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How digital inclusive finance affects the health of the migrant population –evidence from China migrants dynamic survey

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ABSTRACT

Digital inclusive finance plays a pivotal role in enhancing the welfare of the migrant population. This paper adopts data from the 2017–2018 China Migrants Dynamic Survey to analyse the effect of digital inclusive finance on migrants' health and the underlying mechanisms. The results show that digital inclusive finance significantly improves migrants' health, which remains robust after taking full consideration of endogeneity. The mechanism analysis suggests that digital inclusive finance alleviates environmental pollution and enhances the accessibility of healthcare services, which in turn improves the health of migrants. Furthermore, the heterogeneity analysis reveals that compared with other migrants, digital inclusive finance has a greater health-enhancing effect on the middle-aged and those without higher education or with public health education.

I. Introduction

Migration has become a critical global issue in the 21st century, marked by significant migration and cross-border movements in recent years. The Global Migration Report 2020 indicates an increase in the global migrant population from 221 million in 2010 to 281 million in 2020. This trend is mirrored in China, where rapid urbanization has led to significant rural-to-urban migration (Gong et al. 2012). Migrants are crucial for national development, yet they encounter numerous challenges that categorize them as a health-disadvantaged group (Olawo, Pilkington, and Khanlou 2021). They endure poor living conditions and work in hazardous environments, increasing their risk for infectious diseases and occupational health issues. Urban high living costs and limited social integration contribute to their psychological stress. The restrictive 'hukou' system intensifies these challenges by restricting access to social security, emphasizing the urgent need to tackle health issues among migrants (Wu and Wang 2014).

Migrant populations, upon departure from their resource-rich places of origin and arrival at new destinations, encounter structural barriers to health improvement, including limitations in economic resources and a scarcity of opportunities for health enhancement. In times of health crises, they urgently require financial services to alleviate the liquidity constraints arising from disease intervention and treatment. However, traditional financial systems often favour customer groups with better economic conditions, exhibiting a degree of exclusivity towards migrant populations with weaker economic capabilities and lower financial literacy. The integration of digital technology offers a breakthrough opportunity for the transformation of traditional financial services, effectively surmounting geographical and temporal constraints, while reducing operational costs and mitigating issues of information asymmetry (C. Wang et al. 2024). This has enabled financial institutions to provide more robust financial support to remote areas and economically disadvantaged groups, significantly expanding the breadth, depth, and sustainability of financial services (Lan, Pan, and Yu 2024). Moreover, the widespread application of innovative tools such as mobile payments, digital currencies, online insurance, peer-to-peer lending, and digital financial platforms has not only greatly broadened the accessibility of financial services but also injected innovative momentum into the construction of a more inclusive and

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equitable financial system (Xu et al. 2024). Therefore, this paper attempts to explore the impact of digital inclusive finance on the health of the migrant population and its underlying mechanisms, aiming to offer references and insights for other developing countries in enhancing the health human capital of their migrant populations.

Drawing from the existing literature, academia widely employs Grossman's health economic framework to analyse the factors affecting the health status of the migrant population. Prevailing research suggests that the self-selection mechanism of migrants leads to a tendency for younger and healthier individuals to migrate, resulting in a health status above that of urban residents. However, over time, migrants may succumb to a variety of health issues, including infectious diseases and occupational illnesses, due to the impact of both internal and external environmental factors (Hu, Cook, and Salazar 2008). This transition from health-driven migration to potential health risks underscores the intricate nature of migrants' health conditions and the imperative for scholarly investigation. The influencing factors of migrant population health can be summarized into two aspects: First, demographic characteristics, including gender (Dunn and Dyck 2000), health education (Van Der Heide et al. 2013) and language proficiency (Lu, Chen, and Wang 2019); second, social environmental factors, which mainly include living environment (Tian, Kong, and Li 2021), social discrimination (LeBel 2008), and social support and social capital (Li and Rose 2017). However, there is still a dearth of literature exploring the impact of digital transformation on the health of vulnerable groups in contemporary society, indicating a gap that requires further research.

In recent years, the importance of digital transformation for sustainable economic growth has been increasingly prominent (Ahmad and Schreyer 2016; Ahmed 2020; ALshubiri, ALmaashani, and Thuaar 2022). Existing research has focused on the macroeconomic effects of digital inclusive finance in aspects such as economic growth (ALshubiri, ALmaashani, and Thuaar 2022), industrial structure optimization (Zhanbayev and Bu 2023), and the impact on traditional financial systems, as well as its microeconomic effects on aspects like residents' income, consumption and investment and the allocation of household risky financial assets (C. He et al. 2022; Shen, Hu, and Zhang 2022; C. Yu et al. 2021). Yet, whether it can become an important driving force in improving the health level of migrants remains to be in-depth investigated.

