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Influence of health education on clinical parameters in type 2 diabetic subjects with and without hypertension: A longitudinal, comparative analysis in routine primary care settings

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ABSTRACT

Aim: To assess the influence of health education for type 2 diabetic patients with and without coexisting hypertension in routine primary care where intensive educational consultations were absent.

Methods: A longitudinal cohort was constructed from 342 diabetic subjects who previously had regular exposure to face-to-face health education delivered quarterly during 2016–2017 under the national basic public health (BPH) service provision in an urbanised township in China. Clinical parameters were retrieved electronically from computerised BPH data platform at prior check-ups (2016–2017) and at the most recent check-up (2019).

Results: The satisfactory clinical improvements upon health education were not sustained during subsequent observational years among study subjects. A significant increase in total cholesterol (0.28 mmol/L for between-group net changes, 95% confidence interval [CI] = 0.01–0.55 mmol/L, $p = 0.039$) were observed in diabetic subjects with coexisting hypertension. Older patients (adjusted odds ratio [aOR] = 0.87, 95%CI = 0.83–0.91, p less than 0.001), males (aOR = 0.50, 95%CI = 0.26–0.98, $p = 0.043$), and subjects with lower education level (aOR = 0.34, 95%CI = 0.17–0.67, $p = 0.002$) were less likely to maintain improvement of

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biomedical parameters.

Conclusion: The influence of face-to-face health education may not be prolonged in routine primary care where intensive provisions of educational consultations were less common. Diabetic patients with coexisting hypertension tend to have more difficulties in maintaining optimal lipid profiles.

1. Introduction

Diabetes mellitus is a worldwide health problem with increasing rates of impaired functional status, morbidity, disability, and mortality [1–2]. Elevated fasting plasma glucose (FPG) level was the third most common global risk factor for disability-adjusted life years in 2017 [3]. A most recent global modelling study in 2020 suggested that people with chronic conditions, such as diabetes, are at increased risk of severe COVID-19 [4]. The prevalence of diabetes among adults aged 20–79 years throughout the world has reached 9.3% [5]. In China, the weighted prevalence of diabetes has increased to 11.2% in 2017 [6]. The prevention and management of diabetes complications represent a tremendous, continuing challenge for front-line clinicians, patients, and their families. People with diabetes often have high blood pressure (BP) and are at increased risk for cardiovascular disease [7–9]. There is a wealth of evidence that lowering BP can substantially reduce premature morbidity and mortality [10].

In view of the rising trend of long-term conditions such as diabetes and hypertension, China's ongoing health-care reforms have invested in a nation-wide basic public health (BPH) service provision to improve equitable primary care access and reduce the burden of long-term conditions [11–13]. The 'Healthy China' initiative, originally endorsed in October 2015 and subsequently underpinned by the 'Healthy China Action (2019–2030)', has become a national strategy with an ambitious goal of improving population health [14–15]. The service model entitled 'family doctor team', characterised by general medical practitioners (GPs) working within multidisciplinary primary care teams based on population-based health-care registration, has been piloted in China since 2016 [16]. The goal is to enable systematic preventive care including annual health check-ups and tailor-made health advice, in which health education programmes with intensive consultations are embedded to support patients' self-management. All registered diabetic and hypertensive patients are expected to benefit from improved knowledge, capacity building, and self-care behaviours for blood glucose and BP control.

However, due to the availability of routine manpower and clinical resources in primary care settings, most face-to-face health education were difficult to continue for more than 12 months on a regular basis. The hypothesis that the beneficial influence of health education upon completion is sustainable needs to be further tested in the subsequent years with the absence of actively-provided, intensive consultation sessions in routine care. From a multimorbidity perspective, whether type 2 diabetic patients with the coexistence of hypertension are more prone to poorer health outcomes also remains largely uncertain.

The main objective of this study was to compare the influence of health education on clinical parameters between diabetic subjects with and without hypertension in routine primary care settings. The study also aimed to explore socio-demographic factors that were associated with a patient's ability to maintain improvement of clinical parameters during observational follow-up in the study.

