institute is defined as the institute that the given research subject visited the greatest number of times. The patients' main medical institutes were also classified into four levels: medical centers; regional hospitals; district hospitals; and other medical clinics. Hospitals were then divided into public and non-public hospitals. Based on the annual service volume of the research subject's attending physician, a quartile method was applied to divide the service volumes into low (<25%), mid (25—75%), and high (>75%) levels for subsequent analysis.

Much of the literature has shown correlations between the use of glucocorticoids, anticonvulsants, loop diuretics, calcium, vitamin D, and bisphosphonates with hip fractures.[5–11] Therefore, medication use is defined as having used of the aforementioned medications Non-long-term use refers to less than 3 months of use of the aforementioned medications, whereas long-term use is defined as using the aforementioned drugs for 3 months or more.

2.4. Statistical analysis

When we conducted the PS matching method, the dependent variable was whether or not the T2DM patients enrolled in a P4P program. The independent variables which were used in the logistic regression model to predict the likelihood of P4P enrollment for T2DM patients included age, gender, monthly salary, comorbid condition, and severity of diabetes complications. The PSM was performed by using the greedy matching by digit without replacement to form a subject matching set with a 1:1 matching ratio. The algorithm performed the "best" match first, followed by the "next best" match in hierarchical sequence, until no more matches could be made. Best matches were those with the highest digit match on propensity score. Approximately 25% of total study population were matched in the final matched sample. We performed the PS matching method using the SAS software, version 9.4. The matching macro presented here was OneToManyMTCH.

In this study, we utilized descriptive statistics to distinguish characteristic differences between enrollees and non-enrollees and to study the distribution of the control variables. In addition to calculating the frequency and percentages, chi-squared test was used to determine any significant statistical differences ($P < .05$) for each variables. We used the log-rank test for inferential statistical analysis to test for any statistically significant difference ($P < .05$) between enrollment in P4P and each control variables and incidence of hip fractures in T2DM patients.

The Cox proportional hazards model was applied to investigate the influence of enrolling in P4P and P4P compliance as well as other factors on the risk of hip fractures after controlling for related variables (including patient characteristics, health status, characteristics of healthcare organization and medication status). Additionally, stratified analysis of DCSI was conducted to investigate whether enrolling in P4P had an influence on the incidence of hip fractures for T2DM patients with various severities of diabetes complications.

We tested the assumption of proportional hazards model. The method was plotting log (-log (survival probability)) versus log (survival time) curves. If the 2 lines are not parallel or intersect, the assumption of proportional hazards is invalid. If the assumption of proportional hazards is invalid, we would add a time variable to the model and used the extended Cox proportional hazard model for further analyses.

Finally, we used the bootstrap method to perform sensitivity analysis by random sampling with replacement. We randomly selected 10,000 patients from both P4P enrollee group and the matched P4P non-enrollee group, respectively, and repeatedly sampled 1000 times. Sensitivity analysis aimed to explore the robustness of the main findings.

In this study, all statistical analyses were performed using the SAS software, version 9.4 (SAS Institute Inc., Cary, NC). All reported P values were 2-sided, and P values less than .05 were considered statistically significant.

3. Results

3.1. Enrollment and patient characteristics

Between 2001 and 2012, 1,618,740 patients were diagnosed with type 2 diabetes (T2DM). A total of 528,060 patients were excluded, of which 210,210 were diagnosed with T2DM for more than 1 year before participating in the P4P program; 56,312 died within 3 months after diagnosed with T2DM; 17,214 patients had hip fractures before they were diagnosed with T2DM; 1019 patients had hip fractures within 3 months after they had been diagnosed with T2DM; 17,483 patients had missing data and 225,822 patients were under 45 years of age. A total of 1,090,680 patients were included in the analysis, of which 127,476 were P4P enrollees and 963,204 were P4P non-enrollees (Table 1). Males constituted a majority (comprising 52.04%); most of the patients were aged between 45 and 54 (comprising 31.06% of the total); and the majority of patients had never enrolled in P4P (comprising 88.31%). In the variates of gender, patient age, monthly salary, severity of CCI and DCSI, the characteristics of non-enrollees and enrollees exhibited significant differences ($P < .05$). Patients who were aged (≧75 years old), had low socioeconomic status (low income households), had comorbidity (CCI≧1), and had diabetes complications (DCSI≧1) enrolled less in P4P (Table 1).

