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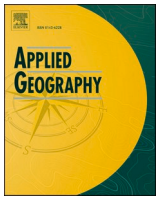

Associations between spatial access to medical facilities and health-seeking behaviors: A mixed geographically weighted regression analysis in Shanghai, China

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ABSTRACT

Enhancing the spatial accessibility to medical facilities is an important public health strategy in many countries. However, it is not clear whether enhancing spatial accessibility is capable of addressing medical care issues due to the complexity of individuals' health-seeking behavior. This study draws from Andersen's behavioral model to identify enabling factors in the associations of spatial accessibility to medical facilities and socio-institutional factors with individuals' health-seeking behavior. Logistic regression and mixed geographically weighted regression techniques are used to analyze large-scale health survey data collected in Shanghai, China. The results show that spatial accessibility to medical facilities plays a significant role in health-seeking behaviors, but the mechanism at play is complicated, involving people's preference for high-grade hospitals and the demand for easy access to public transit. Moreover, there is spatial heterogeneity in the relationship between spatial accessibility to medical facilities and health-seeking behaviors. Especially, people who live in the inner suburb of Shanghai have worse access to these facilities and thus are more likely to perform self-treatment compared with urban residents. Moreover, localized contexts formed by the interweaving of spatial accessibility and socio-institutional factors, such as registered residence status (*hukou*), complicate the association between spatial accessibility and health-seeking behaviors.

1. Introduction

Access to multi-grade medical facilities is an important issue in promoting public health. Over the past few decades, urban residents around the world have seen remarkable improvements in health status due to thorough health care reforms and high-quality medical care (Meade, 2014). However, poor and uneven access to medical facilities is still an outstanding problem, especially in cities of developing countries, posing a threat to timely and efficient medical care. To tackle this problem, national governments (e.g., the Chinese central government) and transnational organizations (e.g., the World Bank) have proposed the equal access to medical facilities as a priority in the long-term planning and development of the health care industry (Scott, 2009). However, the evidence is not clear whether expanding and enhancing the spatial accessibility to medical facilities is effective in steering urban residents' health-seeking behaviors because people's health seeking involves a complicated decision-making process concerning, among others, the influence of irrational demands for high-quality medical services and local socio-institutional contexts.

Research on the determinants of health-seeking behaviors primarily draws from Andersen's behavioral model of health service use, indicating that the utilization of health services depends on predisposing, need, and enabling factors (Andersen, 1968). The predisposing and need factors from Andersen's model have been well-studied, with the consistent finding for the significant effect of socio-demographic characteristics and long-term health status on health-seeking behaviors (Andersen et al., 2014; Belgrave & Abrams, 2016; Kain et al., 2019). By contrast, research on the enabling factors is relatively limited and has mainly focused on economy-related aspects such as disposable income and medical insurance coverage. Few studies have examined the role of

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spatial enablers, such as easy access to medical facilities, in directing people's health-seeking behaviors.

The importance of spatial accessibility to medical facilities should not be understated for at least three reasons. First, there are multiple dimensions of spatial accessibility to medical facilities that are relevant to health-seeking, including not only the proximity to medical resources but also medical grade and quality as well as the availability of motorized means of travel (e.g., cars and public transit; Porter et al., 2017). Second, decisions on health-seeking may be impulsive under the attack of acute diseases, or depend on a range of considerations other than spatial accessibility. For example, patients may seek high-grade general hospitals for treatment regardless of the severity of illness and spatial proximity to the hospital (Luo et al., 2016). Third, residents' health-seeking behaviors are more complex in urban China given the interweaving influence of spatial accessibility to medical facilities and local socio-institutional contexts. Especially, current institutional designs, such as the hierarchical medical system, the household registration (*hukou*) system and the operation of government-run medical insurance, aggravate the distributional mismatch between populations and medical facilities, and ultimately, impose barriers to seeking easy-access medical treatment for socio-economically disadvantaged groups (Shao et al., 2018). Consequently, it is of great importance to enrich the contextual understanding of the relationship between spatial access to medical facilities and health-seeking behaviors.

This study draws upon Andersen's (1968, 2008) behavioral model of health service use and semi-global modeling techniques (i.e., mixed geographically-weighted regression, or MGWR) to assess the relationship between residents' health-seeking behaviors and spatial accessibility to medical facilities, with the consideration of local socio-institutional contexts in Shanghai, China. This nuanced spatial perspective will contribute to the international literature in three fronts. First, this study establishes a bridge between research on health care accessibility from the geographical perspective and health-seeking behaviors in the discipline of public health, which are highly related to each other but have been separately examined by previous research. Second, it refines the measurement of spatial access to medical facilities, considering both access to hospitals of different grades and the availability of public transit. The decomposition of accessibility measures takes into account the trade-offs among travel time, travel cost, and medical quality in the complex decision-making process of health-seeking. Third, it assesses the contextual effects of medical accessibility on residents' health-seeking behaviors by MGWR. This not only lends support for more targeted policies of medical resource allocation rooted in localized contexts, but also draws attention to the combination of specific socio-institutional contexts (e.g., *hukou*) and medical accessibility in shaping people's health-seeking behaviors in urban China.

2. Literature review

Andersen's behavioral model of health service use is widely used to account for the determinants of health-seeking behaviors. The model regards health service use as a function of predisposing characteristics (e.g., gender, age, and health beliefs), need characteristics (e.g., whether people perceive that they are unwell or need help), and enabling characteristics (e.g., wealth, social support, or access to health services; Andersen, 1968, 2008). A plethora of research based on Andersen's model has indicated that demographic predispositions and need factors explain most of the variances in health-seeking behaviors (Andersen, 2008). Specifically, women, African-Americans, young people, and less-educated people are less likely to visit a physician for medical treatment than their counterparts (Belgrave & Abrams, 2016; Gan-Yadam et al., 2013; Tan & Mays, 2014). In addition, people with chronic physical diseases and mental problems are more in need of specialized medical treatment and services, and thus are more likely to seek and receive regular treatment (Andersen et al., 2014; Kain et al., 2019).