2. Methods

2.1. Study design

This was a longitudinal study conducted in the context of the free-of-charge, national basic public health (BPH) service provision in primary care [17]. A cohort of diabetic subjects were followed up from their initial check-up attendance in 2016, at the prior check-up upon regular exposure to health education consultations in 2017, and at the most recent check-up attendance in 2019. Changes in clinical parameters were compared between diabetic participants with and without coexisting hypertension at observational follow-up in routine primary care (Fig. 1).

2.2. Setting and data source

The check-ups were performed onsite at local community health centres (CHCs) in Shishan, an urbanised township consisting of 47 communities with a resident population size of 0.8 million in Guangdong province, southern China. During the pilot delivery of the 'family doctor team' service package in primary care, a total of 48,874 individuals aged ≥ 35 years attended check-ups in 2016. All patients newly diagnosed with type 2 diabetes (N = 3,104) were offered a series of face-to-face health education consultations at CHCs on a quarterly basis for one year. Each individualised educational series lasted approximately 30 min, including mixed review sessions on the patient's blood glucose records, lifestyle behaviours, and physician-prescribed medications, coupled with interactive counselling sessions to discuss clinical recommendations, skill building, and management plans for self-care in detail. Patients enrolled in the health-care registration and had prior, regular exposure to all consecutive educational sessions (N = 342) were subsequently followed up with routine care only for two years (Fig. 1). There were no specific educational services additionally delivered during routine care, and only sparse and scattered pieces of short instruction on self-care were given over the phone, or when necessary,

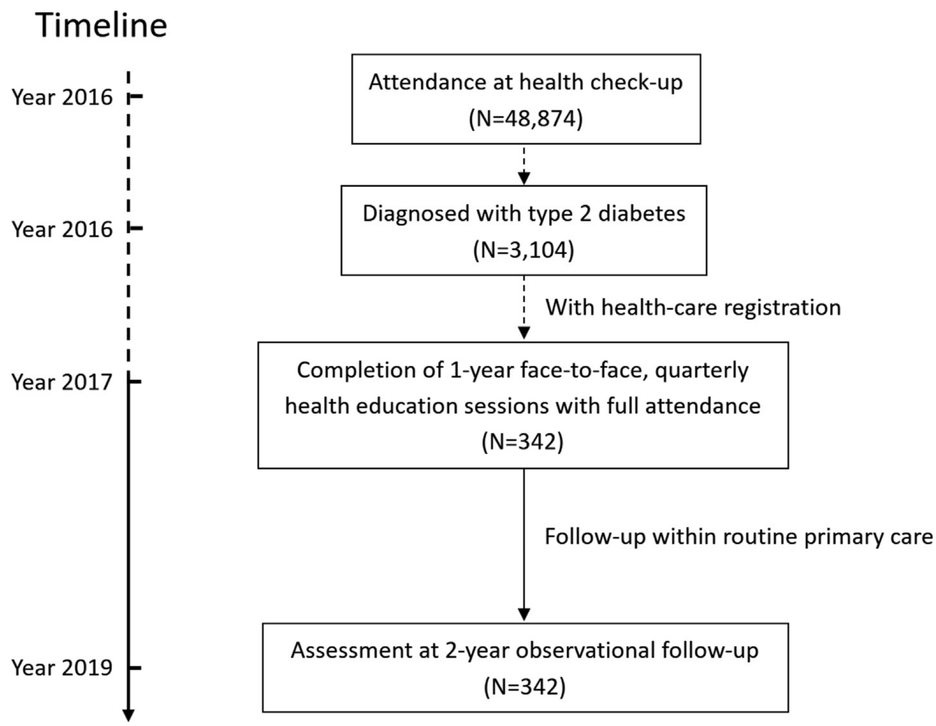

Fig. 1 – Study flow and timeline.

within the context of time-limited clinical encounters for episodic treatment. At each check-up, the public health staff at CHCs documented the individuals' health reports electronically on the BPH service platform where computerised data were captured in the study.

