

What role does healthcare geographic accessibility play in the association between personal health responsibility and family doctor contract services?

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Abstract

Limited research has examined the nexus between personal health responsibility and family doctor contract services, particularly the moderating role of healthcare geographic accessibility in this relationship. This study aimed to investigate the association between personal health responsibility and family doctor contract services and to determine how healthcare geographic accessibility shapes this relationship among rural older adults in China. A cross-sectional study was conducted from July to August 2022 in Shandong Province, China. A total of 3164 rural older adults aged 60 years and above were included in the analysis. Multivariable binary logistic regression models and the margins plots were used for the moderating effect analysis. The rates of signing up for family doctor contract services and support for personal health responsibility among rural older adults in Shandong Province were 64.85% and 61.54%, respectively. Participants who supported personal health responsibility were more likely to contract for family doctor services ($OR = 1.38$, 95% $CI = 1.13–1.69$) after controlling for confounding factors. Only among older adults with good healthcare geographic accessibility, personal health responsibility was associated with higher contracting rates for family doctor services ($OR = 1.47$, 95% $CI = 1.19–1.82$). Our findings reveal a correlation between personal health responsibility and engagement with family doctor contract services, with healthcare geographic accessibility serving as a pivotal moderating factor. Policymakers should consider targeted educational campaigns and improved outreach for rural older adults. Elevating their understanding of personal health responsibilities and enhancing healthcare geographic accessibility may be important steps to encourage their participation in family doctor services.

Introduction

Population aging has become a defining demographic trend globally, placing increasing demands on the continuity, accessibility, and integration of healthcare systems (Hambleton et al., 2023). These pressures are particularly acute in countries like China, where chronic non-communicable diseases (NCDs) intersect with longstanding disparities in healthcare infrastructure. Historically, China's healthcare system has been oriented toward hospital-based, specialist-driven care concentrated in urban centers. This has contributed to service fragmentation, excessive reliance on tertiary institutions, and underutilization of primary care, particularly in rural areas where health resources remain scarce (Tang and Wang, 2021; Zhang et al., 2020). Older adults in rural communities, in particular, face compounded

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barriers to consistent and preventive care, including geographic isolation, workforce shortages, and institutional underdevelopment (Chen et al., 2022). As a group marked by physical decline, multimorbidity, and high dependence on continuous care, their health behaviors (e.g., chronic disease self-management and utilization of preventive care) are further complicated by cognitive limitations, socioeconomic vulnerabilities, and relatively low health literacy (Lawless et al., 2021; Organization, 2022). These interacting challenges underscore an urgent need to strengthen rural primary care and promote equitable service distribution.

To address these challenges, the Chinese government launched the Family Doctor Contracting Services (FDCSs) policy in 2016 as a key component of its national health reform strategies (Sun et al., 2021). The FDCSs initiative involves a team of family doctors (usually general practitioners, nurses, public health practitioners, etc.) who provide contracted families or individuals with continuous, comprehensive, and personalized primary medical care, public health, and health management services (Council, 2016). Globally, similar models built on long-term, trust-based patient-provider relationships have been adopted in many countries, although regulatory and financing arrangements differ (Lai et al., 2024). While China's FDCSs shares conceptual underpinnings with family doctor systems in other countries, it has unique institutional features, such as its policy emphasis on rural and elderly populations (Lai et al., 2024). However, despite these policy priorities and the generally high willingness of rural older adults to engage with FDCSs (Li et al., 2021b), their actual utilization remains low. Previous studies suggest that this may be attributed to both structural factors (e.g., lack of well-trained family doctors) and agency-based factors (e.g., doctor reputation and insufficient trust in doctors) (Zhang et al., 2023). Among the agency-based factors influencing engagement with FDCSs, personal health responsibility plays a critical role (Ebrahimi et al., 2021).

Personal health responsibility has been widely promoted as a central strategy in the prevention and management of NCDs, especially those associated with modifiable health behaviors, such as diet, physical activities, and adherence to treatments (Cockerham, 2005). Many countries have adopted personal health responsibility as one of the basic principles of public health action and health policy formulation to control healthcare costs and improve national health (Lavery and Harris, 2018; Pillutla et al., 2018; Schirmer and Michailakis, 2011; Schmidt et al., 2010; Traina and Feiring, 2022). Since 2014, China's national guiding documents have repeatedly mentioned the goal of "strengthening personal health responsibility" (NHFPC, 2014). In 2019, China formally incorporated the concept of "personal health responsibility" into its laws through the Basic Medical and Health Care Promotion Law (Article 69), which explicitly states that "citizens are the first responsible persons for their own health" (National People's Congress, 2019). This principle is further reinforced by the Civil Code (Article 1004) and several provincial regulations, such as those of Shanghai and Henan, which emphasize individuals' responsibility to maintain and promote their own health (Shanghai People's Congress, 2023; Henan People's Congress, 2023).

Given that personal health responsibility may carry different connotations depending on its context and application (Vincent, 2011; Nodeh et al., 2024), this study distinguishes between its broader conceptual meaning and its empirical operationalization. At the conceptual level, personal health responsibility refers to individuals' responsibilities for maintaining and enhancing their own health, including seeking health-related information, maintaining personal health resources, and engaging in preventive practices (Borghian et al., 2023). In this study, however, it is operationalized as an attitudinal orientation toward health responsibility. Despite its theoretical prominence and widespread policy endorsement, the empirical relationship between personal health responsibility and the uptake of contract-based primary care services, such as FDCSs, remains underexplored. Previous studies have largely focused on general lifestyle behaviors, with little examination of how personal health responsibility shapes individual engagement in formalized health services (Brown et al., 2019; Temmann et al., 2021). In the Chinese context, related work has begun to examine psychological and attitudinal determinants of older adults' participation in digital feedback and community-based home care services (Li et al., 2025; Sun, 2025), but evidence on contract-based primary care remains limited. This gap is particularly pronounced among rural older adults, whose engagement is often shaped by cognitive, physical, and socioeconomic vulnerabilities. Against this background, this study examines whether rural older adults who place greater emphasis on personal health responsibility are more likely to engage with FDCSs. In this study, personal health responsibility is treated as an attitudinal predictor of FDCSs engagement. We therefore hypothesize:

H1: Older adults who prioritize personal health responsibility are more likely to engage with FDCSs.

