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Association Between Neighborhood Built Environment and Mental Health: Differences Between Older Adults With and Without Restricted Mobility

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Abstract: The mobility restrictions faced by older adults pose significant challenges to understanding the association between the neighborhood built environment and their mental health. Neglecting the role of restricted mobility hinders a comprehensive analysis of how the built environment impacts older adults' mental health. Furthermore, the differences in this association between older adults with and without restricted mobility remain unclear. Based on data from 1405 adults aged 60 and older in Hangzhou, China, this study explored the association between the neighborhood built environment and the mental health of older adults using multivariable linear regression, with multivariable logistic regression being employed for the sensitivity analysis. The results indicated that access to public canteens and outdoor fitness spaces were significantly positively associated with the mental health of older adults. Notably, the protective effect of outdoor fitness spaces was significant for older adults with restricted mobility, while the supportive effect of public canteens was significant for those without restricted mobility. This study demonstrated an association between the neighborhood built environment and mental health among older adults, highlighting differences in this effect between those with and without restricted mobility. These insights underscore the necessity of designing sustainable and inclusive neighborhoods that cater to the varied needs of older adults, ultimately fostering environments that promote healthy and active aging.

Keywords: neighborhood built environment; mental health; older adults; restricted mobility; healthy aging

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1. Introduction

The global challenge of population ageing is becoming increasingly critical [1]. By 2025, it is projected that over 20% of China's population will be aged 60 and older [2]. As individuals age, life events such as the loss of a spouse, declining physical health, cognitive decline, and alterations in social networks can trigger psychological challenges. Consequently, the mental health (MH) of older adults has emerged as a pressing social issue. A systematic review has identified a global prevalence of major depression among older adults at 13.3% [3], while anxiety disorders are even more prevalent, affecting 50% of this population [4]. In China, the situation is similarly alarming, with a depression prevalence rate of 23.6% among older adults [5]. Therefore, addressing and preventing MH issues among older adults has become an urgent priority to promote active ageing.

Maintaining mobility in older adults is fundamental to achieving active ageing [6]. Mobility plays a crucial role in aligning individual needs with available resources for older adults. Those with better mobility tend to engage more frequently in physical exercise, recreational activities, and visits to attractive destinations [7,8]. As their life space expands, the variety of locations they visit increases, thereby enhancing their overall life satisfaction [9].

However, with advancing age and declining physical function, mobility often decreases, resulting in a reduced scope of daily activities [10–12]. Low levels of mobility can diminish the daily engagement of older adults, potentially leading to psychological issues [13]. A reduction in life space not only indicates a risk of frailty [12], but also heightens the risk of mental illness [14]. Nonetheless, some studies have found that many older adults maintain a high level of subjective well-being, even when their life space is severely restricted [15].

Previous studies have identified various cognitive-behavioral and compensatory strategies that older adults employ to mitigate the impact of a reduced living space, thereby enhancing their MH [16,17]. Internally, older adults often utilize mobility aids to maintain their daily activities [18]. Externally, age-friendly features of the built environment (BE) support older adults' participation in daily activities [19], even when mobility is impaired [10]. For instance, the development of age-friendly communities [20,21] and the provision of sports and leisure facilities in residential areas [22] can promote daily activities among older adults, thereby improving their MH. Conversely, a restrictive BE may compel older adults to forgo certain outdoor activities [23]. It is important to recognize that older adults with and without mobility restrictions may experience the same BE features differently [24,25]. This variability can alter the relationship between the BE and the MH of older adults. To date, few studies have investigated the differential effects of the BE on the MH of older adults, based on their mobility status.

In China, residential neighborhoods serve as a unique living arrangement and a central gathering place for older adults to engage in daily activities. The age-friendliness of the neighborhood BE (NBE) plays a crucial role in determining social participation among older adults [26,27], which, in turn, impacts their MH [27–29]. Evidence from Hong Kong has identified positive associations between NBE elements, such as leisure seating, road paving, and crosswalks, and the MH of older adults [30]. However, other studies have found no significant direct correlation between the NBE and depression in older adults [27,31]. Furthermore, it remains unknown whether the relationship between the NBE and MH varies between older adults with and without mobility restrictions. Therefore, this study focuses on Hangzhou, China, to explore the association between the NBE and the MH of older adults, and to examine how this association differs between older adults with and without restricted mobility.