However, few studies have examined the associations between health-seeking behaviors and enabling attributes, and if so, their main focus is economic enablers such as disposable income and medical insurance coverage (Philpotts et al., 2019). The evidence has shown that residents who live in impoverished neighborhoods tend to delay going to the hospital (Jiang et al., 2014), while higher-income individuals are less restricted by financial barriers when seeking medical treatment (Luo et al., 2016). In addition, public health insurance enables individuals to receive timely treatment and decreases the morbidity of non-communicable diseases (Hirshfield et al., 2018).

On the other hand, spatial features of medical facilities are less studied as enablers of people's health-seeking behaviors. In the updated behavioral model of health service use, Andersen and Newman (2005) has suggested that health-seeking behaviors are a product of various social and environmental constraints. In this regard, spatial access to medical resources—defined as the geographical proximity and transportation access to medical facilities and services—might be an important but neglected contextual enabler of receiving formal healthcare. Recent studies have documented the uneven distribution of medical facilities within cities, such as the disparity in the access to medical facilities between urban and suburban areas. It shows that medical facilities, particularly high-quality medical facilities, are often concentrated in central urban areas, even if a great number of urban population has relocated to the suburbs. Moreover, the development of suburban transportation and medical infrastructure often lags behind the construction of suburban housing (Wang & Luo, 2005). Consequently, people residing in the medically underserved areas might delay or abandon treatment when they fall ill, which poses threats to their long-term health status (Fisher-Owens et al., 2016; Laditka et al., 2005; Mathison et al., 2013).

Notably, the aforementioned research misrepresents the spatial determinants of health-seeking behaviors in two ways. First, accessibility indicators are customarily operationalized as geographic proximity to or the availability of medical services at one's place of residence. Most of these studies measure accessibility using the Euclidean distance to the nearest medical facility or the number of health services or physicians within a given area. However, geographic proximity to medical facilities captures neither the ways in which people move within a city nor their personal preferences for convenience or high-quality treatment when seeking medical help. For example, people might travel further and pay more to access higher-quality medical services (Luo et al., 2016). For this reason, measuring the ease of traveling through the city can be a better way to assess residents' access to medical facilities. This claim can be further justified by the strive for mobility-based environmental justice considering that socio-economically disadvantaged groups often lack mobile tools, such as private cars, to access the medical facilities far away ((Tao et al., 2021)). In this vein, a study on young people in Sub-Saharan Africa supported that the greater people's access to public transit was, the more frequently they went to physicians for treatment (Porter et al., 2017). Another study in Guangzhou, China also found that the utilization of outpatient services was more associated with self-reported travel time than the distance to the nearest medical facility (Luo et al., 2016).

Second, previous studies on access to medical facilities and health-seeking behaviors have not taken into account localized socio-institutional contexts and the spatial dependence of health-seeking behaviors. The common approach is constructing a global model (e.g., discrete choice models) to estimate the average and invariable effect size of behavioral changes with each unit change in the accessibility to medical facilities (Bhuiya et al., 2018; Chan et al., 2018). Actually, health-seeking behavior might be heterogeneous over space and reflect the uniqueness of different local physical and social environments (Jin et al., 2018). For example, certain social groups (e.g., migrants and ethnic minorities) prefer to live in the same or adjacent neighborhoods and exhibit similar health-seeking behaviors. If researchers ignore how geographic and socio-institutional contexts combine over space, they

might fail to discern the localized or individualized impetuses or barriers for seeking medical treatment (Andersen & Davidson, 2007). A neighborhood-scale analysis in New Zealand does show that residents of secondary or minor urban areas were less likely to consult general practitioners than those from main urban areas (Hiscock et al., 2008). However, this result should be interpreted with caution because the demarcation of geographic areas into three urban strata was coarse and arbitrary, and residents' health-seeking behaviors might still present varying patterns within the administratively defined urban strata.

In urban China, residents' health-seeking involves a complicated process with the contradiction between government-led medical reforms and the accessibility dilemma of medical facilities. Considering the excessive demands for medical treatment, especially for high-quality medical resources, the Chinese central government has been striving for the past two decades to build a hierarchical medical system to steer residents' health-seeking behaviors. Drawing from the experience in developed countries, the Chinese government envisions that patients would firstly be diagnosed at primary community hospitals, after which general practitioners, rather than patients themselves, make the transfer decision based on the severity of illness and the hospital capacity (Zhou et al., 2020). Despite the good intention, the hierarchical medical system might not work well without the consideration of socio-spatial factors. First, the system overlooks the variations in spatial access to medical facilities of different grades across urban areas. Given that local governments allocate medical resources according to the administrative boundary of urban sub-districts (*jiedaos*), residents living in suburban areas might still face poor medical accessibility because most suburban *jiedaos* are too large in geographic scale and low in population density to support easy-access community hospitals. Second, health-seeking problems might be further aggravated if the population composition among different areas is considered. Under the urban-rural dual registration (*hukou*) system, rural-to-urban migrants are excluded from official medical services in connection with both institutional (e.g., social benefits provided exclusively to urban residents) and spatial barriers (e.g., residing in low-rent suburban or urban-rural fringe areas lacking access to medical facilities; Shao et al., 2018).

3. Data and methods

3.1. Study area

The study area is Shanghai, a rapidly developing megacity and the economic center of China, with a population of approximately 25 million and an area of 6340 km^2. Drawing from Wang et al. (2016), we divided the urban areas of Shanghai into three sub-regions, with the city's outer ring road and suburban ring road as boundaries. These sub-regions were labeled as central city areas, inner suburban areas, and outer suburban areas (Fig. 1a). Over decades of suburbanization in Shanghai, many residents have relocated to the inner- and outer-suburbs due to lower housing prices and a better living environment (Fig. 1b). The metro lines have also expanded to the inner suburbs, with a total operating length of over 700 km. Although there are relatively abundant medical resources in Shanghai compared with other Chinese cities, most high-grade hospitals (i.e., secondary and tertiary hospitals) with advanced medical techniques are located in the central city (Fig. 1c). A recent trend is that large-scale suburban towns are newly equipped with high-grade hospitals to satisfy local residents' medical needs whereas the spatial mismatch between urban populations and medical resources might still impose strict barriers on residents' health-seeking behaviors.