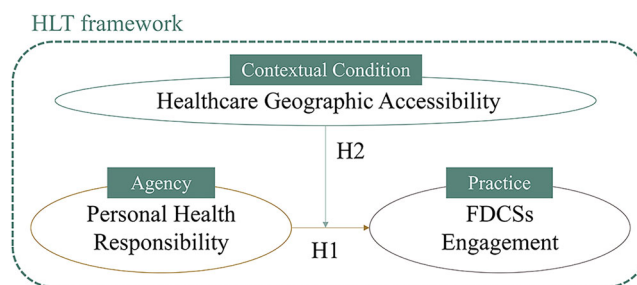


Fig. 1 Theoretical framework linking personal health responsibility, healthcare geographic accessibility, and FDCSs engagement. The model is grounded in Health Lifestyle Theory (HLT), which provides the overarching agency-context framework for this study. Personal health responsibility is treated as an attitudinal predictor of engagement with FDCSs (H1), and healthcare geographic accessibility is treated as a contextual condition that may moderate this relationship (H2). HLT Health Lifestyle Theory.

However, the association between personal health responsibility and FDCSs engagement may also depend on healthcare accessibility, a factor that plays a critical role in shaping actual service utilization (Albertsen and Tsiakiri, 2023). Healthcare accessibility is a multidimensional concept encompassing geographic, economic, and social dimensions (UN, 2000). In the rural Chinese context, geographic accessibility is particularly salient because limited transportation infrastructure, long travel distances, and the uneven distribution of healthcare personnel often constrain timely access to primary care services (Chen et al., 2022). Accordingly, this study focuses on healthcare geographic accessibility, which is assessed using respondents' self-reported travel time to the nearest health facility and is interpreted as a reported indicator of geographic access rather than a purely objective measure of structural access. Under such conditions, even when older adults place greater emphasis on personal health responsibility, engagement with FDCSs may still be hindered if services are physically distant or logistically difficult to reach (Ford et al., 2016; Levesque et al., 2013).

To frame this relationship, we draw on the Health Lifestyle Theory (HLT), which links individual agency with broader contextual conditions in shaping health practices (Cockerham, 2023). Within this framework, personal health responsibility is located on the agency side, whereas healthcare geographic accessibility is treated as a contextual condition that may shape whether agency is translated into practice. This perspective is particularly relevant in rural China, where disparities in health infrastructure and service provision remain substantial. In this study, the three sampled counties in Shandong Province differ in the availability of rural primary care institutions, inpatient beds, and healthcare personnel, reflecting broader patterns of uneven development within China's rural healthcare system (Shandong Provincial Bureau of Statistics, 2023). In this study, healthcare geographic accessibility is primarily measured using respondents' self-reported travel time to the nearest health facility and is interpreted as a reported indicator of geographic access. This context provides a meaningful basis for examining whether healthcare geographic accessibility conditions the association between personal health responsibility and FDCSs engagement. However, few studies have examined whether healthcare geographic accessibility moderates the relationship between personal health responsibility and FDCSs engagement. We thus hypothesize:

H2: Healthcare geographic accessibility moderates the association between personal health responsibility and the engagement of FDCSs. Specifically, poor healthcare geographic accessibility weakens this association.

To synthesize the theoretical perspectives outlined above and to guide the empirical investigation, we developed an integrated conceptual framework, presented in Fig. 1. This framework is centered on HLT and distinguishes among agency (personal health responsibility), contextual condition (healthcare geographic accessibility), and practice (FDCSs engagement). The proposed relationship between personal health responsibility and FDCSs engagement is interpreted here as an attitudinal association, while healthcare geographic accessibility is hypothesized to moderate this association by shaping the contextual conditions under which agency is translated into practice. Taken together, the framework reflects an “agency-context-practice” logic that underscores the necessity of attending to both individual motivations and institutional contexts in explaining rural health service engagement.

This study aims to 1) explore the association between personal health responsibility and the engagement of FDCSs among rural older adults in Shandong Province, China, and 2) determine whether healthcare geographic accessibility moderates this relationship. By doing so, we aim to contribute to the empirical evidence supporting the expansion and optimization of FDCSs, ultimately promoting healthier aging in rural areas.

Methods

Data source and participants

This study leveraged cross-sectional data from the Shandong Rural Elderly Health Cohort (SREHC) survey, conducted in Shandong Province, China, from July to August 2022. We employed a multi-stage stratified cluster sampling method to select participants, which was also elaborated in our previous publications (Wang et al. 2021b). Initially, counties in Shandong Province were categorized into three groups based on their per capita Gross Domestic Product (GDP) in 2018. One sample county was randomly selected from each category. In this study, three sample counties (Rushan in Weihai, Qufu in Jining, and Laoling in Dezhou) were selected as the study sites. Subsequently, five townships were randomly selected from each sampled county. From each township, four communities/villages were randomly selected, and older adults aged 60 years and above were randomly chosen from these communities or villages to ensure a diverse and representative sample of the rural elderly population.

Data were collected through face-to-face interviews using structured questionnaires (Wang et al. 2021b), administered by trained investigators with adequate medical knowledge. To ensure data completeness and accuracy, respondents were excluded if they: (1) could not communicate clearly in Chinese, (2) had a diagnosis of dementia or mental illness, or (3) were uncooperative during the survey. Besides, participants with missing primary variables ($n = 87$) were also excluded. Following these criteria, a total of 3164 older adults aged 60 years and above were included in the study. Figure S1 shows a flowchart of this study sample.

