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Impact of family doctor system on diabetic patients with distinct service utilisation patterns: a difference-in-differences analysis based on group-based trajectory modelling

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ABSTRACT

Introduction This study examines the impact of China's family doctor system (FDS) on healthcare utilisation and costs among diabetic patients with distinct long-term service utilisation patterns.

Methods Conducted in City A, eastern China, this retrospective cohort study used data from the Health Information System and Health Insurance Claim Databases, covering diabetic patients from 1 January 2014 to 31 December 2019.

Patients were categorised into service utilisation trajectories based on quarterly outpatient visits to community health centres (CHCs) and secondary/tertiary hospitals from 2014 to 2017 using group-based trajectory models. Propensity score matching within each trajectory group matched FDS-enrolled patients (intervention) with non-enrolled patients (control). Difference-in-differences analysis compared outcomes between groups, with a SUEST test for cross-model comparison. Outcomes included outpatient visits indicator, costs indicator and out-of-pocket (OOP) expenses.

Results Among 17 232 diabetic patients (55.21% female, mean age 62.85 years), 13 094 were enrolled in the FDS (intervention group) and 4138 were not (control group). Patients were classified into four trajectory groups based on service utilisation from 2014 to 2017: (1) low overall outpatient utilisation, (2) high CHC visits, (3) high secondary/tertiary hospital visits and (4) high overall outpatient utilisation. After enrolled in FDS From 2018 to 2019, the group with high secondary/tertiary hospital visits saw a 6.265 increase in CHC visits (225.4% cost increase) and a 3.345 decrease in hospital visits (55.5% cost reduction). The high overall utilisation group experienced a 4.642 increase in CHC visits (109.5% cost increase) and a 1.493 decrease in hospital visits. OOP expenses were significantly reduced across all groups.

Conclusion The FDS in China significantly increases primary care utilisation and cost, while reducing hospital visits and costs among diabetic patients, particularly among patients with historically high hospital usage. Policymakers should focus on enhancing the FDS to further encourage primary care usage and improve chronic disease management.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Previous studies have shown that the family doctor system (FDS) generally increases primary care utilisation and reduces unnecessary hospital visits and medical costs in countries such as the UK, Australia and Canada.
⇒ However, in China, FDS's impact is inconsistent; some studies report reductions in hospital visits, improved primary care usage and cost reduction, while others find no significant changes in patient behaviour or healthcare costs.

WHAT THIS STUDY ADDS

⇒ This study categorises diabetic patients into four distinct groups based on historical service utilisation patterns: (1) low overall outpatient utilisation, (2) high community health centre (CHC) visits, (3) high secondary/tertiary hospital visits and (4) high overall outpatient utilisation.
⇒ It examines the heterogeneous effects of the FDS across these patient groups.
⇒ The findings reveal that the FDS significantly increases CHC visits and costs while reducing hospital visits and costs, particularly among patients with historically high hospital usage.
⇒ FDS enrolment led to no significant changes in hospitalisation costs or total medical expenses across all groups, but it significantly reduced out-of-pocket costs.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study underscores the need for targeted FDS services that address the specific needs of different patient groups.
⇒ Policymakers should focus on enhancing the quality and accessibility of CHC services to encourage a shift from secondary/tertiary care to primary care, ultimately reducing healthcare costs and improving chronic disease management.

INTRODUCTION

As advocated by the WHO, a well-established family doctor system (FDS) lays a solid foundation for the effective management of chronic diseases and encourages patients to seek medical care in primary healthcare institutions.[1] For patients with chronic diseases, seeking medical care in primary healthcare institutions is crucial as it ensures continuous, accessible and coordinated care, which can lead to better management of their conditions, reduced complications and overall lower healthcare costs.[1] Despite the lack of restrictions in China's healthcare system on patients' choice of medical institutions,[2] patients with chronic diseases often rely on secondary or tertiary hospitals for long-term treatment,[3–5] which can exacerbate imbalances in medical resource distribution and continuity of care issues.[6 7]

In recent years, China's healthcare reform has seen significant advancements, particularly through the implementation of the FDS.[7] The FDS is designed to streamline healthcare delivery by encouraging patients to use primary care services at community health centres (CHCs) before seeking higher-level care. By serving as gatekeepers, family doctors not only enhance chronic disease management through continuous and coordinated care but also reduce the burden on secondary and tertiary hospitals.[8 9] This redirection of patient flow is expected to optimise resource utilisation across healthcare institutions, ultimately influencing healthcare costs and enhancing the efficiency of the overall system.[8 10 11] Evaluating the FDS's effectiveness in altering patients' long-term service utilisation patterns and directing chronic disease patients to primary care is essential for determining whether the reform optimises resource distribution and strengthens chronic disease management.

Extensive research has examined the impact of the FDS globally. In countries like the UK, Australia and Canada, family doctors play a key role in enhancing chronic disease management, reducing emergency visits and hospitalisations, and managing medical costs.[12–18] As China's healthcare reform progresses, the effectiveness of the FDS has attracted scholarly attention both domestically and internationally. However, consensus on its outcomes in China remains elusive. Some studies suggest that the system reduces redundant use of medical resources, decreases hospital and emergency department visits,[8 19–21] and improve the use of primary care services.[21] Conversely, other studies find no significant impact on altering patients' service utilisation behaviours.[22–24] Regarding medical expenses, some research indicates that the system helps control healthcare spending and reduces financial burdens,[21 25 26] while others show no significant effect.[27] Factors such as patients' gender, age, type of illness, education level, awareness of FDS policies and economic status[28 29] influence the utilisation of family doctor services, suggesting that outcomes may vary among different patient groups. What is more, research on patient heterogeneity through group classification is key to promoting patient-centred service provision.[30–33] Understanding how the FDS affects service utilisation patterns is vital for evaluating its effectiveness in altering long-established healthcare behaviours. However, few studies have examined FDS heterogeneity based on patients' previous service utilisation patterns.