The remainder of this study is organized as follows: The second part introduces the materials and methods, including the study area, data collection, the definition of measures, and the construction of the statistical analysis. The third part summarizes the main results. The last two parts show the discussion and conclusion, respectively.

2. Materials and Methods

2.1. Study Area

Hangzhou, the capital city of Zhejiang Province, China, as well as the second largest city in the Yangtze River Delta, was selected as the study area for this research. By the end of 2021, Hangzhou had a permanent population of 12.2 million, with 17.3% aged 60 and older and 12.4% aged 65 and older. This demographic shift highlights the notable ageing population in Hangzhou. As a result, the elderly care services resources are relatively abundant in Hangzhou compared with other regions in China [32]. In recent years, Hangzhou has been actively developing age-friendly communities, with plans to achieve full urban and rural coverage by 2035 [33]. These made Hangzhou an ideal setting to explore the association between the NBE and MH among older adults.

For this study, we focused on urban areas, first screening administrative districts with 100% urbanization as the study area. Second, based on the proportion of the elderly residents, the more representative Shangcheng District, Gongshu District, and Xiacheng District (aged 60 and older: 33.09%, 27.53%, and 25.18%, respectively) were selected as the study areas. In terms of mortality rates, Shangcheng (6.15%) and Gongshu (5.65%) had slightly higher rates than the Hangzhou average (5.29%), while Xiacheng (4.86%) showed a lower rate. A stratified random sampling method was then used to select ten

residential neighborhoods in each of three districts as study areas. Figure 1 displays the precise locations of the sampled neighborhoods and uses Xiaohejiayuan as an example to illustrate the specific indicators of an NBE.