Measures

Family doctor contract services

Family Doctor Contract Services (FDCSs) engagement was measured by the following question: “In 2021, did you contract for family doctor services?”. Responses were categorized as a dichotomous variable (yes or no), with “yes” indicating that the respondent had engaged for services and “no” indicating otherwise.

Personal health responsibility

Personal health responsibility was measured using two questions (see Table S1): (1) “To what extent do you believe that you have a responsibility to protect your health?” Responses were rated on a 5-point scale from “1=not at all” to “5=very much” (2) “To what extent do you agree with the following statement: If a person’s disease is caused by modifiable causes, such as lung disease that may be caused by long-term smoking, then we should make him overpay for the treatment of the disease.” The response options were given on a 3-point scale, “1= disagree”, “2=indifferent (not sure)”, and “3= agree” (Traina et al., 2019). However, due to the skewed distribution of responses to the first question (95% of responses fell into categories 4 and 5), this question was not included in the regression analysis. Accordingly, the inferential analyses reported in this study rely on the second item and should be interpreted as reflecting an attitudinal orientation toward health responsibility rather than a broad self-directed behavioral manifestation of personal health responsibility.

Healthcare geographic accessibility

Healthcare geographic accessibility was measured by the question: “How many minutes does it take to get from your home to the nearest health facility (using the most accessible mode of transport rather than walking only)?” Time was categorized as ≤ 10 minutes or > 10 minutes (Devkota and Panda, 2016; Ford et al., 2016; Levesque et al., 2013; Li et al., 2021b). This self-reported measure was used as the primary indicator of healthcare geographic accessibility in the main analyses.

Covariates

Previous studies have identified a range of influencing factors for family doctor contract services (Li et al., 2021a; Shang et al., Shang et al., 2019; Yang et al., 2021). Drawing from the Anderson model, covariates were categorized into three groups (Andersen and Newman, 1973; Li et al., 2021a): (1) Predisposing Characteristics: age, gender (male, female), highest level of education (illiterate, primary school, middle school or above), and marital status (single, married); (2) Enabling Factors: household income (Q1, Q2, Q3, Q4, quartiles from poorest to richest) and insurance type (none, urban and rural resident basic medical insurance, urban employee basic medical insurance, free medical); Household income was measured by asking the total income of the respondent’s household in the previous year (2021). (3) Needs Factors: body mass index (BMI), chronic health conditions (no chronic condition, one chronic condition, multimorbidity), and activities of daily living (ADL). BMI was calculated as weight in kilograms divided by height in square meters (Zhou et al., 2002). ADL was assessed using the Katz index scale, with scores ranging from 14 to 56, where higher scores indicate worse activities of daily living (Katz et al., 1963). Additionally, indicators of healthcare utilization experiences, including two-week outpatient care (yes, no) and annual inpatient care (yes, no), were included as covariates due to their correlation with FDCSs engagement.

Statistical analyses

Statistical analyses were conducted using Stata 15.1 (Stata Corp, College Station, TX, USA). First, descriptive statistics were employed to summarize the basic characteristics of rural older adults, presented as means (standard deviations) for continuous variables and frequencies (percentages) for categorical variables. Student’s t-test was used for continuous variables, while chi-square tests were applied to compare FDCSs status across different subgroups. Second, a binary logistic regression model was used to assess the relationship between personal health responsibility and FDCSs. Model 1 was unadjusted; Model 2 included adjustments for all predisposing characteristics, enabling factors, needs factors, and health behavior factors; Model 3 built on Model 2 by incorporating the interaction term (personal health responsibility $\times$ healthcare geographic accessibility) to examine whether healthcare geographic accessibility moderated the association between personal health responsibility and FDCSs engagement. Margins plots illustrated the predicted FDCSs status based on personal health responsibility and healthcare geographic accessibility. Third, after controlling for all influencing factors, a stratified analysis was conducted based on varying levels of healthcare geographic accessibility to identify potential differences across subgroups.

Additionally, we conducted sensitivity analyses to assess the robustness of the interaction effect to alternative operationalizations of healthcare geographic accessibility: (1) modeling travel time to the nearest health facility as a continuous variable (in minutes) for interaction analysis, and (2) redefining the binary geographic accessibility variable using a stricter 5-minute threshold (≤ 5 minutes vs. > 5 minutes) for interaction analysis.

To address the potential clustering of respondents within counties and towns, we performed additional analyses: (1) County-level heterogeneity was examined via logistic regression, including interaction terms between personal health responsibility and county, alongside county-stratified results; (2) Multilevel mixed-effects logistic regression was estimated, first with town-level random intercepts, then with towns nested within counties, and additionally with village-level random intercepts to reflect the hierarchical structure of the data; (3) we used a fixed-effects model with town dummy variables to control for time-invariant unobserved town-level heterogeneity.

Table 1 Basic characteristic of the participants among older adults in rural Shandong, China, 2022 ($N = 3164$).