Thus, our study focused on diabetic patients, who require continuous, integrated care across different healthcare levels, to explore their service utilisation patterns and assess the impact of the FDS on their health-seeking behaviours and medical expenditures. We aimed to address the knowledge gap on the heterogeneity of effects based on service utilisation history, potentially guiding more effective healthcare policies and tailored chronic disease management strategies.

METHODS

Study design

This research was structured as a retrospective cohort study focusing on diabetic patients residing in City A, a provincial capital city along the eastern coast of China.

We designated the years 2014–2017 as the preintervention period, during which we analysed the service utilisation patterns of diabetic patients to establish baseline trends. The enrolment of the FDS, starting from 2018, marks the intervention phase of our study, with the years 2018 and 2019 considered as the postintervention period. The study's design allows for an in-depth examination of how enrolling in the FDS—a pivotal component of China's healthcare reform aimed at improving primary care services—alters healthcare service utilisation and costs among diabetic patients with diverse service utilisation patterns.

Settings

City A is a provincial capital city located along the eastern coast of China, covering a total area of approximately 17 000 km^2. The city is administratively divided into 10 districts and two counties, with a resident population of 10.36 million as of the end of 2019. In 2019, City A's per capita Gross Domestic Product was 152 465 RMB (approximately US$22 102 at the average exchange rate), and the per capita disposable income was 59 261 RMB (approximately US$8590).

The FDS in City A was introduced in 2015, with the goal of enhancing healthcare management for residents, particularly those with hypertension and diabetes, and was gradually rolled out in City A. According to the policy of FDS in City A, patients can register with family doctors at any time during the year, with the provision of services commencing from 1 January of the following year. The following health services were offered by family doctors: (1) personalised health management services and consultation; (2) priority treatment and expedited referrals; (3) health assessment once a year. Residents are encouraged to register with family doctors in nearby CHCs each year and to use primary care and disease management provided by family doctors. According to the policy development of FDS in City A, it can be divided into two stages.

Stage 1: pilot phase (2015–2017)

City A initiated the implementation of FDS from 1 January 2015. The period from 2015 to the end of 2017 represented the pilot phase of policy implementation for FDS in City A, characterised by pilot exploration and promotion. The primary focus of this reform was on exploring and establishing related policy, reform objectives and implementation methods. During the pilot phase, only some select districts within City A were involved in the pilot of the FDS.

Stage 2: matured phase (2018–present)

From 2018, the FDS in City A transitioned into a comprehensive implementation phase, marking a deepened development that expanded its coverage to encompass all areas of City A. During this stage, the scope of family doctor services was expanded, and the performance evaluation of family doctors was improved. In terms of service expansion, by the end of 2017, four key departments of City A jointly issued a notice allowing patients with specific chronic conditions under FDS to access 'Long-term Prescription Services'. Family doctors could prescribe up to 12 weeks of medication for these patients, provided they met certain criteria, including stable health conditions and prior management at CHCs for more than 6 months. This policy marked a substantial improvement in the FDS.

In this study, the evaluation of the effectiveness of FDS in City A focused on the more refined and matured phase of the FDS that commenced in 2018.

Data source

Our study employed data from two key databases: (1) Health Management Information System: managed by the Health Commission of City A, this database provided detailed records of patients diagnosed with diabetes before January 2015. It included variables such as social demographics, complications and patients' registration status (whether registered with any family doctor, registration time and duration). (2) Medical Insurance Claim Database: managed by the Healthcare Security Bureau of City A, this database allowed us to extract healthcare utilisation and costs for patients from 2014 to 2019, including both outpatient records and admission records. These two databases can be linked through the patients' identification.

Participants

In this study, diabetic patients were identified through the Health Management Information System. After identification, additional information such as patient ID numbers, enrolment status in the FDS, and details of their enrolling institution and registered doctor were extracted. These patient IDs were then matched with the Medical Insurance Claim Database, allowing us to extract data on their healthcare service utilisation and costs for the period between 1 January 2014 and 31 December 2019. The extracted data included pertinent details such as the dates of medical visits, the healthcare facilities where the services were delivered, the specific diagnoses of the diseases and the financial expenses incurred for these services.

To ensure the integrity of our cohort and mitigate the impact of potential loss to follow-up, we implemented strict inclusion criteria: first, only patients covered by either urban employee basic medical insurance (UEBMI) or urban-rural resident basic medical insurance (URRBMI) were included in the study. Second, we included only those patients who had at least one outpatient visit per year during the study period (2014–2019). This criterion was crucial in ensuring that the study population remained consistently present in City A, thereby minimising the likelihood of including patients who had relocated, passed away or otherwise been lost to follow-up.

According to their status of enrolment in FDS, patients were classified into two groups: an intervention group comprising those who registered with a family doctor in 2018 or 2019, and a control group consisting of those who did not register with a family doctor during the study period.

