Effect of a Structured Diabetes Education Program in Primary Care on Hospitalizations and Emergency Department Visits among Type 2 Diabetes Mellitus: Results from the Patient Empowerment Programme (PEP)

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Novelty Statements

- Hospital service utilizations with respect to hospital admission and emergency department visits were significantly reduced after PEP participation in 'real-world' primary care setting.
- Our population-based cohort study showed that structured diabetes education program led to the benefits of substantial reductions in the initial episode and frequencies of hospital service utilizations and their associated direct medical costs.

Abstract

Aims: To assess whether a structured diabetes education program, Patient Empowerment Programme (PEP), was associated with a lower rate of all-cause hospitalization and emergency department (ED) visits in a population-based cohort of type 2 diabetes mellitus (T2DM) patients in primary care.

Methods: A cohort of 24,250 patients was evaluated using linked administrative database during 2009-2013. We selected 12,125 T2DM patients who had at least one PEP session attendance. Non-PEP participants were matched one-to-one with PEP participants using propensity-score method. Episodes of hospitalization and ED visit are the events of interest. Cox proportional hazard and Negative binomial regressions were performed to estimate the hazard ratios (HR) for initial episode of event, and incidence rate ratios (IRR) for the number of event episode, respectively.

Results: During a median 30.5 months of follow-up, PEP participants had a lower incidence of initial episode of hospitalization (22.09% vs 25.19%; HR: 0.879; P<0.001) and ED visit (40.49% vs 44.00%; HR: 0.901; P<0.001) than those without PEP. PEP was associated with statistically significant decreased number of ED visits (IRR: 0.903; P<0.001), from 40.424 ED visits per 100 patients annually without PEP to 36.153 per 100 patients annually with PEP. There were statistically significant reductions in number of hospitalizations (IRR: 0.854; P<0.001), from 19.984 hospitalizations per 100 patients annually without PEP to 16.878 hospitalizations per 100 patients annually with PEP.

Conclusions: Among T2DM patients, PEP was shown to be effective in delaying the initial episode of hospital utilization and reducing their frequencies.

Keywords: Hospitalization; Emergency department; type 2 diabetes, Structured education; Self management; Primary Care

Manuscript Text

Introduction

Diabetes mellitus is one of the commonest chronic diseases experienced by patients treated in primary care, and it is highly prevalent chronic disease associated with the development of both the mortality and morbidity including diabetes-related complications over the past decades.[1] In the US, owing to the substantial rise in the prevalence, diabetes mellitus projected to result in 43.1 million hospital inpatient days and 15.3 million times of emergency department visits each year.[2] While about one-four of all hospital inpatients days were incurred by patients with diabetes and about one-nine of all emergency department visits were incurred by patients with diabetes, the annual direct health care expenditures of hospitalization and emergency department visits incurred by patients with diabetes were projected to exceed 138 billion dollars.[2] Such economic burden of diabetes is expected to increase with the aging population worldwide, and underlined the important of developing multi-faceted clinical care and effective management strategies to reduce consequently preventable hospital service utilizations for patients with diagnosed diabetes.

Currently, structured diabetes education program is one of the key components of a clinical care and management strategy for patients with diabetes and those at high risk for developing diabetes-related complication.[3] Clinical benefits of structured diabetes education program has been well-recognized and confirmed in several systematic reviews[4-6] and meta-analyses,[7-9] in which thereby theoretically reduce health care expenditures and hospital service utilization. Apart from studies in Type 1 diabetes population[10], there is mixed and limited evidence on the effects of structured diabetes education program on the use of hospital services including avoidable hospitalizations and unfavourable adverse events presented at emergency department visits. Most previous studies[11-13] reported the one-year effect of the education program on hospital service utilization that were not reduced significantly, whereas three studies[14-16] initiating more than one-year horizon reported that patients in education group experienced significantly lower frequency of the hospital services related to diabetes compared with those without. However, education programs delivered in specialist clinics and secondary care might not reflect current 'real-world' practice in primary care setting. In such, limited evidence is available on population-

based data comparing the utilization rates of hospital service with and without structured diabetes education program.