Characteristic	N (%)	Family doctor contract services		<i>P</i> -value
		Yes (%)	No (%)	
Observations	3164	2052 (64.85)	1112 (35.15)	
Age (years), mean (<i>SD</i>)	72.40 (5.90)	72.19 (5.70)	72.78 (6.23)	0.007
Gender				<.001
Male	1268 (40.08)	877 (42.74)	391 (35.16)	
Female	1896 (59.92)	1175 (57.26)	721 (64.84)	
Education				<.001
Illiterate	1216 (38.43)	733 (35.72)	483 (43.44)	
Primary school	1259 (39.79)	827 (40.30)	432 (38.85)	
Middle school or above	689 (21.78)	492 (23.98)	197 (17.72)	
Marital status				<.001
Single ^a	701 (22.16)	393 (19.15)	308 (27.70)	
Married	2463 (77.84)	1659 (80.85)	804 (72.30)	
Household income ^b				0.004
Q1	798 (25.22)	477 (23.25)	321 (28.87)	
Q2	795 (25.13)	531 (25.88)	264 (23.74)	
Q3	779 (24.62)	529 (25.78)	250 (22.48)	
Q4	792 (25.03)	515 (25.10)	277 (24.91)	
Insurance type				<.001
None	111 (3.51)	48 (2.34)	63 (5.67)	
URRBMI	2966 (93.74)	1944 (94.74)	1022 (91.91)	
UEBMI	79 (2.50)	55 (2.68)	24 (2.16)	
Free medical	8 (0.25)	5 (0.24)	3 (0.27)	
Body mass index, mean (<i>SD</i>)	24.62 (3.76)	24.72 (3.76)	24.44 (3.75)	0.047
Chronic health conditions				<.001
No chronic condition	479 (15.14)	281 (13.69)	198 (17.81)	
One chronic condition	838 (26.49)	522 (25.44)	316 (28.42)	
Multimorbidity	1847 (58.38)	1249 (60.87)	598 (53.78)	
Activities of daily living limitations, mean (<i>SD</i>)	17.42 (4.93)	17.18 (4.72)	17.86 (5.28)	<.001
Outpatient care				0.641
Yes	292 (9.23)	193 (9.41)	99 (8.90)	
No	2872 (90.77)	1859 (90.59)	1013 (91.10)	
Inpatient care				0.840
Yes	566 (17.89)	365 (17.79)	201 (18.08)	
No	2598 (82.11)	1687 (82.21)	911 (81.92)	
Healthcare geographic accessibility				0.003
≤10	2927 (92.51)	1919 (93.52)	1008 (90.65)	
>10	237 (7.49)	133 (6.08)	104 (9.35)	
Personal health responsibility				0.001
Disagree	528 (16.69)	319 (15.55)	209 (18.79)	
Indifferent	689 (21.78)	421 (20.52)	268 (24.10)	
Agree	1947 (61.54)	1312 (63.94)	635 (57.10)	

The total percentage may not equal to 100 due to rounding.

URRBMI Urban and rural resident basic medical insurance, UEBMI Urban employee basic medical insurance, *SD* Standard deviation. Statistically significant $p < .05$ values are indicated in bold.

^aSingles include those who are unmarried, divorced and widowed;

^bQuartile 1 (Q1) was the poorest and Quartile 4 (Q4) was the richest.

Table 2 Association between personal health responsibility and family doctor contract services among older adults ($N = 3164$).

Characteristics	Model 1 ^a		Model 2 ^b		Model 3 ^c	
	OR (95% CI)	<i>P</i> -value	OR (95% CI)	<i>P</i> -value	OR (95% CI)	<i>P</i> -value
<i>Main terms</i>						
Personal health responsibility (Disagree ^{Ref})						
Indifferent	1.03 (0.82, 1.30)	0.808	1.13 (0.89, 1.44)	0.308	1.18 (0.92, 1.52)	0.181
Agree	1.35 (1.11, 1.65)	0.003	1.38 (1.13, 1.69)	0.002	1.47 (1.19, 1.82)	<0.001
Healthcare geographic accessibility (≤ 10 ^{Ref})						
>10			0.74 (0.56, 0.97)	0.032	1.49 (0.72, 3.06)	0.279
<i>Interaction term</i>						
Personal health responsibility×Healthcare geographic accessibility (Disagree × ≤ 10 minutes ^{Ref})						
Indifferent×>10 minutes					0.52 (0.21, 1.28)	0.153
Agree×>10 minutes					0.41 (0.18, 0.91)	0.028
<i>Controls</i>						
Age			1.00 (0.98, 1.01)	0.832	1.00 (0.98, 1.01)	0.808
Gender (Male ^{Ref})						
Female			0.78 (0.66, 0.93)	0.004	0.78 (0.66, 0.93)	0.005
Education (Illiterate ^{Ref})						
Primary school			1.07 (0.90, 1.28)	0.418	1.08 (0.90, 1.28)	0.407
Middle school or above			1.28 (1.02, 1.60)	0.033	1.28 (1.02, 1.61)	0.031
Marital status ^d (Single ^{Ref})						
Married			1.37 (1.13, 1.65)	0.001	1.37 (1.13, 1.65)	0.001
Household income ^e (Q1 ^{Ref})						
Q2			1.14 (0.92, 1.42)	0.227	1.14 (0.92, 1.42)	0.229
Q3			1.13 (0.90, 1.42)	0.276	1.13 (0.90, 1.41)	0.305
Q4			1.02 (0.82, 1.27)	0.855	1.02 (0.82, 1.27)	0.879
Insurance type (None ^{Ref})						
URRBMI			2.14 (1.45, 3.17)	<0.001	2.13 (1.44, 3.16)	<0.001
UEBMI			2.27 (1.21, 4.28)	0.011	2.27 (1.21, 4.28)	0.011
Free medical			1.63 (0.36, 7.40)	0.530	1.65 (0.36, 7.53)	0.518
Body mass index			1.01 (0.99, 1.03)	0.471	1.01 (0.99, 1.03)	0.498
Chronic health conditions (No chronic condition ^{Ref})						
One chronic condition			1.23 (0.97, 1.56)	0.087	1.22 (0.96, 1.54)	0.101
Multimorbidity			1.65 (1.32, 2.05)	<0.001	1.64 (1.32, 2.05)	<0.001
Activities of daily living limitations			0.98 (0.97, 1.00)	0.043	0.98 (0.97, 1.00)	0.048
Outpatient care (No ^{Ref})						
Yes			1.07 (0.83, 1.40)	0.599	1.08 (0.83, 1.41)	0.559
Inpatient care (No ^{Ref})						
Yes			0.91 (0.74, 1.11)	0.328	0.91 (0.74, 1.11)	0.346

Statistically significant $p < .05$ values are indicated in bold. *URRBMI* Urban and rural resident basic medical insurance, *UEBMI* Urban employee basic medical insurance.