Variables

The primary outcome variables analysed in this study were healthcare service utilisation and medical costs, categorised into several specific indicators. These included the annual total number of outpatient visits, annual outpatient visits at CHCs and annual outpatient visits at secondary/tertiary hospitals. Additionally, medical cost indicators comprised annual outpatient costs, segmented into costs at CHCs and secondary/tertiary hospitals, annual inpatient costs, total medical costs and out-of-pocket (OOP) costs. Detailed definitions were provided in online supplemental table 1. These outcomes were defined and calculated for each patient annually during the study period to assess the impact of the FDS on diabetic patients' healthcare utilisation patterns and financial burden.

In this study, several covariates including sociodemographic characteristics and health status indicators of patients during the baseline period (ie, in 2014) were incorporated. We included variables that reflected patients' sociodemographic characteristics, such as age, gender and types of medical insurance (UEBMI or URRBMI), which were derived from the Medical Insurance Claim Database. Patients were categorised into several age groups: ≤30 years, 31–40 years, 41–50 years, 51–60 years, 61–70 years, 71–80 years, 81–90 years and ≥90 years. Furthermore, we included body mass index (BMI) representing the subjects' health conditions, which was derived from the Health Management Information System. Patients were categorised into several BMI status groups: classified as normal ($18.5\,kg/m^2 \le BMI \le 24.0\,kg/m^2$), above normal ($BMI > 24.0\,kg/m^2$) and below normal ($BMI < 18.5\,kg/m^2$). Additionally, we incorporated the average fasting blood glucose (FBG) score in 2014, using

FBG data from the Health Management Information System. In this study, the average FBG score was computed by assigning 1 point to values within the normal FBG range and 0 points otherwise. The average FBG score was based on FBG scores from all follow-up visits in 2014. The normal FBG range was defined as 4.4–7.0 mmol/L, in accordance with the control target for type 2 diabetes in China.[34]

In addition, we included diabetes-related chronic complications and common chronic comorbidities in our analysis. These were identified using ICD codes from patients' medical records during the preintervention period (2014–2017). The diabetes-related chronic complications in our study encompass nine conditions: end-stage renal disease, non-end-stage diabetic nephropathy, diabetic retinopathy, diabetic neuropathy, diabetic peripheral circulation complications, coronary atherosclerotic heart disease (CHD), other cardiovascular diseases, stroke and other cerebrovascular diseases. We separated end-stage renal disease from diabetic nephropathy, CHD from other cardiovascular diseases and stroke from other cerebrovascular diseases, as these severe conditions rank among the top five diagnoses in outpatient and inpatient costs or visit frequency (shown in online supplemental table 2). Their significant impact on healthcare utilisation and costs, along with their representation of advanced stages of their respective complications, warranted their inclusion as separate variables in our controlled analyses. We also included six common chronic comorbidities: hypertension, hyperlipidaemia, malignant tumours, chronic respiratory diseases, Alzheimer's disease and cataracts. The selection criteria for common chronic comorbidities were as follows: (1) diagnoses that ranked among the top five for outpatient visit frequency and expenses, or among the top ten for inpatient admission frequency and expenses (see online supplemental table 2 for details). (2) Exclusion of diseases already classified as diabetes-related chronic complications. (3) Combination of diseases within the same category, such as consolidating different tumour types under 'malignant tumours'. (4) Inclusion of only chronic or persistent complications due to their significant long-term impact on health and healthcare utilisation. The specific ICD codes used for identification of each condition mentioned above were provided in online supplemental table 3.

Statistical methods

Group-based trajectory model

To fit and categorise the service utilisation pattern of diabetics, we employed group-based trajectory model (GBTM) using healthcare service utilisation data from 2014 to 2017. This model enabled the classification of diabetic patients into groups with similar health service utilisation patterns. GBTM, developed by Nagin in 1999, is a finite mixture modelling technique that uses maximum likelihood estimation to identify and cluster individuals with similar change trajectories, distinguishing several subgroups with different trajectories.[35 36] It has been widely used in healthcare studies to analyse longitudinal patterns in patient health status, service utilisation and disease progression.[37–40]

In our study, we selected GBTM for its effectiveness in analysing longitudinal data, making it ideal for identifying distinct healthcare utilisation patterns among diabetic patients. GBTM was chosen over cluster analysis because it captures temporal patterns, grouping data based on trajectories over time rather than similarity at a single time point.[38 41 42] Compared with latent class mixed-effect models, GBTM more simply distinguishes subgroups with different developmental trends, treating similar behaviour characteristics as homogeneous without considering random effects for each individual.[36 43] Additionally, GBTM allows for the construction of multivariate models, facilitating comprehensive analysis of multiple variables over time.[44]

In our study, we used patients' quarterly outpatient visit counts at both CHCs and secondary/tertiary hospitals as outcome variables. The measurement period for these quarterly outpatient visit counts spans from the first quarter of 2014 to the fourth quarter of 2017, covering a total of 16 quarters prior to the intervention in 2018. This approach aligns with the core principles of the FDS, which emphasises primary care at CHCs and the role of family doctors as gatekeepers directing patients to higher-level hospitals when necessary. The detailed information used in GBTM were provided in online supplemental material 3 (pages 4–6).

