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Telehealth, medical decisions and new health inequality in China

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Abstract

Background The widespread of telehealth has not only improved medical service accessibility and convenience, and has also played an active role in the COVID-19 Epidemic. This suggests that telehealth is becoming increasingly important in both normality and emergency. It is therefore essential to evaluate the use of the technology and its impact on the healthcare system.

Objective This paper studied the use of telehealth in China, the socio-demographic characteristics of users, its impact on patients' choice of first-visit, and potential health inequalities.

Methods We obtained 14,944 valid questionnaires from a multistage stratified sample of 41 cities in the Yangtze River Delta, China, and multinomial logit was mainly used.

Results The utilization rate of telehealth in the study area was 10.43%. Residents that were younger, more educated, had higher household incomes, were more health literate, used more adequate medical insurance, ordered food delivery more often, and had chronic diseases were more likely to use telehealth. Residents who used telehealth had significantly higher odds of choosing high-level hospital instead of primary care provider as their first visit (B = 0.168, $P < 0.05$;B = 0.192, $P < 0.05$). And this substitution effect is more pronounced among the younger, more educated, and higher household income residents.

Conclusions Telehealth is still underutilized in China's actual healthcare services, and use of telehealth is more likely to be seen among younger, higher-income, and well-educated groups. The use of telehealth may lead residents to skip primary health care more easily and occupy secondary and tertiary health care inappropriately. It maybe impacts China's hierarchical medical system, and further leading to new potential health inequalities due to the "digital divide".

Keywords Telehealth, Medical choice, The hierarchical medical system, Health inequality

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Introduction

"Telemedicine" was coined by Thomas Bird in the United States in the 1970s [1], and after decades of evolution of the concept, "Telehealth" is now more widely used. The World Health Organization provided a standard definition of telehealth in 2007: "The delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities [2]. " Originally conceived as a solution to improve healthcare accessibility [3], telehealth also showed to improve clinical outcomes [4, 5], reduce mortality [6], increase health system efficiency [7] as well as improve economic benefits [8]. The COVID-19 epidemic had overwhelmed healthcare systems and had accelerated the development of Internet medical services, including policy support, people's acceptance. For example, In China, the government proposed for the first time "promoting the first visit of Internet medical services" and "carrying out the Internet settlement of medical insurance" in 2020 [9], and the number of consultations on some Internet medical service platforms increased more than 20 times compared to the same period [10]. The great potential of this technology in both normality and emergency are becoming apparent. Therefore, it is essential to assess the impact of telehealth on patients, physicians, and the whole healthcare system. In China, the government launched the first pilot telehealth pilots in 1998 and issued the first document of telehealth, *the Circular on Strengthening the Management of Telehealth*, in 1999 [11]. Until June 2022, the scale of online medical users in China reached 300 million [12], and there are more than 1,600 registered Internet hospitals [13]. Now telehealth has been carried out in China mainly by relying on Internet hospitals [14]. These Internet hospitals are generally run directly by tertiary hospitals or operated by Internet medical service platforms such as Ding Xiang Doctor and WeDoctor, carrying on Internet social media (e.g., WeChat), payment software (e.g., Alipay) and shopping platforms (e.g., Jingdong) [15]. More specifically, telehealth in the study refers to a new medical model that carries an Internet platform to provide medical consultation, diagnosis, prescription, health management and other services. Patients can conveniently and quickly log in to the telehealth platform through common social, shopping, or other internet applications, and interact with doctors in real-time through text, voice, video, etc., to learn about their health status, diagnose diseases, and obtain medical advice, etc. They can also obtain electronic prescriptions from doctors and purchase medicines directly through the platform, and part of the platform also provides drug delivery services.

There is a substantial body of research that demonstrates differences in access to telehealth across different groups [16]. Liaw et al. found that patients who were employed and well-educated were more likely to receive telehealth [17]. Talbot et al.'s study showed that telehealth users were more likely to be white, under 19 years of age and eligible for Medicaid for children [18]. The results of these studies are usually consistent: people who use telehealth are younger, have higher incomes, are more educated, and so on. More importantly, as telemedicine plays an increasingly critical role in the healthcare system, it should be understood for its impact on patient medical behavior. For example, Chen et al. suggested that telehealth could not eliminate the effect of distance on patients' choice of healthcare provider [19]. A review showed a significant reduction in rehospitalization rates among older residents after using telehealth for malnutrition [20]. Downes et al. suggested that the use of telehealth, although leading to an increase in repeat visits, still results in reduction in overall time spent by patients [21]. There are also concerns about whether differences in residents' medical behaviors caused by digital divide will lead to the emergence of new health inequalities [22, 23].

Although relevant studies on socio-demographic factors influencing the use of telehealth are common and relatively consistent, they have been conducted mainly in Europe and the United States, and the evidence on this topic in other regions is insufficient. The hierarchical medical system is now common worldwide. In general, governments use administrative orders, insurance or other compulsory means to ensure that people go first to primary health care. In China, however, due to social culture, medical habits and so on, the free flow of patients has always been allowed, which leads many people to go directly to the highest-level health care for first visit. Primary care is underutilized, but high-level hospitals is overcrowded. In the study area, the rates of first visit in primary health care in different cities are shown in Fig. 1. Therefore, improving the hierarchical medical system has been an important goal of China's medical reform, but the impact of embedding of telehealth in healthcare services is unclear. Therefore, this study explored the characteristics and satisfaction of telehealth users, as well as the impact of telehealth use on patients' choice of first visit, and the potential health inequalities. Exploring the use and impact of telehealth is of great significance for rational planning of the telehealth development, optimizing the hierarchical medical system in the context of new technologies, and providing basis for the relevant health policies.