^a Model 1: Unadjusted;

^b Model 2: Additionally adjusted for healthcare geographic accessibility, age, gender, education, marital status, household income, insurance type, body mass index, chronic health conditions, activities of daily living limitations, outpatient care, and inpatient care;

^c Model 3: Adjusted for model 2 criteria and the interaction between personal health responsibility and healthcare geographic accessibility;

^d Singles include those who are unmarried, divorced and widowed;

^e Quartile 1 (Q1) was the poorest and Quartile 4 (Q4) was the richest.

To account for differences in observed characteristics between contracting and non-contracting groups, we performed propensity score matching (PSM) analysis. Propensity scores were estimated using a logistic regression model

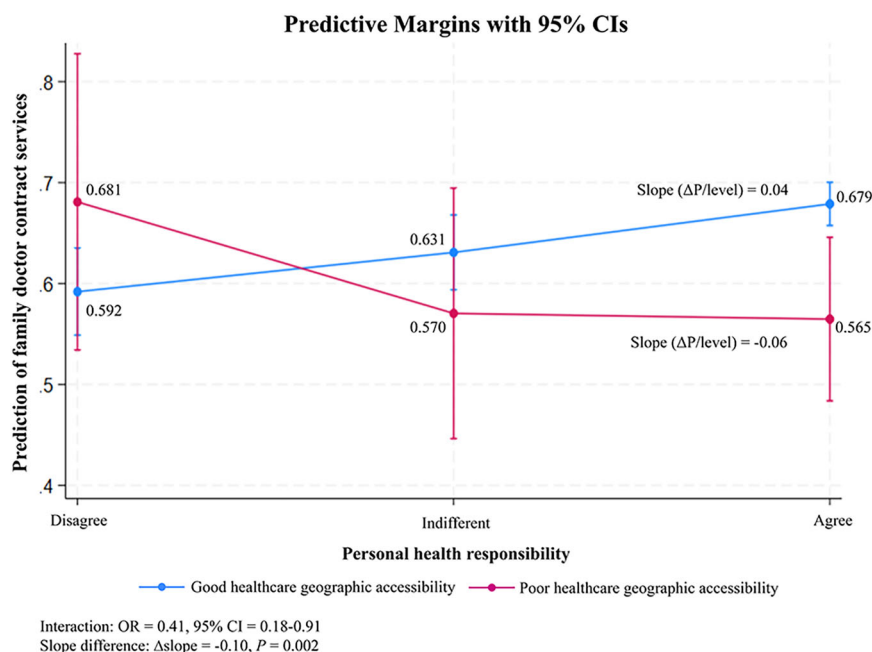


Fig. 2 Interaction between personal health responsibility and healthcare geographic accessibility in the prediction of FDCSs engagement. Predicted probabilities (with 95% confidence intervals) were derived from a logistic regression model adjusting for age, gender, education, marital status, household income, insurance type, body mass index, chronic health conditions, activities of daily living limitations, outpatient care, and inpatient care. The slopes represent the change in predicted probability from “disagree” to “agree” with personal health responsibility within each geographic accessibility group, calculated as $[P(\text{agree}) - P(\text{disagree})] / 2$. These values are expressed on the probability scale (0-1) and should not be interpreted as logistic regression coefficients (log-odds). The difference in the probability-scale slopes between the two accessibility groups is -0.10 ($P = 0.002$). Robustness check using average marginal effects (AMEs): For good accessibility, the AME of “agree” vs. “disagree” was +8.69% ($P < 0.001$); for poor accessibility, the AME was -11.61% ($P = 0.175$). The difference in AMEs between the two groups was significant ($P = 0.023$), consistent with the logistic regression interaction (OR = 0.41, 95% CI: 0.18-0.91). *Note:* The higher probability among poor-access respondents who disagree with personal health responsibility reflects county-level heterogeneity in contracting rates (see Supplementary Table S4); the moderating effect remains significant after accounting for this heterogeneity.

including all covariates listed in Table 1, and 1:1 nearest neighbor matching with common support was employed. Covariate balance before and after matching was assessed using standardized differences and overall balance tests.

Furthermore, to explore potential heterogeneity in the association between personal health responsibility and FDCSs, we conducted a series of subgroup analyses stratified by age, gender, education, marital status, household income, and chronic health conditions.

Odds ratios (OR) and corresponding 95% confidence interval (95% CI) were reported, with statistical significance set at two-tailed $P < 0.05$.

Results

Characteristics of participants

Table 1 presents the demographic characteristics of the participants in this study. A total of 3164 rural older adults aged 60 years and above participated, with a mean age of 72.40 years (SD = 5.90). Among the respondents, 1896 (59.92%) were women; 1216 (38.43%) were illiterate; and 2463 (77.84%) were married. Of these, 2052 (64.85%) participants reported contracting for FDCSs. Significant differences were observed between the contracting and non-contracting groups across several characteristics. Among them, compared to non-contracting individuals, those who

Table 3 Association between personal health responsibility and family doctor contract services among older adults stratified by healthcare geographic accessibility.

Variable	≤10 minutes (n = 2927)				>10 minutes (n = 237)			
	Model 1		Model 2		Model 1		Model 2	
	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Personal health responsibility								
Disagree	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
Indifferent	1.08 (0.85, 1.38)	0.525	1.17 (0.92, 1.50)	0.205	0.57 (0.24, 1.34)	0.198	0.64 (0.25, 1.62)	0.347
Agree	1.45 (1.18, 1.79)	<.001	1.47 (1.19, 1.82)	<.001	0.56 (0.26, 1.20)	0.138	0.68 (0.30, 1.56)	0.365

Model 1 was unadjusted;

Model 2 was adjusted for age, gender, education, marital status, household income, insurance type, body mass index, chronic health conditions, activities of daily living limitations, outpatient care, and inpatient care.