This paper makes contributions to the literature in three aspects. First, regarding the research perspective, the Chinese government has elevated financial inclusion to a national strategy, aiming to provide comprehensive financial services to all social strata, particularly economically disadvantaged groups (Lan, Pan, and Yu 2024; Xu et al. 2024). However, academic research on the micro-level impacts of digital inclusive finance still largely relies on overall resident samples to explore the general effects of digital inclusive finance on individuals (C. He et al. 2022; Shen, Hu, and Zhang 2022; C. Yu et al. 2021), which fails to fully reflect the 'inclusiveness' of digital inclusive finance. While these studies have laid the groundwork for understanding the micro-effects of digital inclusive finance, they lack in-depth discussion on its differentiated impact on specific groups, especially the migrant population. Some literature related to this paper's theme has attempted to incorporate the health dimension into the multi-dimensional poverty index (F. Wang et al. 2024), but its primary aim is to explore the relationship between digital finance and multi-dimensional poverty among residents, without fully revealing how digital inclusive finance affects residents' health. To our knowledge, we are among the first to examine the unique advantages of digital inclusive finance in serving 'disadvantaged groups', revealing the greater 'inclusiveness' of digital inclusive finance. It systematically explores the impact of digital inclusive finance on the health of the migrant population, offering a new perspective for understanding the welfare effects of digital inclusive finance in the field of individual health.

Second, regarding the mechanism pathways, there is still a lack of attention within academia regarding the impact of digital societal transformation on public health, and an even greater scarcity of analysis on the corresponding mechanisms. While some literature has investigated the effects of the development of digital finance and fintech on environmental pollution (Muganyi, Yan, and Sun 2021; Zeng, Wang, and Wu 2022), and other

studies have examined how digital finance and internet usage can enhance the accessibility of medical services (Bessière et al. 2010; Hollis et al. 2015), these research have not extended to the impact on the health of the migrant population. This paper connects to the aforementioned literature and selects two pathways – environmental pollution and medical service accessibility – to provide solid empirical evidence on the health promotion effects of digital inclusive finance, thereby enriching the literature on digital inclusive finance and public health.

Third, regarding policy implications, the heterogeneity analysis sheds further light on the inclusive essence of digital inclusive finance for disadvantaged groups. It reveals that the health promotion effects are particularly significant among less educated, middle-aged migrant populations. The conclusions drawn from this study deepen the understanding of the impact of digital inclusive finance and provide insights into the driving force behind health equity enhancement in the context of developing countries, offering policymakers with reliable empirical evidence to shape their strategic initiatives.

II. Theoretical analysis and research hypotheses

Digital inclusive finance and the health of migrant populations

Traditional financial institutions often confront high transaction costs and significant risks when providing credit to vulnerable groups, which substantially reduces their motivation to offer such services. However, digital inclusive finance improves the accessibility of financial services, effectively alleviating the liquidity constraints that the migrant population encounters regarding health and medical expenses. By lowering barriers to service and utilizing technologies like big data and cloud computing, digital inclusive finance addresses financial exclusion for groups such as the migrant population, reduces borrowing costs, and lessens the financial burden on their health and medical expenditures (F. Wang et al. 2024). Furthermore, the scope of digital inclusive finance is not limited to basic financial services; it also includes a range of financial products, notably medical and health insurance. The beneficial effects

of medical and health insurance, along with other financial products, on the health of residents have been extensively verified (Anderson, Dobkin, and Gross 2012; Don Eliseo Lucero-Prisno et al. 2022). Based on this, we propose the following hypothesis:

H1: Digital inclusive finance can improve the health of the migrant population.

Boosting the accessibility of medical services

Medical services form the backbone of the urban public service system and are crucial for the health of residents. As urbanization accelerates, ensuring the adequacy and equitable accessibility of medical resources becomes particularly critical (Liu et al. 2024), directly affecting the health and well-being of the mobile population (Van Gaans and Dent 2018). Digital inclusive finance, on one hand, can alleviate the financing constraints in the healthcare sector, thereby improving issues such as the inadequacy of primary-level healthcare facilities, scarcity of medical personnel, and low service capabilities, enhancing the accessibility of medical services (Xu et al. 2024). On the other hand, access to traditional medical services is relatively complex, and the highly mobile nature of the migrant population makes it difficult to establish stable relationships with local hospitals, hindering their ability to obtain timely and accurate medical services. Digital inclusive finance can optimize the efficiency of medical utilization and thereby improve the health of the migrant population through services such as digital medical insurance, online consultations, and online registration(Huang, Yu, and Ledsky 2006). Therefore, we propose the following hypothesis:

H2: Digital inclusive finance can enhance the health of the migrant population by boosting the accessibility of medical services.