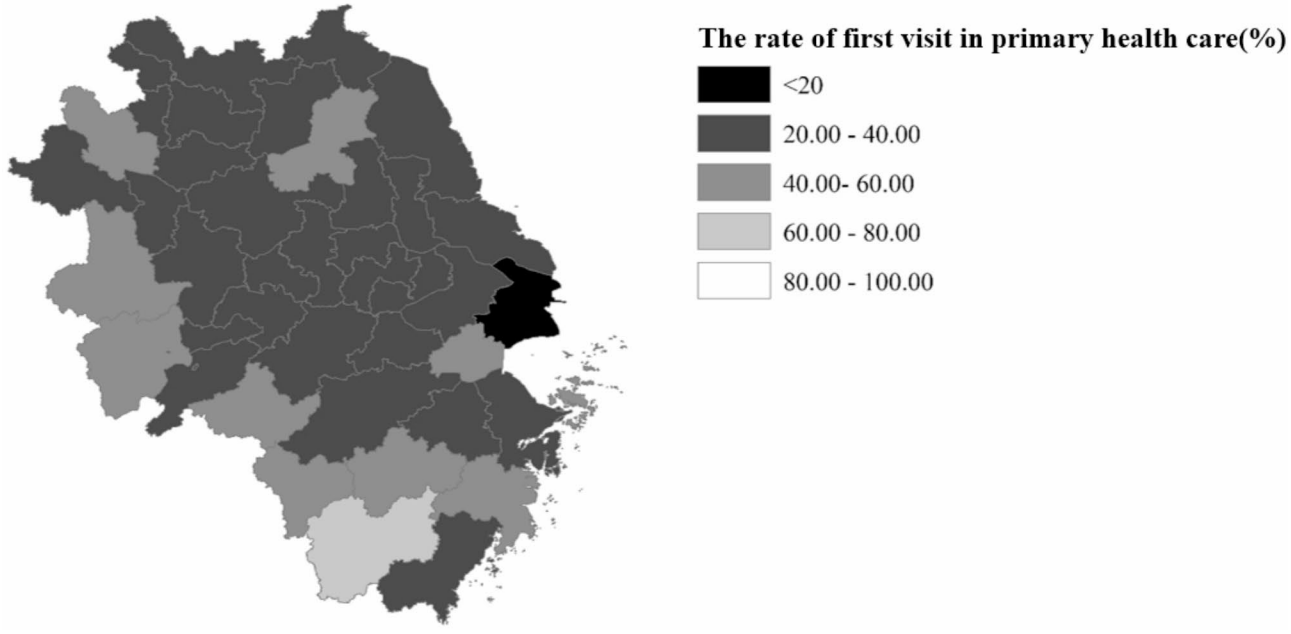

Fig. 1 The rates of first visit in primary health care in 41 cities of the study area

Materials and methods

Study area and data collection

This study was conducted in the Yangtze River Delta region of China. The Yangtze River Delta region is the largest urban cluster in China, with 41 cities, a population of 530,000 and an area of 358,000 km^2 [24]. For a long time, the medical "siphoning phenomenon" of the Yangtze River Delta has been particularly obvious due to the closer social co-operation network, more convenient transport facilities, etc. Therefore, the selection helps to obtain a richer and deeper sample, as well as better practical value.

The study data comes from the *Yangtze River Delta Healthy Living Satisfaction Survey 2021* conducted by our research team. This survey is tracked every two years. The whole questionnaire involves 94 main questions and related additional questions, and we have extracted the questions used in this study in Supplementary Table 1 of the Appendix. The data collection was based on multistage stratified sampling, stratified by region, age, and gender. And the questionnaire was collected both online and offline. Most of the questionnaires were completed online, mainly commissioned to a survey company. We also completed 1,523 questionnaires offline, mainly in shopping districts in various cities. 19,870 questionnaires were distributed, and 18,031 questionnaires were returned, with a return rate of 90.74%. By checking the time-consuming of completion, consistency questions, and removing questionnaires of low quality, 14,944 questionnaires were finally obtained.

Measures

Dependent variables

Three dependent variables were designed based on the research questions. Firstly, since telehealth in China is currently based mainly on Internet medical services [14], we used two questions to measure use of telehealth: "Have you ever used Internet medical services?", and an additional item: "If yes, what kinds of Internet medical service types have you experienced?". Alternative answers included Internet reservation, telehealth, online medication purchase, patient communication, other. Only respondents who chose "telehealth" in the additional question and "Yes" in the main question were defined as having used telehealth. Satisfaction with telehealth use was measured by the question "How satisfied are you with Internet medical services?" Regarding the measurement of "choice of first visit", many existing surveys essentially measure the healthcare providers that residents frequent rather than the providers of first visit [25]. Therefore, the corresponding question in the study was "What is the level of healthcare providers at your first visit?" Alternative answers include: tertiary hospitals, secondary hospitals, primary health care providers, others.