2.3. *Participants*

The study participants were adults newly diagnosed with type 2 diabetes by physicians during the initial health check-up, irrespective of the presence of coexisting hypertension, who had prior exposure to the intensive face-to-face health education consultations delivered from 2016 to 2017. Diabetes was defined as fasting plasma glucose (FPG) $\geq$ 7.0 mmol/L. Hypertension was defined as systolic blood pressure (SBP) $\geq$ 140 mmHg and/or diastolic blood pressure (DBP) $\geq$ 90 mmHg on repeated clinical measurements, or under antihypertensive therapy. Those who were not enrolled in the population-based health-care registration, or were absent in any of the four consecutive educational sessions, were excluded.

2.4. *Study variables and measurements*

Information on basic characteristics including age, gender, education level, and household income were collected at the point of health check-up. Individual's self-management profiles were assessed before and after the health education consultations using an interviewer-administered questionnaire. The presence of self-reported unhealthy daily lifestyles included barefoot walking, cigarette smoking, non-scheduled meals, and having aerobic exercise less than 30 min daily. Aerobic activities referred to moderate-to-vigorous physical activities such as brisk walking, jogging, swimming, Tai Chi, or dancing. The frequencies of physician-recommended behaviours, including the regularity of blood glucose monitoring at home, foot self-monitoring, and regular medication taking as prescribed per week, were recorded. Clinical parameters were retrieved electronically from the routine computerised BPH data platform at prior check-ups (2016–2017) and at the most recent check-up (2019). BP was measured in a seated position by routinely validated automatic sphygmomanometers. The arm with the higher BP values was used. The average of two BP readings, 1–2 min apart, was recorded. A venous blood sample at fasting was collected and FPG was determined by enzymatic methods according to routine operating procedures. The lipid profiles including plasma cholesterol and triglycerides were all directly measured in the fasting states. All the onsite measurements including laboratory tests have internal quality control in accordance with clinical standard.

2.5. *Statistical analysis*

Descriptive analysis was performed to describe the basic characteristics of study participants. Independent *t*-tests or chi-square tests, where appropriate, were used to compare type 2 diabetic patients with and without coexisting hypertension. Within-group differences between time points were assessed using paired *t*-test, whereas between-group differences were assessed as net changes with 95% confidence interval [CI] at routine check-ups. Participants who had BP, blood glucose, lipid parameters, and body mass index (BMI) levels improved between 2017 and 2019, or had these improved profiles maintained unchanged overtime since 2017, were regarded as having the ability to maintain improvement of clinical parameters. A binary, multiple logistic regression model was constructed to explore socio-demographic factors associated with patients' ability to maintain long-term health improvement, after adjusting for patient-level confounders. We used a 15:1 rule for regression analysis where a minimum number of 315 participants was required for a regression model consisting of up to 21 independent predictor categories. Data analyses were conducted using R (version 3.5.3). A p value less than 0.05 was considered statistically significant.

2.6. *Ethics consideration*

All study participants provided written consent upon the enrolment registration with primary care teams at the CHCs. Data anonymisation was performed by removing all subject identifiers from the dataset prior to data analysis. Ethics approval was initially granted and subsequently renewed from the School of Public Health Biomedical Research Ethics Review Committee at Sun Yat-Sen University (Refs: SYSU-SPH2016027 and SYSU-SPH2019032), respectively, in accordance with the Declaration of Helsinki 2013.

3. Results

3.1. *Characteristics of study subjects*

A total of 342 eligible patients diagnosed with type 2 diabetes from health-care registration at 2016 were included in the comparative, follow-up analysis. More than half (58.8% [201/342]) of study subjects had coexisting hypertension. This group of subjects were older (mean age 69.0 ± 7.8 years *versus* 66.8 ± 9.0 years, p = 0.014), and had greater SBP (130.6 ± 10.2 mmHg *versus* 126.6 ± 8.0 mmHg, p less than 0.001) and slightly higher BMI levels (24.9 ± 3.5 *versus* 24.2 ± 3.5, p = 0.049) than their counterparts without hypertension. There were no significant differences in the distribution of sex (p = 0.944), education level (p = 0.108), household income (p = 0.803), and other biomedical parameters between the two groups. (Table 1).