Alleviating environmental pollution

Digital inclusive finance, as an emerging financial technological innovation, is an important driving force for achieving green development and improving environmental pollution (Du et al. 2022; C. He

et al. 2022). On one hand, the digital online office model reduces the consumption of physical resources in the financial service process, which can directly reduce the emission of pollutants. On the other hand, financial technology innovation has brought an information revolution to the development of the financial industry, reducing the information asymmetry between financial institutions and enterprises. By incorporating environmental factors such as clean production and energy conservation and emission reduction into credit policy assessment criteria, it avoids financing for substandard enterprises and promotes the improvement of green financial resource allocation quality and efficiency (Zhang et al. 2023; Zhang, Fan, and Zhao 2023; Zhao, Chen, and Zhang 2023).

Furthermore, according to the health capital theory, health capital is defined as an accumulative stock asset, the value of which can be enhanced through health investment behaviours or delayed depreciation by reducing environmental exposure. However, the migrant population, due to generally lower levels of education and skills, often engages in positions with high labour intensity and long working hours, which are often accompanied by higher occupational and public health risks. Moreover, the migrant population has dual deficiencies in knowledge and economy in terms of environmental pollution protection, making them more susceptible to high concentrations of air and water pollution, accelerating the depreciation process of their health capital (Schoolman and Ma 2012). Therefore, the improvement of environmental quality by digital inclusive finance has a more significant positive effect on curbing the depletion of health capital among the migrant population. Therefore, this study proposes the following hypothesis:

H3: Digital inclusive finance can enhance the health of migrant populations by alleviating regional environmental pollution.

III. Data and empirical design

Data sources and description

This study utilizes the following datasets: China Migrants Dynamic Survey (CMDS, hereinafter the same). This dataset, conducted annually by the National Health Commission since 2009, represents a large-scale national survey on the migrant population. Considering that health-related metrics for the migrant population were first included in 2017, this study employs data from the 2017–2018 CMDS. City-level data. The study adopts the China Digital Inclusive Finance Index compiled by the Digital Finance Research Center at Peking University. This index, which leverages transaction data from Ant Financial, effectively reflects the development level of digital inclusive finance across different regions (Guo et al. 2020). Control variables at the city level are sourced from the 'China City Statistical Yearbook'. Following the matching at the prefecture-level city and limiting the study's scope to the migrant population aged between the legal working age of 16 and the statutory retirement ages (60 for males and 55 for females), the final sample encompasses 275 prefecture-level cities with a total of 273,993 migrant population samples.

The dependent variable in this study is $Health_{ict}$, with $Disease_{ict}$ serving as an alternative dependent variable. $Health_{ict}$ represents the self-assessed health status of the migrant population. In the 2017 and 2018 survey questionnaires, respondents were asked, 'How is your health condition? 1. Healthy, 2. Basically healthy, 3. Unhealthy, but capable of self-care, 4. Unable to take care of oneself'. Following the approach of existing literature, assigns the values of 0 to 'Unable to take care of oneself' and 'Unhealthy but capable of self-care', and the value of 1 to 'Healthy'. $Disease_{ict}$ indicates whether the respondent has been ill or felt unwell in the past year. In the questionnaire, respondents were asked, "Have you been ill (injured) or felt unwell in the past year? The options in the questionnaire include: within the last two weeks, more than two weeks ago, no. This study assigns the values of 1 to 'within the last two weeks' and 'more than two weeks ago', and 0 to 'no'.

This study utilizes the first-order lagged data of the China Digital Inclusive Finance Index as the independent variable.

Control variables are selected at two levels: Individual and household level. The study includes controls for household registration status, political affiliation, health insurance, duration of mobility,

Table 1. Level of DIF and health status of the migrant population.

	Individuals with health status in 2017		Individuals with health status in 2018	
DIF Level	Numbers	Percentage	Numbers	Percentage
Low	61341	83.49%	57757	88.11%
High	60166	85.62%	58364	90.21%
Total	121507	84.53%	116,121	89.15%

age, gender, classification as a high-skilled worker, marital status, income, and employment status. At the city level, we initially control for per capita GDP. Meanwhile, given the government's influential position in economic activities and its potential to enhance the health of the migrant population through strategic fiscal policies, we include fiscal autonomy and fiscal expenditure scale as control variables.

Mediating Variables. Based on the theoretical analysis in the previous sections, the impact pathways of urban inclusive finance development on the health of the migrant population include reducing environmental pollution and improving the accessibility of healthcare services. Specifically, this study employs industrial dust removal and industrial sulphur dioxide removal as indicators to measure the reduction in environmental pollution, and the number of hospital and health institutions per 10,000 people as an indicator to measure the accessibility of medical and health services. The precise definitions of each variable, along with their respective descriptive statistics, are shown in Appendix Table A1.