3.2. Data

Data are derived from the China Migrants Dynamic Survey (CMDS) in 2013. The CMDS is a periodic and large-scale survey conducted by the National Health Commission of the People's Republic of China. The survey employed a multi-stage probability proportional-to-size sampling method to randomly select 16,000 participants with the coverage of all towns and *jiedaos* in Shanghai. Approximately 80 participants in each town or *jiedao* were selected to fill in a paper questionnaire. The survey collected information on participants' socio-economic characteristics, residential addresses, medical insurance, health-seeking behaviors, etcetera. For more detailed description of the sampling processes and survey contents, see Huang et al. (2018). In total, 15,853 participants returned valid responses to the questionnaire. This study further restricted the sample size to 2821 participants who reported that they had been sick in the past six months and whose questionnaire had no missing value on any relevant variables. Table 1 presents the socio-economic characteristics of the study participants. Overall, the socio-economic characteristics of the participants are similar to and thus representative of the population of Shanghai according to the Sixth National Population Census in 2010, with the exception that women (60.0%) were overrepresented.

3.3. Measurement

The variable settings and description are provided in Table S1.

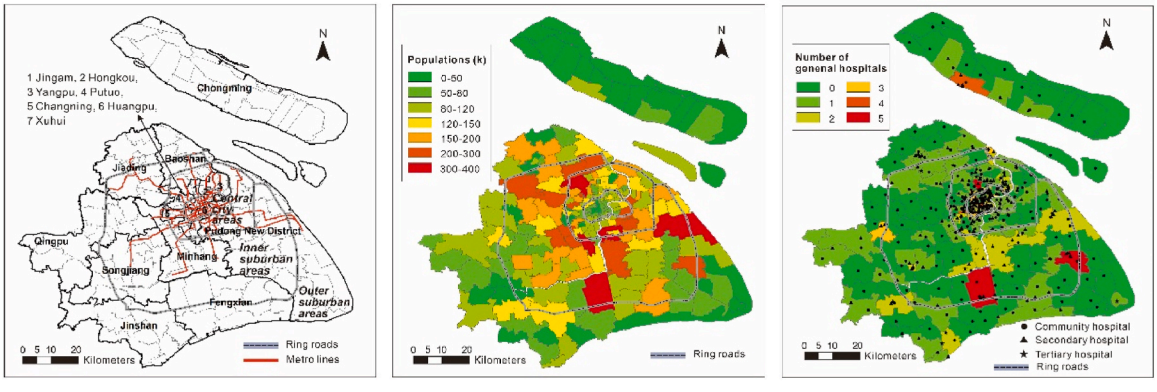


Fig. 1. Study area and distributions of populations and medical facilities. Note Population data were obtained from the Sixth National Population Census in 2010, and medical facility data were obtained from the Shanghai Municipal Health Commission in 2013.

Table 1
Socio-economic characteristics of the study participants (N = 2821).

		Study participants		Census
		N	%	%
Gender	Men	1128	40.0	51.5
	Women	1692	60.0	48.5
Age	16–29	715	25.3	30.0
	30–45	727	25.8	28.2
	46–60	745	26.4	25.3
	Above 60	634	22.5	16.5
Education	Middle school and below	1295	46.0	48.7
	High school and college	1185	42.0	35.8
	University and above	341	12.1	15.5
Registered residence status (*hukou*)	Local residents	1909	67.7	73.3
	Migrants	912	32.3	26.7
Individual monthly income	No income	243	8.6	–
	Below 3000 RMB	1770	62.7	–
	3000–6000 RMB	616	21.8	–
	Above 6000 RMB	192	6.8	–
Local medical insurance	Yes	2028	71.9	–
	No	793	28.1	–

Note. RMB = renminbi, the official currency of China.

Residents' latest health-seeking behavior was the study outcome, which was measured by asking participants the question, "How did you address your latest illness in the past six months?" Their answers included self-treatment (e.g., doing nothing or buying medicine at the pharmacy), seeing a doctor at the community hospital, and seeing a doctor at the general hospital. Note that "general hospitals" in this study represent all government-owned secondary and tertiary hospitals, excluding private clinics and specialized hospitals (e.g., cosmetic hospitals and cancer hospitals), because the majority of urban residents in China seek medical advice at these public hospitals (Shao et al., 2018).

To explain people's health-seeking behaviors, we drew from Andersen's behavioral model to construct predisposing, need, and enabling factors. The predisposing factors, including gender, age, and education status, were chosen to represent biological imperatives, health beliefs and the social structure that indicate individuals' predisposition and preferences for using health services (Andersen, 1995). These chosen factors have also been empirically studied to explain the predisposing determinants of health-seeking behaviors and health outcomes (e.g., Andersen et al., 2014; Belgrave & Abrams, 2016; Gan-Yadam et al., 2013; Shen et al., 2021). The need factor was operationalized as the ordinal measure of perceived severity of illnesses. Because specific information on the type of diseases was not available in the dataset, we treated the severity of illnesses as a proxy for patients' evaluations on functional states and perceived symptoms of illnesses and pain.

Enabling factors in our study included participants' monthly income, registered residence status (*hukou*), local medical insurance, and spatial access to medical facilities. The first three socio-economic enablers embody personal capacity and community resources relevant to the willingness to receiving medical care, while the last acts as the spatial enabler of our particular interest. Specifically, spatial access to medical facilities was measured using the network distance from the residence to the nearest general hospital, community hospital, and metro station. Whereas the former two indicators measured participants' on-road proximity to medical facilities of different grades, the third indicator estimated the availability of public transportation around participants' residential neighborhoods. According to Sun and Yin (2018) and Tan et al. (2019), we also included three sub-regions of Shanghai to control for the spatial heterogeneity of health-seeking behaviors delineated from the city center to the fringe areas.

3.4. Methods

We adopted both global (logistic regression) models and semi-global (MGWR) models to assess the global effects of access to medical facilities on health-seeking behaviors and the spatial heterogeneity of this effect, respectively (Fig. 2). Before the modelling analysis, all continuous independent variables were Z-score standardized to facilitate the interpretation of the model and the comparability of the regression coefficients. The VIF values of all independent variables were below 6.0, indicating a low probability of multi-collinearity (O'Brien, 2007; Tao et al., 2020). The global Moran's I for health-seeking behavior was 0.268 ($p < 0.01$), suggesting the spatial autocorrelation. Considering that some participants were recruited from the same residential neighborhood, the cluster-robust estimation method of standard errors was employed to control for neighborhood-level variations of health-seeking behaviors.

