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Pay-for-performance programmes reduce stroke risks in patients with type 2 diabetes: a national cohort study

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ABSTRACT

Objectives A pay-for-performance (P4P) programme is a management strategy that encourages healthcare providers to deliver high quality of care. In Taiwan, the P4P programme has been implemented for diabetes, and certified diabetes physicians voluntarily enrol patients with diabetes into the P4P programme. The objectives of this study were to compare the risk of stroke and its related factors in patients with type 2 diabetes who were enrolled in a P4P programme compared with those who were not.

Study design This study is a natural experiment in Taiwan. A retrospective cohort investigation was conducted from 2002 to 2013, which included 459 726 patients with type 2 diabetes, who were grouped according to P4P enrolment status following a propensity score matching process.

Methods We reviewed patients ≥45 years of age newly diagnosed with type 2 diabetes mellitus (DM) from the National Health Insurance Research Database in Taiwan. A Cox proportional hazards model was used to compare the relative risk of stroke between patients with type 2 DM enrolled in the P4P programme and those who were not enrolled.

Results Compared with the patients not enrolled, there was a significantly lower stroke risk in P4P participants (HR=0.97, 95% CI 0.95 to 0.99). Although a significantly lower risk of haemorrhagic stroke was observed (HR=0.87, 95% CI 0.82 to 0.93) in P4P participants, no statistically significant difference for the risk of ischaemic stroke between P4P and non-P4P patients (HR=0.99, 95% CI 0.97 to 1.02) was found. Following stratification analysis, a significantly reduced stroke risk was observed in male patients with type 2 diabetes, but not in women.

Conclusions Participants in Taiwan's Diabetes P4P programme displayed a significantly reduced stroke risk, especially haemorrhagic stroke. We recommend the continual promotion of this programme to the general public and to physicians.

INTRODUCTION

In 2017, approximately 425 million people worldwide between 20 and 79 years of age were diabetic, and this figure is expected to increase to 629 million by 2045.[1] Type 2 diabetes accounts for more than 90% of the present cases globally.[2] The longer the duration of this disease, the more likely that macrovascular (atherosclerotic changes) and small vessel disorders (retinopathy, nephropathy and neuropathy) will develop, leading to blindness, kidney failure and amputation, while also contributing to death by heart attack and severe stroke.[2] Compared with non-diabetic patients, diabetes mellitus (DM) is an independent factor that causes the risk of a stroke to at least double.[3] Fortunately, it is possible to prevent or delay the occurrence of diabetic complications through intensive treatment and care. A 9-year follow-up study revealed that type 2 diabetes, when under intensive blood pressure control, reduced the composite of cardiovascular death, non-fatal myocardial infarction and non-fatal stroke by 25%.[4] A reduction in glycosylated haemoglobin (HbA1c) and systolic blood pressure below guideline target levels was associated with a lower risk of stroke.[5] More generally, risk factors for stroke are divided into those that are modifiable and non-modifiable. The former include hypertension, DM, cardiac causes, waist-to-hip ratio, current smoking, dyslipidaemia, alcohol consumption, physical inactivity, diet, and other.[6] The non-modifiable risk factors include age, sex, ethnicity and genetics.[6]

The Taiwanese healthcare system is a government-administered single-payer health insurance programme.[7] Its characteristics

include comprehensive coverage, high accessibility, quick service and relatively low expenditure.[7] Taiwan's National Health Insurance (NHI) launched the pay-for-performance (P4P) programme in November 2001 to incentivise healthcare institutions to actively participate and to establish quality control indicators, including new patient acceptance rates, complete patient follow-up, poor control of HbA1c, good control of HbA1c and poor control of low-density lipoprotein (LDL).[8] A P4P arrangement is a management strategy that encourages healthcare providers to deliver high-quality care services and a high continuity of care.[9] In the P4P programme, physicians, nurses, pharmacists, nutritionists and case managers were required to form teams and co-care for patients with diabetes, using clearly established clinical guidelines,[10] which were largely based on the clinical practice guidelines of the American Diabetes Association.[11] In 2009, 27.56% of Taiwan's patients with diabetes had been voluntarily enrolled into the P4P programme by certified diabetes physicians or endocrinologists.[8 12] Patients in the P4P programme are followed by the same doctor who enrolled them. Patients who do not participate in the P4P received conventional treatment by physicians, who may or may not be certified diabetes specialists or endocrinologists.[12]

Beyond general care, participants in the DM P4P programme receive additional comprehensive services, including the taking of a full history, a physical examination, laboratory checks, the development of a management plan and diabetes self-management education. For this programme, there is a bonus examination payment to physicians and also a case management payment, both of which are paid by the NHI.[8] For Taiwan's Diabetes P4P programme, the amount of bonus payment is calculated using a point system, where the case management fee includes 400 points for the initial visit of any patient, 200 points for each follow-up visit (every 3 months) and 800 points for performing an annual assessment.[8] In this context, we note that 1 point is worth about 1 New Taiwan dollar (NT$), and in 2019, US$1 was worth NT$31. To encourage physicians to improve the quality of medical care they provide, Taiwan's NHI offers financial incentives for higher levels of performance in the Diabetes P4P programme, based on four quality indicators, which are the rate of complete follow-ups, the positive HbA1c control rate (HbA1c <7.0%), the negative HbA1 control rate (HbA1c >9.5%) and the negative LDL rate (LDL >130 mg/dL).[13–15] On the basis of these performance indicators, the extra payment for being in the top 25th percentile in quality metrics was combined for all four quality metrics (ie, the maximum extra points per patient is 1000).[13–15] Hospitals in the Taiwan healthcare industry are a closed system, and the incentive payments were given directly to healthcare organisations rather than to physicians. The distribution of bonuses to physicians in the P4P programme is based on the policy of each healthcare organisation.