Independent variables

The independent variables were selected using the 2013 *Andersen's Behavioral Model of Health Service Use* as the theoretical basis [26], as shown in Fig. 2. The final selected independent variables included predisposing under the individual characteristics (age, gender, education level), enabling (household income, medical insurance, nearest

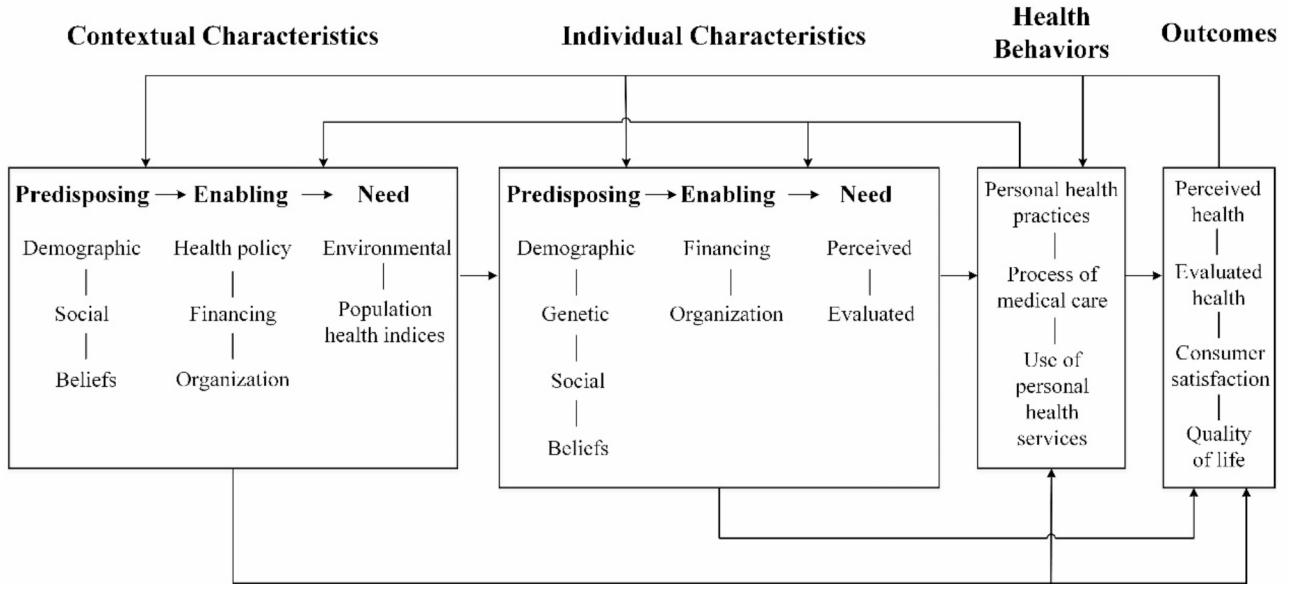

Fig. 2 Andersen's Behavioral Model of Health Service Use (2013 edition)

healthcare providers level), need (chronic disease history), personal health practices under the health behaviors (weekly exercise frequency, frequency of weekly ordering food delivery, annual physical examination, health literacy), and evaluated health under the outcomes (health self-assessment), and consumer satisfaction (satisfaction with reimbursement rates of medical insurance, assessment of healthcare services). Descriptive statistics for all variables are shown in Table 1.

Statistical analyses

Firstly, socio-demographic characteristics affecting the use of telehealth were assessed using binomial logit models. Second, observations that answered that they have used telehealth were selected to form a new dataset to assess patient satisfaction with telehealth, as well as to explore the socio-demographic characteristics influencing satisfaction using a linear regression model. Then a multinomial logit model was used to estimate the effect of telehealth use on residents' choice of first visit. Since there are many types of answers for "Other" and the number for each type is no more than 10, the corresponding observations were deleted. Considering endogeneity problems such as omitted variables, the instrumental variable approach was used, with "arrival time to the first visit providers" as the instrumental variable. The rationale for choosing this variable as an instrumental variable is as follows. This instrumental variable is closely related to telehealth use. The more travel time residents spend away from their first visit providers, the more likely they are to use telehealth. Moreover, this instrumental variable is uncorrelated with the error term. The arrival time of residents to the first visit providers don't directly affect which type of providers they choose for their first visit and are not highly related with control variables. And two-stage residual inclusion (2SRI) was used for the instrumental variables model. 2SRI is an extension of the two-stage least squares (2SLS), which is widely used to solve endogeneity problems in nonlinear models [27]. In the first stage of 2SRI, endogenous variables are regressed on instrumental variables, and in the second stage, the first-stage residuals are included as additional regressors in second-stage estimation. Finally, through moderation analysis and heterogeneity analysis, we explored the mechanisms by which telehealth influences residents' choice of first visit and whether the effect of telehealth on patients' choice of first visit varied across groups. In addition, it should be stated that variables such as household income, education are ordinal variables and have five categories, and are treated as continuous variables in the regression in order to avoid excessively lengthy results. All models use city fixed effects to control for regional differences. All analyses were performed with R version 4.2.0. The conceptual model is shown in Fig. 3.