Recent observational matched studies[17-19] addressed the knowledge gaps regarding the uncertainties surrounding effectiveness of structured diabetes education program in 'real-world' setting. The Patient Empowerment Programme (PEP) is a structured diabetes education program for individuals with type 2 diabetes. Evaluation of PEP in Hong Kong has shown to have significant improvement in metabolic control and reduction in the risk of cardiovascular diseases and all-cause mortality. Meanwhile, our aim of this population-based propensity score matched cohort study was to evaluate the influence of PEP implemented in primary care on hospital service utilizations as compared to the alternative usual clinical practice without PEP. The incidence of emergency department visits and hospitalizations over the two years were examined between PEP and the usual clinical practice. It was hypothesised that PEP participants would be significantly associated with lower risks of initial and multiple episodes of hospital service utilizations.

Methods

The PEP structured education program has been launched by the Hong Kong Hospital Authority since 2010. It serves as a component of the multi-faceted management strategy to facilitate quality enhancement in primary care setting. It aims at providing participants with the knowledge, skills and self-awareness of their own disease condition and promoting autonomous self-regulation to maximise their potential for health and well-being. Individual's lifestyle modification and risk factor management can be enhanced through different areas such as health education, skill transfer, self-efficacy enhancement, mutual support groups in the program. In order to enhance and maintain the participants' self-management, 6-8 sessions on disease-specific knowledge and self-management skills, self-efficacy and lifestyle modification and post-program follow-ups were delivered by the expertise in community medical service and education of the non-government organisations. The detailed description of PEP setting and mode of education delivery has been reported previously[17-19].

Subjects

As of 31 March, 2012, the PEP has now been delivered to 15,497 adults with T2DM through four non-government organizations in Hong Kong. Informed consent was obtained from all individual participants included in the study. All subjects with T2DM who had attended at least one PEP session were included in the outcome evaluation from a population-based cohort through the clinical management system administrative database of Hong Kong Hospital Authority which is the largest and sole public health service provider in Hong Kong. T2DM subjects were identified with the *International Classification of Primary Care-2* (ICPC-2) code of 'T90', through the administrative database of Hong Kong Hospital Authority. This study included patients attended at least one session of PEP on a date from 1 March, 2010 to 30 June, 2012. Each patient was observed from baseline date to whichever following event came first until 31 Dec 2013 i.e. the date of death, or last follow-up as censoring. The first date of PEP session attendance was regarded as baseline data.

To assess the net effect of PEP on post-intervention, the same number of 172,448 T2DM patients who had not ever participated in PEP on or before 31 Dec 2013 were matched to PEP subjects on propensity score matching by summarising the baseline covariates as the non-PEP group described as below. The subjects were defined as having history of co-morbidities and diagnosis of diabetes-related complications according to the diagnosis coding system of *International Classification of Diseases, Ninth Edition, Clinical Modification* (ICD-9-CM) in administrative database of the Hong Kong Hospital Authority. The use of ICD-9-CM diagnosis coding systems were managed to capture the history of co-morbidities and diagnosis of diabetes-related complications in hospital care settings. Treatment modality, duration of T2DM, history of hypertension and family history of T2DM was retrieved from Diabetes Mellitus Complication Screening module of clinical management system database.

Baseline Covariates

Covariates of patients included the collection of socio-demographic, biomedical data and disease characteristics, and treatment modalities and enrolment of co-intervention[20, 21] for diabetes at baseline. Socio-demographic characteristics of patients included sex (female; male), age, smoking status (non-smoker; smoker), alcohol status (non-drinker; drinker), and educational level (no formal education/primary; secondary/tertiary). Biomedical data

consisted of body mass index (BMI), Haemoglobin A1c (HbA1c), blood pressure, lipid profile, triglyceride and estimated glomerular filtration rate (eGFR) on the date within six-month period of baseline date. Disease characteristics included duration of T2DM (≤5 years; 5-10 years; >10 years), history of hypertension, history of macrovascular complication (including coronary heart disease, stroke, heart failure), history of microvascular complication (including retinopathy, nephropathy and neuropathy), family history of T2DM (yes; no; unknown), and number of severe hypoglycaemic events (0; 1; ≥2).