Statistically significant $p < .05$ values are indicated in bold.

contracted for FDCSs were more likely to be women ($P < 0.001$), married ($P < 0.001$), with higher educational levels ($P < 0.001$), and report multimorbidity ($P < 0.001$). Regarding education, the contracting group had a lower proportion of illiterate participants (35.72% vs. 43.44%) and a higher proportion of those with middle school education or above (23.98% vs. 17.72%) compared to the non-contracting group. Additionally, 1947 participants (61.54%) expressed support for personal health responsibility. Supplementary Table S4 presents the descriptive statistics by county. The three sampled counties (Laoling, Rushan, and Qufu) differed in contracting rates, while the proportion of respondents with good geographic accessibility was similar across counties.

Associations between personal health responsibility and FDCSs

Table 2 demonstrates the logistic regression results examining the relationship between personal health responsibility and FDCSs among rural older adults. In Model 1, older adults who supported personal health responsibility were more likely to contract for FDCSs compared to those who did not (OR = 1.35, 95% CI: 1.11-1.65). In Model 2, after adjusting for covariates, the significant positive association between personal health responsibility and FDCSs persisted (OR = 1.38, 95% CI: 1.13-1.69).

Interaction effects between personal health responsibility and healthcare geographic accessibility

In Model 3, we incorporated an interaction term of personal health responsibility and healthcare geographic accessibility to further explore whether the relationship between personal health responsibility and FDCSs varied by healthcare geographic accessibility. The significant negative interaction term (OR = 0.41, 95% CI: 0.18-0.91) indicated that poor geographic accessibility weakened the positive association between personal health responsibility and FDCSs engagement. As shown in Fig. 2, in good healthcare geographic accessibility areas, supporting personal health responsibility significantly increased the probability of signing up for FDCSs from 59.2% (disagree) to 67.9% (agree), demonstrating a positive slope ($\beta = 0.04$). Conversely, under poor accessibility, the signing probability decreased from 68.1% (disagree) to 56.5% (agree), showing a negative slope ($\beta = -0.06$). The significant slope difference ($\Delta\beta = -0.10$, $P = 0.002$) indicated that poor accessibility weakened the positive association between personal health responsibility and FDCSs engagement.

It is noteworthy that among respondents who disagreed with personal health responsibility, those in the poor-access group exhibited a higher predicted contracting probability (68.1%) than those in the good-access group (59.2%). This pattern reflects county-level heterogeneity in baseline contracting rates. As shown in Supplementary Table S4, the three sampled counties differ substantially in FDCSs enrollment (ranging from 53.0% in Qufu to 75.4% in Laoling), and the poor-access subgroup contains a higher proportion of respondents from high-contracting counties

(e.g., Laoling). Importantly, after accounting for county- and town-level differences through multilevel modeling (Section 3.5), the interaction between personal health responsibility and geographic accessibility remained significant, confirming that the moderating effect is not an artifact of county-level confounding.

The robustness of this moderating effect was further assessed through a series of sensitivity analyses. First, modeling travel time as a continuous variable yielded result consistent with the main finding (Supplementary Table S2). Second, using a stricter 5-minute threshold (≤ 5 minutes vs. > 5 minutes) also confirmed the interaction effect (Supplementary Table S3).

Association between personal health responsibility and FDCSs in subgroups

Table 3 reports the stratified analysis of the relationship between personal health responsibility and FDCSs based on healthcare geographic accessibility. The findings reveal that personal health responsibility was positively associated with higher contracting rates for FDCSs among older adults with good healthcare geographic accessibility (OR = 1.47, 95% CI: 1.19–1.82, $P < 0.001$). In contrast, no statistically association was observed between personal health responsibility and FDCSs among older adults with poor healthcare geographic accessibility.

To further explore the heterogeneity in this association, we conducted additional subgroup analyses stratified by age, gender, education, marital status, household income, and chronic health conditions, with full results shown in Supplementary Table S12. The positive association between personal health responsibility and FDCSs was consistently observed across most subgroups. More positive associations were observed among females (OR = 1.44, 95% CI: 1.10–1.89), adults aged 60–74 years (OR = 1.51, 95% CI: 1.17–1.95), those with lower education (OR = 1.71, 95% CI: 1.23–2.38), married participants (OR = 1.49, 95% CI: 1.19–1.87), middle-income groups (Q2: OR = 1.56, 95% CI: 1.04–2.32; Q3: OR = 1.67, 95% CI: 1.09–2.53), and those with multimorbidity (OR = 1.70, 95% CI: 1.29–2.23). Conversely, the association was not significant among males, adults aged 75 years and older, individuals with higher education, unmarried participants, the lowest or highest income groups, and those with none or only one chronic condition.

Robustness tests

To assess the robustness of our main findings, we conducted a series of sensitivity analyses accounting for location-level heterogeneity and differences in observed characteristics. First, we examined whether our results were confounded by location-level factors. County-level heterogeneity was tested by including interaction terms between county and personal health responsibility, which were not statistically significant (Supplementary Table S5 and S6). Multilevel models with random intercepts at the town level confirmed the presence of location clustering (town-level variance = 0.30, 95% CI 0.13–0.66, LR test $P < 0.001$). After accounting for this clustering, as well as in two-level models with county and town random intercepts, fixed-effects models with town dummy variables, and a village-level random-intercept model, the interaction between personal health responsibility and healthcare geographic accessibility remained significant and consistent with our main findings (Supplementary Tables S7 and S8). Second, to address differences in observed characteristics between contracting and non-contracting groups, we performed PSM analysis. The matching procedure successfully balanced all covariates (Supplementary Table S9). In the matched sample, re-estimation of both the main effect and the interaction effect yielded results consistent with our primary analyses (Supplementary Tables S10 and S11). These robustness checks confirm that our main conclusions are not sensitive to location-level heterogeneity or differences in observed characteristics.