Results

Effects of Socio-demographic characteristics on telehealth use and satisfaction

First, our survey found that 10.43% of residents in the study area had used telehealth. The results in Table 2 showed that, using "≥60" as the reference, residents of other age stages had significantly higher rates of using telehealth. Particularly, residents in "30–39" were the most likely to use telehealth (B = 1.629, $P < 0.01$). The group that used telehealth had higher education level (B = 0.473, $P < 0.01$), higher household income (B = 0.137,

Table 1 Basic characteristics of the variables

Variables		Telehealth		Total
		Not used 13,386 (89.57)	Used 1558 (10.43)	
		N (%)	N (%)	N (%)
choice of first visit	Tertiary hospitals	4972 (37.14)	640 (41.08)	5612 (37.55)
	Secondary hospitals	3941 (29.44)	458 (29.40)	4399 (29.44)
	Primary health care providers	4473 (33.42)	460 (29.53)	4933 (33.01)
Age stages	< 30	2773 (20.72)	431 (27.66)	3204 (21.44)
	30–39	3366 (25.15)	677 (43.45)	4043 (27.05)
	40–49	1442 (10.77)	195 (12.52)	1637 (10.95)
	50–59	2800 (20.92)	214 (13.74)	3014 (20.17)
	≥ 60	3005 (22.45)	41 (2.63)	3046 (20.38)
Gender	Male	6675 (49.87)	813 (52.18)	7488 (50.11)
	Female	6711 (50.13)	745 (47.82)	7456 (49.89)
Education	junior school or below	1479 (11.05)	21 (1.35)	1500 (10.04)
	high school	4689 (35.03)	211 (13.54)	4900 (32.79)
	Associate	4547 (33.97)	650 (41.72)	5197 (34.78)
	Bachelor or above	2671 (19.95)	676 (43.39)	3347 (22.40)
Household income	¥2000 or below	43 (0.32)	2 (0.13)	45 (0.30)
	¥2001–10,000	2650 (19.80	163 (10.46)	2813 (18.82)
	¥10,001–20,000	7402 (55.30)	831 (53.34)	8233 (55.09)
	¥20,001–40,000	2901 (21.67)	488 (31.32)	3389 (22.68)
	¥40,001 or above	390 (2.91)	74 (4.75)	464 (3.10)
Medical insurance	Basic	11,492 (85.85)	1171 (75.16)	12,663 (84.74)
	Supplemental	1317 (9.84)	334 (21.44)	1651 (11.05)
	None	275 (2.05)	19 (1.22)	294 (1.97)
	Other	302 (2.26)	34 (2.18)	336 (2.25)
Closest health care providers	Tertiary hospitals	936 (6.99)	155 (9.95)	1091 (7.30)
	Secondary hospitals	2163 (16.16)	298 (19.13)	2461 (16.47)
	Primary health care providers	10,287 (76.85)	1105 (70.92)	11,392 (76.23)
Chronic disease history	Yes	3415 (25.51)	118 (7.57)	3533 (23.64)
	No	9971 (74.49)	1440 (92.43)	11,411 (76.36)
Weekly exercise frequency	0	1403 (10.48)	91 (5.84)	1494 (10.00)
	1	2710 (20.25)	268 (17.20)	2978 (19.93)
	2–3	6535 (48.82)	921 (59.11)	7456 (49.89)
	4–5	2454 (18.33)	256 (16.43)	2710 (18.13)
	6 or above	284 (2.12)	22 (1.41)	306 (2.05)
frequency of weekly ordering food delivery	0	5804 (43.36)	199 (12.77)	6003 (40.17)
	1–2	5761 (43.04)	913 (58.60)	6674 (44.66)
	3–6	1601 (11.96)	394 (25.29)	1995 (13.35)
	7 or above	220 (1.64)	52 (3.34)	272 (1.82)
Annual physical examination	Yes	8983 (67.11)	938 (60.21)	9921 (66.39)
	No	4403 (32.89)	620 (39.79)	5023 (33.61)
Health literacy	Completely unaware	734 (5.48)	69 (4.43)	803 (5.37)
	unaware	1856 (13.87)	149 (9.56)	2005 (13.42)
	neutral	3893 (29.08)	375 (24.07)	4268 (28.56)
	aware	6091 (45.50)	823 (52.82)	6914 (46.27)
	very aware	812 (6.07)	142 (9.11)	954 (6.38)
Health self-assessment	Very unhealthy	62 (0.46)	3 (0.19)	65 (0.43)
	unhealthy	776 (5.80)	50 (3.21)	826 (5.53)
	average	2696 (20.14)	256 (16.43)	2952 (19.75)
	healthy	8181 (61.12)	872 (55.97)	9053 (60.58)
	very healthy	1671 (12.48)	377 (24.20)	2048 (13.70)

Table 1 (continued)