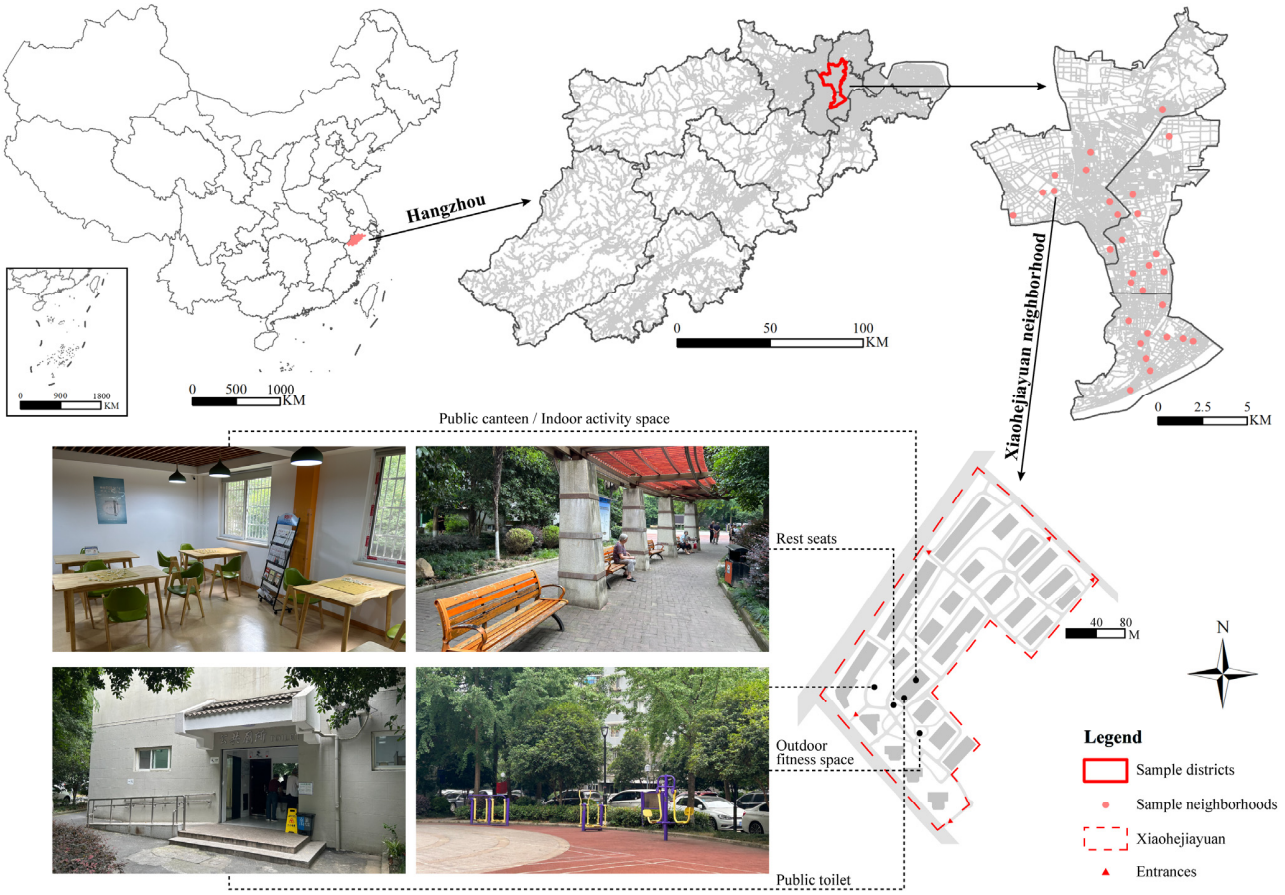

Figure 1. Location map of sampled neighborhoods.

2.2. Data Collection

In this study, data were collected at the individual level using a questionnaire method. The pre-survey was conducted in June 2022, followed by the formal survey from September to October 2022. The questionnaire survey was administered on working days with favorable weather conditions. Eight professional, trained students assisted in collecting the questionnaires as research assistants. Given the diverse educational backgrounds of the older adults, independently completing the questionnaire could have been challenging and potentially introduce information bias. Therefore, face-to-face interviews were conducted to gather relevant data from participants.

The surveys were conducted in 30 residential neighborhoods, mentioned earlier, with 50 questionnaires being randomly distributed in each neighborhood, resulting in a total of 1500 questionnaires. To be eligible for this survey, the participants had to meet the following criteria: be aged 60 or older, have resided in the neighborhood for at least six months, and exhibit no symptoms of cognitive impairment. Questionnaires that did not meet these criteria were deemed invalid. Ultimately, a total of 1405 valid questionnaires were obtained, yielding an overall response rate of 93.67%.

In this study, the process of data collecting using questionnaires complies with the relevant legal regulations [34]. No ethical approval was required since the present study involved no biomedical research on humans [34]. Prior to initiating the questionnaire survey, the researcher was required to disclose their identity, the purpose of the study, and the content of the survey to the participants. It was emphasized that the questionnaire was anonymous and no personal information would be disclosed in any subsequent scientific

research. The collected data would be securely stored and protected, accessible only for scientific research purposes. Participation was voluntary, and the participants could withdraw at any time without penalty. It was essential to respect the participants' rights, ensuring that the questionnaire did not involve any potential dangers. The questionnaire survey would only commence once the participants' informed consent had been signed.

2.3. Measures

MH was the dependent variable, measured by the 12-item Short-form Health Survey (SF-12) scale. The SF-12 was a simplified version of the 36-item Short-form Health Survey (SF-36) scale, widely used in clinical health assessment due to its simplicity and high completion rate. Furthermore, the SF-12 has demonstrated high reliability and validity within the Chinese context [35]. The SF-12 involved 12 items: two items each from the domains of physical functioning, "role—physical", "role—emotional", and MH, and one item each from the domains of bodily pain, general health, vitality, and social functioning. The items related to "role—physical" and "role—emotional" were used to identify participants with restricted mobility. Scoring was conducted according to the standardized scoring manual [34]. The Mental Component Summary (MCS) score, ranging from 0 to 100, was used to evaluate MH, with higher scores indicating better MH. The MCS score was treated as a continuous variable in statistical models to explore the association between NBE and MH of older adults. In addition, the MCS score was used as a categorical variable for the sensitivity analysis. A cut-off score of 50 or above on the SF-12 indicated positive MH (SF-12 < 50 scored as "0", SF-12 $\geq$ 50 scored as "1") [36].