A literature review of P4P programmes regarding patients with diabetes revealed that most focused on the quality of care, medical use and complication improvements.[12 13 16 17] One aspect of several earlier studies addressing this area has explored the association between P4P programmes and macrovascular complications (cardiovascular disease (CVD), stroke and peripheral vascular disease (PVD)) in patients with diabetes, but their research methods did not clarify whether the patients were hospitalised.[11] We think that patients suffering from the consequences of stroke should be hospitalised for treatment.

To date, very few studies have addressed the effect of P4P programmes on stroke risk in patients with type 2 diabetes, and none have explored the relationship between P4P programmes and risks by subtype of stroke (ischaemic and haemorrhagic) in patients with diabetes. Therefore, we used a national database to explore whether the P4P programme had positive effects on reducing the incidence of stroke (including ischaemic stroke and haemorrhagic stroke) in patients with diabetes and to determine the factors associated with incidence of stroke in patients with type 2 diabetes.

METHODS
Data sources and participants
This was a retrospective cohort study, in which we collected nationwide data on patients with type 2 diabetes who were enrolled in the P4P programme and others who were not, during the period 2002–2012, and we followed them until the end of 2013 to investigate the risk of stroke between these two groups. We obtained the secondary data from Taiwan's NHI Research Database. The study participants were ≥45 years old and were newly diagnosed with type 2 DM, defined as having a primary diagnosis or subdiagnosis of DM (International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) 250, A code: A181) in one hospitalisation or ≥3 outpatient visits within 365 days. We excluded patients who were not newly diagnosed with type 2 diabetes based on the 2 years, 2000 and 2001, as washout period. Those with neonatal or gestational diabetes, glucose intolerance and type 1 diabetes as per the relevant ICD-9-CM codes[18 19] were excluded. The definition of P4P programme enrolment was based on the treatment code 'E4' for patients with DM being specified in medical records after they had been diagnosed with diabetes (n=229 863). An E4 was coded for any patient with diabetes being enrolled in the Diabetes P4P programme by Taiwan's NHI Administration. Patients with diabetes and a history of stroke were excluded. We estimated the propensity score of each patient with type 2 diabetes for inclusion in the P4P programme to perform a propensity score matching (PSM) aimed at reducing the possible selection bias of patients with and without P4P enrolment. A total of 459 726 participants were matched in a 1:1 ratio between patients with diabetes who participated in the P4P programme and those with diabetes who did not participate in it.

Patient and public involvement

No patients were actively involved in this study, as it was based on the NHI Research Database, published by the Ministry of Health and Welfare, Taiwan.

Variable descriptions

The dependent variable was the occurrence of stroke in patients with type 2 diabetes. The key independent variable was whether or not the patients were enrolled in the P4P programme. Other control variables included characteristics of the patients (gender and age), their economic status (monthly salary, divided into six levels), environmental factors (residential area: level 1, highest degree of urbanisation; level 7, lowest degree of urbanisation[20]), health status (severity of Charlson Comorbidity Index (CCI) based on 17 comorbidity categories and severity of diabetic complications), characteristics of their primary medical institute (type of healthcare organisation: medical centre, regional hospital, district hospital, or clinic; ownership of organisation: public or private) and the characteristics of the primary treating physicians (an endocrinologist or not; the annual proportion of patients with diabetes of the primary physician: low, ≤25%; medium, 25%–75%; high, ≥75%). In addition, since Taiwan's NHI Program provides a free adult health check once every 3 years for people ≥40 years of age and once every year for those ≥65,[21] we used as a relevant variable whether patients had an adult health check before matching. Also, the duration of diabetes was divided into four levels (<3, 3–6, 6–9 and ≥9 years).

We defined a stroke as the first primary diagnosis of stroke (ICD-9-CM 430.XX–438.XX) at admission during the study period. Haemorrhagic stroke and ischaemic stroke were defined as the leading causes of hospitalisation for stroke (ICD-9-CM 430.XX–432.XX and ICD-9-CM 433.XX–435.XX, respectively) during the study period. A patient's CCI was based on the relevant primary and secondary ICD-9-CM diagnostic codes in the previous 1-year medical record, which included hospitalisations, as well as emergency department and outpatient visits, which were all converted into a weighted numerical score according to comorbidity severity. The weighted scores were summed to calculate the CCI,[22] which we then scored as 0, 1 or ≥2 for this study. The Diabetes Complications Severity Index (DCSI) scores were classified as stroke, peripheral neuropathy, retinopathy, endocrine complications, nephropathy, PVD and CVD, according to the research of Young et al,[23] and then converted into weighted numerical scores (0, 1 or ≥2) based on the patient's ICD-9-CM primary and secondary diagnostic codes. The numerical scores were then summed to calculate the severity of diabetic complications.[23] The 'primary medical institution' was defined as the one most frequented by the patient for diabetes treatment. The institution with the most recent treatment date was named the primary medical institution in cases having the same number of visits to different medical institutions. The physician with the highest number of visits was defined as the primary care provider.