Difference-in-differences model after propensity score matching

To ensure robust and reliable comparisons between the intervention and control groups, a difference-in-differences (DID) model following propensity score matching (PSM) was constructed to analyse the effects of the FDS on diabetics with different service utilisation patterns.

In our study, PSM was used to ensure comparability between patients enrolled in the FDS (intervention group) and those not enrolled (control group) in each trajectory group. The matching was based on several baseline covariates: age, gender, type of medical insurance, baseline BMI, average FBG score in 2014, the presence of nine diabetes-related chronic complications and six common chronic comorbidities of diabetic patients as mentioned above during preintervention period. We used a calliper value of 0.05 and a matching ratio of 1:3, allowing for matches with replacement. Propensity scores were calculated using a logistic regression model, and patients with similar scores were matched accordingly.

After PSM, we constructed DID analysis models for each trajectory group to assess the impact of enrolling in the FDS on service utilisation and costs. Logarithmic transformations were applied to the cost variables in our analysis. We conducted parallel trend tests separately for each outcome variable to ensure the validity of the parallel trends' assumption.

The model expression of DID analysis is as follows:

$$Y_{it} = \beta_0 + \beta_1 T_t + \beta_2 \text{Group}_i + \beta_3 T_t \cdot \text{Group}_i + A_i + B_t + \beta_{4j} X_{ij} + \varepsilon_{it}$$

Where Y_{it} refered to the average value of the outcome variables for the ith patient at year t (with cost indicators logarithmically transformed); Group_i was 1 for the intervention group and 0 for the control group. T_t was a dummy variable indicating preintervention and postintervention periods (0 for 2014–2017, 1 for 2018 and 2019). A_i and B_t represented individual and time fixed effects, respectively. X_{ij} represented a set of covariates (age, gender, insurance type, BMI status, average FBG score and presence of nine diabetes-related chronic complications and six common chronic comorbidities of diabetic patients during preintervention period, where 'j' is the number of covariates), with β_{4j} as the corresponding regression coefficients. The interaction term β_3 estimated the effect of enrolling in the FDS.

SUEST test

To compare the impact of the FDS on patients with different service utilisation patterns, we used the SUEST test (also known as the 'generalised Hausman test'). This statistical technique allows for hypothesis testing across different regression models that may have correlated error structures, providing a comprehensive understanding of the system's varied impacts across patient subgroups. Detailed information for the SUEST test were provided in online supplemental materials 3 (pages 6–7).

In our study, data analysis was conducted using Stata V.16.0 (StataCorp, College Station, Texas, USA). The significance level for all statistical tests was set at 0.05.

RESULTS

Participants

Initially, 118036 diabetic patients were identified based on their residence in City A and their registration in the Health Management Information System. Of these, 73724 patients were covered by city-level medical insurance. After excluding 11258 patients who had no corresponding medical records in the Medical Insurance Claim Database, 62466 patients were further assessed for eligibility. Following the application of the inclusion criteria, 49121 patients met the eligibility requirements, including the necessity for at least one outpatient visit per year during the study period, thus ensuring they had not relocated, passed away or been otherwise lost to follow-up.

According to patients' status of FDS-enrolment, a total of 17232 diabetic patients were included in the final analysis, divided into an intervention group (13094 patients enrolled in the FDS between 2018 and 2019) and a control group (4138 patients who did not enrol in the FDS). All included patients completed the follow-up, resulting in a total follow-up time of 103392 person-years, with each patient observed for up to 6 years (see online supplemental figure 1 for details).

The overall mean age of the study population was 62.85 years and the proportion of female patients was 55.21% (see online supplemental table 4 for detailed information).

Descriptive statistics

Among these diabetics, four distinct patient groups with different characteristics of service utilisation pattern were identified using GBTM based on patients' 2014–2017 claim database, as figure 1 shows, including: (1) trajectory group 1 (Traj 1): low overall outpatient visit group, which comprised patients with low utilisation levels of outpatient services in both CHCs and secondary/tertiary hospitals; (2) trajectory group 2 (Traj 2): high CHCs visit group, which comprised patients with high level of outpatient services utilisation in primary healthcare institutions, but relatively low level of utilisation in secondary/tertiary hospitals; (3) trajectory group 3 (Traj 3): high hospitals visit group, which comprised patients with relatively high level of outpatient services utilisation in secondary/tertiary hospitals, but low level of utilisation in CHCs; (4) trajectory group 4 (Traj 4): high overall outpatient visit group, which comprised patients with high level of outpatient services utilisation in both CHCs and secondary/tertiary hospitals. The process, results and validation test of the GBTM model fitting were shown in online supplemental material 5 (online supplemental tables 5–11). Detailed information on the numbers of average quarterly outpatient visits at CHCs and secondary/tertiary hospitals for each trajectory group was provided in online supplemental table 12.

Patients with varying characteristics, including age, gender, type of medical insurance and type and number of comorbid chronic diseases, exhibited differences in service utilisation pattern grouping, and the demographic characteristics of patients in each trajectory group were presented in table 1. The characteristics of patients in the intervention and control groups within each trajectory group were shown in online supplemental table 13.

The variations in healthcare service utilisation and cost indicators from 2014 to 2019 for patients in each trajectory group were available in online supplemental tables 14–18.

Main results of PSM-DID analysis

The results of the PSM for intervention and control group patients within each trajectory group of diabetic patients, were provided in online supplemental tables 19–23 and figures 2–5.