3.2. *Comparison of self-management profiles between groups*

Both groups demonstrated reductions in unhealthy daily lifestyles and increases in practicing recommended behaviours per week, upon prior exposure to 1-year face-to-face health education consultations. In particular, a greater proportion of people were unable to maintain daily scheduled meals (28.4% *versus* 15.6%, p = 0.006) and adequate physical exercises (29.4% *versus* 17.7%, p = 0.014) among participants with coexisting hypertension compared to those with normal BP. Similar patterns were observed in the frequency of home blood glucose monitoring (2.59 days *versus* 3.03 days, p = 0.048) and regular medication taking (5.32 days *versus* 5.61 days, p = 0.041) per week between the two groups (Table 2).

3.3. *Trends of biomedical parameters between enrolment registration and follow-up*

When compared to enrolment registration, clinical parameters including SBP, FPG, plasma cholesterol, triglycerides, and BMI levels were improved with a varying degree in all study participants at prior health check-up of 2017. In particular, a greater within-group reduction in SBP was observed in diabetic subjects with coexisting hypertension (−2.74 mmHg) compared to those without hypertension (−0.80 mmHg), accompanying a statistically significant between-group net changes (−1.94 mmHg, 95%CI: −3.64 mmHg to − 0.23 mmHg, p = 0.026) (Table 3).

The satisfactory improvements of clinical outcomes demonstrated were not sustained in both groups during the subsequent observational years between 2017 and 2019. Except for BMI, both groups exhibited consistent increases in BP, FPG, total cholesterol (TC), and triglycerides levels. A significant increase in TC level (0.28 mmol/L for between-group net changes, 95%CI: 0.01 mmol/L to 0.55 mmol/L, p = 0.039) was observed in diabetic subjects with hypertension (Table 4). No deaths or serious adverse events occurred during the observational follow-up.

3.4. *Factors associated with patient's ability to maintain improvement of biomedical parameters*

Multiple regression analysis revealed a significant association between socio-demographic factors and patient's ability to maintain improvement of clinical parameters. The presence (or absence) of hypertension did not significantly influence the long-term health outcomes. Older patients (adjusted odds ratio [aOR] = 0.87, 95%CI: 0.83 to 0.91, p less than 0.001), males (aOR = 0.50, 95%CI: 0.26 to 0.98, p = 0.043), and those with lower education level (aOR = 0.34, 95%CI: 0.17 to 0.67, p = 0.002) were less likely to maintain improvement of clinical parameters (Table 5).

4. Discussion

4.1. *Main findings*

Our observation suggested that the influence of health education was unable to be maintained among people newly diagnosed with type 2 diabetes, irrespective of the presence of coexisting hypertension, in the context that no intensive education sessions were given on top of routine care. Although participants with concurrent hypertension exhibited an immediate, greater drop in BP than their counterparts without hypertension, both groups had their BP increased again in the subsequent observational years. Participants with hypertension on top of diabetes were more likely to have difficulties in maintaining lipid profiles particularly the total cholesterol level. Socio-demographic factors were significantly associated with patient's ability to maintain the improvement of clinical parameters.

Table 1 – Basic characteristics of study participants.