Main outcome measurements

The primary outcome metric was the relative incidence risk of stroke between patients with type 2 diabetes who were enrolled in the P4P programme compared with those who were not. We likewise examined the risk of haemorrhagic stroke and the risk of ischaemic stroke in patients enrolled in the P4P programme compared with those who were not enrolled.

Statistical analysis

This study used SAS V.9.4 statistical software (SAS Institute) for descriptive and inferential statistics. To reduce the selection bias of patients with and without P4P enrolment, their characteristics, economic status, environmental factors, health status, nature of the primary medical institution, type of primary physician, use of an adult health check and the duration of diabetes were paired using PSM at a 1:1 ratio.

First, descriptive statistics analysed the characteristics of the patients and their P4P programme participation. The differences were presented as an average and as a percentage. Then, the log-rank test was used for inferential statistical analysis to determine whether there was a significant difference ($p<0.05$) in the incidence of stroke between patients with type 2 diabetes who were enrolled in the P4P programme compared with those who were not and control variables. Finally, Cox proportional hazards model explored the relative risk of stroke in patients with type 2 diabetes enrolled in the P4P programme, compared with those not enrolled.

The incidence of stroke was viewed as an 'event', and others were marked as 'censored' in the analyses. We further conducted a stratification analysis to examine the effect of P4P enrolment on the risk of stroke for related variables in patients with type 2 diabetes.

RESULTS

Descriptive statistics of patients with type 2 diabetes enrolled or not enrolled in the P4P programme

Following PSM, there were no significant statistical differences observed between the two groups (enrolled vs not enrolled in the P4P programme) (table 1). After matching, the study population consisted of 459 726 patients with newly diagnosed type 2 diabetes from 2002 to 2013 (50.01% female and 49.99% male). The largest patient group was those 55–64 years old (34.87%), with the numbers then decreasing with age. A monthly salary between US$557 and US$712 (in 2019, NT$31=US$1) was the most commonly earned by the participants (44.46%). A CCI=0 and a DCSI=0 were observed in most patients (63.16% and 79.21%, respectively). Regional hospitals were the most frequently visited (33.56%), and 76.56% of the visited medical institutions were privately owned. Non-endocrinologists accounted for 83.11% of

Table 1 Comparisons of study participants after propensity score matching for P4P participating status

| | 1:1 matched | | | | | | |
| | Total | | Non-P4P | | P4P | | |
	n	%	n_1	%	n_2	%	P value*
Total	459 726	100.00	229 863	50.00	229 863	50.00	
Gender							0.953
Female	229 913	50.01	114 967	50.02	114 946	50.01	
Male	229 813	49.99	114 896	49.98	114 917	49.99	
Age							0.997
45–54	139 411	30.32	69 704	30.32	69 707	30.33	
55–64	160 294	34.87	80 165	34.88	80 129	34.86	
65–74	108 797	23.67	54 369	23.65	54 428	23.68	
≥75	51 224	11.14	25 625	11.15	25 599	11.14	
Monthly salary (US$)							0.435
≤557	24 032	5.23	12 033	5.23	11 999	5.22	
557–735	204 412	44.46	102 053	44.40	102 359	44.53	
735–929	107 915	23.47	53 887	23.44	54 028	23.50	
929–1171	40 241	8.75	20 135	8.76	20 106	8.75	
1171–1477	42 068	9.15	21 242	9.24	20 826	9.06	
≥1477	41 058	8.93	20 513	8.92	20 545	8.94	
CCI score							
0	290 375	63.16	145 165	63.15	145 210	63.17	0.991
1	106 462	23.16	53 245	23.16	53 217	23.15	
≥2	62 889	13.68	31 453	13.68	31 436	13.68	
DCSI score							0.984
0	364 132	79.21	182 050	79.20	182 082	79.21	
1	60 442	13.15	30 221	13.15	30 221	13.15	
≥2	35 152	7.65	17 592	7.65	17 560	7.64	
Level of the healthcare organisation							0.984
Medical centre	82 286	17.90	41 188	17.92	41 098	17.88	
Regional	154 294	33.56	77 158	33.57	77 136	33.56	
District	93 194	20.27	46 579	20.26	46 615	20.28	
Clinic	129 952	28.27	64 938	28.25	65 014	28.28	
Ownership of organisation							0.227
Public	107 746	23.44	53 699	23.36	54 047	23.51	
Non-public	351 980	76.56	176 164	76.64	175 816	76.49	
The main physician is an endocrinologist							0.872
No	382 096	83.11	191 027	83.10	191 069	83.12	
Yes	77 630	16.89	38 836	16.90	38 794	16.88	
Duration of DM (years)							0.996
<3	254 127	55.28	127 034	55.27	127 093	55.29	
3–6	119 380	25.97	59 718	25.98	59 662	25.96	
6–9	61 596	13.40	30 810	13.40	30 786	13.39	
≥9	24 623	5.36	12 301	5.35	12 322	5.36	

*χ^2 test.
CCI, Charlson Comorbidity Index; DCSI, Diabetes Complications Severity Index; DM, diabetes mellitus; P4P, pay for performance.

the physicians visited by patients in this study. Most of the participants had diabetes for <3 years (55.28%).