We analysed both unadjusted and confounder-adjusted estimates, with unadjusted results available in online supplemental tables 24–27. This section presents the confounder-adjusted estimates with 95% CIs. Adjustments were made for age, gender, type of medical insurance, baseline BMI, average FBG score and the presence of nine diabetes-related complications and six common comorbidities, given their potential impact on patients' healthcare utilisation and costs.[45] The complete results

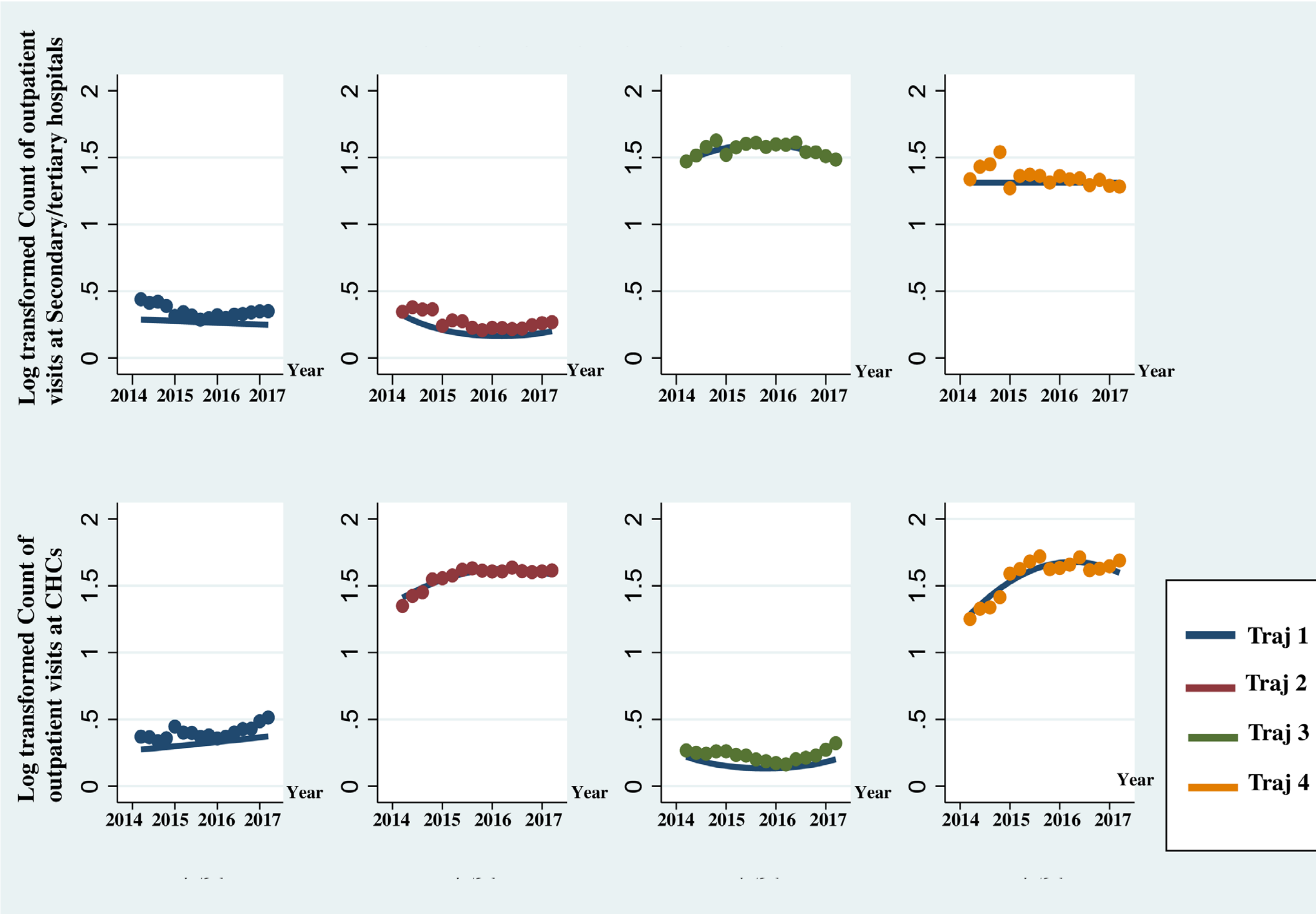

Figure 1 Group-based trajectory model grouping of service utilisation patterns for diabetic patients 2014–2017. The vertical axis represents the logarithmic values of the number of patient visits per quarter to community health centres (CHCs) or to secondary/tertiary hospitals.

of the confounder-adjusted regression analysis were provided in online supplemental tables 28–31. The results of the parallel trend tests were provided in online supplemental figures 6–14.

Impact of FDS on patients' outpatient services utilisation and cost

Table 2 reveals that after enrolling the FDS, patients in trajectory group 1, who previously had low utilisation of both primary care and secondary/tertiary hospitals, experienced the most significant increase in annual outpatient visits (an average increase of 4.312 visits) and costs (an average rise of 39.0%) among all groups. Meanwhile, patients in trajectory groups 3 and 4, who frequently visited secondary/tertiary hospitals previously, demonstrated more significant changes in healthcare service utilisation after enrolling with family doctors. Specifically, diabetics in trajectory group 3 showed a marked increase in CHCs average outpatient visits and costs, rising by 6.265 visits and 225.4%, respectively, the highest among all groups, while their secondary/tertiary hospital visits and costs decreased notably by 3.345 visits and 55.5%. Patients in trajectory group 4 also saw increased CHCs visits and costs, by 4.642 visits and 109.5%, while their annual outpatient visits at secondary/tertiary hospital decreased by 1.493 visits.