	Total (N = 342)	Without hypertension (n = 141)	With hypertension (n = 201)	P-value
Age, years	68.1 (8.4)	66.8 (9.0)	69.0 (7.8)	**0.014**
Age groups				
Below 60 years	43 (12.6%)	24 (17.0%)	19 (9.5%)	**0.038**
60 years or above	299 (87.4%)	117 (83.0%)	182 (90.5%)	
Gender				
Female	236 (69.0%)	97 (68.8%)	139 (69.2%)	0.944
Male	106 (31.0%)	44 (31.2%)	62 (30.8%)	
Education level				
Primary school or below	260 (76.0%)	99 (70.2%)	161 (80.1%)	0.108
Junior secondary school	70 (20.5%)	36 (25.5%)	34 (16.9%)	
Senior secondary school or above	12 (3.5%)	6 (4.3%)	6 (3.0%)	
Household income level				
Below CNY1,000	73 (21.3%)	33 (23.4%)	40 (19.9%)	0.803
CNY1,000–2,999	190 (55.6%)	78 (55.3%)	112 (55.7%)	
CNY3,000–4,999	65 (19.0%)	24 (17.0%)	41 (20.4%)	
CNY5,000 or above	14 (4.1%)	6 (4.3%)	8 (4.0%)	
Biomedical parameters				
SBP, mmHg	128.97 (9.58)	126.62 (8.01)	130.62 (10.24)	**<0.001**
DBP, mmHg	77.05 (5.78)	76.62 (5.10)	77.35 (6.21)	0.247
FPG, mmol/L	6.93 (2.13)	6.95 (2.44)	6.92 (1.89)	0.897
TC, mmol/L	5.55 (1.37)	5.55 (1.64)	5.56 (1.16)	0.930
LDL-C, mmol/L	2.98 (0.91)	3.09 (0.97)	2.91 (0.86)	0.117
HDL-C, mmol/L	1.32 (0.41)	1.34 (0.38)	1.30 (0.43)	0.487
TG, mmol/L	2.40 (1.79)	2.42 (1.64)	2.39 (1.89)	0.891
BMI, kg/m^2	24.62 (3.50)	24.17 (3.52)	24.93 (3.45)	**0.049**

Data are presented as n (%) or mean (SD) where appropriate. Independent *t*-tests or Chi-square tests, where appropriate, were used to compare diabetic subjects with and without coexisting hypertension.
SBP = systolic blood pressure; DBP = diastolic blood pressure; FPG = fasting plasma glucose; TC = total cholesterol; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; TG = triglyceride; BMI = body mass index.

4.2. *Relationship with other studies*

International guidelines recommended that appropriate health education and community-based management, apart from medical treatment, are needed to empower self-monitoring of blood glucose, smoking cessation, dietary restrictions, daily exercise and regular foot care to reduce the incidence or advancement of diabetes-related complications [18]. Previous studies have documented benefits of intensified diet education, supervised exercise, individualised weight consultation, and self-monitoring on lowering blood glucose, BP, and lipid profiles [19]. A large retrospective cohort study with an average length of follow-up time per patient of almost 7 years in the United States suggested that persistent lifestyle counselling had lasting influence in primary care patients, and that benefits were better achieved in subjects who were counselled at least once a month [20]. Another retrospective study in the US showed that intensive lifestyle counselling at least monthly can reduce the risk of cardiovascular diseases and mortality among a cohort of diabetic patients [21]. However, most existing studies adopted a research design that involved active and intensive provisions of care during the entire investigation period. This may not be widely feasible in routine primary care settings where existing clinical capacity and daily manpower are limited to enable resource-demanding provision of care.

In contrast to previous studies that investigated the ‘immediate’ effect in health outcomes upon the completion of health education, our focus of the present study was on the extent to which such improved health outcomes could be sustained in the long term. The satisfactory short-term improvements in SBP, FPG, plasma cholesterol, triglycerides, and BMI levels observed during prior intensive exposure to health education were largely in line with conclusions drawn from a review of diabetes education in China [22]. Our observation that these improvements were unable to be sustained in the subsequent two years of follow-up was interesting as few studies have thus far evaluated whether the immediate, positive improvements could be durable in resource-limited settings over time. Although existing evidence from a low-resource setting supported the long-term effectiveness of a self-management programme in maintaining key achieved gains, active emotional and behavioural supports were continuously provided through weekly sessions delivered by volunteer peer leaders, whereas improvements were not sustained among subjects in the usual care group [23]. A recent study conducted in the UK showed that voluntary sector-led programmes were capable of reaching a wide and diverse range of the local population, yet the programme exerted no significant impacts on BP and blood glucose levels [24]. Hence, additional research is clearly needed to seek appropriate ways of providing continuous support to ensure the long-term sustainability of health outcomes in resource-poor settings.