The NBE was the independent variable, measured by the age-friendly community standards published by the Chinese National Health Commission and the National Office on Aging in 2020 [37]. To comprehensively address the daily activity needs of older adults, this study selected 10 items as evaluation indicators of the NBE across three categories: daily travel (including barrier-free travel, elevators, rest seats, the diversion of pedestrians and vehicles, road surfaces, and public toilets), neighborhood services (including public canteens and elderly care), and social participation (including outdoor fitness spaces and indoor activity spaces). Researchers assessed and scored these ten indicators through on-site investigations. Table 1 showed the specific evaluation criteria. During the evaluation process, the variables were assigned a value of 1 if the NBE met the described criteria; otherwise, they were assigned a value of 0.

Table 1. Evaluation indicators of the neighborhood built environment.

Independent Variables		**Description**
Daily travel	1. Barrier-free travel	Provide barrier-free travel at the ramps, stairs, and handrails in the public areas of the neighborhood.
	2. Elevator	Provide elevators in residential buildings.
	3. Rest seat	Place resting benches in key activity areas and passageways of older adults.
	4. Diversion of pedestrian and vehicle	Separate driving and walking paths within the neighborhood.
	5. Road surface	The pedestrian road surface is flat, and no illegal parking on the pedestrian road.
	6. Public toilet	Provide public toilets near places where the elderly gather together.
Neighborhood services	7. Public canteen	Provide public canteens.
	8. Elderly care	Set up medical and health institutions to provide rehabilitation, nursing, and other services for older adults.
Social participation	9. Outdoor fitness space	Provide outdoor fitness spaces.
	10. Indoor activity space	Provide indoor activity spaces.

Eight covariates were used to control for individual-level variables, including gender (1 = female, 0 = male), age (1 = 60–69 years old, 2 = 70–79 years old, 3 = 80 years old and older), pension (1 $\leq$ 3000 RMB, 2 = 3000–5000 RMB, 3 = 5000–7000 RMB, 4 $\geq$ 7000 RMB), educational level (1 = secondary school and below, 2 = high school, 3 = college or undergraduate and above), household registration (1 = Hangzhou, 0 = other cities), lifestyle (1 = living alone, 0 = living with family), the length of residency (1 = more than 5 years, 0 = less than 5 years), and chronic disease (1 = no chronic diseases, 0 = suffering from chronic disease).

Descriptive statistics were performed to describe the main characteristics of the participants and the NBE. Multivariable linear regression models were used to examine the associations between the NBE and the MH of older adults. Model 1 included the indicators of the NBE and MH for all participants. Model 2 was additionally adjusted for covariates. Models 3 and 4 were constructed similarly for participants with unrestricted mobility, while Models 5 and 6 were built for participants with restricted mobility. Multivariable logistical regression models were used for the sensitivity analysis. All the statistical analyses were completed using Stata 17.0, with a significance criterion set at $p < 0.05$.

3. Results

3.1. Descriptive Statistics

The descriptive statistics of the study participants were summarized in Table 2. Among the total participants (n = 1405), the mean MH score was 56.30, with the majority of participants (85.20%) exhibiting positive MH. Demographically, a higher proportion of the participants were female (56.94%), aged between 70 and 79 years (36.72%), received a pension of 3000–5000 Chinese yuan (43.49%), and had an education level of junior high school or below (71.96%). The majority were registered residents of Hangzhou (79.72%), lived with family members (89.40%), had resided in their neighborhood for more than five years (87.76%), and had a chronic disease (70.89%).

Table 2. Descriptive statistics for study participants.