Variables		Telehealth		Total
		Not used 13,386 (89.57)	Used 1558 (10.43)	
		N (%)	N (%)	N (%)
Satisfaction with medical insurance	very unsatisfied	28 (0.21)	3 (0.19)	31 (0.21)
	unsatisfied	252 (1.88)	34 (2.18)	286 (1.91)
	neutral	2198 (16.42)	219 (14.06)	2417 (16.17)
	satisfied	9099 (67.97)	984 (63.16)	10,083 (67.47)
	Very satisfied	1809 (13.51)	318 (20.41)	2127 (14.23)
Assessment of healthcare services	very dissatisfied	45 (0.34)	8 (0.51)	53 (0.35)
	dissatisfied	538 (4.02)	105 (6.74)	643 (4.30)
	neutral	1490 (11.13)	147 (9.44)	1637 (10.95)
	satisfied	9404 (70.25)	988 (63.41)	10,392 (69.54)
	Very satisfied	1909 (14.26)	310 (19.90)	2219 (14.85)
Satisfaction with telehealth use	very dissatisfied		6 (0.39)	6 (0.39)
	dissatisfied		1 (0.07)	1 (0.07)
	neutral		153 (9.96)	153 (9.96)
	satisfied		853 (55.53)	853 (55.53)
	Very satisfied		523 (34.05)	523 (34.05)

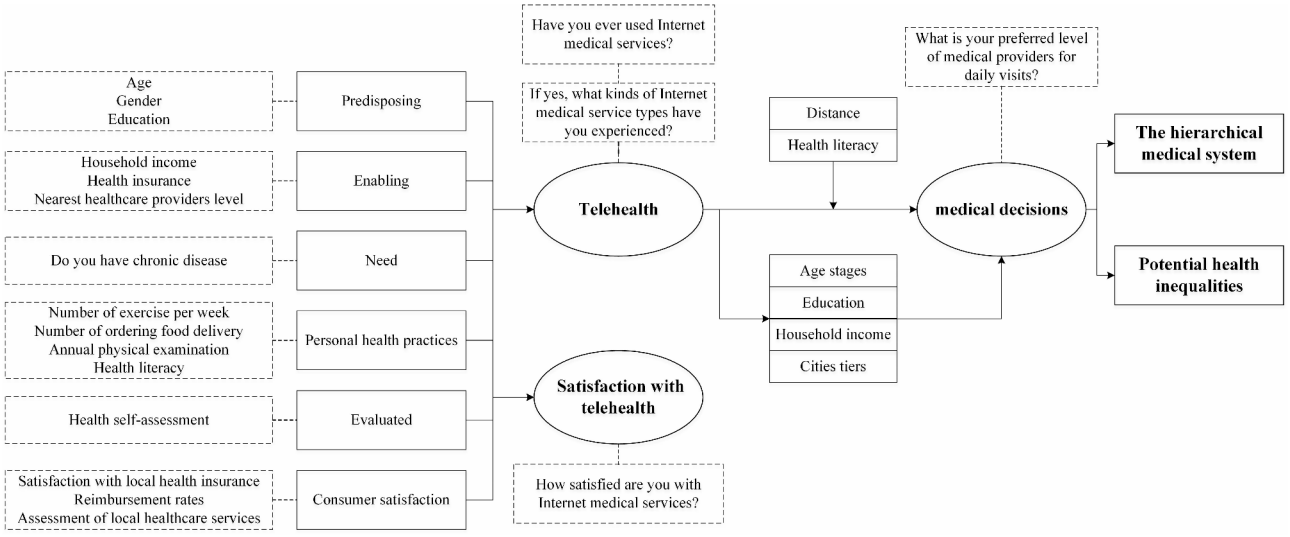

Fig. 3 The conceptual model of the study

$P<0.01$), ordered more food delivery (B = 0.478, $P<0.01$), had higher satisfaction with the reimbursement rate of the medical insurance (B = 0.269, $P<0.01$), and had higher health literacy (B = 0.127, $P<0.01$), had chronic diseases (B = 0.243, $p<0.05$). Residents with supplemental medical insurance used telehealth 1.91 times more than the reference (B = 0.650, $P<0.01$), and residents without medical insurance used telehealth 38% less than the reference (B=-0.476, $P<0.1$). Residents whose closest health care providers was tertiary hospitals had significantly higher rate of telehealth use (B = 0.223, $p<0.05$).

More frequent ordering of food delivery (B = 0.074, $P<0.01$), higher satisfaction with medical insurance reimbursement rates (B = 0.124, $P<0.01$), higher assessment of healthcare services (B = 0.070, $P<0.01$), higher health self-assessment (B = 0.175, $P<0.01$), higher health literacy (B = 0.092, $P<0.01$) were associated with higher satisfaction with telehealth use.

Effect of telehealth use on choice of first visit

The results in column (1) of Table 3 show that, with primary health care as the reference, the use of telehealth is significantly associated with higher rates of choosing tertiary and secondary hospitals as the first visit (B = 0.168, $P<0.05$; B = 0.192, $P<0.05$). Specifically, the ratio of residents who had used telehealth to choose tertiary hospitals and secondary hospitals as their first visit providers increased by 18% and 21%, respectively. The Multinomial

Table 2 Effects of Socio-demographic characteristics on telehealth use and satisfaction