Diabetes and hypertension are the two most common long-term conditions, and patients with either hypertension or diabetes are 1.5 to 2.0 times more likely to suffer from both conditions than the general population [25]. Epidemiological

Table 2 – Comparison of self-management profiles between groups upon prior exposure to health education.

	Without hypertension		With hypertension		*P*[*]	*P*[†]
	At registration	Upon exposure	At registration	Upon exposure		
Presence of unhealthy daily lifestyles						
Walk barefoot	26 (18.4%)	5 (3.5%)	55 (27.4%)	9 (4.5%)	0.056	0.669
Smoking	13 (9.2%)	11 (7.8%)	15 (7.5%)	14 (7.0%)	0.560	0.770
Cannot maintain the timing of meals	62 (44.0%)	22 (15.6%)	92 (45.8%)	57 (28.4%)	0.742	**0.006**
Less than 30 min of aerobic activities daily	84 (59.6%)	25 (17.7%)	106 (52.7%)	59 (29.4%)	0.210	**0.014**
Frequencies of behaviours per week						
Home glucose monitoring, days	2.84 (2.05)	3.03 (2.06)	2.46 (1.93)	2.59 (2.00)	0.087	**0.048**
Foot self-monitoring, days	2.52 (2.11)	3.50 (2.11)	2.08 (2.10)	3.21 (2.16)	0.062	0.211
Medication taking at regular times, days	4.75 (1.77)	5.61 (1.24)	4.78 (1.80)	5.32 (1.29)	0.901	**0.041**
Taking medications as prescribed, days	4.88 (1.73)	5.76 (1.37)	4.99 (1.78)	5.64 (1.28)	0.567	0.419

Data are presented as n (%) or mean (SD) where appropriate. Chi-square tests or independent *t*-tests, where appropriate, were used to compare diabetic subjects with and without coexisting hypertension.

Aerobic activities refer to moderate-to-vigorous physical activities such as brisk walking, jogging, swimming, Tai Chi or dancing.

[*] Subjects without hypertension *versus* subjects with hypertension at health-care registration.

[†] Subjects without hypertension *versus* subjects with hypertension upon exposure to health education.

Table 3 – Changes of clinical parameters of study participants between 2016 and 2017.

2016–2017	Within-group changes		Between-group net changes with 95%CI	P-value
	Subjects without hypertension	Subjects with hypertension		
SBP, mmHg	−0.80	−2.74*	−1.94 (−3.64, −0.23)	**0.026**
DBP, mmHg	0.07	−0.40	−0.47 (−1.57, 0.63)	0.397
FPG, mmol/L	−0.48§	−0.44*	0.04 (−0.37, 0.46)	0.839
TC, mmol/L	−0.09	−0.22*	−0.13 (−0.31, 0.05)	0.159
LDL-C, mmol/L	−0.04§	−0.07§	−0.03 (−0.11, 0.05)	0.412
HDL-C, mmol/L	0.00	0.03	0.03 (−0.02, 0.07)	0.223
TG, mmol/L	−0.18	−0.18§	0.00 (−0.24, 0.25)	0.986
BMI, kg/m^2	−0.14	−0.13	0.01 (−0.41, 0.43)	0.960

CI = confidence interval.

SBP = systolic blood pressure; DBP = diastolic blood pressure; FPG = fasting plasma glucose; TC = total cholesterol; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; TG = triglyceride; BMI = body mass index.

* Within-group changes with *P*-value less than 0.001

§ Within-group changes with *P*-value less than 0.05

Table 4 – Changes of clinical parameters of study participants between 2017 and 2019.