Variables	Mean (SD) or N (%)			p [a]
	Total (n = 1405)	**Unrestricted Mobility (n = 1059)**	**Restricted Mobility (n = 346)**	
Mental health (continuous)	56.30 (7.17)	57.52 (4.65)	52.55 (11.12)	<0.001
Mental health (categorical)				
Positive	1197 (85.20)	979 (92.45)	218 (63.01)	<0.001
Negative	208 (14.80)	80 (7.55)	128 (36.99)	
Gender				
Male	605 (43.06)	487 (45.99)	118 (34.10)	<0.001
Female	800 (56.94)	572 (54.01)	228 (65.90)	
Age (years old)				
60–69	461 (32.81)	388 (36.64)	73 (21.10)	<0.001
70–79	516 (36.72)	385 (36.36)	131 (37.86)	
>80	428 (30.46)	286 (27.01)	142 (41.04)	
Pension (Chinese yuan)				
<3000	291 (20.71)	226 (21.34)	65 (18.79)	0.415
3000–5000	611 (43.49)	450 (42.49)	161 (46.53)	
5000–7000	360 (25.62)	270 (25.50)	90 (26.01)	
>7000	143 (10.18)	113 (10.67)	30 (8.67)	
Educational level				
Secondary school and below	1011 (71.96)	759 (71.67)	252 (72.83)	0.677
High school	204 (14.52)	152 (14.35)	52 (15.03)	
College and beyond	190 (13.52)	148 (13.98)	42 (12.14)	
Household registration				
Hangzhou	1120 (79.72)	833 (78.66)	287 (82.95)	0.085
Other cities	285 (20.28)	226 (21.34)	59 (17.05)	

Table 2. *Cont.*

Variables	Mean (SD) or N (%)			p [a]
	Total (n = 1405)	**Unrestricted Mobility (n = 1059)**	**Restricted Mobility (n = 346)**	
Lifestyle				
Living with family	1256 (89.40)	960 (90.65)	296 (85.55)	0.007
Living alone	149 (10.60)	99 (9.35)	50 (14.45)	
Length of residency (year)				
Living more than 5 years	1233 (87.76)	916 (86.50)	317 (91.62)	0.012
Living less than 5 years	172 (12.24)	143 (13.5)	29 (8.38)	
Chronic disease				
No chronic diseases	409 (29.11)	375 (35.41)	34 (9.83)	<0.001
Suffering from chronic disease	996 (70.89)	684 (64.59)	312 (90.17)	

[a] Based on independent *t*-test or Chi-squared test.

For participants with restricted mobility (n = 346), their average MH score was significantly lower at 52.55 compared to those with unrestricted mobility. Furthermore, the proportion of individuals with negative MH was considerably higher (36.99%) among this group. A larger percentage of those with restricted mobility were aged 80 and older (41.04%), and over 90% had at least one chronic disease (90.17%).

The descriptive statistics of the NBE were presented in Table 3. More than half of the residential neighborhoods provided features such as barrier-free travel, rest seat, public toilet, elderly care, outdoor fitness space, and indoor activity space. Notably, over 70% of the neighborhoods provided barrier-free travel and outdoor fitness spaces, while features such as elevators, smooth road surfaces, and public canteens were less common, presented in only about 40% of the residential neighborhoods. Furthermore, only 10% of the neighborhoods provided the diversion of pedestrians and vehicles.

Table 3. Descriptive statistics for neighborhood built environment.

Variables	N (%)
Barrier-free travel	22 (73.33%)
Elevator	11 (36.67%)
Rest seat	17 (56.67%)
Diversion of pedestrian and vehicle	3 (10.00%)
Road surface	12 (40.00%)
Public toilet	17 (56.67%)
Public canteen	11 (36.67%)
Elderly care	17 (56.67%)
Outdoor fitness space	21 (70.00%)
Indoor activity space	16 (53.33%)