Discussion

This study identifies a clear and consistent association between personal health responsibility and engagement with FDCSs among rural older adults in China. However, this relationship is shaped by contextual conditions. Geographic

accessibility to healthcare moderates the extent to which individuals are able to translate health responsibility into service engagement. Specifically, in areas with good accessibility, supporting personal health responsibility was associated with an 8.7-percentage-point higher FDCS engagement rate; conversely, in areas with poor accessibility, this positive relationship was no longer evident. This contrast underscores that the translation of personal health responsibility into practice is not automatic but depends on the accessibility of healthcare services.

The strong association between personal health responsibility and FDCSs engagement persists even after controlling for a variety of demographic and health-related factors, suggesting that an attitudinal orientation toward health responsibility is associated with greater formal engagement with primary care among rural older adults. This finding is broadly consistent with previous literature showing that personal health responsibility is associated with greater engagement with health-related matters and healthcare utilization (Chan, 2019; Han et al., 2012; Huang et al., 2018; Borghian et al., 2023; Horton, 2014; Yang et al., 2021; Zhao et al., 2017). In this study, however, this association is best understood at the level of attitudinal endorsement of health responsibility, rather than as direct evidence of a specific self-directed motivational pathway. Even so, the result suggests that placing greater emphasis on health responsibility is associated with a greater likelihood of engaging with FDCSs as a form of formal primary care.

However, healthcare geographic accessibility plays a critical moderating role in this relationship. Our analysis demonstrates that limited access to healthcare weakens the positive association between personal health responsibility and FDCSs engagement. HLT provides the core explanatory framework for this finding. This theory emphasizes that health behaviors (e.g., FDCSs engagement) are the result of interactions between individual agency (e.g., personal health responsibility) and contextual conditions (e.g., healthcare geographic accessibility) (Cockerham, 2023). In this study, poorer healthcare geographic accessibility appears to constrain the extent to which personal health responsibility is translated into contracting behavior. This challenge is particularly pronounced in rural areas, where underdeveloped transportation infrastructure and a lack of healthcare facilities exacerbate the barriers to healthcare access (Dai et al., 2019; Li et al., 2015). While family doctors do offer proactive home visits, these services are typically reserved for individuals who are disabled, bedridden, or otherwise mobility-impaired (Ma, 2020). Consequently, older adults with less acute health conditions may face barriers in accessing care, especially in rural areas where healthcare resources and well-trained healthcare professionals are lacking (Wang et al., 2021a). Thus, enhancing healthcare geographic accessibility, alongside fostering health responsibility, is essential for increasing engagement with FDCSs (Dai et al., 2019; Levesque et al., 2013).

These findings align closely with China's national health policies, including Healthy China 2030 initiative and the newly enacted Basic Healthcare and Health Promotion Law (National People's Congress, 2019), which emphasize the importance of personal health responsibility in addressing the dual burdens of an aging population and the rising prevalence of NCDs. Both policies aim to foster a culture of personal responsibility for health, encouraging individuals to adopt proactive health behaviors. However, as this study illustrates, the ability to exercise personal health responsibility is not solely dependent on individual motivation but is heavily shaped by healthcare geographic accessibility. In rural areas, where healthcare infrastructure remains underdeveloped, even individuals who are motivated to manage their health face significant challenges. This underscores the need for structural reforms to complement the goals of national health policies, particularly in rural regions where healthcare is less accessible (Schmidt, 2009; Traina and Feiring, 2022).

The need for improved healthcare geographic accessibility is particularly pressing for older adults with chronic NCDs, who require integrated care, regular health monitoring and preventive interventions—services typically provided by family doctors (Council, 2016). However, in rural areas, where transportation and healthcare resources are often limited, logistical and financial barriers deter many from signing up for FDCSs, particularly those with less acute health conditions or from lower socioeconomic backgrounds (Dai et al., 2019; Li et al., 2015). Within the HLT framework, personal health responsibility is treated as an attitudinal aspect of agency, whereas healthcare geographic accessibility is treated as a contextual condition under which this agency may or may not be translated into practice. In this sense, geographic barriers can narrow the feasible range of health-seeking behaviors among rural older adults, making the translation of responsibility into practice dependent not only on individual orientation but also on access to care (Albertsen and Tsiakiri, 2023; Cockerham, 2005).

These findings offer important implications for the improvement of the FDCSs and the health outcomes of rural older adults in China. In line with the agency-context interpretation, we propose a structured package of policy actions aligned with distinct implementation horizons. Short-term operational measures include leverage existing infrastructure and implementing targeted support. These include intensifying health education and FDCS awareness campaigns through accessible community platforms (e.g., Shandong's "Health Stations" in village clinics) and expanding telehealth services (e.g., the provincial telemedicine network piloted in rural Linyi and Heze) to ensure broad outreach; simultaneously, introducing temporary transportation subsidies or financial incentives to alleviate the immediate economic and logistical burdens faced by rural populations, especially for older adults with chronic conditions, in accessing medical services. These short-term measures reduce immediate access barriers and make it easier for health-responsible older adults to use FDCSs. In the long-term, systematic foundational investment and capacity building strategies are also essential. These include prioritizing targeted investments in transportation and digital infrastructure to mitigate structural geographic constraints; strengthening the FDCSs infrastructure and workforce in underserved rural areas, which includes developing personalized, long-term care plans with an emphasis on integrated chronic disease management and effective care coordination; and promoting sustained health literacy to foster a durable culture of personal health responsibility. In sum, these recommendations reflect the empirical insight that without removing geographic access barriers, efforts to enhance personal health responsibility may fall short. Addressing both structural factors (particularly healthcare geographic accessibility) and enabling factors (awareness, responsibility, and tailored services) through a combination of immediate facilitative measures and long-term structural investments will help create a more equitable and sustainable FDCSs system that supports healthier aging in rural China. Subgroup analyses further suggest that the positive association between personal health responsibility and FDCSs engagement was more evident among women, younger older adults, and those with multimorbidity. Conversely, additional tailored outreach and support are needed to improve engagement among men, the oldest-old, and socially or economically disadvantaged subgroups.