Considering that the outcome (i.e., health-seeking behaviors) involves three discrete choices, we tested whether the assumption of independence from irrelevant alternatives (IIA hypothesis) was met before fitting the global models. The Small-Hsiao test indicated that the option of choosing general hospitals for treatment passed the test with the reference of choosing community hospitals, while the self-treatment option rejected the IIA hypothesis (Table S2). That said, individuals' health-related decision-making follows a nested structure: they determine whether they treat themselves or seek official medical help when falling ill or injured, and then decide which grade of hospitals to visit. Therefore, we demarcated residents' health-seeking behaviors into a two-step process, including disease treatment (self-treatment versus seeking medical facilities for help; formula 1) and medical facility choices (choosing community hospitals versus choosing general hospitals; formula 2), as shown in Table S1. Accordingly, two binomial ordinal logistic regression models (i.e., global models) were constructed. Note that we followed a step-by-step approach that included explanatory variables of increasing complexity to explore how different sets of variables confounded with each other, especially the confounding effect of spatial accessibility factors and spatially heterogeneous factors. The software environment for global models was Stata 15.1.

$$y = \ln\left[\frac{\pi_{mh}}{\pi_{st}}\right] = \ln\left[\frac{P(y = hc|x)}{P(y = st|x)}\right] = \beta_g + \sum_{g=1}^{n}\beta_{1g}x_g \quad (1)$$

$$y = \ln\left[\frac{\pi_{gh}}{\pi_{ch}}\right] = \ln\left[\frac{P(y = gh|x)}{P(y = ch|x)}\right] = \beta_g + \sum_{g=1}^{n}\beta_{1g}x_g \quad (2)$$

In formula (1), option (π_{mh}) represents seeking care at a medical facility and option (π_{hc}) is the reference item, denoting self-treatment; in formula (2), option (π_{gh}) represents choosing general hospitals, while option (π_{ch}) is the reference item, denoting choosing a community hospital. β_g is the intercept of the model; x_k is the independent variable, and β_{1g} is the correspondent average slope coefficient.

Considering that conventional regression analysis only produced average and global parameter estimates across the space, we used MGWR techniques to include the contextual determinants of individuals' health-seeking behaviors. Compared with the global models such as OLS models and spatial autoregressive models, MGWR does not assume the relationship between predictors and outcomes constant over space. Compared with the discrete way to account for spatial heterogeneity by, to name a few, fixed effects models, random effect models and multilevel models, MGWR has the advantages of not predefining the spatial unit where the heterogeneity manifests itself and extrapolating the spatial process by a data-driven modelling technique (Helbich et al., 2014). Besides, MGWR is more flexible in explaining the spatial non-stationarity by introducing local variables whose effects vary over space while retaining global variables with fixed parameters. Given the aforementioned virtue of modelling spatial patterns, the GWR approach has been widely used in a range of research areas, such as transport geography (Kuai & Wang, 2020; Pu et al., 2017), spatial epidemiology

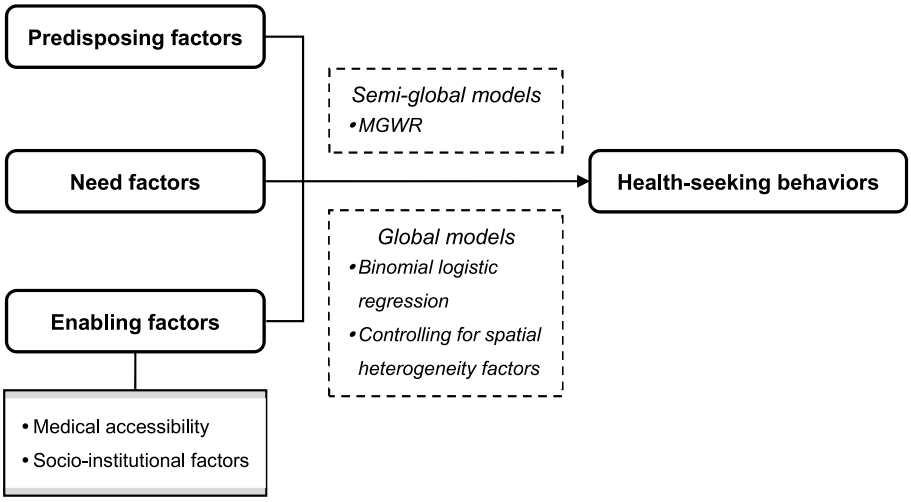


Fig. 2. The model settings.

(Lin & Wen, 2011; Mansour et al., 2021), as well as health care (Bagheri et al., 2009).

In this study, we treated access to medical facilities as local variables and other independent variables as global variables (formulas 3, 4, and 5). Regarding the parameters of MGWR, spatial weighting functions and bandwidths were commonly used in estimating the modeling goodness-of-fit (Yin et a., 2018; Murakami et al., 2019). Given that our study participants were distributed unevenly over the city, adaptive bi-square functions was used to adjust for the number of estimated samples in an adaptive spatial window. The optimum adaptive bandwidth was determined by minimization of AIC values based on multiple iterations of MGWR models (for more, see Fotheringham et al., 2003). The MGWR models were fitted in GWR 4.0 and geo-visualized in ArcMap 10.3.

$$y_i = \ln\left[\frac{\pi_{mh}}{\pi_{st}}\right] = \ln\left[\frac{P\,(\,y = hc|x\,)}{P\,(\,y = st|x\,)}\right] = \beta_0 + \sum_{g=1}^{n}\beta_{1g}x_g + \beta_l(\mu_i, v_i) + \sum_{l=1}^{n}\beta_{1l}(\mu_i, v_i)x_{il} + \varepsilon_i \quad (3)$$

$$y_i = \ln\left[\frac{\pi_{gh}}{\pi_{ch}}\right] = \ln\left[\frac{P\,(\,y = gh|x\,)}{P\,(\,y = ch|x\,)}\right] = \beta_0 + \sum_{g=1}^{n}\beta_{1g}x_g + \beta_l(\mu_i, v_i) + \sum_{l=1}^{n}\beta_{1l}(\mu_i, v_i)x_{il} + \varepsilon_i \quad (4)$$

where x_{il} is the local variable, and ε_i is the random error term; (μ_i, v_i) is the spatial coordinate of the location i; $\beta_l(\mu_i, v_i)$ is the local intercept of the model, and $\beta_{1l}(\mu_i, v_i)$ is the local slope coefficient of the lth independent variable at location (μ_i, v_i).

$$\widehat{\beta}(\mu_i, v_i) = \left[X^T \mathrm{W}(\mu_i, v_i)\mathrm{X}\right]^{-1} X^T \mathrm{W}(\mu_i, v_i)\mathrm{y} \quad (5)$$

where $\widehat{\beta}(\mu_i, v_i)$ is the unbiased estimates of β, and $\mathrm{W}(\mu_i, v_i)$ is the spatial weighting matrix, which ensures that observations near a specific location are weighted more heavily.