Impact of FDS on patients' hospitalisation costs, total medical costs and OOP costs

The results shown in table 3 indicated that FDS reduced patients' OOP costs, but not hospitalisation costs or total expenses. There were no significant changes in hospitalisation costs or total medical expenses among diabetic patients in all of the four trajectory groups (p>0.05) after the enrolment with family doctors in 2018. Nevertheless, patients in all groups experienced a marked reduction in OOP costs after enrolling with family doctors (p<0.05).

DISCUSSIONS

Key results

Our study fitted patient groups to four different outpatient service utilisation patterns using GBTM. Our group-based PSM-DID analysis revealed significant differences in service utilisation behaviours and medical costs among patients after enrolling in the FDS.

First, our results showed that patients in trajectory group 1 (low overall outpatient utilisation previously)

Table 1 Demographic characteristics of patients in each trajectory group, 2014

Descriptive statistics	Traj 1	Traj 2	Traj 3	Traj 4
Number of patients	2664	7121	3328	4119
Number of patients in the intervention group	1563	6674	1333	3524
Number of patients in the control group	1101	447	1995	595
Age, years	61.63 (11.86)	64.57*** (9.64)	63.19*** (12.27)	63.54*** (9.62)
Gender: male, n (%)	1337 (50.19)	2938*** (41.26)	1789*** (53.76)	1655*** (40.18)
Types of medical insurance, n (%)				
URRBMI	924 (34.68)	4085*** (57.37)	276*** (8.29)	906*** (22.00)
UEBMI	1740 (65.32)	3036 (42.63)	3052 (91.71)	3213 (78.00)
BMI, kg/m^2	23.65 (2.98)	23.93*** (3.03)	23.77 (3.02)	23.92*** (3.10)
Average fasting blood glucose score, point	0.89 (0.22)	0.89 (0.23)	0.88*** (0.24)	0.88*** (0.24)
Diabetes-related chronic complication, N (%)				
End-stage renal disease	3 (0.11)	0*** (0.00)	24*** (0.72)	12 (0.29)
Diabetic nephropathy	128 (4.80)	356 (5.00)	566*** (17.01)	613*** (14.88)
Diabetic retinopathy	18 (0.68)	92** (1.29)	186*** (5.59)	244*** (5.92)
Diabetic neuropathy	70 (2.63)	203 (2.85)	251*** (7.54)	383*** (9.30)
Diabetic peripheral circulation complications	23 (0.86)	27*** (0.38)	30 (0.90)	48 (1.17)
CHD	165 (6.19)	754*** (10.59)	632*** (18.99)	1097*** (26.63)
Cardiovascular diseases other than CHD	171 (6.42)	876*** (12.30)	463*** (13.91)	982*** (23.84)
Stroke	70 (2.63)	158 (2.22)	273*** (8.20)	336*** (8.16)
Cerebrovascular diseases other than stroke	67 (2.52)	368*** (5.17)	163*** (4.90)	380*** (9.23)
Common comorbidities, N (%)				
Hypertension	910 (34.16)	4953*** (69.55)	1717*** (51.59)	3006*** (72.98)
Hyperlipidaemia	131 (4.92)	512*** (7.19)	440*** (13.22)	775*** (18.82)
Malignant tumour	28 (1.05)	36*** (0.51)	83*** (2.49)	131*** (3.18)
Chronic respiratory diseases	435 (16.33)	1587*** (22.29)	977*** (29.36)	1661*** (40.33)
Alzheimer's disease	6 (0.23)	6* (0.08)	26*** (0.78)	20* (0.49)
Cataracts	87 (3.27)	189 (2.65)	246*** (7.39)	312*** (7.57)

The mean (SD) was calculated for continuous variables. N (%) was for categorical variables. There were no missing data for any of the variables included in this study for all participants. The significance levels indicate the statistical significance of differences between trajectory group 1 and each of the other trajectory groups. Significance levels were *p<0.10; **p<0.05; ***p<0.01.
BMI, body mass index; CHD, coronary atherosclerotic heart disease; UEBMI, urban employee basic medical insurance; URRBMI, urban-rural resident basic medical insurance.

Table 2 Results of propensity score matching-difference-in-differences analysis of effect of family doctor system on patients' annual outpatient services utilisation and cost