The effect of the P4P programme on incidence risk of stroke and relevant factors in patients with type 2 diabetes

The percentage of stroke incidence in patients with diabetes enrolled in the P4P programme was 6.41%, whereas for those not enrolled, it was 6.39%. A Cox proportional hazards model analysis found, after controlling for other variables, that the risk of stroke in patients enrolled in the P4P programme was 0.97 times that of the not enrolled patients (95% CI 0.95 to 0.99) (table 2 and figure 1). That is, the incidence of stroke in patients with diabetes enrolled in the P4P programme was less than that of the non-P4P group by 3%.

The other significant risk factors associated with incidence of stroke included gender, age, monthly salary, urbanisation of the residence area, CCI score, DCSI score, level of healthcare organisation, whether the main physician was an endocrinologist, the main physician's annual service volume, use of adult health check and the duration of DM. With regard to the gender factor, the risk of stroke in males was 1.42 times that of females. Concerning monthly salaries, and using low-income households as the reference group, the risk of stroke at increasingly higher income levels was between 0.99 and 0.68 times. For the severity of diabetic complications (DCSI), the higher the score, the higher the risk of stroke. When the main medical department was an endocrinologist unit, the risk of stroke was 0.91 times that of a non-endocrinologist main medical department. Regarding the adult health check, the risk of stroke was 0.92 times for those who took advantage of this option compared with those who did not.

The effect of the P4P programme on incidence risks of haemorrhagic stroke and ischaemic stroke and related factors in patients with type 2 diabetes

A Cox proportional hazards model analysis found that the risk of haemorrhagic stroke in patients enrolled in the P4P programme was 0.87 times (95% CI 0.82 to 0.93) that of not enrolled patients (table 3 and figure 2). The incidence of haemorrhagic stroke in patients with diabetes enrolled in the P4P programme was 13% lower than that of the non-P4P group. In contrast, the Cox proportional hazards model determined that the risk of ischaemic stroke was similar between the P4P patients and those not included in this programme (HR=0.99, 95% CI 0.97 to 1.02, p=0.632) (table 3 and figure 2).

With regard to personal characteristics, both males and older patients had a higher risk of haemorrhagic and ischaemic stroke (table 3). As for the urbanisation of residence areas, with level 1 as the reference group, the risk of ischaemic stroke was higher at greater levels of urbanisation, but the risk of haemorrhagic stroke was not significantly influenced by this variable. Patients with a higher CCI score had a greater risk of haemorrhagic stroke rather than ischaemic stroke. Also, when patients had a higher DCSI score, the risk of ischaemic stroke was higher. The risks of both haemorrhagic and ischaemic stroke for patients who used an adult health check were lower compared with those who did not.

Stratified analysis of the risk of stroke in patients with type 2 diabetes by P4P programme

After we examined the interaction relationship between P4P enrolment status and related variables regarding the risks of stroke, this study found that only gender had a significant interaction relationship (p<0.001), and all of our other numerous explanatory variables did not (p>0.05). This study further conducted a stratified analysis for gender to compare the effect of P4P enrolment status on risk of stroke in both males and females, respectively. This effort showed that the reduced risk of stroke in males with diabetes enrolled in the P4P programme was greater than that of their female counterparts (table 4).

In addition, after we further analysed the average number of primary care visits per year by arm, we found that these values were 12.82 and 7.76 times for the P4P group and non-P4P group, respectively.

DISCUSSION

The results of our Cox proportional hazards model showed a lower risk of stroke for patients with diabetes enrolled in the P4P programme (HR=0.97). The reason may be that the programme's clinical guidelines require physicians, nurses, pharmacists, nutritionists and case managers to form a team to co-care patients with diabetes.[10] Such a team approach to disease management might enhance the quality of care, thereby reducing the stroke risk in patients with diabetes.

Previous studies revealed that patients with diabetes enrolled in P4P programmes were more likely to receive all clinically specified tests (including HbA1c, blood pressure and LDL cholesterol),[24] and have lower hospitalisation expenses than those for non-participants.[13] The number of visits to diabetes clinics was much higher in patients with diabetes enrolled in P4P programmes, indeed 2.01 times more than that for the not enrolled patients.[13] Compared with those having low-continuity care scores, patients with higher scores on this metric were more likely to have better medication compliance.[10] The link between continuity of care and healthcare outcomes is partly due to better drug compliance in patients with type 2 diabetes.[10] This study found that the average number of annual primary care visits was higher in the P4P group than that in the non-P4P group (12.82 and 7.76 times, respectively). This result was similar to the existing literature.[13]

In 2006, Taiwan's NHI Administration hoped to, through quality incentives, encourage physicians to devote more attention to providing excellent medical care. One of the positive indicators is the patient's completed follow-up rate (based on a regular annual assessment to ensure continuous care). A previous study

Table 2 Relative risks of stroke and related factors in patients with type 2 diabetes