4. Results

4.1. Descriptive statistics

Table 2 shows the characteristics of participants' access to medical facilities and health-seeking behaviors across urban areas. Approximately half of the participants visited general hospitals, 32.2% visited community hospitals, and 12.4% opted for self-treatment. Moreover, their health-seeking behaviors followed a clear pattern over space. More than 60% of the participants in central city areas chose general hospitals for treatment, while less than 50% of participants in suburban areas went for general hospitals and nearly 20% of suburban participants chose self-treatment.

The spatial patterns of participants' access to medical facilities to some extent coincided with their health-seeking behaviors. Specifically, participants living in the central city area could easily access metro stations and hospitals of different grades. The mean values of the network distance to the nearest community hospital, general hospital, and metro station were all approximately 1 km. By contrast, the mean values for participants from suburban areas were about 3 km, and participants from outer suburban areas were located an average of 6.45 km and 11.66 km away from the nearest general hospital and metro station, respectively.

Table 2
Characteristics of residents' access to medical facilities and health-seeking behaviors across urban areas.

		All urban areas		Central city areas		Inner suburban areas		Outer suburban areas	
		N or Mean (km)	% or SD	N or Mean (km)	% or SD	N or Mean (km)	% or SD	N or Mean (km)	% or SD
Health-seeking behaviors	Treatment at a community hospital	907	32.2	376	28.9	337	33.9	194	36.8
	Treatment at a general hospital	1564	55.4	840	64.7	475	47.7	249	47.3
	Self-treatment	350	12.4	83	6.4	183	18.4	84	15.9
Medical accessibility	Proximity to a community hospital	1.96	1.58	0.98	0.53	2.25	1.52	2.68	1.87
	Proximity to a general hospital	3.76	4.12	1.12	1.06	3.98	3.22	6.45	5.25
	Proximity to a metro station	5.36	7.10	0.89	0.62	4.25	4.72	11.66	8.76

4.2. Global model results

The global model results are shown in Table 3. Regarding predisposing factors, men were less likely to receive medical treatment and visit general hospitals for treatment compared with women. Older people were more likely to seek professional medical help than the younger counterparts. Education status was positively associated with choosing general hospitals rather than community hospitals for treatment. In addition, the need factor was a strong indicator of health-seeking behaviors. For more severe illnesses, participants were inclined to seek medical treatment and visit general hospitals. Regarding non-spatial enabling factors, high-income residents preferred to seek treatment at high-grade hospitals, while migrants opted for self-treatment and treatment at community hospitals at much higher likelihoods than urban residents. Local medical insurance also encouraged patients to proactively see a doctor of their own accord and sought out high-quality medical services (Models 1 and 2).

Models 3 and 4 included the accessibility to medical facilities as a spatial enabler. Surprisingly, proximity to a general hospital was not associated with the choice to seek professional treatment. This suggests that individuals might see high-grade hospitals as a suboptimal choice when these hospitals are far from their home. By contrast, proximity to a community hospital was related with a lower preference for self-treatment, and participants were more likely to visit general hospitals when community hospitals were further away than general hospitals. In addition, proximity to a metro station was predictive of people's health-seeking behaviors. Each one standard unit rise in the distance to a metro station corresponded with a 15% increase in the likelihood of participants' seeking medical treatment and 6% increase in the likelihood of choosing to be treated at a general hospital.

Models 5 and 6 took into account the effect of spatially heterogeneous factors commonly used in previous studies. The only significant result is that compared with residents from central city areas, inner suburban residents were marginally less likely to take the initiative to receive medical treatment and visit general hospitals. However, the inclusion of residential area predictors did not influence the effect size and significance of access to medical facilities, implying that the rough division of urban areas are incapable of capturing the spatial heterogeneity of residents' health-seeking behaviors.

4.3. MGWR model results

We constructed MGWR models to explore the contextual associations between access to medical facilities and health-seeking behaviors among different areas of Shanghai. Table 4 presents the goodness-of-fit indices of the MGWR models and the global models. The result indicates that the construct of the global models was acceptable, considering that the p values of the Hosmer-Leme show test were over 0.10, and the adjusted R^2 was 0.20 and 0.14 for medical treatment and medical facility choices, respectively. Compared with the global models, the MGWR model settings accounted for the spatial autocorrelation and heterogeneity of health-seeking behaviors, thereby producing better-fitted models with lower AICc and Moran's I, greater R squares, and spatial validity of local accessibility indicators (F values > 2).

Table 5 shows the MGWR results of global variables. We found that the effect of predisposing and need factors did not change significantly, but most of the enabling factors were not associated with health-seeking behaviors. In particular, migrants did not prefer to medicate themselves or choose community hospitals any more. Furthermore, the availability of local medical insurance was not linked to actively seeking medical treatment. This suggests that socio-institutional factors and medical accessibility had combined and localized effects on health-seeking behaviors.

The MGWR results of local accessibility factors are illustrated in Figs. 3–5. We found that proximity to a community hospital had mixed associations with health-seeking behaviors, and the majority of

Table 3
Global models of residents' health-seeking behaviors.