These findings are also relevant to primary care reforms in other countries. China's FDCS initiative has similar objectives to international models of continuous, person-centered primary care, such as the Patient-Centered Medical Home, but it is distinctive in its policy-driven implementation and explicit focus on rural older populations (Lai et al., 2024). Many countries have sought to formalize personal health responsibility in order to address modifiable behavioral risk factors, for example through the NHS Constitution for England, the Basic Healthcare and Health Promotion Law in China, and key Norwegian and German policy documents that link individual responsibility to priority setting and entitlement to publicly funded care (Traina and Feiring, 2022; Schmidt, 2007, 2009). Across these settings, a common challenge is to ensure equitable access and sustained engagement, particularly for underserved or geographically dispersed populations. Our results from rural China highlight a broader international issue: policies that appeal to personal health responsibility are more likely to be effective when they are supported by adequate structural enablers, for example geographic access to primary care. The theoretical framework used in this study can therefore provide a useful lens for thinking about similar primary care initiatives elsewhere, even though the empirical estimates reported here are specific to the Chinese context.

This study offers several strengths that enhance its contribution to understanding rural healthcare and personal health responsibility in China. First, it is one of the few empirical studies to examine the moderating role of healthcare geographic accessibility in the relationship between personal health responsibility and FDCSs engagement. This contributes to a more nuanced understanding of how structural factors, such as healthcare access, shape health-seeking behaviors, particularly in underserved rural areas. Second, by using a large, representative sample of rural older adults in China, the study provides valuable insights into the specific healthcare challenges faced by this population. The findings offer evidence-based insights that can inform policy interventions aimed at improving healthcare geographic accessibility and engagement with FDCSs in rural areas, which is crucial given the rising burden of chronic diseases and the aging population.

Despite the insights provided by this study, several limitations must be acknowledged. First, the cross-sectional design precludes causal inference. Second, the use of self-reported data may introduce recall and reporting bias. Third, this study assessed only the geographic dimension of healthcare accessibility, and did so using respondents' self-reported travel time rather than GIS-derived or administratively measured distance. The findings should therefore

be understood as reflecting self-reported geographic access rather than purely objective structural accessibility. Other important dimensions of accessibility, such as economic affordability and socio-cultural acceptability, were not captured. Fourth, personal health responsibility was measured with a single item due to psychometric constraints, precluding reliability assessment. Moreover, although the broader concept of personal health responsibility may encompass self-directed responsibilities for protecting one's own health, the retained analytic item in this study primarily captured a normative/moral orientation toward health responsibility. Accordingly, the findings should be interpreted as speaking primarily to the role of this moral/normative orientation in service engagement. Fifth, regional health system indicators reflect prefecture-level rather than county-specific data because of inconsistent local reporting, though they provide standardized contextual proxies. Lastly, the generalizability of our findings to different national contexts and healthcare systems requires further empirical validation.

Building on these limitations, future research should prioritize longitudinal designs to explore causal pathways and clarify the mechanisms linking personal health responsibility, healthcare accessibility, and FDCSs engagement. Such studies would benefit from employing validated multi-item instruments to capture the multidimensional nature of personal health responsibility and its behavioral manifestations. Importantly, future work must adopt a multi-dimensional conceptualization of healthcare accessibility, going beyond geographic limitations to integrate economic, social, and cultural dimensions, thereby providing a holistic understanding of the structural constraints on health-seeking behavior. Validating these relationships in diverse national and healthcare system contexts remains another crucial avenue for advancing the generalizability of knowledge in this field.

Conclusions

This study identifies a clear association between personal health responsibility and engagement with FDCSs among rural older adults in China, with healthcare geographic accessibility shaping the extent to which association is expressed. While individuals with higher levels of personal health responsibility are more likely to engage with FDCSs, poor healthcare geographic accessibility weakens this positive association. These findings underscore the importance of addressing both personal health responsibility and healthcare access conditions in promoting equitable access to primary care.

This study offers important implications for rural health policy. Ensuring that personal health responsibility translates into service engagement requires parallel investments in healthcare infrastructure, particularly to reduce geographic barriers. A policy approach that strengthens individual engagement while addressing systemic constraints provides a more equitable and sustainable foundation for primary care reform in aging rural populations.

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Author contributions CCZ and ZYL designed the study; JJL and ZYL conducted the data acquisition, performed the statistical analyses and interpreted the data; JJL drafted the manuscript; CCZ, ZYL and JJL critically reviewed and revised the manuscript; All authors read and approved the final manuscript. Prof. Chengchao Zhou and Prof. Ziyu Liu jointly supervised this work.

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Data availability The datasets used in the current study are not publicly available due to the confidential policy but are available from the corresponding author on reasonable request.

Declarations

Competing interests The authors declare no competing interests.

Ethics approval and consent to participate This study was reviewed and approved by the Ethics Committee of the School of Public Health, Shandong University (approval number, 20181228; approval date, 28 December 2018). All procedures were in accordance with the ethical standards of the Helsinki Declaration and relevant international guidelines and regulations.

Informed consent Before data collection, written informed consent was obtained directly from each participant included in the present analysis. Before the consent form was signed, interviewers provided the study information in writing and explained it orally in clear and accessible language. Participants were given an opportunity to ask questions and confirmed their understanding and voluntary agreement to participate before signing the form themselves. All participants included in the present analysis were able to communicate with the interviewers and answer the survey questions independently; no proxy consent was used. The data used in the present cross-sectional analysis were collected from July to August 2022 as part of the 2022 survey wave of the Shandong Rural Elderly Health Cohort (SREHC).

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