Propensity Score Matching

A propensity score matching was first introduced in 1983 [22] as the conditional probability of being intervention given the observed covariates[23]. The key purpose in this study was to create equivalent PEP intervention and non-PEP comparison groups by logistic regression analysis with summarising relevant baseline characteristics of each patient into a single-index variable (the propensity score) and then matching patients in the non-PEP pool to the patients in PEP intervention group based on the value of the propensity score [22, 24, 25]. Correspondingly, the propensity score was generated for each patient, modelling PEP intervention as a dependent variable while the baseline covariates (including sex, age, smoking status, alcohol status, educational level, HbA1c level, BMI, blood pressure, triglyceride, total cholesterol-to-high density lipoprotein cholesterol ratio, low density lipoprotein cholesterol, eGFR, duration of T2DM, history of hypertension, history of macrovascular complication, history of microvascular complication, family history of diabetes mellitus, the use of insulin and enrolment of co-intervention for diabetes) of patients as independent variables. The propensity score mapping was made by using the "psmatch2" command[26] with one-to-one matching without replacement method in the STATA.

Data Analysis

Descriptive statistics for the baseline characteristics of socio-demographic and clinical data in PEP and non-PEP groups were calculated after propensity score matching, and their differences were tested using *Chi*-square test or independent *t*-test for continuous or

categorical variables, respectively. Episodes of hospitalization and emergency department visit are the outcome events of interest. The cumulative incidence rate and incidence rate of outcome events with 95% confidence interval based on the assumption that the observed incident cases followed a Poisson distribution in PEP and non-PEP groups were reported.

Multivariable Cox proportional hazards regression was performed to estimate the effect of PEP on the initial episode of outcome events, accounting for all baseline characteristics of patients. For each event model, survival curves were estimated by Kaplan-Meier method and their differences between PEP and non-PEP groups were compared using the log-rank test. Hazard ratio (HR) with 95% confidence intervals was reported for each factor in the regression models. Predictive accuracy of Cox models was assessed and compared using Harrell's discrimination C-index, ranging from zero to one. A value of 0.5 indicates no predictive discrimination, and values of 0 or 1.0 indicate perfect separation of patients[27]. Goodness-of-fit for Cox regression model were assessed using Akaike information criterion (AIC) and Bayesian information criterion (BIC).

Frequencies of outcome events were compared between the PEP and non-PEP groups by Poisson regression analyses when adjusted all baseline characteristics of patients. Negative binomial regression models were used instead of Poisson regression models in cases when the ratio of residual deviance to degrees of freedom was far greater than one, indicating the overdispersed count outcomes.

In addition to intention to treat analysis, per protocol analysis was also performed using PEP participants who had completed the program and the propensity-matched non-PEP participants. All statistical analyses were performed using STATA Version 13.0 (StataCorp LP. College Station, Texas, U.S.). All significance tests were two-tailed and those with a p-value less than 0.05 were considered statistically significant.

Ethics approval of this study was granted by Institutional Review Board in Hong Kong, and international clinical trial registry (NCT01935349, ClinicalTrials.gov).

Results

Socio-demographic, baseline laboratory results and clinical characteristics of both PEP and non-PEP participants after propensity score matching are displayed in Table 1. Out of a total of 15,497 T2DM subjects, 12,125 (78.2%) were successfully matched with non-PEP participants by socio-demographic and clinical characteristics. Both groups had similar socio-demographic and clinical characteristics, as reflected by p-values all greater than 0.05. Moreover, 6,099 PEP participants who completed the programme were also paired with non-PEP participants on a one-to-one basis for sensitivity analysis. These two groups also showed insignificant difference in all socio-demographic and baseline characteristics.

Figure 1 and Table 2 show the Kaplan-Meier survival curves and the incidence rates of all-cause hospitalization and emergency department visit. PEP participants had fewer numbers of all-cause hospitalization. After a median follow-up period of 30.5 months, 5,733 cases of all-cause hospitalization (2,679 PEP participants and 3,054 non-PEP participants) occurred during a total of 27,625 person-years for PEP participants and 27,217 person-years for non-PEP participants. Similar findings were observed for event of emergency department visit. During a median 26.5 months of follow-up and a total of 23,882 person-years for PEP participants and 23,369 person-years for non-PEP participants, only 4,909 incidences were resulted for PEP participants compared with 5,335 incidences for non-PEP participants.