Variables	Annual outpatient visits		Annual outpatient visits at CHCs		Annual outpatient visits at secondary/tertiary hospitals	
	Count (Y1)	Cost (Y4)	Count (Y2)	Cost (Y5)	Count (Y3)	Cost (Y6)
Traj 1	4.312***	0.390***	5.092***	1.527***	0.153	−0.232
	(2.961, 5.663)	(0.200, 0.580)	(4.265, 5.919)	(1.217, 1.837)	(−0.547, 0.854)	(−0.586, 0.122)
Traj 2	1.930**	0.284***	2.155**	0.821***	0.431	−0.005
	(0.166, 3.694)	(0.083, 0.485)	(0.227, 4.083)	(0.416, 1.226)	(−0.213, 1.076)	(−0.519, 0.508)
Traj 3	2.985***	0.274***	6.265***	2.254***	−3.345***	−0.555***
	(1.726, 4.244)	(0.160, 0.389)	(5.524, 7.007)	(1.984, 2.524)	(−4.312, −2.378)	(−0.734, −0.376)
Traj 4	3.632***	0.266***	4.642***	1.095***	−1.493**	−0.112
	(1.641, 5.624)	(0.145, 0.388)	(2.915, 6.368)	(0.838, 1.352)	(−2.810, −0.177)	(−0.373, 0.149)
P value of SUEST test						
Traj 1 vs Traj 2	0.036	0.45	0.006	0.007	0.567	0.476
Traj 1 vs Traj 3	0.159	0.305	0.038	0.001	<0.001	0.11
Traj 1 vs Traj 4	0.58	0.281	0.645	0.035	0.03	0.593
Traj 2 vs Traj 3	0.34	0.937	<0.001	<0.001	<0.001	0.047
Traj 2 vs Traj 4	0.209	0.886	0.059	0.263	0.01	0.716
Traj 3 vs Traj 4	0.59	0.926	0.09	<0.001	0.026	0.006

The robust 95% CIs for the estimates are in parentheses. Significance levels were *p<0.10; **p<0.05; ***p<0.01; the control covariates included: a group dummy, gender, age group dummies, types of medical insurance dummies, body mass index status, the average fasting blood glucose score in 2014, diabetes-related chronic complications and common chronic comorbidities of diabetic patients. In these regression models, we included the year dummy to control for fixed effects of the calendar years, and used the robust SEs clustered on the institution-individual level.
CHCs, community health centres.

experienced the greatest increase in annual outpatient visits and costs among all groups after enrolling the FDS. A possible explanation could involve the initial underutilisation of healthcare services by this group. These patients, who previously may not have sought medical treatment regularly, likely had unmet healthcare needs or undiagnosed conditions. The FDS, by providing easier access to primary care and promoting regular health check-ups and management, could have facilitated better engagement with the healthcare system for these patients.[10] Additionally, the role of family doctors in providing continuous care, education and management for chronic conditions like diabetes could have led to increased awareness and proactive management of their health.[46] The increase in primary care utilisation could indicate a positive shift towards preventive care and better management of chronic conditions, potentially leading to improved long-term health outcomes and reduced need for more intensive, costly secondary and tertiary care,[46] aligning with the family doctor's role in chronic disease management and preventive health practices.

Second, our analysis of patients' outpatient service utilisation and costs indicates that the FDS can effectively redirect patients with a long-term high outpatient utilisation pattern in secondary/tertiary hospitals (trajectory groups 3 and 4) towards primary healthcare facilities. This redirection optimises their healthcare-seeking behaviour. These findings are consistent with existing research that shows the FDS in China improves chronic disease management, enhances the utilisation of community healthcare services and promotes orderly healthcare-seeking behaviours among patients with chronic diseases.[20 46 47] While other studies generalise the effects of the FDS, our study identifies specific impacts on patient subgroups based on their historical healthcare service utilisation patterns, extending and refining current research. The effectiveness of this redirection can be attributed to several mechanisms: family doctors receive economic incentives for patient care,[48] patients benefit from higher insurance reimbursements at primary care facilities[48] and the system's policies emphasise comprehensive health management, including assessments, screenings and interventions for chronic disease patients, which foster patients' trust in primary care providers.[49] This finding highlights the evolving role of family doctors as the 'gatekeepers' of the healthcare system and aligns with the policy direction of medical reform. These changes have, to a certain extent, facilitated the implementation of a hierarchical diagnosis and treatment system.

Table 3 Results of propensity score matching-difference-in-differences analysis of effect of family doctor system on patients' costs

Variables	Annual inpatient costs (Y7)	Annual total medical costs (Y8)	Annual OOP costs (Y9)
Traj 1	–0.272	–0.008	–0.953***
	(–0.702, 0.159)	(–0.172, 0.156)	(–1.288, –0.619)
Traj 2	–0.612*	–0.026	–1.885***
	(–1.229, 0.005)	(–0.190, 0.138)	(–2.215, –1.555)
Traj 3	–0.150	0.017	–0.587***
	(–0.517, 0.216)	(–0.060, 0.093)	(–0.807, –0.368)
Traj 4	–0.116	0.084*	–0.498***
	(–0.601, 0.370)	(–0.009, 0.176)	(–0.782, –0.214)
P value of SUEST test			
Traj 1 vs Traj 2	0.376	0.879	<0.001
Traj 1 vs Traj 3	0.674	0.789	0.073
Traj 1 vs Traj 4	0.637	0.339	0.042
Traj 2 vs Traj 3	0.207	0.644	<0.001
Traj 2 vs Traj 4	0.215	0.253	<0.001
Traj 3 vs Traj 4	0.911	0.273	0.625

The robust 95% CIs for the estimates are in parentheses. Significance levels were *p<0.10; **p<0.05; ***p<0.01; The control covariates included: a group dummy, gender, age group dummies, types of medical insurance dummies, body mass index status, the average fasting blood glucose score in 2014, diabetes-related chronic complications and common chronic comorbidities of diabetic patients. In these regression models, we included the year dummy to control for fixed effects of the calendar years, and we used the robust SEs clustered on the institution-individual level.
OOP, out-of-pocket.