3.2. The Association Between the Neighborhood Built Environment and the Mental Health of Older Adults

The association between the NBE and the MH of older adults is illustrated in Figure A1. For the total participants group (Models 1 and 2), the availability of public canteens (β = 1.327, p = 0.004) and outdoor fitness spaces (β = 1.812, p = 0.008) was found to be significantly and positively associated with the MH of older adults, even after adjusting for the social-demographic characteristics. Among the older adults with unrestricted mobility (Models 3 and 4), after adjusting for the covariates, significant positive associations were observed for the presence of elevators (β = 0.919, p = 0.039), public toilets (β = 0.940, p = 0.037), and public canteens (β = 0.984, p = 0.004), while elderly care (β = −1.061, p = 0.029) showed a significantly negative association. In contrast, for older adults with restricted mobility (Models 5 and 6), the availability of outdoor fitness spaces (β = 5.959, p = 0.002) showed a significantly positive association with MH, whereas the public toilets (β = −4.663, p = 0.020) were significantly negatively associated.

3.3. Sensitive Analysis

The sensitivity analysis using multivariable logistic regression confirmed the robustness of the main findings (Figure A2). Specifically, the positive association between public canteens, outdoor fitness spaces, and the MH of older adults remained significant. Additionally, the association between public canteens and the MH of older adults without restricted mobility, as well as the association between public toilets, outdoor fitness spaces, and the MH of older adults with restricted mobility were consistent with the main analysis.

4. Discussion

Overall, the results demonstrated a significant association between the NBE and the MH of older adults. Specifically, both public canteens and outdoor fitness spaces were significantly positively associated with the MH of older adults. Notably, these associations varied between older adults with and without restricted mobility. For those with unrestricted mobility, public canteens exhibited a robust positive association with their MH, providing not only nutritional benefits but also essential social engagement opportunities. In contrast, older adults with restricted mobility showed greater benefits from outdoor fitness spaces, which play a crucial role in facilitating physical activity and enhancing social interactions. Conversely, public toilets were negatively associated with the MH of older adults with restricted mobility.

The protective effect of outdoor fitness spaces on the MH of older adults has been supported by other studies [22]. Exercise has been shown to release dopamine, which can enhance mood and foster positive emotions [38]. This explains why outdoor fitness spaces positively impact MH. For older adults with restricted mobility, exercise is one of the most effective intervention measures [39]. For example, for older adults with restricted mobility, these spaces often include equipment designed for rehabilitation, thus serving as convenient locations for necessary physical activity [40]. When their primary need for physical rehabilitation training is met, their MH improves. Additionally, the informal or non-contact social interactions that occur in these spaces can further bolster MH, as older adults engage with neighbors, creating both active and passive social influences [41]. However, older adults without restricted mobility may prefer more expansive venues, such as parks and squares, which may diminish the perceived benefits of nearby fitness facilities. Thus, the design of outdoor fitness spaces should consider the varying needs of older adults to maximize their MH benefits.

The positive impact of public canteens on the MH of older adults is similarly supported by prior studies [29,42]. While modern conveniences such as express delivery and takeout provide options for home dining, public canteens align more closely with the social and dietary habits of older adults. In China, public canteens often offer subsidies for seniors, promoting greater accessibility and enhancing community integration. Studies indicate that older adults residing in communities with public canteens report better MH compared to those in communities lacking such services [42]. In this study, the benefits of public canteens were significant, primarily for older adults with unrestricted mobility, likely due to their increased ability to access and utilize these facilities. Conversely, older adults with restricted mobility may face psychological barriers that limit their participation [14], thus reducing the potential positive impact of public canteens. This underscores the necessity of fostering social dining environments that are accessible and inviting for all older adults, regardless of their mobility status, to promote inclusivity and enhance MH.

A negative correlation between public toilets and MH among older adults with restricted mobility may stem from their heightened need for essential facilities during outdoor activities, such as public toilets [43]. As physiological functions decline with age, older adults may not engage in prolonged outdoor activities, especially for those with restricted mobility. Public toilets offer convenient services for physiological needs and extend their time outdoors [44]. However, public toilets are often prone to substandard sanitation due to their specific functional attributes, particularly in humid summers like those in Hangzhou. A study on the relationship between the BE and MH found that environmental sanitation

mediated up to 55% of the impact on MH [45], underscoring that the effectiveness of even essential facilities like public toilets can be compromised by inadequate maintenance. Therefore, improving the sanitation and accessibility of public toilets is crucial for enhancing the outdoor experience and MH of older adults with mobility challenges.