	Telehealth	Satisfaction
Age stages		
< 30	1.279***	-0.014
	(0.198)	(0.110)
30–39	1.629***	-0.016
	(0.191)	(0.107)
40–49	1.558***	-0.044
	(0.196)	(0.110)
50–59	1.290***	-0.082
	(0.183)	(0.105)
≥ 60	Ref	Ref
Gender		
Male	Ref	Ref
Female	-0.004	-0.017
	(0.056)	(0.030)
Education	0.473***	0.035
	(0.045)	(0.024)
Household income	0.137***	0.028
	(0.043)	(0.026)
Medical insurance		
Basic	Ref	Ref
Supplemental	0.650***	0.022
	(0.077)	(0.040)
None	-0.476*	-0.071
	(0.249)	(0.143)
Other	-0.217	0.028
	(0.193)	(0.104)
Exercise	0.044	-0.114***
	(0.034)	(0.020)
Chronic diseases	0.243**	0.104
	(0.120)	(0.069)
Food delivery	0.478***	0.074***
	(0.046)	(0.026)
Physical examination	-0.431***	-0.0001
	(0.065)	(0.036)
Satisfaction with medical insurance	0.269***	0.124***
	(0.052)	(0.027)
Assessment of healthcare services	0.019	0.070***
	(0.044)	(0.022)
Health self-assessment	0.037	0.175***
	(0.050)	(0.026)
Health literacy	0.127***	0.092***
	(0.033)	(0.018)
Closest healthcare providers		
Tertiary hospitals	0.223**	-0.0006
	(0.100)	(0.052)
Secondary hospitals	0.118	-0.111***
	(0.073)	(0.040)
Primary health care providers	Ref	Ref
Constant	-7.848***	2.372***
	(0.367)	(0.186)
Province fixed effects	√	√
R^2	0.1241	0.1922
Prob > chi^2	0.000	0.00
Observations	14,944	1536

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$。

Table 3 Effect of telehealth use on choice of first visit

	Multinomial logit (1)	
	Secondary hospitals VS Primary health care	Tertiary hospitals VS Primary health care
Telehealth use	0.192**	0.168**
	(0.078)	(0.079)
Closest health care providers		
Tertiary hospitals	0.981***	2.801***
	(0.163)	(0.140)
Secondary hospitals	2.951***	2.282***
	(0.096)	(0.100)
Primary health care providers	Ref	Ref
Physical examination	0.738***	1.084***
	(0.049)	(0.050)
Medical insurance		
Basic	Ref	Ref
Supplemental	-0.028	0.382***
	(0.087)	(0.081)
None	0.623***	0.185
	(0.154)	(0.181)
Other	0.387***	-0.221
	(0.145)	(0.166)
Satisfaction with medical insurance	0.129***	0.435***
	(0.041)	(0.042)
Gender	0.007	-0.047
	(0.045)	(0.045)
Health literacy	0.390***	0.554***
	(0.026)	(0.026)
Exercise	-0.236***	-0.371***
	(0.025)	(0.025)
Assessment of healthcare services	0.107***	0.467***
	(0.036)	(0.039)
Constant	-2.659***	-5.352***
	(0.206)	(0.219)
Province fixed effects	√	
Prob > chi^2	0.000	
R^2	0.1739	
Observations	14,944	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4 Small-Hsiao test results for IIA assumption

	Chi^2	*P*
Tertiary hospitals	-3099.57	0.294
Secondary hospitals	-3162.12	0.743
Primary health care providers	-3330.07	0.926

Logit model was required to meet the independence of irrelevant alternatives (IIA) assumption, so the Small-Hsiao test was used for this assumption. The results are shown in Table 4, and the null hypothesis that the options of the dependent variable are independent cannot be rejected. Therefore, the model used in this study meets the IIA assumptions. Based on the baseline results, Table 5 shows the regression results for the instrumental

Table 5 Effect of telehealth use on choice of first visit with instrumental variable

	First Stage	Second Stage	
	Telehealth use	Secondary hospitals VS Primary health care	Tertiary hospitals VS Primary health care
Telehealth use		0.228***	0.275***
		(0.005)	(0.005)
Arrival time to the first visit providers	0.085***		
	(0.016)		
Controls	√	√	
Province fixed effects	√	√	
Prob > chi^2	0.000	0.000	
R^2	0.129	0.327	
Observations	14,944	14,944	

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

variable, arrival time to the first visit providers. In the first stage, the regression results of instrumental variable on telehealth use are significantly positive and the F-value is significantly greater than 10, indicating that the instrumental variables selected are not weak instrumental variables. The regression results in the second stage are basically consistent with Table 3, indicating that the baseline results are robust.

The moderating effect of distance and health literacy

Arrival time to the Closest health care providers and health literacy of respondents were used as moderating variables to test the mechanisms by which telehealth influences residents' choice of first visit. The results, as shown in Table 6, showed that residents' arrival time to the closest health care providers positively moderated the effect of telehealth on residents' choice of secondary and tertiary hospitals for their first visit (B = 0.019, $P<0.05$; B = 0.025, $P<0.05$), and residents' health literacy negatively moderated the effect of telehealth on residents' choice of secondary and tertiary hospitals for their first visit (B=-0.469, $P<0.01$; B=-0.171,$P<0.05$).

Heterogeneous effects of telehealth use on choice of first visit

The results in Table 7 showed that telehealth use is associated with an increased odds of first visit to higher-level hospitals in all age stages. In the Heterogeneous effects across education levels, it was found that the use of telehealth is significantly associated with higher rate of first visit to tertiary hospitals among residents with bachelor's degree or higher (B = 0.603, $P<0.01$). For residents with a monthly household income of ¥10,001–20,000 and residents with a monthly income of ¥20,001 and above, the use of telehealth is significantly associated with higher probability of first visit to tertiary hospital (B = 0.203, $P<0.1$) and secondary hospitals (B = 0.335, $P<0.05$), respectively. Heterogeneous effects across different cities tiers showed that the use of telehealth is significantly associated with an increased odds that residents of Tier 1 cities and Tier 3 and below cities choose tertiary (OR = 2.45, $P<0.01$; OR = 1.57, $P<0.01$) and secondary hospitals (OR = 1.59, $P<0.05$; OR = 1.42, $P<0.01$) for their first visit provider, respectively.