In this study, utilizing the median values of the Digital Inclusive Finance Development Index across various years, we categorize the development levels of digital inclusive finance in disparate cities and years into distinct tiers: low and high. Table 1 illustrates two significant trends: on the one hand, there is a positive upward trend in the proportion of the migrant population rating their health as good, increasing from 84.53% in 2017 to 90.21% in 2018. On the other hand, a higher level of development in digital inclusive finance correlates with an enhanced degree of health among the urban migrant population.

Empirical strategy

Considering that both the dependent variable and its alternative variables in this study are binary 0–1

dummy variables, the use of a linear probability model (LPM) would imply that the dependent variable represents a probability (ranging between 0 and 1), yet the linear fit values may extend beyond this range, adversely affecting the model's probabilistic estimation. This characteristic is not only at odds with the theoretical constraints for binary outcomes but also poses a significant challenge to the interpretability of the model's predictions. Moreover, LPM is prone to heteroskedasticity issues, necessitating estimation via generalized least squares (GLS) or feasible generalized least squares (FGLS), This concern is also pivotal when assessing the validity of statistical inferences. Consequently, nonlinear models generally offer superior performance in probabilistic estimation. Therefore, this study employs a probit model as the primary analytical tool and further conducts robustness checks using a logit model. The specific model construction is as follows:

$$P(Health_{ict} = 1) = \phi\big(\alpha_0 + \alpha_1 DFI_{c,t-1} + \alpha_2 controls \\ + year_t + city_c + year_t \times prov_s\big) \tag{1}$$

$$P(Disease_{ict} = 1) = \phi\big(\alpha_0 + \alpha_1 DFI_{c,t-1} + \alpha_2 controls \\ + year_t + city_c + year_t \times prov_s\big) \tag{2}$$

In the equation: $Health_{ict}$ is the dependent variable, representing the self-rated health level of migrant individual i in city c at year t; $Disease_{ict}$ is the alternative variable for the dependent variable, indicating whether migrant individual i in city c at year t has been ill or felt unwell in the past year; $DFI_{c,t-1}$ denotes the level of digital inclusive finance in city c at year $t-1$; $controls$ represent the control variables at both the migrant population and city levels; ε_{ict} is the error term; $year_t$ and $city_c$ are the year fixed effects and city fixed effects, respectively; The interaction term between $year_t$ and $prov_s$ represents the temporal trend at the provincial level. The coefficients that we mainly focus on are α_1 and β_1. If α_1 is significantly positive and β_1 is significantly negative, it would indicate that digital inclusive finance can enhance the health levels of the migrant population.

To identify the impact of digital inclusive finance on the health of the migrant population, two types of problems need to be addressed. The first is that even if we control the variables at both the migrant population and city levels, there remains the potential influence of unobservable confounding variables that could bias the regression results. These latent factors, which are not captured by our control variables, may correlate with both the digital inclusive finance development and health outcomes. To address the potential influence of unobservable confounding variables, this study controls for both time and city fixed effects to address the potential influence of unobservable confounding variables. Furthermore, to capture broader regional trends that might affect health and financial development, we have also controlled for provincial time trends.

The second is the endogeneity issue, which can be primarily attributed to three factors: (1) the impact of digital inclusive finance development on the health of the migrant population is not instantaneous but rather accumulates over time, indicating the gradual nature of economic and social changes. (2) There is a potential for reverse causality between the development of digital inclusive finance and the health of the migrant population, suggesting that enhancements in health may, in turn, fuel the growth of digital finance, and vice versa. (3) despite controlling for time and city fixed effects, as well as provincial time trends in this study, there remains the potential for endogeneity that could bias the regression results. This endogeneity could stem from unobservable factors that are correlated with both the development of digital inclusive finance and health outcomes, such as cultural differences, and regional health policies, which are not captured by the included controls.

Therefore, we address these concerns by incorporating a first-order lag of digital inclusive finance as an independent variable. This method captures the delayed impact of digital inclusive finance on health improvement and helps to alleviate the potential for reverse causality. Additionally, to further overcome omitted variable bias and potential endogeneity, we select two instrumental variables for the following endogeneity analysis: 'the

geographical distance from cities to Hangzhou' and 'the number of mobile phone users in each city'.

IV. Empirical analysis

Baseline regression

This section empirically analyzes the impact of digital inclusive finance on the health of the migrant population. After controlling for variables at both the migrant population and city levels, time as well as time, city fixed effects, and provincial time trends, the results in columns (1)-(2) of Table 2 indicate that digital inclusive finance is positively correlated with

Table 2. Baseline regression results.