This study has several limitations. First, as a cross-sectional study, this study cannot establish causal relationships between the NBE and MH. Second, while this study relies on objective evaluations to measure the NBE, future research could incorporate both subjective and objective measurement methods for a more comprehensive assessment. Third, this study assessed mobility restrictions among older adults through subjective evaluation. Future studies could utilize advancements in communication technology, such as GPS, to more objectively analyze the travel patterns of the elderly. Additionally, the sample size of participants with mobility restrictions was limited (346 out of 1405), which may affect the robustness of the findings related to this group.

5. Conclusions

This study explored the association between the NBE and MH among older adults, demonstrating that this association varied based on the participants' mobility status. Specifically, the presence of public canteens and outdoor fitness spaces was significantly positively associated with the MH of older adults, but the association varied by mobility. The protective effect of public canteens was significant among older adults without restricted mobility, while the beneficial effect of outdoor fitness spaces was significant for those with restricted mobility. These findings highlight that the needs for neighborhood facilities differ among older adults in relation to their mobility, which in turn affects their MH in distinct ways. The results suggest that neighborhood facilities must be designed not only to meet the general supply and demand but also to address the specific needs of older adults, particularly in terms of mobility. For instance, age-friendly facilities are recommended to be implemented at the level of residential neighborhoods, such as public canteens and outdoor fitness locations, which may markedly enhance the MH of older adults. Specifically, outdoor fitness spaces should incorporate rehabilitation equipment that is tailored to the needs of older adults with restricted mobility. These findings have important implications for urban planners and policymakers, who should focus on developing age-friendly facilities that cater to diverse mobility needs.

Author Contributions: Conceptualization, X.K. and H.H.; methodology, X.K.; software, X.K.; formal analysis, X.K.; investigation, X.K., F.C., and M.Z.; data curation, X.K.; writing—original draft preparation, X.K.; writing—review and editing, H.H. and X.S.; visualization, X.K.; funding acquisition, H.H. and X.S. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: Ethical review and approval were waived for this study due to no biomedical research on humans, according to the Chinese government.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data used in this study are not available to other researchers for replication purposes. The analytic methods and materials are available to other researchers by sending requests to the authors via email. The study reported in the manuscript is a cross-sectional study and was not preregistered.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