Of 1,090,680 T2DM patients, 21,738 (1.99%) had hip fractures. In 963,204 non-P4P enrollees, 20,130 (2.09%) had hip fractures. Hip fractures occurred in 1608 (1.26%) of 127,476 P4P enrollees (Table 1).

The PSM was applied by using a 1:1 matching ratio. After using the greedy matching by digit without replacement method, a total of 252,266 patients were included in the analysis, of which 126,133 were P4P enrollees and 126,133 were P4P non-enrollees. The proportion of matched sample size was approximately 23.1%.

After the matching process, the 2 groups of patients exhibited no significant difference ($P > .05$) in the variates for gender, age, monthly salary, CCI, and DCSI (Table 1).

Table 1

Summary of study population before and after propensity score matching.

	Before Matching							After Matching						
	Total Population (1,090,680)		Non-P4P (963,204)		P4P (127,476)			Total Population (252,266)		Non-P4P (126,133)		P4P (126,133)		
Category	N	%	N	%	N	%	*P* value	N	%	N	%	N	%	*P* value
Patient Characteristics														
Gender							<.001							.861
Female	523,057	47.96	461,062	47.87	61,995	48.63		122,629	48.61	61,292	48.59	61,337	48.63	
Male	567,623	52.04	502,142	52.13	65,481	51.37		129,637	51.39	64,841	51.41	64,796	51.37	
Age, yr	62.33±11.04		62.72±11.17		59.38±9.51		<.001	59.53±9.67		59.61±9.76		59.44±9.57		<.001
							<.001							.961
45–54	338,781	31.06	289,422	30.05	49,359	38.72		97,548	38.67	48,724	38.63	48,824	38.71	
55–64	333,028	30.53	289,477	30.05	43,551	34.16		86,219	34.18	43,103	34.17	43,116	34.18	
65–74	249,725	22.90	224,753	23.33	24,972	19.59		49,395	19.58	24,734	19.61	24,661	19.55	
≥75	169,146	15.51	159,552	16.56	9,594	7.53		19,104	7.57	9,572	7.59	9,532	7.56	
Monthly salary (NTD)							<.001							.253
Low-income	5,501	0.50	5,042	0.52	459	0.36		841	0.33	382	0.30	459	0.36	
≤17280	162,062	14.86	142,092	14.75	19,970	15.67		39,687	15.73	19,858	15.74	19,829	15.72	
17281–22080	418,299	38.35	371,346	38.55	46,953	36.83		93,003	36.87	46,603	36.95	46,400	36.79	
22081–28800	157,035	14.40	140,547	14.59	16,488	12.93		32,613	12.93	16,299	12.92	16,314	12.93	
28801–36300	99,400	9.11	87,045	9.04	12,355	9.69		24,334	9.65	12,132	9.62	12,202	9.67	
36301–45800	128,111	11.75	110,677	11.49	17,434	13.68		34,475	13.67	17,217	13.65	17,258	13.68	
≥45801	120,272	11.03	106,455	11.05	13,817	10.84		27,313	10.83	13,642	10.82	13,671	10.84	
Health Status														
CCI							<.001							.847
0	632,957	58.03	545,775	56.66	87,182	68.39		172,622	68.43	86,334	68.45	86,288	68.41	
≥1	457,723	41.97	417,429	43.34	40,294	31.61		79,644	31.57	39,799	31.55	39,845	31.59	
DCSI							<.001							.402
0	803,445	73.66	701,791	72.86	101,654	79.74		201,444	79.85	100,807	79.92	100,637	79.79	
≥1	287,235	26.34	261,413	27.14	25,822	20.26		50,822	20.15	25,326	20.08	25,496	20.21	
Hip fracture							<.001							.733
No	1,068,942	98.01	943,074	97.91	125,868	98.74		249,124	98.75	124,552	98.75	124,572	98.76	
Yes	21,738	1.99	20,130	2.09	1,608	1.26		3,142	1.25	1,581	1.25	1,561	1.24	

CCI = Charlson's comorbidity index, DCSI = diabetes complications severity index, NTD = new Taiwan dollars, P4P = pay for performance enrollees.