		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
		Disease treatment		Medical facility choices		Disease treatment		Medical facility choices		Disease treatment		Medical facility choices	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95 CI	OR	95% CI
Predisposing factors	Women	Reference		Reference		Reference		Reference		Reference		Reference	
	Men	0.64**	0.56,0.72	0.82*	0.75,0.89	0.63**	0.56,0.72	0.83*	0.76,0.90	0.64**	0.56,0.73	0.84*	0.77,0.91
	Age	1.27**	1.18,1.37	1.01	0.96,1.06	1.26**	1.16,1.36	0.96	0.91,1.01	1.24**	1.15,1.35	0.95	0.91,1.00
	Education status	1.14	1.05,1.23	1.48**	1.41,1.55	1.11	1.03,1.20	1.38**	1.31,1.45	1.10	1.02,1.19	1.37**	1.30,1.44
Need factors	Severity of illnesses	1.81**	1.61,2.04	1.49**	1.42,1.56	1.80**	1.60,2.03	1.48**	1.42,1.55	1.80**	1.60,2.03	1.49**	1.42,1.56
Enabling factors	Individual monthly income	1.00	0.93,1.08	1.10*	1.06,1.15	0.99	0.92,1.07	1.09	1.05,1.15	0.99	0.92,1.06	1.07	1.02,1.13
	Local residents	Reference		Reference		Reference		Reference		Reference		Reference	
	Migrants	0.26**	0.22,0.30	0.64**	0.57,0.72	0.25**	0.21,0.30	0.64**	0.56,0.72	0.27**	0.22,0.32	0.67**	0.60,0.76
	Local medical insurance	1.24*	1.07,1.44	1.38**	1.23,1.54	1.21	1.04,1.40	1.35**	1.20,1.50	1.21	1.04,1.40	1.34**	1.19,1.49
	Proximity to a general hospital					1.04	1.01,1.06	1.01	0.96,1.06	1.03	1.00,1.06	1.03	1.01,1.06
	Proximity to a community hospital					0.90*	0.83,0.96	1.08**	1.06,1.10	0.88*	0.82,0.94	1.10**	1.08,1.11
	Proximity to a metro station					0.84**	0.81,0.88	0.94*	0.93,0.96	0.85**	0.82,0.88	0.94*	0.93,0.96
Spatially heterogeneous factors	Central city areas									Reference		Reference	
	Inner suburban areas									0.85*	0.79,0.91	0.90*	0.86,0.93
	Outer suburban areas									0.81	0.64,1.01	1.08	0.92,1.28
Constants		1.26	1.03,1.49	1.19	1.06,1.33	1.36	1.13,21.58	1.44	1.26,1.63	1.51	1.16,1.85	1.48	1.30,1.69

Note. *$p < 0.05$, **$p < 0.01$.

Table 4
Goodness-of-fit indices of global and MGWR models.

	Medical treatment		Medical facility choices	
	Global models	MGWR models	Global models	MGWR models
Hosmer–Lemeshow test: γ^2 (p)	5.79 (0.67)		18.79 (0.16)	
Spatial weighting functions		Adaptive bi-squares		Adaptive bi-squares
Bandwidths		197.00		242.00
AICc	1752.07	1650.36	2937.34	2831.10
Moran's I	0.25	0.15	0.29	0.18
Adjusted R^2	0.20	0.24	0.14	0.19
F (AICc)				
Proximity to a general hospital		6.87		7.81
Proximity to a community hospital		8.03		7.15
Proximity to a metro station		5.08		5.69

Note: MGWR, mixed geographically-weighted regression.

Table 5
MGWR results of global variables.

		Medical treatment		Medical facility choices	
		OR	95% CI	OR	95% CI
Predisposing factors	Women	Reference		Reference	
	Men	0.61**	0.51,0.74	0.90	0.77,1.05
	Age	1.14*	1.07,1.20	0.99	0.97,1.01
	Education status	1.09	0.93,1.25	1.40**	1.27,1.53
Need factors	Severity of illnesses	1.80**	1.57,2.04	1.49**	1.40,1.57
Enabling factors	Individual monthly income	0.96	0.85,1.07	1.08	1.02,1.15
	Local residents	Reference		Reference	
	Migrants	0.28	0.06,1.33	0.56	0.30,1.13
	Local medical insurance	1.12	0.61,2.07	1.20*	1.06,1.33

Note. *p < 0.05, **p < 0.01.

significant areas appeared in the inner suburban areas (Fig. 3). Specifically, participants living in inner suburban areas relied on primary medical treatment from easy-access community hospitals and thus were sensitive to the proximity of community hospitals. In particular, we found that distance to community hospitals was inversely related to proactively seeking medical advice for people living south of the outer ring road, and that distance was positively related to these peoples' preference for visiting general hospitals. By contrast, residents in the south of *Jinshan* District still sought medical treatment even though the community hospital was not accessible in the living areas. This might be due to the relatively low accessibility to the community hospital and the availability of an alternative tertiary hospital relocated in this area. Furthermore, residents in some outer suburban towns would rather visit community hospitals than general hospitals even if the former was far away. This indicates that people might make complex trade-offs and cost-benefit decisions when deciding where and whether to seek professional medical treatment.

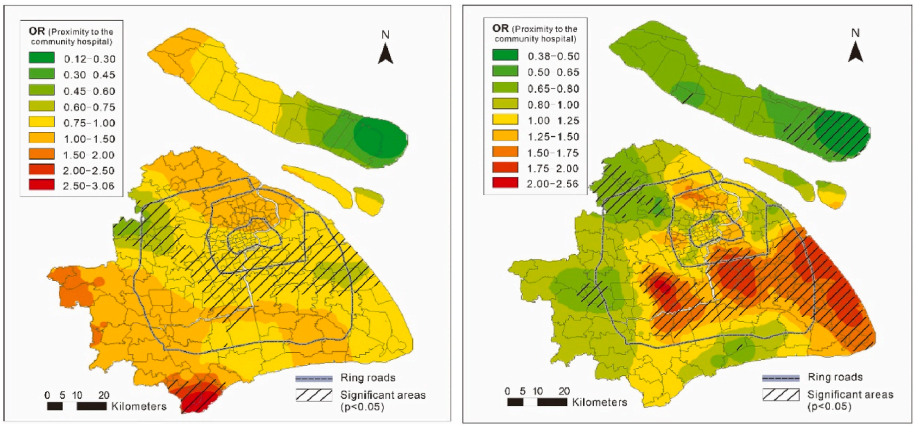
Proximity to a general hospital was insignificantly associated with peoples' health-seeking behaviors in most areas of the city, and the effect size for significant areas was moderate-to-low (Fig. 4). Generally, residents were more likely to visit general hospitals for medical treatment when these hospitals were close to their residences, especially in some suburban areas where the relocated or newly-built general hospitals effectively met residents' medical needs. However, residents from some suburban areas (e.g., west of the outer ring road and *Jinshan* District) were more likely to seek medical treatment at general hospitals even if these hospitals were distant from home. That said, the poor access to general hospitals did not prevent them from seeking high-quality medical services at these hospitals.