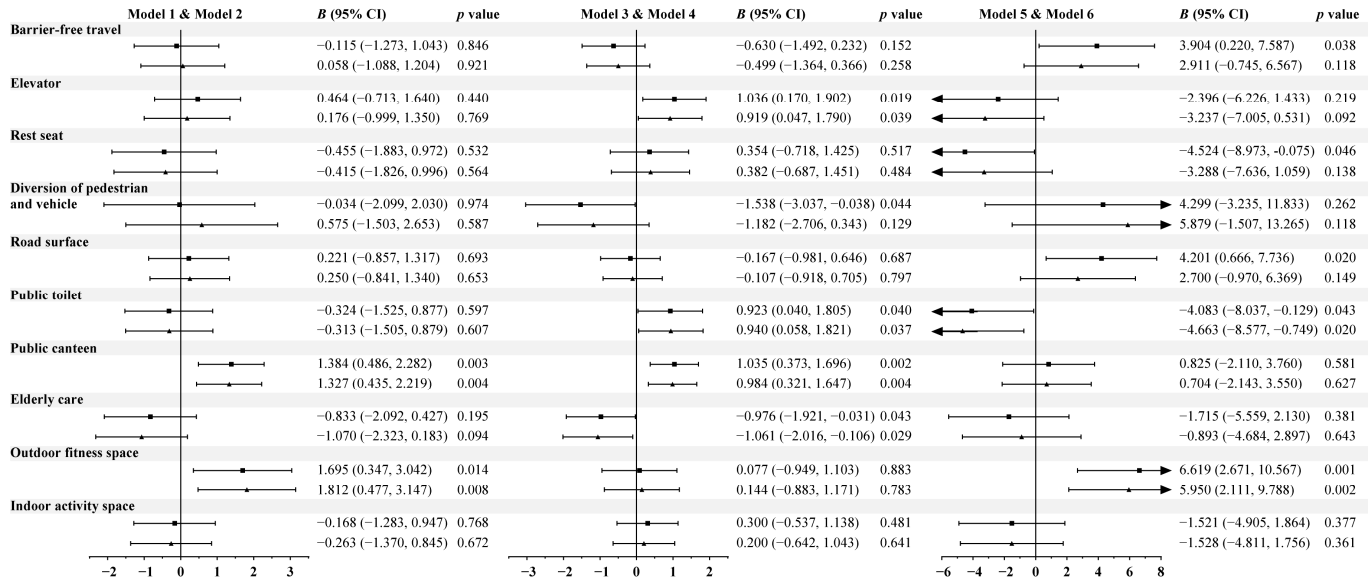

Figure A1. Multivariable linear regression models of the mental health of older adults.

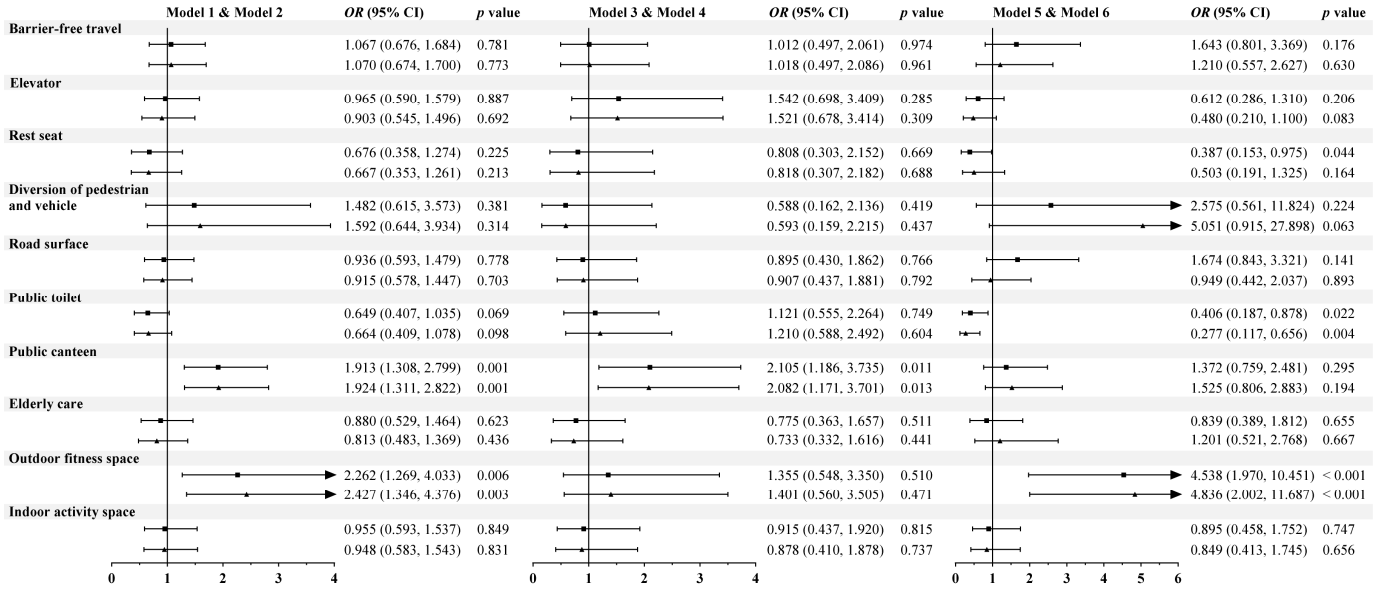

Figure A2. Multivariable logistic regression models of the mental health of older adults.

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