3.2. Risk Analysis for incidence of hip fracture in T2DM patients

Gender, patient age, monthly salary, degree of urbanization of residence areas, catastrophic illness, CCI, DCSI, medication use (steroids, anticonvulsants, diuretics, calcium, and bisphosphonates), and level of main medical institute were statistically significant ($P < .05$) by bivariate analysis. No significant statistical differences were found between P4P enrollment and hip fractures ($P = .160$). However, there was a statistically significant difference in the incidence of hip fractures between P4P non-enrollees, P4P enrollees receiving irregular treatments, and P4P enrollees who received regular treatments (Table 2).

After controlling for other variables, analysis using the Cox proportional hazards model showed that P4P enrollees exhibited lower risks of hip fractures than non-enrollees. The risk of hip fractures for P4P enrollees was 0.92 times that of P4P non-enrollees, with statistically significant differences (hazards ratio [HR] = 0.92; 95% confidence interval [CI]: 0.85–0.99). However, there were no statistically significant difference in the effect of hip fractures between P4P non-enrollees and P4P enrollees who received irregular treatment (HR = 0.94, 95%CI: 0.87–1.03). Using the extended Cox proportional hazard model, P4P enrollees who received regular treatment had lower risk of hip fracture than that of P4P non- enrollees in the first 4 years (HR = 0.90; 95%CI: 0.84–0.96), but there was no statistical difference between these 2 groups after 4-year enrollment (HR = 0.99; 95%CI: 0.93–1.06) (Table 3).

In the Cox proportional hazards model, female patients, higher age groups, low income households, presence of catastrophic illness, and patients with diabetes complications (DCSI ≧1) exhibited relatively higher risks of hip fracture ($P < .05$). Female patients exhibited a risk of hip fracture 1.50 times that of male patients (HR = 1.50; 95% CI: 1.39–1.62). In terms of age, every 10-year increment beyond the reference group of 45 to 54-year-old patients showed increased risks of hip fractures. When patient age exceeds 75, the risk of hip fracture is 21.29 times that of the 45 to 54 year-old patient group (HR = 21.29; 95% CI: 18.60–24.37). Patients with catastrophic illness exhibited risks of hip fractures 1.27 times that of those without catastrophic illness (HR = 1.27; 95% CI: 1.10–1.46). As for DCSI, the risk of hip fractures for patients with diabetes complications (DCSI ≧ 1) was 1.22 times that of those without diabetes complications (HR = 1.22; 95% CI: 1.13–1.32). The risk of hip fractures for patients on long-term diuretic use was 0.90 times that of those on non-long-term diuretic use (HR = 0. 90; 95% CI: 0.82–0.98) (Table 3).

3.3. Influence of P4P Enrollment on the risks of hip fractures for diabetic patients with varying DCSIs

To further investigate the influence of enrollment on the risk of hip fractures for T2DM patients with varying DCSIs, the subjects

Table 2

Bivariate analyses: relationships between hip fracture and relevant variables in type 2 diabetic patients.