Accessibility to public transit also played an important role in residents' health-seeking behaviors, and this was especially the case for residents of inner suburban areas (Fig. 5). Easy access to metro stations was significantly associated with a lower prevalence of self-treatment in most areas of *Jiading*, *Baoshan*, and *Qingpu* District, where two newly-operational metro lines made travel to hospitals much more convenient. Furthermore, proximity to a metro station was also related to visiting general hospitals rather than community hospitals for medical treatment, especially when participants were located near terminal and transfer stations. For example, in some inner suburban towns where high-grade medical facilities were not available, residents relied heavily on public transit to access general hospitals. Here, the closer residents lived from metro stations, the more likely they were to seek medical care at a general hospital.

5. Discussion and conclusions

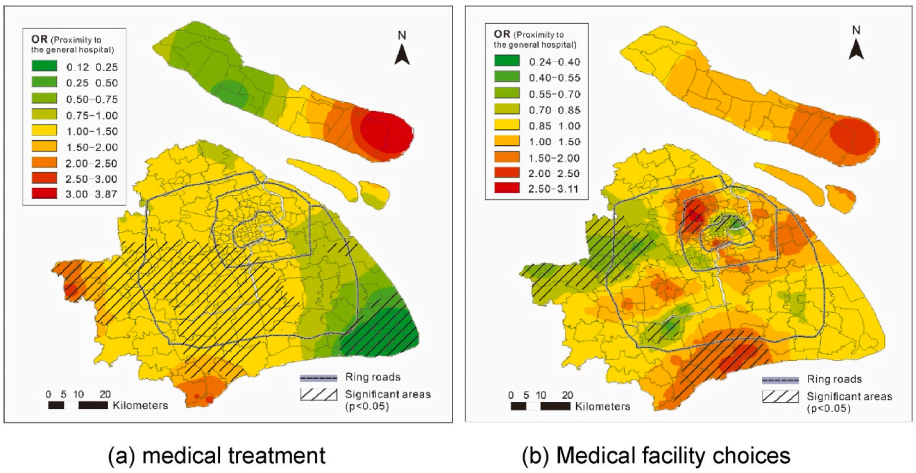
5.1. Discussion

The main finding of our study is that spatial accessibility to medical facilities is an important indicator of people's health-seeking behaviors. This could be corroborated by some existing evidence from developed countries. A study in Washington DC, the United States demonstrated



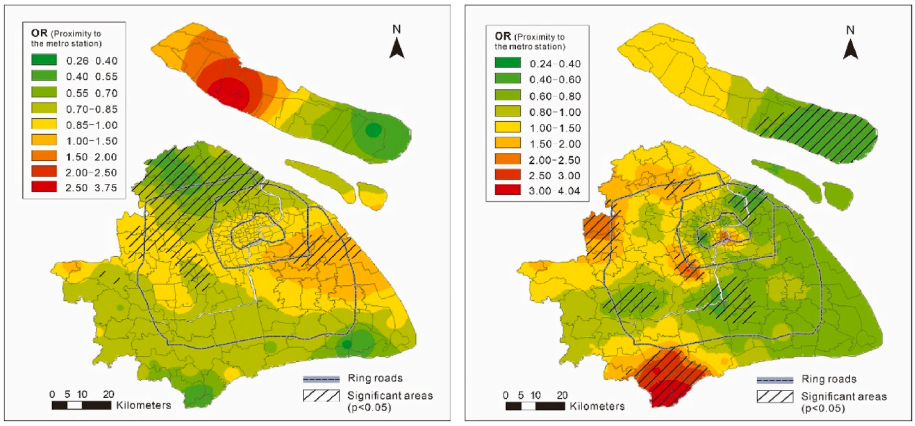
(a) medical treatment (b) medical facility choices

Fig. 3. Contextual associations of proximity to a community hospital with health-seeking behaviors.



(a) medical treatment (b) Medical facility choices

Fig. 4. Contextual associations of proximity to a general hospital with health-seeking behaviors.



(a) medical treatment (b) medical facility choices

Fig. 5. Contextual associations of proximity to a metro station with health-seeking behaviors.

that a low spatial density of primary care providers induced patients to pay more non-urgent visits to the emergency department, resulting in the misuse of medical resources meant for different functions (Mathison et al., 2013). Another state-level analysis showed that better access to oral care centers attracted people to undertake routine oral care and maintain their oral health (Fisher-Owens et al., 2016). Furthermore, our empirical analysis highlighted the complexity of this relationship in urban China, involving the issues of medical quality, public transit accessibility, the spatially heterogeneous effect of medical facilities, and the implicit socio-institutional contexts, which deserve in-depth attention and discussion.

First, our study showed that it is essential to take into account the quality and grade of medical facilities and the availability of public transit when measuring spatial accessibility to medical facilities. The reason is that access to hospitals of different grades would have varying effects on people's propensity to seek professional medical care and their choice of medical facilities. Specifically, easy access to a community hospital was significantly associated with seeking professional care at a medical facility, while the effect of access to a general hospital was weak. This indicates people's rigid demand for high-grade hospitals regardless of spatial proximity. Meanwhile, proximity to a metro station was significantly related to the likelihood of seeking professional care, especially at high-quality hospitals. Future researchers and policy-makers are recommended to consider the difference in residents' mobile abilities, and analyze access to medical facilities and transportation facilities together rather than in isolation.