	(1) health	(2) disease	(3) health	(4) health	(5) health
DIF	0.018***	−0.007**			
	(0.003)	(0.003)			
DIF_breadth			−0.001		
			(0.003)		
DIF_depth				0.012***	
				(0.001)	
DIF_digit					0.003***
					(0.001)
File	0.170***	−0.092***	0.168***	0.169***	0.169***
	(0.010)	(0.008)	(0.010)	(0.010)	(0.010)
Sex	0.083***	−0.103***	0.083***	0.083***	0.083***
	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
Age	−0.030***	−0.001	−0.029***	−0.030***	−0.029***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Duration	−0.008***	0.007***	−0.008***	−0.008***	−0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Edu	0.024**	0.072***	0.024**	0.024**	0.024**
	(0.012)	(0.010)	(0.012)	(0.012)	(0.012)
Hukou	0.011	−0.014	0.011	0.012	0.011
	(0.011)	(0.009)	(0.011)	(0.011)	(0.011)
Party	0.016	0.028*	0.016	0.016	0.016
	(0.019)	(0.016)	(0.019)	(0.019)	(0.019)
Mari	0.009	0.043***	0.009	0.009	0.009
	(0.013)	(0.011)	(0.013)	(0.013)	(0.013)
Insurance	0.031*	0.030**	0.031*	0.030*	0.031*
	(0.016)	(0.015)	(0.016)	(0.016)	(0.016)
Inincome	0.102***	0.026***	0.101***	0.102***	0.102***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Employ	0.036***	−0.104***	0.035***	0.036***	0.036***
	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)
Rjgdp	−0.000***	−0.000***	−0.000***	−0.000***	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Fisspt	0.006	−0.066*	0.008	0.029	0.014
	(0.037)	(0.036)	(0.038)	(0.037)	(0.037)
Fiscal	−0.821	−0.213	−0.220	−0.953	−0.065
	(0.854)	(0.836)	(0.868)	(0.847)	(0.850)
_cons	−3.005***	1.667***	0.240	−1.965***	−0.835*
	(0.591)	(0.590)	(0.550)	(0.448)	(0.437)
City FE	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Time × Province FE	Y	Y	Y	Y	Y
N	185681	185749	185681	185681	185681
R Squared	0.081	0.231	0.080	0.081	0.081

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses. Without special statements, the following tables are annotated as in Table 2.

the self-rated health of the migrant population at a 1% significance level. For every one standard deviation increase in digital inclusive finance, the probability of the migrant population rating their health as 'healthy' increases by 8.43%, and the probability of the migrant population experiencing 'illness or discomfort in the past year' decreases by 4.22%, thereby supporting Hypothesis 1. Additionally, regarding the regression results with the three sub-dimensions of digital inclusive finance as explanatory variables, it can be seen from columns (3)-(5) of Table 2 that usage depth and digitalization degree index are significantly positive at the 1% level, while the coverage breadth index is not significant.

Usage depth and digitalization degree reflect the degree of acceptance and utilization of digital financial services by users, as well as the external accessibility and availability of digital finance. Regression results indicate that the health improvement effect of digital inclusive finance on the migrant population stems from its accessibility and the degree to which digital inclusive finance is accepted and utilized. This conclusion is consistent with the research findings of J. Yu and Meng (2022) and Don Eliseo Lucero-Prisno et al. (2022). Both studies found that the development of financial technology, represented by digital transformation, has improved the accessibility of financial services, reduced health inequality, and enhanced access to healthcare.

Robustness checks

Changing the dependent variable and regression models

This study further categorizes the health status as follows: individuals who cannot take care of themselves are assigned a value of 1; those who are unhealthy but capable of self-care are assigned a value of 2; those who are in basic health are assigned a value of 3; and those who are healthy are assigned a value of 4. The Ordered Probit model is employed for robustness checks, and the regression results, as shown in the first column of Table 3, are consistent with the baseline regression. Meanwhile, this study further employs the OLS and Logit models for regression. The regression results are shown in columns (2) and (3) of

Table 3. Robustness tests.

	(1) Oprobit health	(2) Logit health	(3) OLS health	(4) Probit health	(5) Probit disease
DIF	0.017***	0.035***	0.004***	0.007**	−0.005*
	(0.003)	(0.005)	(0.001)	(0.003)	(0.003)
Controls	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Time × Province FE	Y	Y	Y	Y	Y
N	185749	185681	185749	145341	145409
R Squared	0.077	0.081	0.064	0.074	0.227

Table 3, which align with the baseline regression. This consistency underscores the robustness of the conclusions derived from the baseline analysis.