	Total Population (N = 252,266)		No Hip Fracture (N = 249,124)		Hip Fracture (N = 3,142)		
	N	%	N	%	N	%	*P*- value (Log-rank)
P4P participation							.160
No	126,133	50.00	124,552	98.75	1,581	1.25	
Yes	126,133	50.00	124,572	98.76	1,561	1.24	
Compliance							<.001
Non-P4P	126,133	50.00	124,552	98.75	1,581	1.25	
P4P but irregular treatment	59,395	23.54	58,492	98.48	903	1.52	
P4P and gular treatment	66,738	26.46	66,080	99.01	658	0.99	
Patient Characteristics							
Gender							<.001
Male	122,629	48.61	120,688	98.42	1,941	1.58	
Female	129,637	51.39	128,436	99.07	1,201	0.93	
Age (years)							<.001
45–54	97,548	38.67	97,250	99.69	298	0.31	
55–64	86,219	34.18	85,564	99.24	655	0.76	
65–74	49,395	19.58	48,206	97.59	1,189	2.41	
≥75	19,104	7.57	18,104	94.77	1,000	5.23	
Monthly salary (NTD)							<.001
Low-income	972	0.67	953	98.05	19	1.95	
≤17280	5,258	3.65	5,223	99.33	35	0.67	
17281–22080	47,955	33.3	47,440	98.93	515	1.07	
22081–28800	41,144	28.57	40,761	99.07	383	0.93	
28801–36300	14,970	10.39	14,887	99.45	83	0.55	
36301–45800	18,148	12.6	18,068	99.56	80	0.44	
≥45801	15,581	10.82	15,473	99.31	108	0.69	
Level of urbanization							<.001
1	39,331	27.31	39,082	99.37	249	0.63	
2	45,410	31.53	45,047	99.2	363	0.8	
3	20,755	14.41	20,572	99.12	183	0.88	
4	23,890	16.59	23,612	98.84	278	1.16	
5	3,014	2.09	2,985	99.04	29	0.96	
6	6,114	4.25	6,046	98.89	68	1.11	
7	5,514	3.83	5,461	99.04	53	0.96	
Health status							
Catastrophic illnesses							<.001
No	237,415	94.11	234,502	98.77	2,913	1.23	
Yes	14,851	5.89	14,622	98.46	229	1.54	
CCI							<.001
0	172,622	68.43	170,859	98.98	1,763	1.02	
≥1	79,644	31.57	78,265	98.27	1,379	1.73	
DCSI							<.001
0	201,444	79.85	199,257	98.91	2,187	1.09	
≥1	50,822	20.15	49,867	98.12	955	1.88	
Medication Use							
Steroids							<.001
Non-chronic use	247,500	98.11	244,441	98.76	3,059	1.24	
Chronic use	4,766	1.89	4,683	98.26	83	1.74	
Anti-epileptics							<.001
Non-chronic use	235,404	93.32	232,564	98.79	2,840	1.21	
Chronic use	16,862	6.68	16,560	98.21	302	1.79	
Diuretics							<.001
Non-chronic use	211,942	84.02	209,443	98.82	2,499	1.18	
Chronic use	40,324	15.98	39,681	98.41	643	1.59	
Calcium							<.001
Non-chronic use	237,653	94.21	234,859	98.82	2,794	1.18	
Chronic use	14,613	5.79	14,265	97.62	348	2.38	
Vitamin D							.164
Non-chronic use	251,236	99.59	248,115	98.76	3,121	1.24	
Chronic use	1,030	0.41	1,009	97.96	21	2.04	
Bisphosphonate							<.001
Non-chronic use	249,043	98.72	246,022	98.79	3,021	1.21	
Chronic use	3,223	1.28	3,102	96.25	121	3.75	
Primary physician service volume							.137
Low	2,329	0.92	2,306	99.01	23	0.99	
Moderate	38,614	15.31	38,108	98.69	506	1.31	
High	211,323	83.77	208,710	98.76	2,613	1.24	
Level of health care organization							<.001
Medical center	47,457	18.81	46,898	98.82	559	1.18	
Regional	74,624	29.58	73,609	98.64	1,015	1.36	
District	43,624	17.29	42,937	98.43	687	1.57	
Other clinic	86,561	34.31	85,680	98.98	881	1.02	
Ownership of organization							.007
Public	59,207	23.47	58,391	98.62	816	1.38	
Nonpublic	193,059	76.53	190,733	98.80	2,326	1.20	

CCI = Charlson's comorbidity index, DCSI = diabetes complications severity index, NTD = new Taiwan dollar, P4P = pay for performance enrollees.

Table 3

Factors associated with hip fracture risk in type 2 diabetic patients, including P4P participation status and other variables.