	No stroke		Stroke			Adjusted model†		
	n_1	%	n_2	%	P value*	HR	95%CI	P value
Total	430308	93.60	29418	6.40				
P4P participating status					0.057			
Non-P4P	215169	93.61	14694	6.39				
P4P	215139	93.59	14724	6.41		0.97	0.95 to 0.99	0.022
Gender					<0.001			
Female	216760	94.28	13153	5.72				
Male	213548	92.92	16265	7.08		1.42	1.39 to 1.45	<0.001
Patient's age (years)					<0.001			
45–54	134266	96.31	5145	3.69				
55–64	151675	94.62	8619	5.38		1.52	1.47 to 1.57	<0.001
65–74	98986	90.98	9811	9.02		2.42	2.34 to 2.51	<0.001
≥75	45381	88.59	5843	11.41		3.52	3.38 to 3.66	<0.001
Monthly salary (US$)					<0.001			
≤557	22435	93.35	1597	6.65				
557–735	189078	92.50	15334	7.50		0.99	0.94 to 1.04	0.584
735–929	101042	93.63	6873	6.37		0.89	0.84 to 0.94	<0.001
929–1171	38473	95.61	1768	4.39		0.82	0.77 to 0.88	<0.001
1171–1477	40086	95.29	1982	4.71		0.78	0.73 to 0.83	<0.001
≥1477	39194	95.46	1864	4.54		0.68	0.64 to 0.73	<0.001
Urbanisation of residence area					<0.001			
Level 1	118433	94.70	6623	5.30				
Level 2	134561	94.07	8478	5.93		1.08	1.05 to 1.12	<0.001
Level 3	64792	93.33	4630	6.67		1.14	1.1 to 1.19	<0.001
Level 4	65460	92.32	5448	7.68		1.21	1.17 to 1.26	<0.001
Level 5	10661	91.98	929	8.02		1.15	1.07 to 1.23	<0.001
Level 6	19275	91.07	1890	8.93		1.34	1.27 to 1.41	<0.001
Level 7	17126	92.34	1420	7.66		1.17	1.1 to 1.24	<0.001
CCI score					<0.001			
0	273814	94.30	16561	5.70				
1	98841	92.84	7621	7.16		1.04	1.01 to 1.07	0.013
≥2	57653	91.67	5236	8.33		1.07	1.04 to 1.11	<0.001
DCSI score					<0.001			
0	342788	94.14	21344	5.86				
1	55999	92.65	4443	7.35		1.09	1.06 to 1.13	<0.001
≥2	31521	89.67	3631	10.33		1.41	1.36 to 1.46	<0.001
Level of the healthcare organisation					<0.001			
Medical centre	77925	94.70	4361	5.30		0.9	0.86 to 0.93	<0.001
Regional	144496	93.65	9798	6.35		1.05	1.02 to 1.08	0.002
District	86243	92.54	6951	7.46		1.08	1.05 to 1.12	<0.001
Clinic	121644	93.61	8308	6.39				
Ownership of organisation					0.141			
Public	100928	93.67	6818	6.33				
Non-public	329380	93.58	22600	6.42		1.11	1.08 to 1.14	<0.001
The main physician is an endocrinologist					<0.001			

Continued

Table 2 Continued

|	No stroke		Stroke			Adjusted model†		
	n_1	%	n_2	%	P value*	HR	95% CI	P value
No	356 581	93.32	25 515	6.68				
Yes	73 727	94.97	3903	5.03		0.91	0.87 to 0.94	<0.001
Physician's annual service volume						<0.001		
Low	6328	93.09	470	6.91				
Medium	46 021	93.08	3424	6.92		1.10	1.00 to 1.21	0.058
High	377 959	93.67	25 524	6.33		1.03	0.94 to 1.13	0.544
Use of adult health check					<0.001			
No	191 154	94.68	10 735	5.32				
Yes	239 154	92.75	18 683	7.25		0.92	0.89 to 0.94	<0.001
Duration of DM (years)					<0.001			
<3	239 792	94.36	14 335	5.64				
3–6	109 852	92.02	9528	7.98		1.20	1.17 to 1.23	<0.001
6–9	57 133	92.75	4463	7.25		1.24	1.20 to 1.29	<0.001
≥9	23 531	95.57	1092	4.43		1.11	1.04 to 1.18	0.001

*Log-rank test.
†Cox proportional hazards model.
CCI, Charlson Comorbidity Index; DCSI, Diabetes Complications Severity Index; DM, diabetes mellitus; P4P, pay for performance.

revealed that those who participated in P4P programmes had a 4.27-fold increase in continuous care compared with non-participants.[25] Furthermore, Chen *et al* found that P4P programme participants significantly improved

Figure 1 The relative risk of stroke in patients with type 2 diabetes whether there were P4P participants or not participants (adjusted Cox proportional hazards model with controlling for other relevant variables). P4P, pay for performance.

their survival without increasing medical expenses when compared with non-participants.[12]

The cardiovascular complications of diabetes may cause myocardial infarction and stroke, with approximately 50% of deaths of patients with diabetes attributed to CVD.[2] An earlier study showed better HbA1c results and glycaemic control could be achieved by participating in a P4P diabetes programme.[26] Another investigation revealed that the enrolment of patients with type 2 diabetes in a P4P programme had a positive effect on HbA1c and glycaemic control; produced a decline in HbA1c within 6 months; and reduced the risk of stroke, myocardial infarction and death.[27] Moreover, it has been shown that a patient-centred, multidisciplinary care model could effectively reduce the incidence of cardiovascular complications (coronary heart disease, heart failure and stroke) in patients with diabetes (HR=0.652).[28] These earlier studies may help explain the lower risk of stroke observed in our study regarding patients who were enrolled in Taiwan's Diabetes P4P programme.