Multivariable analyses on the dependent variable of all-cause hospitalization and emergency department visit are shown in Table 3. After adjusting for the socio-demographic and clinical characteristics in Cox proportional hazard model, PEP participants were associated with a lower risk of all-cause hospitalization (22.09% vs 25.19%; HR 0.879; 95% CI 0.834-0.926; P<0.001) than the non-PEP participants. Results from log-rank tests also reveal that there was significant difference between groups (chi-squared = 32.42; P<0.001). Additionally, there was a lower incidence of emergency department visit among PEP participants (40.49% vs 44.00%; HR 0.901; 95% CI 0.867-0.937, P<0.001) than those non-PEP participants and the difference in time to emergency department visit was also statistically significant (*chi-square* test= 27.92; P<0.001). In sensitivity analysis, similar results were obtained for PEP participants who completed the programme. Lower risks of all-cause hospitalization (23.91% vs 20.56%; HR: 0.835; 95% CI 0.773-0.901; P<0.001) and emergency department visit (42.81% vs 39.56%; HR 0.890;

95% CI 0.842-0.942; P<0.001) were observed among PEP completer than those without PEP. The differences in time to hospitalization were also significant (all-cause hospitalization: chi-squared = 26.13; P<0.001, emergency department visit: chi-squared = 18.38; P<0.001).

For the estimation of incidence rate ratios (IRR) using negative binomial regression model, PEP participants was associated with a significant decreased number of all-cause hospitalizations (IRR: 0.854; P<0.001), from 19.984 hospitalizations per 100 patients annually without PEP to 16.878 hospitalizations per 100 patients annually with PEP. Also, the reduction in the number of emergency department visit was highly significant (IRR: 0.854; P<0.001), from 40.424 visits per 100 patients annually without PEP to 36.153 per 100 patients annually with PEP.

Discussions

This is the large scale population-based cohort study investigating the associations between structured diabetes education program and hospital service utilizations, among T2DM patients predominantly treated in primary care setting. In a population-based cohort of T2DM patients in primary care setting, our analyses have demonstrated that the incidence rates of hospitalization and emergency department visits were reduced by 14.6% and 9.7% in a median 2.5 years of follow-up after PEP participation compared to usual clinical practice without PEP. The reductions in hospitalization (PEP vs non-PEP: 16.878 vs 19.984 per 100 person-years) due to education intervention was encouraging although the reductions were less promising than those reported in the US Urban Diabetes Study (29.12 vs 38.05 per 100 person-years)[16]. Likewise, there were 12.1% and 9.9% decreased risk of experiencing an initial episode of hospitalization and emergency department visits after PEP participation. One of the plausible explanations was that such associations may be attributable to improvement in clinical outcomes and prevention of diabetes-related complications, ultimately leading to reductions in hospitalization and emergency department visits, although structured diabetes education program acts through many pathways to produce the reductions of hospital service utilizations.

More importantly, the population-based data quantified the impact of PEP implementation on economic burden of T2DM patients to health care system. Reducing the overall

frequencies of hospitalization and emergency department visits due to the PEP implementation is projected to save the medical expenditure of at least annual direct medical cost of US$34,202 (3.106*$9,200+4.271*$1,318) for each T2DM patient, assuming that the standard cost of a hospitalization was US$9200 and cost of an emergency department visit was US$1,318 in 2009[28]. As a result of reduced episodes of hospital service utilization, we hypothesized the considerable reductions in the direct medical costs for health care system but the precise cost of PEP implementation has not yet taken into account. More in-depth cost-effectiveness analysis should be conducted to calculate the net reduction (or gain) in medical expenditure as a whole, and to provide a recommendation of whether the PEP was cost-saving or cost-effective when compared to usual clinical practice without PEP.