	Adjusted Cox model (Non P4P vs P4P)				Adjusted Cox model (Non P4P vs Irregular P4P)				Adjusted Cox model (Non P4P vs Regular P4P)			
	HR	95%CI		*P*-Value	HR	95%CI		P-Value	HR	95%CI		P-Value
P4P participation												
No(ref.)												
Yes	0.92	0.85	0.99	.019								
Compliance												
Non-P4P(ref.)												
P4P but irregular treatment					0.94	0.87	1.03	0.180				
Compliance												
Non-P4P(ref.)												
P4P with regular treatment												
≤4 year									0.90	0.84	0.96	0.002
>4 year									0.99	0.93	1.06	0.727
Patient Characteristics												
Gender												
Male(ref.)												
Female	1.50	1.39	1.62	<.001	1.45	1.33	1.57	<.001	1.48	1.35	1.62	<.001
Age, yr												
45∼54(ref.)												
55∼64	2.59	2.26	2.97	<.001	2.56	2.19	2.99	<.001	2.67	2.28	3.14	<.001
65∼74	7.58	6.66	8.62	<.001	7.55	6.52	8.73	<.001	7.97	6.84	9.28	<.001
≥75	21.29	18.60	24.37	<.001	20.43	17.53	23.81	<.001	22.87	19.49	26.85	<.001
Monthly salary (NTD)												
Low-income(ref.)												
≤17280	0.57	0.36	0.90	.015	0.72	0.41	1.29	0.272	0.54	0.32	0.91	.020
17281∼22080	0.66	0.43	1.03	.067	0.88	0.50	1.56	0.669	0.58	0.35	0.96	.035
22081∼28800	0.59	0.38	0.93	.021	0.77	0.43	1.36	0.363	0.53	0.31	0.89	.016
28801∼36300	0.52	0.33	0.82	.005	0.71	0.40	1.28	0.258	0.39	0.23	0.67	.001
36301∼45800	0.42	0.26	0.66	<.001	0.56	0.31	1.00	0.050	0.37	0.21	0.62	<.001
≥45801	0.44	0.28	0.69	<.001	0.57	0.32	1.01	0.056	0.38	0.22	0.64	<.001
Level of urbanization												
1(ref.)												
2	1.18	1.05	1.33	.007	1.21	1.05	1.38	0.007	1.21	1.05	1.39	.009
3	1.29	1.11	1.49	.001	1.39	1.18	1.64	<.001	1.29	1.09	1.54	.004
4	1.12	1.01	1.25	.041	1.16	1.02	1.31	0.020	1.13	0.99	1.28	.069
5	1.18	0.93	1.50	.164	1.15	0.88	1.51	0.293	1.25	0.93	1.66	.137
6	1.29	1.09	1.52	.004	1.34	1.11	1.62	0.002	1.33	1.08	1.62	.006
7	1.12	0.92	1.38	.261	1.15	0.91	1.45	0.232	1.12	0.88	1.42	.377
Health status												
Catastrophic illnesses												
No(ref.)												
Yes	1.27	1.10	1.46	.001	1.29	1.10	1.50	0.002	1.29	1.09	1.53	.003
CCI												
0(ref.)												
≧1	1.08	1.00	1.16	.050	1.08	1.00	1.18	0.065	1.09	1.00	1.20	.049
DCSI												
0(ref.)												
≧1	1.22	1.13	1.32	<.001	1.23	1.13	1.35	<.001	1.17	1.07	1.29	.001
Medication Use												
Steroids												
Non-chronic use(ref.)												
Chronic use	1.11	0.89	1.38	.356	1.23	0.98	1.55	0.072	0.97	0.74	1.28	.845
Anti-epileptics												
Non-chronic use(ref.)												
Chronic use	1.06	0.94	1.19	.349	1.00	0.88	1.15	0.965	1.12	0.97	1.29	.127
Diuretics												
Non-chronic use(ref.)												
Chronic use	0.90	0.82	0.98	.014	0.89	0.81	0.98	0.022	0.94	0.85	1.04	.231
Calcium												
Non-chronic use(ref.)												
Chronic use	1.01	0.90	1.13	.931	1.02	0.90	1.16	0.723	0.97	0.84	1.11	.646
Vitamin D												
Non-chronic use(ref.)												
Chronic use	0.90	0.59	1.39	.637	0.88	0.55	1.40	0.593	0.60	0.31	1.16	.132
Bisphosphonate												
Non-chronic use(ref.)												
Chronic use	1.02	0.85	1.23	.820	0.98	0.79	1.20	0.819	1.01	0.81	1.26	.953
Primary physician service volume												
Low(ref.)												
Moderate	1.12	0.74	1.70	.607	1.04	0.69	1.58	0.850	1.08	0.68	1.71	.753
High	1.00	0.66	1.50	.980	0.92	0.61	1.39	0.694	0.97	0.61	1.52	.879
Level of health care organization												
Medical center(ref.)												
Regional	1.14	1.03	1.26	.015	1.16	1.03	1.30	0.015	1.14	1.01	1.28	.040
District	1.14	1.02	1.27	.026	1.15	1.01	1.30	0.035	1.10	0.96	1.26	.167
Other clinic	0.85	0.77	0.95	.004	0.85	0.76	0.96	0.010	0.81	0.71	0.92	.001
Ownership of organization												
Public(ref.)												
Nonpublic	1.01	0.93	1.10	.753	1.00	0.91	1.10	0.980	1.06	0.96	1.17	.256

CCI = Charlson's comorbidity index, CI = confidence interval, DCSI = diabetes complications severity index, HR = hazards ratio, NTD = new Taiwan dollar, P4P = pay for performance.