Second, our study indicated that geographically contextual effects complicate people's health-seeking behaviors. The MGWR results showed moderate spatial heterogeneity in the relationship between access to medical facilities and people's health-seeking behaviors. In Chinese megacities such as Shanghai, most high-grade medical facilities are still concentrated in the central city, even though populations have largely spread out. The mismatch between the distribution of medical resources and residential populations generates spatial heterogeneity regarding the effect of access to medical facilities on people's health-seeking behaviors. According to our research findings, residents living in inner suburban areas were more sensitive to the accessibility to medical services and public transit than those living in other areas. That said, the impact of access to medical facilities on people's health-seeking behaviors was more significant in areas with a high degree of heterogeneous distributions of medical and transportation facilities. Thus, it is important for researchers and policy-makers to carefully consider the localized and contextual impacts of accessibility when allocating medical resources.

Third, our study found that spatial accessibility and socio-institutional factors jointly shape residents' health-seeking behaviors. Some social groups are concentrated in specific areas of the city and form localized contexts in which access to medical facilities and socio-institutional factors intersect and combine to complicate the accessibility–behavior relationship. In particular, the health-seeking dilemma

faced by migrants in urbanizing China is worth great attention. Echoing with the triple jeopardy of social, environmental, and health inequalities proposed by Pearce et al. (2010), socio-economically disadvantaged rural-to-urban migrants (e.g., migrants with low disposable income and lack of medical insurance coverage) are simultaneously exposed to residential and job disadvantages, such as poor access to urban amenities and severe occupational injuries. These disadvantages would further transform into behavior- and health-related disadvantages, as indicated by their high rate of self-treatment in our study. In addition to the registered residence, or *hukou*, system, complex medical insurance system constitutes another institutional barrier for rational health-seeking. This is supported by our result that having local medical insurance (i.e., urban employee basic medical insurance or urban resident basic medical insurance) is a covariate of whether to seek medical treatment or conduct self-treatment. However, this effect turns insignificant after taking into account the spatial accessibility to medical facilities and spatial heterogeneity of health-seeking behaviors, suggesting the coupling of institutional and spatial factors over space. As the coverage of basic medical insurance has greatly improved in China (96.8% in 2020), more attention should be paid to the implementation of medical insurance systems, such as localized management of medical insurance, off-site medical treatment across administrative districts and the actual amount of out-of-pocket medical costs, as well as their spatially heterogeneous impacts on health-seeking behaviors. Overall, current reform regarding the hierarchical medical system is merely oriented at the competing demand for high-quality medical services among urban populations, but rarely touches upon the rigid dichotomy of rural-urban populations and unfair allocation of medical resources and insurance. The alleviation of spatial and institutional barriers for health-seeking at the same time will be an important mission for Chinese governments to promote public health and reduce health inequalities in the future.

6. Conclusions

Health-seeking behavior reflects people's demand for and utilization of medical facilities, which is closely related to public health and quality of life. The spatial analysis of health-seeking behavior contributes to understanding the efficiency and efficacy of medical resource allocation strategies. Our study tentatively examined the spatial relationships among accessibility to medical facilities, local socio-institutional factors, and residents' health-seeking behaviors in Shanghai, China. The results showed that apart from biological predispositions, perceived needs, and social-economic enablers extensively discussed by previous literature, spatial accessibility to medical facilities was another important enabler for urban residents to seek official and timely medical care. The delineation of spatial accessibility included not only the proximity to the hospitals of different grades but also the availability of public transit around the residential neighborhood. Moreover, the effect of spatial accessibility to medical facilities on health-seeking behaviors was not universal over space but involved the complexity of specific geographic contexts and socio-institutional backgrounds. In this regard, there are two interesting findings worthy of further attention. First, the inner suburbs of Shanghai were the areas where spatial accessibility to medical facilities was highly heterogeneous over space; Thus, people's health-seeking behaviors suffered the most impact. Once inner-suburban residents could not easily access medical facilities, which was often the case, they were less likely to seek medical care when ill. Second, rural-to-urban migrants had a high likelihood of engaging in self-treatment even though they often faced high risks of occupational injuries. Their irrational health-seeking behaviors were jointly shaped by the residential disadvantage with low medical accessibility and the deficiency in institutional and economic resources.

Our findings have some policy implications. Considering that easy access to medical facilities would encourage proactive health-seeking behavior, equal access to basic medical services should be actively promoted especially in suburban areas. An ongoing and applicable strategy is establishing suburban branch hospitals and improving suburban public transit networks. Moreover, our analysis regarding the spatial heterogeneity of health-seeking behaviors suggests that policy-makers should tailor the allocation of medical resources to local contexts. For example, city centers should enhance the service quality of community hospitals and encourage residents to seek medical treatment nearby; Inner suburban areas are encouraged to improve their transportation networks while outer suburban areas should build or relocate high-grade hospitals to enhance people's access to high-quality medical services. Finally, in light of the interwoven and combined effects of spatial accessibility and socio-institutional factors, we suggest that policy-makers should pay special attention to the needs of disadvantaged groups (e.g., rural-to-urban migrants) and the neighborhoods they live in.

Our study contributes to the international literature on health-seeking behaviors by introducing a nuanced spatial perspective and employing advanced geospatial modeling methods. The contributions are also manifested as disclosing the role of local socio-institutional contexts and the interweaving with spatial factors in shaping residents' health-seeking behaviors in urban China. It should be noted, however, that our study had several limitations. First, we used a single indicator of severity of illnesses to represent the perceived need for medical services. Due to the data unavailability, we did not consider other components of the perceived need, such as the type of diseases and treatment, which limited our ability to represent biological imperatives in receiving medical treatment. Second, the clustering sampling approach restricted the possibility of examining the spatially heterogeneous effect of more local variables, such as income, on people's health-seeking behaviors. Even though disclosing their spatial heterogeneity is beyond the scope of our study, we admit that it would be interesting for future research to elaborate on the socio-spatial inequalities in health-related behaviors and health outcomes. Third, the cross-sectional design of our study did not uncover causal relationships. Future studies will benefit from longitudinal and experimental designs to further clarify the relationships among spatial accessibility, socio-institutional factors, and health-seeking behaviors.

Author contributions

Yue Shen developed the research idea and wrote the manuscript with some input from Yinhua Tao. Yinhua Tao carried out the statistical analysis and revised the manuscript. All authors approved the final manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.apgeog.2022.102644.

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