In our cohort of T2DM population, all-cause hospitalization and emergency department visit were frequent and occurred in 23.64% and 42.24% of the population, with incidence rates of 18.430 and 38.287 episodes per 100 person-years, respectively. The number of T2DM patients having emergency department visit was greater than those having hospitalized, whereas the frequency of hospitalization episode was one-time greater than that of emergency department visit. The phenomenon was observed in PEP and non-PEP participants. Interestingly, hospital readmission and a repeat of emergency department visit appeared to be avoidable if the PEP started in T2DM patients. Among those having emergency department visit, 2,343 (19.3%) and 2,662 (22.0%) of PEP and non-PEP participants recorded a repeat of emergency department visit with any diagnosis. Moreover, 1,102 (9.1%) and 1,327 (10.9%) of hospitalized PEP and non-PEP participants were readmitted with any cause. Perhaps further studies should continue to breakdown the detailed principal diagnosis of admissions and visits in hospital care associated with PEP intervention to better understand the mechanisms how PEP intervention prevented a repeat episode of admission and emergency department visit. One possible mechanism was that the association between PEP intervention and hospital service utilizations was likely, in part, mediated through changes healthy lifestyle behaviors. PEP intervention promoted healthy lifestyle behaviorial changes which conferred beneficial effects on cardiovascular diseases[29], and thereby prevention of hospital service episodes.

Finding in current study was in line with three prior studies [14-16] which examined the effects of diabetes education program on hospital service utilization over a prolonged

follow-up period. First, structured diabetes education group in a Korean study was significantly lower frequency of hospitalization related to diabetes than control group after a median follow-up of four years. Moreover, results from a retrospective cohort study showed that education program was significantly associated with delaying in first episode of hospitalization. Conversely, the results from one-year studies[11-13, 18] consistently showed that there was no significant difference in the frequency of inpatient visits between structured diabetes education and control groups. By contrast with argument that program effect deteriorated over time[9], the cumulative effects of PEP on the initial and multiple episodes of hospitalization and emergency department visits were recognized in current study.

Besides the main analysis using whole group of PEP participants, risks of hospitalization and emergency department visits after PEP participation were more pronounced among those with program completion at sensitivity analysis. Consistent with our recent work[17, 18], the program completion strengthened the associations of PEP intervention with cardiovascular and microvascular complications, and it enhanced efforts on the preventions of diabetes-related complications. In aggregate, our findings clearly supported that PEP completers experienced greater benefit from PEP intervention.

Limitations

Several limitations of this study should be acknowledged. First, this is an observational database study, subject to the misclassification bias of outcome and comorbidity pre-defined by ICD-9-CM coding as well as the selection bias of PEP participants who are likely to be motivated and involved in healthy lifestyle modification. Likewise, patients who were suffered from multiple chronic conditions may be precluded from PEP enrolment but they may have high likelihood of hospital services utilizations. Furthermore, the confounding variables such as lifestyle behavior, health literacy and motivation were not measurable in administrative database. Nevertheless, the design of propensity score matching was conducted to minimize the selection and confounding biases arising from the comparative study, and further establish a fair comparisons of outcome events between PEP and non-PEP groups. Secondly, unit costs of hospitalization and emergency department visit were not stratified by the principal disease diagnosis represented by the ICD-9-CM diagnosis code system. For instance, hospital admissions related to

macrovascular complications were more costly than that related to microvascular complications[30, 31]. Finally, data from this study were not entirely representative of Chinese populations in other parts of the world, or those under specialist care or in the private sector, even though the findings were generated from a large population-based database of the public service that managed over 50% of diabetic patients in Hong Kong.

Conclusion

In conclusion, hospital service utilizations with respect to hospital admission and emergency department visits were significantly reduced after PEP participation in 'real-world' primary care setting. Our population-based cohort study also showed that structured diabetes education program led to the benefits of substantial reductions in the initial episode and frequencies of hospital service utilizations and their associated direct medical costs.