Table 4

Stratified analyses: influence of P4P participation status on the risk of hip fracture for type 2 diabetic patients with varying DCSI.

		Non-P4P vs P4P		Non-P4P vs P4P regular treatment ≤4 yr		Non-P4P vs P4P regular treatment >4 yr	
	Non-P4P (reference)	HR(95% CI)	*P* - value	HR(95% CI)	*P*- value	HR(95% CI)	*P* -value
DCSI							
0	1	0.90 (0.82∼0.98)	.013				
≥1	1	0.96 (0.84∼1.10)	.551				
DCSI							
0	1			0.90 (0.83∼0.97)	.008	0.98 (0.91∼1.06)	.623
≥1	1			0.97 (0.80∼1.03)	.118	1.00 (0.88∼1.14)	.971

CI = confidence interval, DCSI = diabetes complication severity index, P4P = pay for performance, All Cox proportional hazard models have been controlled for other relevant variables.

in this study were divided into 2 groups: those without complications of DM (DCSI of 0), and those with complications of DM (DCSI ≧1). Stratified analysis showed that patients without DM complications (DCSI = 0) who enrolled in P4P had lower risks of hip fractures than P4P non-enrollees (HR = 0.90; 95%CI: 0.82–0.98). P4P enrollees with a DCSI of 0 who received regular treatment showed a lower risk of hip fracture in the first 4 years (HR = 0.90; 95% CI: 0.83–0.97), but there was no statistical difference after enrollment more than 4 years (HR = 0.98; 95%CI: 0.91–1.06) compared to those P4P non-enrollees (Table 4).

4. Discussion

Our study showed that P4P enrollees had lower risk of hip fractures than non- enrollees (HR = 0.92; 95% CI: 0.85–0.99). Although patients enrolled in P4P who received irregular treatment exhibited relatively low risks of hip fractures, but no significant statistical difference was found (HR = 0.94; $P = .180$). Frequency of outpatient visits and laboratory measurement items increased in P4P enrollees.[18] Regardless of short-term (<1 year) or long-term (>3 year), P4P enrollment improved glycemic control.[25,26] Moreover, patients who received regular treatment may receive increased medical consulting and health education, more thorough testing and exams, and regular drug therapy. Therefore, those with regular treatment can achieve stricter glycemic control.[20] Oie et al found that inadequate glycemic control increased the risk of hip fractures.[27] The aforementioned literature may explain why the P4P enrollees with irregular treatment do not significantly reduce the risk of hip fracture.

The hip fracture patients are defined as patients with hip fractures who require hospitalization and surgical treatment. The orthopaedic surgeons always did the procedure as an urgent operation. The date of surgery can be retrieved from NHIRD. It means that the NHIRD contained information about when the hip fracture occurred. We hypothesized that the Cox proportional hazards model was time independent. We tested the assumption of proportional hazards model. The results showed that the effect of hip fracture between P4P non-enrollees and enrollees were independent of time ($P = .053$). The effects of hip fracture between P4P non-enrollees and enrollees receiving irregular treatment were also time independent ($P = .706$). However the effects of hip fracture occurrence between P4P non-enrollees and enrollees who received regular treatment were time dependent ($P = .003$). Therefore, the participation time was divided into ≤4 years and >4 years to assess the risk of hip fracture between P4P non-enrollees and enrollees receiving regular treatment.

P4P enrollees who received regular treatment had lower risk of hip fracture than that of P4P non-enrollees in the first 4 years (HR = 0.90; 95%CI: 0.84–0.96), but there was no statistical difference between these 2 groups after 4-year enrollment (HR = 0.99; 95%CI: 0.93–1.06). A possible explanation is that after enrollment more than 4 years, the aging effect that may worsen bone quality through progressive osteoporosis is more pronounced than P4P protection.

We further used the bootstrap method to perform sensitivity analysis to explore the robustness of the main findings. The results also showed P4P enrollees had a lower risk of hip fracture than non-enrollees (mean HR = 0.93; 95%CI: 0.91–0.96).

In regard to medication status, long-term loop diuretic administration reduced the risks of hip fractures. Schoofs et al (2003) also published similar findings, indicating that the long-term use of thiazide loop diuretics reduced the risks of hip fractures.[11] The literature has shown that glucocorticoids and anticonvulsants increase the risks of fracture;[5–7] however, calcium, Vitamin D, and bisphosphonates reduce the risks of fractures.[8–10] Use of glucocorticoids, anticonvulsants, calcium, vitamin D, and bisphosphonates exerted no significant influence on the risk of hip fracture in this study.