Our use of a Cox proportional hazards model revealed a lower risk of haemorrhagic stroke (HR=0.87) in patients who were enrolled in Taiwan's DM P4P programme, which includes blood pressure checks during the physical examination in every care visit in the P4P programme. High blood pressure increases the risk of stroke by four times,[29] and the effect of blood pressure on haemorrhagic stroke is more significant than that on ischaemic stroke.[6 30] Previous studies have revealed that chronic kidney disease is also a risk factor for haemorrhagic stroke, and the poorer the renal function, the higher the risk of this outcome.[31] A possible explanation is that chronic
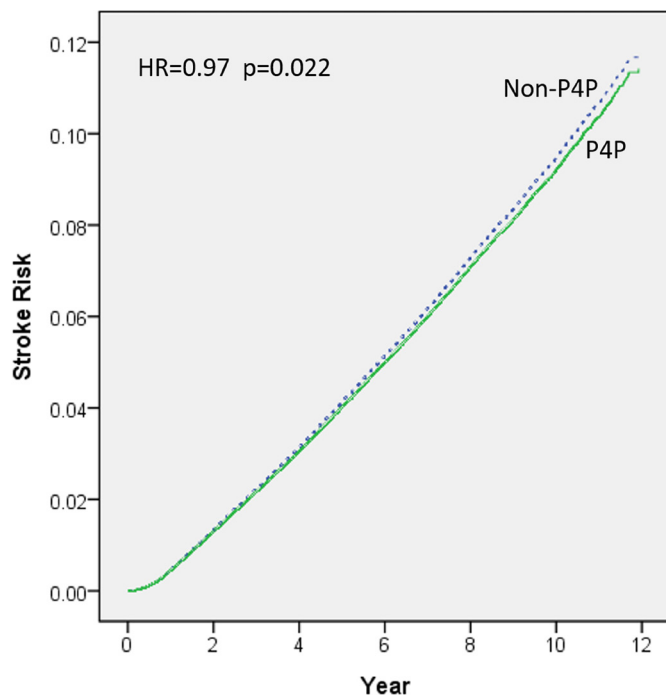
Table 3 The effect of the P4P programme on incidence risks of haemorrhagic stroke and ischaemic stroke in patients with type 2 diabetes

	n	Haemorrhagic stroke				Ischaemic stroke			
		n_1	HR	95% CI	P value*	n_2	HR	95% CI	P value*
P4P participating status									
Non-P4P (ref)	228170	2158				11588			
P4P	228170	1919	0.87	0.82 to 0.93	<0.001	11908	0.99	0.97 to 1.02	0.632
Gender									
Female (ref)	228178	1698				10518			
Male	228162	2379	1.55	1.46 to 1.65	<0.001	12978	1.43	1.39 to 1.47	<0.001
Patient's age (years)									
45–54 (ref)	138867	953				3907			
55–64	159357	1215	1.18	1.08 to 1.28	<0.001	6899	1.61	1.54 to 1.67	<0.001
65–74	107666	1188	1.62	1.48 to 1.77	<0.001	7996	2.63	2.52 to 2.73	<0.001
≥75	50450	721	2.38	2.14 to 2.65	<0.001	4694	3.80	3.63 to 3.98	<0.001
Monthly salary (US$)									
≤557	23823	245				1240			
557–735	202640	2096	0.93	0.82 to 1.07	0.321	12259	1.01	0.95 to 1.07	0.863
735–929	107110	916	0.81	0.70 to 0.93	0.003	5521	0.91	0.86 to 0.97	0.003
929–1171	40062	263	0.79	0.66 to 0.94	0.008	1409	0.84	0.78 to 0.90	<0.001
1171–1477	41864	276	0.70	0.59 to 0.83	<0.001	1597	0.80	0.75 to 0.87	<0.001
≥1477	40841	281	0.67	0.56 to 0.79	<0.001	1470	0.69	0.64 to 0.74	<0.001
Urbanisation of residence area									
Level 1 (ref)	124281	1005				5204			
Level 2	142072	1184	1.00	0.91 to 1.08	0.903	6765	1.10	1.06 to 1.14	<0.001
Level 3	68929	604	1.00	0.90 to 1.10	0.920	3754	1.18	1.13 to 1.23	<0.001
Level 4	70311	725	1.10	0.99 to 1.21	0.065	4396	1.25	1.20 to 1.30	<0.001
Level 5	11461	127	1.08	0.90 to 1.31	0.410	739	1.16	1.08 to 1.26	<0.001
Level 6	20927	267	1.31	1.14 to 1.50	<0.001	1488	1.35	1.27 to 1.43	<0.001
Level 7	18359	165	0.93	0.78 to 1.10	0.386	1150	1.21	1.13 to 1.29	<0.001
CCI score									
0 (ref)	288669	2248				13386			
1	105514	1053	1.13	1.05 to 1.21	0.002	6050	1.01	0.98 to 1.04	0.476
≥2	62157	776	1.30	1.19 to 1.42	<0.001	4060	1.02	0.98 to 1.06	0.282
DCSI score									
0 (ref)	361809	3004				17077			
1	59900	571	1.03	0.94 to 1.13	0.500	3579	1.10	1.06 to 1.14	<0.001