Discussion and conclusions

This paper discussed the use of telehealth in China and the its impact on healthcare system. The results showed that the rate of telehealth use in the study area in 2021 was 10.43%. The use of telehealth was significantly associated with many socio-demographic factors. More specifically, some groups, such as the younger, higher-income, and higher-educated, are more likely to use telehealth. The use of telehealth is significantly associated with higher odds of choosing higher-level hospitals for first visit, and the effect was more pronounced in particular groups.

Our findings showed that the rate of telehealth use in the study area was 10.43%. The value is apparently lower than what would normally be expected during the epidemic. Possible explanations are the absence of a large-scale epidemic in the study area during 2021, and some studies have also shown a significant decline in telehealth use as the impact of the epidemic recovers [28]. Two surveys of telehealth use in China both indicated actual use rates of less than 20% [29, 30]. Numerous studies have demonstrated that the acceptance of telehealth services in actual healthcare settings is not high [31]. The reasons for this phenomenon are complex, and existing studies attribute it to strict government regulation and Medicaid restrictions [14, 32], clinicians' diagnostic habits and willingness [32], patients' preference [33].

For analyses of telehealth use on socio-demographic factors, the results of the China-based were largely consistent with existing studies [28, 34]. That is, residents who were younger, more educated, had higher household incomes, had higher health literacy and purchase more expensive medical insurance were more likely to use telehealth. Additionally, the study found that residents who ordered food delivery more often showed

Table 6 The moderating effect of distance and health literacy

	Distance		Health literacy	
	Secondary hospitals VS Primary health care	**Tertiary hospitals VS Primary health care**	**Secondary hospitals VS Primary health care**	**Tertiary hospitals VS Primary health care**
Telehealth use	-0.046	-0.003	1.763***	0.697**
	(0.157)	(0.164)	(0.275)	(0.316)
Arrival time to the Closest	-0.052***	-0.088***		
	(0.003)	(0.004)		
Arrival time to the Closest × Telehealth	0.019**	0.025**		
	(0.009)	(0.010)		
Health literacy			0.445***	0.575***
			(0.028)	(0.028)
Health literacy × Telehealth			-0.469***	-0.171**
			(0.079)	(0.087)
Closest health care providers				
Tertiary hospitals	1.715***	3.849***	0.993***	2.809***
	(0.180)	(0.165)	(0.163)	(0.140)
Secondary hospitals	3.338***	2.845***	2.975***	2.293***
	(0.104)	(0.109)	(0.096)	(0.100)
Primary health care providers	Ref	Ref	Ref	Ref
Physical examination	0.665***	0.994***	0.714***	1.071***
	(0.049)	(0.052)	(0.049)	(0.051)
Medical insurance				
Basic	Ref	Ref	Ref	Ref
Supplemental	0.058	0.499***	-0.020	0.387***
	(0.088)	(0.083)	(0.087)	(0.081)
None	0.507***	0.065	0.609***	0.177
	(0.155)	(0.181)	(0.155)	(0.181)
Other	0.417***	-0.126	0.385***	-0.224
	(0.146)	(0.168)	(0.145)	(0.166)
Satisfaction with medical insurance	0.086**	0.364***	0.135***	0.436***
	(0.042)	(0.043)	(0.041)	(0.043)
Gender	0.001	-0.055	0.004	-0.047
	(0.046)	(0.046)	(0.045)	(0.045)
Exercise	-0.220***	-0.334***	-0.235***	-0.370***
	(0.026)	(0.026)	(0.025)	(0.025)
Assessment of healthcare services	0.056***	0.394***	0.115***	0.471***
	(0.037)	(0.040)	(0.036)	(0.039)
Constant	-1.397***	-3.925***	-2.781***	-5.757***
	(0.219)	(0.233)	(0.208)	(0.222)
Province fixed effects	√		√	
Prob > chi^2	0.0000		0.0000	
R^2	0.1906		0.1749	
Observations	14,944		14,944	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

significantly higher odds of using telehealth. Mobile payments become commonplace, which also means that users' habits of paying for online healthcare services are gradually being established. The higher rates of telehealth use by residents with chronic diseases is also related to the current policy regulation of telehealth in China [35, 36]. During the epidemic, China also proposed that "the 'Internet+' follow-up services for common and chronic diseases can be included in the payment scope of the medical insurance fund [37]." In addition, the study of satisfaction with telehealth use found that there was no difference based on socio-demographic characteristics such as age, gender. 88.58% of users were either "satisfied" or "very satisfied" with the use of telehealth. Differences in satisfaction with telehealth use were mainly due to patients' health literacy and satisfaction with medical services and insurance.