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Author Contributions

C.K.H.W. wrote the manuscript and researched data. F.W.K.C. contributed to acquisition of data and reviewed/edited the manuscript. W.C.W.W. and C.L.K.L. contributed to study design. Y.F.W. and A.K.C.C reviewed/edited the manuscript, contributed to statistical analysis and interpretation of results. W.C.W.W. and C.L.K.L. reviewed/edited the manuscript.

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Conflict of interest

The authors declare that they have no conflict of interest.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all patients for being included in the study.

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Table 1. Socio-demographic and clinical characteristics

Factor	PEP Participants vs non-PEP Participants				PEP Completers vs non-PEP Participants			
	Total (N=24,250) % (N)	PEP (N=12,125) % (N)	Non-PEP (N=12,125) % (N)	P-value	Total (N=12,198) % (N)	PEP (N=6,099) % (N)	Non-PEP (N=6,099) % (N)	P-value
Socio-demographic								
Sex				0.074				0.419
Female	56.8 (13,770)	57.4 (6,954)	56.2 (6,816)		58.4 (7,120)	58.0 (3,538)	58.7 (3,582)	
Male	43.2 (10,480)	42.6 (5,171)	43.8 (5,309)		41.6 (5,078)	42.0 (2,561)	41.3 (2,517)	
Age (mean±SD), year	63.85±10.67 (24,250)	63.84±9.76 (12,125)	63.86±11.51 (12,125)	0.928	63.89±10.38 (12,198)	63.98±9.34 (6,099)	63.79±11.32 (6,099)	0.321
Smoking status				0.977				0.616
Non-smoker	94.8 (22,989)	94.8 (11,495)	94.8 (11,494)		95.9 (11,697)	95.8 (5,843)	96.0 (5,854)	
Smoker	5.2 (1,261)	5.2 (630)	5.2 (631)		4.1 (501)	4.2 (256)	4.0 (245)	
Alcohol status				0.237				0.891
Non-drinker	80.5 (19,519)	80.8 (9,796)	80.2 (9,723)		80.6 (9,826)	80.6 (4,916)	80.5 (4,910)	
Drinker	19.5 (4,731)	19.2 (2,329)	19.8 (2,402)		19.4 (2,372)	19.4 (1,183)	19.5 (1,189)	
Educational level				0.335				0.638
No formal education/ primary	52.5 (12,739)	52.8 (6,407)	52.2 (6,332)		50.9 (6,212)	51.1 (3,119)	50.7 (3,093)	
Secondary/ tertiary	47.5 (11,511)	47.2 (5,718)	47.8 (5,793)		49.1 (5,986)	48.9 (2,980)	49.3 (3,006)	
Biomedical data at baseline (mean±SD)								
BMI, kg/m^2	25.52±3.94 (24,250)	25.51±3.94 (12,125)	25.53±3.94 (12,125)	0.720	25.38±3.90 (12,198)	25.36±3.86 (6,099)	25.40±3.93 (6,099)	0.621
HbA1c, %	7.31±1.19 (24,250)	7.32±1.16 (12,125)	7.31±1.22 (12,125)	0.540	7.32±1.19 (12,198)	7.32±1.16 (6,099)	7.32±1.21 (6,099)	0.978
Systolic blood pressure, mmHg	134.03±17.07 (24,250)	134.01±17.94 (12,125)	134.05±16.15 (12,125)	0.844	134.40±17.06 (12,198)	134.51±17.80 (6,099)	134.28±16.28 (6,099)	0.453