This study showed that the risks of hip fractures in low income households were higher than those with higher levels of monthly salary. Moreover, relatively few patients with low socioeconomic status enrolled in P4P ($P < .05$). This may be related to inequality of care and increased incidence of diabetes associated with poverty,[28] physicians' intentional or unintentional lack of attention in medical care,[29] and difficulties for patients with low socioeconomic status in establishing adequate relationships and communication with physicians.[30] It also showed that comparatively fewer elderly (≧75) patients and patients with suboptimal health conditions (presence of catastrophic illness or complications of diabetes) enrolled in P4P ($P < .05$). It can be due to selective bias in which the physician tends to select and treat younger and healthier patients in order to aid the physician in acquiring better P4P program outcomes and grants.[31,32]

The literature has previously investigated the relationships between DCSI and mortality, hospitalization, and healthcare utilization. These have shown that higher DCSI scores also result in higher mortality, hospitalization, and healthcare utilization. However, there was no literature to investigate the relationship between DCSI and the incidence of hip fractures. Our study showed that the risk of hip fractures for patients with diabetes complications (DCSI ≧1) was 1.22 times that of those without diabetes complications (DCSI = 0). Stratified analysis showed that patients without diabetes complications who enrolled in P4P reduced the risk of hip fractures by 10% over that of non-P4P

participants. There was no statistically significant difference in the risk of hip fracture between the non-P4P and P4P groups when the patient was diagnosed with diabetic complications (DCSI ≥1). A possible explanation is that patients without complications from T2DM had comparatively better glycemic control. Moreover, after enrolling in P4P and receiving regular medical intervention, such patients were able to further improve their glycemic control. Good glycemic control can reduce the risk of hip fractures. This logically explains how enrollment in P4P and regular treatment has optimal outcomes in hip fracture risk reduction for T2DM patients who have had no complications from DM.

We found that the enrollees accounted for a mere 11.7% of all diabetic patients, in which only 52.9% of P4P enrollees received regular medical attention. It shows that P4P enrollment still has room for improvement. Even after P4P enrollment, more effort is needed in answering the question of how to improve compliance with DM treatment guidelines, in order to establish a regular treatment model. Other concerns remain within P4P. Although National Health Insurance provides universal medical treatment, patients with higher ages, multiple complications, and high severities of diabetes are excluded from P4P. Reasons include communication difficulties with medical and nursing staff due to visual and hearing impairments; low socioeconomic status; low education levels; and mobility problems in seeking medical attention.[31,32] This study also showed similar findings in which patients of higher age groups (≧75), low income households, and suboptimal health conditions are enrolled in P4P at lower rates. However, these patients also exhibit relatively higher risks of hip fractures. These deficiencies significantly compromise P4P performance. Therefore, these patients should be the focus of our future efforts.

5. Limitations

The data in this study was retrieved from a secondary database. Therefore, the influence of patients' lifestyles (including diet), health behaviors (including smoking, alcohol abuse, and regular exercise), biochemical parameters (sugar, HbA1C), body mass index (presence or absence of obesity), and bone density (presence or absence of osteoporosis) were unable to be determined and thus could not be included in this study. The literature showed that considering the matching nature of the sample, the standard error can be estimated more accurately than when the matching nature is not considered.[33] We did not account for the matched nature of the propensity-score matched sample when estimating the significance of the treatment effect. This is another limitation of our study.

6. Conclusion

This study indicated that patients with higher ages, low income households, and DCSIs ≧1 exhibited significantly higher risks of hip fracture. T2DM patients enrolled in P4P can reduce the risks of hip fracture incidence. Stratified analysis showed that patients without DM complications who participated in P4P demonstrated significantly lower risks of hip fracture. Therefore, we recommend removing obstacles for disadvantaged patients (those in poverty, the aged, and those with severe diabetes conditions) to enroll in P4P programs. In addition, early participation in the P4P program in patients without DM complications can effectively reduce the risk of hip fracture. Finally, we recommend that future researchers can include relevant test data such as glycated hemoglobin (HbA1c) and bone density (DXA) to verify the effectiveness of P4P in reducing the incidence of hip fracture.

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