The use of telehealth exacerbates the rates of residents seeking higher-level hospitals for the first visit, and this result is similar to some existing studies [25, 38]. This is

Table 7 Heterogeneous effects of telehealth use on choice of first visit

		Secondary hospitals VS Primary health care	Tertiary hospitals VS Primary health care
Age stages	< 30	-0.445***	0.278**
		(0.169)	(0.147)
	30–59	0.327***	0.033
		(0.094)	(0.100)
	≥ 60	0.856*	0.629
		(0.469)	(0.494)
Education	Junior school and below	-0.134	0.342
		(0.755)	(0.628)
	High school	0.237	-0.016
		(0.191)	(0.201)
	Associate	-0.482***	-0.548***
		(0.125)	(0.129)
	Bachelor and above	0.556	0.603***
		(0.130)	(0.137)
Household income	Below ¥ 10,000	0.238	0.003
		(0.190)	(0.200)
	¥10,000–20,000	0.111	0.203*
		(0.108)	(0.109)
	Above ¥20,000	0.335**	0.094
		(0.141)	(0.147)
Cities tiers	Tier 1 cities	0.467***	0.895***
		(0.209)	(0.184)
	New Tier 1 cities	-0.055	0.402
		(0.245)	(0.253)
	Tier 2 cities	0.021	-0.370*
		(0.190)	(0.211)
	Tier 3 and below cities	0.452***	0.353***
		(0.106)	(0.118)

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

also in line with the traditional medical habits of Chinese - trying to go to the best hospital if at all possible [39]. Especially with the assistance of telehealth, the time cost of patients in high-level hospitals is greatly saved. This analysis is validated by the moderating effect of residents' arrival time to the closest health care providers: the longer residents' arrival time to the closest health care providers, the greater the impact of telehealth on residents' choice of the first visit to a high-level hospital. In addition, online diagnosis is more varied across different Internet medical platforms due to insufficient information and other reasons. And the variability of online medical information may exacerbate their perceived risk of illness and the expected loss of misdiagnosis [40], leading patients to rely more on authoritative medical providers. Residents' health literacy negatively moderated the effect of telehealth on the choice of first visit also indicated that the higher the residents' health literacy, the better they were able to discriminate the diverse medical information on the Internet, which could effectively mitigate the "seeking higher level providers" brought about by telehealth. Moreover, the public attributes of China's medical services make the differences in reimbursement ratios and other economic incentives limited. Finally, Internet hospitals can make it more convenient for patients to receive the services of high-level hospitals. The use of telehealth undoubtedly strengthens patients' habit of visiting high-level hospitals. Therefore, the finding suggested that telehealth may have negative impact on the further improvement of the hierarchical medical system.

In addition, analyses of heterogeneous effects found that the use of telehealth may increase access high-quality medical resources for particular groups. For example, young residents (< 30) would be more likely to use telehealth to visit tertiary hospitals. This was more evident across different education level, where telehealth uses significantly increased the rate of first visit on tertiary hospital in groups with bachelor or higher. Higher household income groups also showed more significant "seeking higher level providers". Combined with the findings of socio-demographic characteristics, it is a reasonable concern whether telehealth will lead to the emergence of new health inequalities: users of telehealth tend to be more educated, have higher incomes, etc., and use telehealth to further access higher quality health resources. This was also seen in some early studies. For example, Ray et al. suggested that early telehealth policies did not reduce the disparity in visit rates of specialty due to children's geographic and socio-demographic characteristics [41]. It is interesting to analyze the heterogeneous effects of cities tiers, showing a U-curve-like effect. It is easy to understand that this effect occurs in "Tier 1 cities" that are characterized by better hospitals, higher incomes, etc. However, the fact that the effect appears in "Tier 3 and below cities" may be related to China's efforts in recent years to use Internet to facilitate residents' access to high-quality resources in many poor regions. It also suggests that digital tools such as telehealth may can either widen health inequalities or be one of the possible options for remedying them, which depends on how it is used.

The study conducted a large-scale questionnaire survey on the use of telehealth, expanded understanding of telehealth use in China. And there is a certain innovative discussion of the impact of telehealth on patients' medical choices and other issues. Based on these findings, we suggest the following recommendations. Telehealth should be used as a means of maximizing the use of high-quality medical resources, rather than as a pathway to cross over to primary healthcare. Therefore, the use of telehealth should be conditional. For example, it must be used only after primary health care services have been carried out. Also, governments should establish better information-sharing mechanisms and provide the necessary education to reduce the digital divide. It should be

ensured that new technologies and policies are available to those who need them most, rather than to those who already have more resources.

There are a few limitations in this study. The first is the recall bias that is difficult to avoid in questionnaires. Secondly the use of cross-sectional data in this paper is prone to problems such as reverse causation. Therefore, it is suggested that panel data with real world can be used in future studies to test these findings.

Abbreviations

2SRI Two	Stage residual inclusion
2SLS Two	Stage least squares
IIA	Independence of irrelevant alternatives
OR	Odds ratio

Supplementary Information

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Supplementary Material 1

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Author contributions
X.Z. wrote the main manuscript text. All authors reviewed the manuscript.

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Data availability
The data that support the findings of this study are available on request from the corresponding author.

Declarations

Ethics approval and consent to participate
Informed consent to participate was obtained from all of the participants in the study. Ethics approval for this study was granted by Shanghai University of Medicine & Health Sciences' Institutional Review Board (2021-gskyb-02-372424198012222511), and was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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