Continued

Table 3 Continued

	n	Haemorrhagic stroke				Ischaemic stroke			
		n_1	HR	95% CI	P value*	n_2	HR	95% CI	P value*
≥2	34 631	502	1.41	1.28	<0.001	2840	1.39	1.34 to 1.45	<0.001
Level of the healthcare organisation									
Medical centre	81 845	607	0.92	0.83	0.120	3518	0.89	0.85 to 0.92	<0.001
Regional	153 179	1408	1.12	1.03	0.008	7790	1.02	0.99 to 1.06	0.187
District	92 136	971	1.16	1.06	0.001	5392	1.03	0.99 to 1.07	0.099
Clinic (ref)	129 180	1091				6796			
Ownership of organisation									
Public (ref)	106 906	937				5426			
Non-public	349 434	3140	1.10	1.02	0.016	18 070	1.12	1.09 to 1.16	<0.001
Main physician is an endocrinologist									
No (ref)	379 138	3534				20 366			
Yes	77 202	543	0.87	0.79	0.003	3130	0.91	0.88 to 0.95	<0.001
Physician's annual service volume									
Low (ref)	6732	69				362			
Medium	49 061	498	1.06	0.82	0.651	2705	1.13	1.01 to 1.26	0.035
High	400 547	3510	0.98	0.77	0.854	20 429	1.07	0.96 to 1.18	0.245
Use of adult health check									
No (ref)	200 805	1664				8481			
Yes	255 535	2413	0.84	0.78	<0.001	15 015	0.92	0.89 to 0.95	<0.001
Duration of DM (years)									
<3 (ref)	252 506	2118				11 342			
3–6	118 168	1238	1.10	1.02	0.013	7621	1.21	1.17 to 1.24	<0.001
6–9	61 121	597	1.19	1.09	<0.001	3605	1.27	1.22 to 1.32	<0.001
≥9	24 545	124	0.89	0.74	0.221	928	1.19	1.11 to 1.28	<0.001

*Cox proportional hazards model.
CCI, Charlson Comorbidity Index; DCSI, Diabetes Complications Severity Index; DM, diabetes mellitus; P4P, pay for performance.
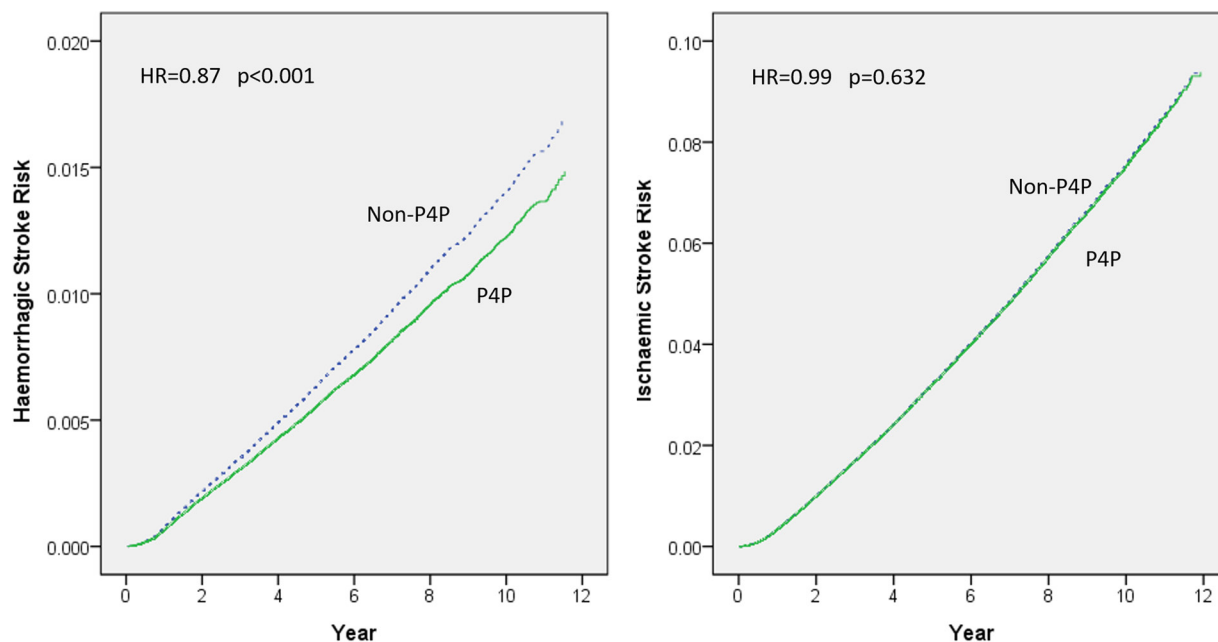
Figure 2 The relative risks of haemorrhagic stroke or ischaemic stroke in patients with type 2 diabetes whether there were P4P participants or not participants (adjusted Cox proportional hazards model with controlling for other relevant variables). P4P, pay for performance.