Altering the sample size

According to the 'Yangtze River Delta Inclusive Finance Index Analysis Report (2019)', it is evident that the overall level of inclusive finance in the Yangtze River Delta region, which includes Shanghai, Jiangsu Province, Zhejiang Province, and Anhui Province, is relatively high, with multiple indicators such as financial service utilization, accessibility, and quality significantly exceeding the national average. Therefore, to ensure that the conclusions are not influenced by the Yangtze River Delta region, this paper reconducts the Probit regression after excluding samples from the region, as shown in columns (4) to (5) of Table 4. The regression results indicate that the regression coefficients after excluding the samples from the Yangtze River Delta region remain consistent with the baseline regression, suggesting that the conclusions of the baseline regression possess a certain degree of robustness.

Table 4. Endogeneity test.

	Transportation distance to Hangzhou		Number of cell phones	
	(1) health	(2) Disease	(3) health	(4) Disease
DIF	0.0351***	−0.0165***	0.0383***	−0.0437***
	(0.0084)	(0.0086)	(0.0128)	(0.0115)
First stage coefficient	−0.0456***	−0.0456***	0.0111***	0.0111***
	(0.0004)	(0.0004)	(0.0001)	(0.0001)
First-stage F-values	274.01	274.01	242.63	242.63
Controls	Y	Y	Y	Y
City FE	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Time × Province FE	Y	Y	Y	Y
N	185681	185749	185681	185749

Endeneity analysis

Endogeneity analysis

Based on the analysis of endogeneity issues in Section 3.2 'Empirical Strategy' of this paper, and having incorporated a first-order lag of digital inclusive finance as an independent variable as well as controlled for fixed effects, this study further employs instrumental variable methods for endogeneity analysis. We first follow the methodology from Guo et al. (2020), using 'the geographical distance from each prefecture-level city or municipality to Hangzhou' as an instrumental variable. This distance effectively isolates the impact of digital inclusive finance, as cities farther from Hangzhou tend to have lower levels of digital inclusive finance, but the distance itself is not influenced by changes in the health of the migrant population (Feng, Zhang, and Li 2022). Additionally, the number of mobile phone users in each prefecture-level city or municipality is used as a second instrumental variable. Since digital inclusive finance is achieved online, the number of mobile phone users, representing the scale of mobile communications, is closely related to the development of digital inclusive finance, yet not directly linked to the health of the migrant population.

This study employs the aforementioned instrumental variables for Ivprobit model regression on the migrant population's self-assessed health and the condition of 'having been ill or feeling unwell in the past year'. The estimation results are shown in Table 4. The first-stage F-values are all significantly greater than 10, and the second-stage regression results indicate that the coefficients for digital inclusive finance are significant at the 1% level, which further confirm the robustness of the baseline conclusions.

Mechanism analysis

Mechanism analysis

Based on the theoretical analysis in the previous section, this paper establishes the following regression model for mechanism testing:

$$Pollution_{ct} = \alpha_0 + \alpha_1 DFI_{c,t-1} + \alpha_2 city\_cv_{ct} + year_t + city_c + year_t \times prov_s + \varepsilon_{ct} \quad (3)$$

$$Medi\_service_{ct} = \alpha_0 + \alpha_1 DFI_{c,t-1} + \alpha_2 city\_cv_{ct} + year_t + city_c + year_t \times prov_s + \varepsilon_{ct} \quad (4)$$

Among them, $DFI_{c,t-1}$ represents the lagged availability of financial services in city c one year prior, $Pollution_{ct}$ represents the pollution emissions in city c at year t, and $Medi\_service_{ct}$ represents the accessibility of medical services in city c at year t. The meanings of the remaining variable names are consistent with those in the baseline regression. Table 5 reports the results of the empirical tests.

Regarding the mechanism analysis of the accessibility of medical services, this paper draws on the research from Yin and Zhang (2018), selecting the number of hospitals and health institutions per 10,000 people in the city where the migrant population resides as a measure of medical accessibility. The regression results, as shown in column (1) of Table 6, indicate that digital inclusive finance has improved the health of the migrant population by enhancing the accessibility of medical services. This is in line with Hollis et al. (2015) and Lucero-Prisno et al. (2022), these results both indicate that digital finance has the potential to revolutionize healthcare services worldwide by enhancing efficiency and effectiveness through innovative applications and services, Therefore, Hypothesis 2 is confirmed.

Regarding the mechanism analysis of environmental pollution, the selected indicators are the local industrial particulate matter removal and industrial sulphur dioxide removal. The regression results are shown in columns (2) to (3) of Table 5, indicating that digital inclusive finance, as a form of green finance, improves the health status of the migrant population by enhancing local industrial particulate matter and sulphur dioxide removal. This conclusion is consistent with and complements the findings of Zeng, Wang, and Wu (2022) and Fan, Kong, and Li (2023), whose research concludes that digital green finance can

Table 5. Results of mechanism analysis.