Factor	PEP Participants vs non-PEP Participants				PEP Completers vs non-PEP Participants			
	Total (N=24,250) % (N)	PEP (N=12,125) % (N)	Non-PEP (N=12,125) % (N)	P-value	Total (N=12,198) % (N)	PEP (N=6,099) % (N)	Non-PEP (N=6,099) % (N)	P-value
Diastolic blood pressure, mmHg	75.25±10.52 (24,250)	75.27±10.82 (12,125)	75.22±10.22 (12,125)	0.723	75.28±10.28 (12,198)	75.23±10.51 (6,099)	75.33±10.05 (6,099)	0.583
Triglyceride, mmol/L	1.55±0.99 (24,250)	1.56±0.93 (12,125)	1.54±1.04 (12,125)	0.338	1.55±1.00 (12,198)	1.56±0.93 (6,099)	1.54±1.07 (6,099)	0.158
TC/HDL-C ratio	3.92±1.12 (24,250)	3.92±1.14 (12,125)	3.91±1.09 (12,125)	0.393	3.90±1.14 (12,198)	3.91±1.18 (6,099)	3.90±1.11 (6,099)	0.550
LDL-C, mmol/L	2.83±0.80 (24,250)	2.84±0.80 (12,125)	2.83±0.79 (12,125)	0.216	2.86±0.81 (12,198)	2.86±0.81 (6,099)	2.86±0.81 (6,099)	0.903
eGFR, ml/min/1.73m^2	84.12±21.53 (24,250)	84.33±20.03 (12,125)	83.90±22.92 (12,125)	0.120	84.82±24.02 (12,198)	84.57±19.90 (6,099)	85.07±27.53 (6,099)	0.254
Clinical								
Duration of T2DM, year	7.27±6.39 (24,250)	7.25±6.51 (12,125)	7.29±6.27 (12,125)	0.642	7.28±6.45 (12,198)	7.25±6.58 (6,099)	7.30±6.32 (6,099)	0.621
Duration of T2DM, year				0.417				0.741
≤5 years	50.2 (12,171)	49.9 (6,050)	50.5 (6,121)		50.5 (6,157)	50.3 (3,067)	50.7 (3,090)	
5-10 years	25.0 (6,057)	24.9 (3,020)	25.0 (3,037)		24.5 (2,990)	24.4 (1,488)	24.6 (1,502)	
>10 years	24.8 (6,022)	25.2 (3,055)	24.5 (2,967)		25.0 (3,051)	25.3 (1,544)	24.7 (1,507)	
History of hypertension	73.8 (17,885)	73.6 (8,930)	73.9 (8,955)	0.715	72.5 (8,847)	72.7 (4,437)	72.3 (4,410)	0.584
Family history of diabetes mellitus				0.900				0.954
Yes	43.8 (10,615)	43.7 (5,301)	43.8 (5,314)		43.4 (5,297)	43.5 (2,656)	43.3 (2,641)	
No	8.7 (2,102)	8.6 (1,043)	8.7 (1,059)		7.7 (938)	7.6 (466)	7.7 (472)	
Unknown	47.6 (11,533)	47.7 (5,781)	47.4 (5,752)		48.9 (5,963)	48.8 (2,977)	49.0 (2,986)	
Insulin used	1.6 (389)	1.7 (207)	1.5 (182)	0.201	1.9 (236)	1.8 (111)	2.0 (125)	0.357
Enrolment of co-intervention	10.2 (2,473)	10.2 (1,233)	10.2 (1,240)	0.882	9.7 (1,185)	9.6 (588)	9.8 (597)	0.783

Factor	PEP Participants vs non-PEP Participants				PEP Completers vs non-PEP Participants			
	Total (N=24,250) % (N)	PEP (N=12,125) % (N)	Non-PEP (N=12,125) % (N)	P-value	Total (N=12,198) % (N)	PEP (N=6,099) % (N)	Non-PEP (N=6,099) % (N)	P-value
on/before baseline								
History of macrovascular events on/before baseline	5.6 (1,353)	5.6 (676)	5.6 (677)	0.978	5.8 (706)	5.7 (350)	5.8 (356)	0.816
History of microvascular events on/before baseline	6.6 (1,608)	6.6 (800)	6.7 (808)	0.836	6.0 (727)	6.1 (371)	5.8 (356)	0.566
Number of severe hypoglycemic events on/before baseline				0.960				0.540
0	99.7 (24,166)	99.7 (12,084)	99.6 (12,082)		99.7 (12,158)	99.7 (6,080)	99.7 (6,078)	
1	0.3 (69)	0.3 (34)	0.3 (35)		0.3 (39)	0.3 (18)	0.3 (21)	
≥2	0.1 (15)	0.1 (7)	0.1 (8)		0.0 (1)	0.0 (1)	0.0 (0)	

Note:

PEP=Patient Empowerment Programme; BMI=Body mass index; HDL=High-density lipoprotein; TC=Total cholesterol; LDL=Low-density lipoprotein; eGFR=estimated Glomerular Filtration Rate ; T2DM=Type 2 Diabetes Mellitus;

* p-value<0.05

Table 2. Number and incidence rate of episodes of all-cause hospitalization and emergency department visit

Event	Number of cases	Initial episode of event during the period						Frequency of episode event during the period			
		Total PYs	Median follow-up period (Months)	Cumulative incidence		Incidence rate		Total PYs	Number of events	Incidence rate	
				Cases with event	Rate	Cases/ 100 PYs	95% CI*			Cases/ 100 PYs	95% CI*
Total (N=24,250)											
All-cause hospitalization	24,250	54,843	30.5	5,733	0.2364	10.454	(10.185,10.728)	61,801	11,390	18.430	(18.093,18.772)
Emergency department visit	24,250	47,251	26.5	10,244	0.4224	21.680	(21.262,22.104)	61,801	23,662	38.287	(37.801,38.778)
PEP Participants (N=12,125)											
All-cause hospitalization	12,125	27,625	27.5	2,679	0.2209	9.698	(9.334,10.072)	30,916	5,218	16.878	(16.423,17.342)
Emergency department visit	12,125	23,882	25.5	4,909	0.4049	20.555	(19.984,21.138)	30,916	11,177	36.153	(35.486,36.829)
Non-PEP Participants (N=12,125)											
All-cause hospitalization	12,125	27,217	30.5	3,054	0.2519	11.221	(10.826,11.626)	30,885	6,172	19.984	(19.488,20.489)
Emergency department visit	12,125	23,369	29.5	5,335	0.4400	22.829	(22.221,23.450)	30,885	12,485	40.424	(39.718,41.139)

Note:

PEP=Patient Empowerment Programme; PYs=Person-years; CI=Confidence interval

* The 95%CI was constructed based on Poisson Distribution

Table 3. Multivariable analysis of the effect of PEP on the dependent variable of all-cause hospitalization and emergency department visit, adjusted for the socio-demographic and clinical characteristics

	Cox proportional hazard regression				AIC	BIC	Harrell's C-statistic
Initial episode of event during the period	HR†	se	95%CI	P-value			
PEP Participants vs non-PEP Participants (N=24,250)							
All-cause hospitalization	0.879	0.024	(0.834,0.926)	<0.001*	111,064	111,266	0.648 (0.640,0.655)
Emergency department visit	0.901	0.018	(0.867,0.937)	<0.001*	199,093	199,295	0.573 (0.567,0.579)
Sensitivity Analysis, PEP Completers vs non-PEP Participants (N=12,198)							
All-cause hospitalization	0.835	0.033	(0.773,0.901)	<0.001*	48,838	49,023	0.655 (0.644,0.666)
Emergency department visit	0.890	0.025	(0.842,0.942)	<0.001*	90,832	91,017	0.577 (0.568,0.585)
	Negative binomial regression				AIC	BIC	Likelihood test with null model
Frequency of episode event during the period	IRR‡	se	95%CI	P-value			
PEP Participants vs non-PEP Participants (N=24,250)							
All-cause hospitalization	0.854	0.034	(0.789,0.924)	<0.001*	56,310	56,529	1293.96*
Emergency department visit	0.903	0.020	(0.864,0.944)	<0.001*	65,549	65,767	697.88*
Sensitivity Analysis, PEP Completers vs non-PEP Participants (N=12,198)							
All-cause hospitalization	0.754	0.044	(0.672,0.846)	<0.001*	26,880	27,080	639.94*
Emergency department visit	0.857	0.028	(0.805,0.913)	<0.001*	32,170	32,370	386.16*

Note:

HR=Hazard Ratio; se=Standard error; AIC=Akaike information criterion; BIC=Bayesian information criterion; IRR=Incidence rate ratio

* p-value<0.05

† HR>1 indicates greater risk for initial episode of event

‡ IRR>1 indicates greater risk for episodes of event

Figure 1 Kaplan-Meier Survival Curves for All-cause Hospitalization and Emergency Department Visit