Additionally, we found that the current implementation of FDS in City A does not exhibit cost-saving effects on inpatient expenses and total medical expenses among diabetic patients. This aligns with the results of previous studies by Rize *et al*[27] and Yuzhu.[50] It suggests that the current implementation of FDS in this area has not yet made family doctors the 'gatekeepers' of patients' healthcare expenses. Additional complementary regulatory measures are necessary to bolster cost saving incentives for family doctors. According to international experiences, the adoption of capitation payment for family doctor outpatient services can incentivise family doctors to prioritise disease prevention and health management for their enrolled patients. This approach has shown promise in reducing medical expenses, enhancing the efficiency of healthcare resource utilisation,[51–54] and has emerged as a significant direction in outpatient healthcare payment reform in recent years in China. Presently, in City A, capitation payment has not been integrated with the FDS. This absence of financial incentives for healthcare providers to manage medical expenses results in the FDS currently lacking a substantial impact on patients' annual inpatient expenses and total medical expenses.

Finally, the OOP costs for patients in all trajectory groups have significantly decreased after registration with family doctors, indicating an improved affordability of medical services for patients. This aligns with the expected policy outcomes of medical insurance reimbursement policies, wherein medical insurance deductibles and patient copayment ratios can be conditionally reduced for patients who have enrolled in the FDS.[55] This significant decrease highlights how the FDS, in partnership with local healthcare insurance policies, successfully enhances service accessibility and broadens coverage for chronic disease management. By reducing the financial burden on patients, the FDS demonstrates its capacity to promote more cost-effective healthcare choices, contributing to the long-term sustainability of chronic disease care.

Limitations

This study possesses several limitations that should be considered when interpreting the results.

First, while our DID analysis generally assumes parallel trends in outcome variables, this assumption was not fully met for several variables, such as the annual outpatient costs at CHCs (online supplemental figures 10). To address this, we used PSM to improve comparability between the intervention and control groups, and included sociodemographic variables such as age, gender, insurance type and disease control parameters including BMI, FBG, diabetes-related complications and comorbidities in our DID models. Despite these efforts, some residual confounding factors may still influence some of our findings, and thus, these results should be interpreted with caution.

Second, the classification of patients into service utilisation patterns using 2014–2017 data through GBTM imposed relatively strict data requirements. This led to the exclusion of patients with incomplete medical records during this period, resulting in some degree of sample loss. While necessary for robust pattern classification, this exclusion might have introduced certain limitations.

Third, the observation period for outcomes among diabetic patients after enrolling with family doctors in this study spanned only 2 years, but the change in service utilisation behaviour among chronic disease patients may require the accumulation of time. Therefore, it is essential to observe the impact of the FDS on healthcare utilisation, medical expenses and even health outcomes of diabetic patients over a more extended time span in the future.

Policy implications

The findings underscore the need for a stratified approach in the FDS, addressing specific patient needs based on their service utilisation patterns and health conditions.

First, diabetic patients who currently use fewer healthcare services, are younger, and have milder conditions require proactive engagement. Efforts should focus on regular health follow-ups, monitoring and educating these patients to prevent complications and promote standardised chronic disease management.

Second, for patients who regularly use primary healthcare services, family doctors should build on this existing pattern by optimising service delivery and enhancing patient satisfaction. This continuity strengthens their reliance on primary care, ensuring consistent and stable management of their health conditions.

Thirdly, patients who prefer secondary or tertiary care but have relatively less severe conditions need gradual encouragement to shift towards primary care, aligning with the goals of a hierarchical medical system. This can be achieved through enhanced services at CHCs, improved patient communication, and ensuring access to necessary medications at the primary level. Building their trust in primary care will facilitate this transition.

Finally, for patients with severe conditions requiring specialised treatment, efficient referral pathways are essential. These should provide prompt access to appropriate secondary or tertiary care while ensuring medication needs are met at the primary level. Family doctors should also offer post-hospitalisation follow-ups and support, aiding effective management after discharge.

Offering differentiated and diverse services tailored to the needs of various patient groups can enhance the appeal and effectiveness of the FDS. This approach supports greater patient engagement and utilisation of primary care services, contributing to the system's sustainability and expanded reach.

CONCLUSION

This study demonstrates that the FDS in China significantly influences healthcare service utilisation patterns among diabetic patients, particularly among patients with historically high hospital usage. By redirecting these patients from secondary/tertiary hospitals to primary care institutions, the system has shown potential in optimising resource allocation and enhancing chronic disease management. Additionally, our analysis revealed that while the FDS significantly increased outpatient costs at CHCs due to higher utilisation, it also led to a substantial reduction in outpatient costs at secondary/tertiary hospitals and a significant decrease in OOP expenses for patients across all trajectory groups. These findings highlight the dual impact of the FDS on both service utilisation and healthcare costs.

Contributors WC, XF and LZ coordinated the study throughout, and oversaw study implementation. XL developed the research question, and was responsible for the modelling, data analysis, result interpretation. XL drafted the manuscript. WC, LZ and XL accessed and verified the data. WC, XF and LZ verified the methodology and ensured the validation of the results, reviewed and edited the manuscript. XL and LZ contributed equally to this manuscript. All authors read and approved the final manuscript. WC is the guarantor.

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Data availability statement Data are available upon reasonable request. The data used in this study is confidential personal health information for which researchers must apply for access to the local health officials to obtain de-identified data. Our data use agreement precludes sharing the patient-level data with other researchers until they have gone through the same ethical review and approval process as for this study.

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