	(1) ln_hospital	(2) ln_smog	(3) ln_SO₂
DIF	0.023***	0.011***	0.002***
	(0.000)	(0.000)	(0.000)
_cons	−0.562***	12.001***	11.2059
	(0.067)	(0.022)	(0.023)
Controls	Y	Y	Y
City FE	Y	Y	Y
Time FE	Y	Y	Y
Time × Province FE	Y	Y	Y
N	232005	237659	235358
R Squared	0.960	0.925	0.943

reduce urban haze pollution and has a significant positive impact on the improvement of residents' health, Therefore, Hypothesis 3 is confirmed.

These findings from mechanism analysis underscore the necessity for government action in fostering an integrative ecosystem for the development of digital inclusive finance and public health. Based on the results above, it is imperative that policies are crafted to stimulate the development of green, low-carbon economic and social systems, as well as advancements in the health sector, to align with and promote the long-term goals of the 'Healthy China' initiative, aimed at improving the overall well-being of the population.

V. Heterogeneity analysis

The baseline regression analysis examined the average effect of digital inclusive finance on the health of the migrant population. In this section, the sample is categorized based on education level, access to public health education, and age groups, with heterogeneous regression results presented in Table 6.

According to the results from columns (1) to (2), digital inclusive finance has a significant positive effect on the health of the group without higher education, while its effect on the group with higher education is not significant. The reason is that, compared to the migrant population with higher education, those with lower levels of education generally face issues such as low income, poor working and living conditions, and a lack of medical and health services, placing their health status at a relatively lower level. This leads to a significant health-promoting effect of digital inclusive finance

on them, whereas its impact on the more educated migrants is not significant. Although there is no literature that directly explores this topic, Liu, Zhang, and Li (2021) have found that digital inclusive finance can alleviate the constraints of insufficient academic education on farmers' entrepreneurial choices. The conclusions of this paper further explore the health-improving effects of digital inclusive finance on vulnerable groups, particularly in situations of inadequate education, effectively supplementing the existing literature.

According to the questionnaire item 'In the past year, have you received health education in your community?', public health education is divided into seven aspects, including occupational disease prevention, mental health, and other health-related topics. Migrants are considered to have received public health education if they have participated in at least one of these activities; otherwise, they are considered not to have received it. The regression results from columns (3) to (4) indicate that digital inclusive finance significantly and positively affects the health of both groups. However, the marginal effect is larger and the significance is stronger for the group that has received health education. A possible explanation is that the various public health education programmes conducted within communities can enhance health awareness. This enables the migrant population to utilize digital inclusive finance to access a range of financial services, more medical services, and to engage in health-related insurance investments, which in turn improves their health conditions. This conclusion is consistent with existing literature, which suggests that health literacy interventions can enhance health literacy, leading to better health behaviours and improved physical and mental health outcomes (Aaby et al. 2017; Walters et al. 2020).

Table 6. Heterogeneity analysis.

	Education Level		Public Health Education		Age	
	(1) High	(2) Low	(3) Yes	(4) No	(5) Middle-aged	(6) Youth
DIF	−0.001	0.022***	0.018***	0.011*	0.021***	0.017***
	(0.007)	(0.003)	(0.003)	(0.006)	(0.005)	(0.003)
_cons	1.768	−3.879***	−2.947***	−1.269	−4.311***	−2.337***
	(1.576)	(0.651)	(0.704)	(1.263)	(1.132)	(0.727)
Controls	Y	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Time × Province FE	Y	Y	Y	Y	Y	Y
N	36817	148178	144142	41330	38532	146925
R Squared	0.067	0.081	0.080	0.090	0.046	0.054

According to the regression results from columns (5) to (6) for age groups. Following the age grouping method of the World Health Organization, the sample is divided into two groups: youth (below 45 years old) and middle-aged (45–59 years old). It can be observed that digital inclusive finance can improve the health of the migrant population across all age groups. However, the health effects are greater for the middle-aged population. A possible explanation is that younger individuals generally enjoy better health conditions than their middle-aged counterparts, resulting in a relatively limited marginal health effect from digital inclusive finance. In contrast, the personal health status of middle-aged individuals tends to decline with age, and the health effects of digital inclusive finance become increasingly significant. This conclusion is consistent with Y. Wang and Chen (2024), which suggests that technological development and applications such as Internet usage have greatly improved the health of middle-aged and older adults.