2017–2019	Within-group changes		Between-group net changes with 95%CI	P-value
	Subjects without hypertension	Subjects with hypertension		
SBP, mmHg	2.36†	2.34†	−0.02 (−2.37, 2.33)	0.988
DBP, mmHg	0.80	0.77	−0.03 (−1.46, 1.40)	0.969
FPG, mmol/L	0.20	0.31§	0.11 (−0.36, 0.58)	0.637
TC, mmol/L	0.04	0.33*	0.28 (0.01, 0.55)	**0.039**
LDL-C, mmol/L	−0.06	0.04	0.10 (−0.11, 0.30)	0.363
HDL-C, mmol/L	−0.04	−0.01	0.03 (−0.08, 0.14)	0.618
TG, mmol/L	0.04	0.06	0.03 (−0.32, 0.38)	0.877
BMI, kg/m^2	−0.37	−0.57	−0.20 (−0.82, 0.42)	0.523

CI = confidence interval.

SBP = systolic blood pressure; DBP = diastolic blood pressure; FPG = fasting plasma glucose; TC = total cholesterol; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; TG = triglyceride; BMI = body mass index.

* Within-group changes with P-value less than 0.001

† Within-group changes with P-value less than 0.01

§ Within-group changes with P-value less than 0.05

Table 5 – Socio-demographic factors associated with patient's ability to maintain improvement of biomedical parameters.

	Univariate model		Multivariate model	
	cOR (95%CI)	*P*	aOR (95%CI)	*P*
Age, years	0.86 (0.83–0.90)	**<0.001**	0.87 (0.83–0.91)	**<0.001**
Gender				
Female	1.00 (Ref)		1.00 (Ref)	
Male	0.92 (0.57–1.50)	0.741	0.50 (0.26–0.98)	**0.043**
Education level				
Junior secondary school or above	1.00 (Ref)		1.00 (Ref)	
Primary school or below	0.30 (0.18–0.50)	**<0.001**	0.34 (0.17–0.67)	**0.002**
Household income level				
Below CNY1,000	1.00 (Ref)		1.00 (Ref)	
CNY1,000–2,999	1.10 (0.62–1.97)	0.737	1.00 (0.50–2.01)	0.999
CNY3,000–4,999	1.19 (0.59–2.42)	0.630	0.97 (0.40–2.35)	0.951
CNY5,000 or above	0.87 (0.25–3.07)	0.828	0.39 (0.08–1.87)	0.239

cOR = crude odds ratio; aOR = adjusted odds ratio.

In the multivariate model, odds ratios were adjusted by the presence of hypertension, unhealthy daily lifestyles (i.e., walk barefoot, smoking, cannot maintain the timing of meals, less than 30 min of aerobic exercise daily), frequencies of behaviours per week (i.e., home blood glucose monitoring, foot self-monitoring, and medication taking), and all other socio-demographic variables.

findings suggested that a series of vascular and neurological injuries caused by diabetes can trigger the development of hypertension [26], and that the coexistence of elevated BP could lead to both microvascular and macrovascular damage, predisposing diabetic patients to cardiovascular disease, stroke, chronic kidney disease and retinopathy, with an increased risk of adverse outcomes [25,27]. We demonstrated from a multimorbidity perspective that diabetic subjects with concomitant hypertension had more difficulties in maintaining lipid levels in daily life. Although considerable debates exist about the target BP that should be achieved in diabetic patients, substantial evidence have supported the benefits of BP reduction alongside the glycaemic control [10,28,29]. In light of a rapid increase in the number of people living with multiple long-term conditions (multimorbidity) [30], the complexity of conditions and the existence of 'patient inertia' may prevent people from taking active steps to improve their behaviours despite physicians' recommendations [31]. Therefore, strategies to target subjects who may be less likely to maintain optimal health status are crucial in the research agenda.