kidney disease affects platelet aggregation, causing a bleeding tendency. Studies of patients with haemorrhagic stroke have shown that those with chronic kidney disease are more likely to develop cerebrovascular bleeds and microbleeds.[32] Chen *et al* demonstrated increased survival in P4P programme participants compared with not enrolled patients, increased compliance with the use of hypoglycaemic agents and a reduced risk of cancer and chronic kidney disease.[12]

Our study revealed that patients with type 2 diabetes in low-income households had a higher risk of stroke than those with higher incomes, perhaps because poor people are less likely to seek medical treatment and are, consequently, less likely to receive diabetes-related tests. Thus, poverty increases the incidence of diabetes and the inequality of diabetic care.[33] Patients with low socioeconomic status are less involved in medical decisions, have less access to medical information and are less likely to communicate effectively with physicians.[34]

Table 4 Stratification analysis: the effect of P4P programme on risk of stroke in different gender patients with type 2 diabetes

	Stroke (%)		Adjusted model		
	P4P	Non-P4P	HR	95% CI	P value*
Gender					
Female	5.87	5.58	1.02	0.98 to 1.06	0.285
Male	6.95	7.21	0.93	0.90 to 0.97	<0.001

*Cox proportional hazards model.
P4P, pay for performance.

This study also found a lower risk of stroke in patients using an adult health check compared with those who did not. A previous study has demonstrated that patients with diabetes who actively use self-care can reduce the incidence of diabetic complications.[35] There is a statistically significant difference between the health-oriented beliefs of health check users and non-users.[35] Compared with non-users, health check users think their health is more valuable and more susceptible to disease.[36] A previous study showed that when people feel more social support, when people believe they have the ability to receive health checks, or when they have more health information, they participate more actively in health checks.[37] Previous studies have also shown that factors related to healthy behaviour could influence the use of the adult health check. For example, smokers, people who chew betel nut and those choosing a sedentary lifestyle had seldom elected to have an adult health check.[38] The Taiwan adult health check includes a physical examination, biochemical blood tests, renal function tests and health consultations, and this annual adult health check is free.[21]

Following a stratified analysis of the gender element, our study revealed that compared with men not in the P4P programme, men in the P4P programme had a significantly lower risk of stroke, whereas this was not true for females enrolled in a P4P programme. An earlier study reported that female patients have better medical compliance behaviour than males.[39] Therefore, when males with diabetes enrolled in the P4P programme, they may have significantly improved their medical compliance and thereby have lowered their risk of having a stroke.

Limitations

Patients with diabetes who visited outpatient clinics less than three times or who were not hospitalised with a primary diagnosis or subdiagnosis of DM (ICD-9-CM 250, A code: A181) within 365 days were excluded from this study. This protocol might cause a reduced actual number of people with diabetes. However, this study still had a big number of study participants to enhance the study findings. Our study database did not include some other factors such as HbA1c, body mass index (BMI), blood pressure and compliance with medication. However, previous studies showed that patients with diabetes enrolled in P4P programmes were more likely to receive clinically specified tests (HbA1c, BMI, blood pressure, LDL cholesterol)[24] and had better medication compliance.[10] Therefore, these limitations may not affect the results of this study.

Behavioural changes regarding adult health checks and new comorbidity conditions that could not be followed were also limitations of this investigation. Finally, we performed PSM between the P4P and non-P4P groups to reduce selection bias which might not have eliminated all selection bias between two groups, but we further conducted multivariate model controlling for relevant variables which would enhance the unbiased results.

CONCLUSIONS

Our results indicate that the factors affecting the risk of stroke in patients with diabetes were P4P programme enrolment status, gender, age, monthly salary, degree of urbanisation, comorbidity (CCI), severity of complications (DCSI), characteristics of the primary healthcare organisation, characteristics of the primary physician, the use of an adult health check and the duration of DM.

Patients with type 2 diabetes enrolled in the P4P programme had a significantly lower risk of stroke (HR=0.97), especially haemorrhagic stroke (HR=0.87). However, there was no statistically significant difference in the risk of ischaemic stroke (HR=0.99). Male patients with diabetes enrolled in the P4P programme exhibited a more significant reduction in stroke risk.

Recommendation

Our results could provide a reference for the quality of care and case management of diabetes. The P4P programme may be promoted to patients with type 2 diabetes, especially male patients, and also to their physicians.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study was approved by the Institutional Review Board at the authors' organisation (IRB No: CMUH 103-REC3-109).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement This study used the National Health Insurance Research Database published by the Ministry of Health, Taiwan. Due to legal restrictions imposed by the Taiwan government related to the Personal Information Protection Act, the database cannot be made publicly available. All researchers can apply for using the databases for conducting their studies. Requests for data can be sent as a formal proposal to the Science Center of the Ministry of Health and Welfare (http://www.mohw.gov.tw/EN/Ministry/Index.aspx). Any raw data are not allowed to be brought out from the Science Center. Only the analytic outputs in format of table or figure can be printed out. The restrictions prohibited the authors from making the minimal data set publicly available.

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