VI. Conclusions and policy implications

This study explores the effect of digital inclusive finance on the health of China's migrant population, utilizing data from the 2017–2018 CMDS matched with urban data. The findings reveal that digital inclusive finance significantly improves the migrant population's health, which is primarily attributed to the reduction in environmental pollution and the enhancement of healthcare service accessibility. Moreover, the heterogeneity analysis indicates that individuals without higher education, those who have not received public health education, and the middle-aged group exhibit a more significant enhancement in their health condition. Based on the research findings, this study proposes the following policy implications:

First, efforts should be intensified to advance the development of digital inclusive finance. On one hand, digital infrastructure is the foundation for the development of digital finance and a prerequisite for improving the health and welfare of vulnerable groups through digital inclusive finance. Therefore, it is essential to strengthen the construction of digital infrastructure and to encourage more financial institutions to build and participate in digital inclusive finance service platforms, thereby better promoting

financial services to mobile terminals; on the other hand, encouraging financial institutions to actively promote financial innovation in products, outreach channels, and service processes based on the behavioural habits and real needs of the migrant population, allowing more migrants to benefit from the health improvements offered by digital inclusive finance (Alraja et al. 2023; Falco and Kleinhans 2018).

Second, the government should strengthen the mechanisms for reducing environmental pollution and increasing the accessibility of financial services. On one hand, the government should enact and enforce stringent environmental protection regulations to reduce pollution emissions. In conjunction with this, the provision of financial incentives such as subsidies, tax reductions, and low-interest loans should be utilized to drive green innovation among enterprises and individuals. Additionally, leveraging digital technology to enhance the accessibility and efficiency of green financial services is crucial, promoting the deep integration of digital inclusive finance with green finance. On the other hand, the government should fully utilize digital inclusive financial services to lower the financing and credit barriers for building medical infrastructure, thereby improving the efficiency of public medical expenditures. Furthermore, it is essential to enrich internet-based medical services supported by digital inclusive financial platforms. This includes encouraging more hospitals and doctors to participate in providing health monitoring, online pharmacies, online registration, and online consultations through these platforms, thereby enhancing the accessibility of medical services for the migrant population.

Third, heterogeneity analysis reveals that the health-promoting effect of digital inclusive finance has a greater marginal effect and stronger significance for the migrant population that has received public health education. This indicates that government-provided public services are crucial for the health of the migrant population. Therefore, it is essential to continue advancing the reform of the household registration and residence permit systems, eliminating the current shortcomings of providing basic public services based on household registration status. This will enhance the provision of basic public services to the migrant population and better meet their needs for a better life.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix

Table A1. Variable definitions and descriptive statistics.

Variables	Description	Obs	Mean	SD	Median	Min	Max
Dependent variables:							
Health	Life unable to self-care, unhealthy but can self-care, basic health = 0, Healthy = 1	273993	0.867	0.339	1.000	0.000	1.000
Sick	Past year illness = 1,No illness = 0	273993	0.308	0.462	0.000	0.000	1.000
Independent variables:							
DIF	Digital inclusive finance Index	273993	228.824	24.806	228.363	159.488	285.432
Control variables:							
File	Community Health Profiles, Not registered = 0 Registered = 1	249633	0.282	0.450	0.000	0.000	1.000
Sex	Female = 0, Male = 1	273993	0.515	0.500	1.000	0.000	1.000
Age	Survey year – Birth year	273993	35.425	9.421	34.000	16.000	60.000
Duration	Survey year – year of moving to the current location	273993	6.084	5.846	4.000	0.000	57.000
Edu	College degree or above = 1, Others = 0	273993	0.198	0.398	0.000	0.000	1.000
Hukou	Non-agricultural, urban = 0, Agricultural = 1	273993	0.734	0.442	1.000	0.000	1.000
Party	Party member = 1, Non-party member = 0	273993	0.048	0.213	0.000	0.000	1.000
Mari	Unmarried, divorced, widowed = 0, First marriage, remarriage, cohabiting = 1	273993	0.821	0.383	1.000	0.000	1.000
Insurance	Participating in at least one of the insurances in the survey = 1, Otherwise = 0	273993	0.928	0.259	1.000	0.000	1.000
lnincome	Logarithm of average monthly income, annualized by multiplying by 12	273852	11.220	0.730	11.184	0.000	16.195
Employ	Employer = 1, Employee = 0	235574	0.379	0.485	0.000	0.000	1.000
Rjgdp	Regional Per Capita GDP	273993	92534.142	39673.898	88272.000	12308.220	382410.000
Fisspt	Fiscal Autonomy: Ratio of local fiscal expenditure to regional GDP	273192	1.900	1.153	1.479	0.921	13.939
Fiscal	Fiscal Expenditure Scale: Ratio of local fiscal expenditure to regional GDP	237659	0.172	0.072	0.153	0.073	0.837