4.3. *Meaning of the study*

Community-based health management of diabetes and hypertension has been a major priority for re-strengthening primary care worldwide and particularly in China. The enrolment rate of health-care registration was relatively low at the study commencement in 2016, during when the concept of 'family doctor team' was initially translated from key attributes of primary care [13] into practice. An intensive health education was universally available for all people newly diagnosed with type 2 diabetes to increase the enrolment rate in the study area. As the health-care registration size expanded across China, the provision of such intensified preventive care becomes increasingly time-consuming and resource-demanding in daily care. As shown in this longitudinal study using real-world data captured from routine health check-ups, improvements of clinical parameters were not durable for long term in the absence of continuing educational support. There are several implications of our findings, which build on prior research. Firstly, we targeted those newly diagnosed with diabetes who had optimal compliance to clinic-based service provision, as reflected by attendances of all face-to-face health education at CHCs, to maximise the extent of which health outcomes could be changed over subsequent observational years. Secondly, it was possible that the follow-up changes in BP we observed from 2017 to 2019 could be an expected increase with normal ageing, as old age was identified as an independent risk factor in the analysis. Thirdly, male gender and low education level were found to be negatively associated with patient's ability to maintain improvement of health status. This might be partly explained by common understanding that males tend to be less health conscious than females, or that men are more prone to physically challenging or hazardous occupations in developing countries albeit information on employment details were not collected. Further in-depth investigations on the combination of physical, mental, and social differences might contribute to the understanding of long-term impact of gender differentials in health among people with diabetes in routine care. Alongside the exploration of practical models to empower diabetic patients with the coexistence of common long-term conditions, formulations of novel model to deliver educational consultation in patients with inadequate advanced education are of equal importance to deepen their insights into the disease and improve intrinsic motivation to pursue self-management skills [32–33].

4.4. *Strengths and weakness of the study*

We constructed a long-term observational cohort in which clinical outcomes of study subjects were evaluated over time in routine primary care setting with minimal loss to follow-up. Objective measures were used to assess the influence of health education to avoid subjective bias. All clinical measures including routine laboratory tests were performed according to a standard protocol with quality control. The clinical data were retrieved from routine, computerised BPH platform to ensure data completeness and accuracy. However, our study had several limitations. Firstly, we did not adopt a trial design that included a 'pure' control group. It is worth noting that the main purpose of the study was not to evaluate the contribution of health education *per se*. Instead, we are interested to assess whether improved health outcomes associated with health education intensively offered only on a temporary basis could be long lasting in the absence of continuing educational support. This also enabled a further exploration on whether the presence of comorbid hypertension on top of diabetes was more prone to poorer, long-term health outcomes. Secondly, the use of assessment questionnaire on subjects' self-management profiles was not part of the real-world provision of national BPH service package, and such information were unavailable at the latest follow-up. However, the existing data collected have adequately shown that immediately improved self-management capacities were not associated with the long-term sustainability of improved biomedical parameters. The current knowledge gap on how acquired capabilities can be permanently translated into better health outcome necessitates future large-scale investigations. Thirdly, we did not collect information on other potential confounders, such as the categories of medications and patients' experiences of primary care [34] that may be associated with health outcomes. However, the primary care settings in the study were of the same organisational model and all medical treatments were physician-prescribed according to the existing clinical practice guidelines. Thus, the impact of heterogeneity in the process of care on health outcomes can be considered minimal.

5. Conclusion

The influence of face-to-face health education may not be prolonged in routine primary care settings where provisions of intensive educational consultations during clinical encounters were less common. Further efforts are needed to optimise routine care delivery for subjects with risk factors identified in the study, and in particular, diabetic patients with coexisting hypertension as they may have more difficulties in maintaining optimal lipid profiles.

Author contributions

HHXW and XJH conceived the idea of the study. HFW participated in the data collection and coordination. Data analysis was conducted by XJH and YTL. All authors contributed to the literature search and interpretation of the data. XJH and HHXW wrote the first draft. All authors have read, contributed to, and approved the final version of the manuscript.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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