The built environment and mental health among older adults in Dalian: the mediating role of perceived environmental attributes

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Abstract: The basic attributes of the urban built environment are an important factor affecting mental health. However, research has rarely distinguished objective and perceived built environment characteristics to explore the associations with older adults' mental health. Based on data of 879 respondents aged 60 or older in Dalian, China, we explored the mediating roles of perceived built environmental attributes in the relationship between objective built environmental characteristics and mental wellbeing by structural equation modelling. Furthermore, to control for residential self-selection, the model was further tested by excluding the participants who self-selected their residences. The results showed that accessibility to daily living service facilities was positively associated with older adults' mental wellbeing through an indirect role of perceived built environmental attributes. The positive direct effect of aggregation of daily living service facilities on mental wellbeing was offset by the negative indirect effects of perceived built environmental attributes. In addition, the street interface density was negatively related to mental wellbeing through indirect effects. The diverse leisure, exercise and landscape facilities, underground parking and presence of elevators within neighborhoods were all positively associated with older adults' mental wellbeing through direct and/or indirect effects. The results were verified after excluding residential self-selection samples. These findings are helpful for evidence-based planning strategies and can provide guidelines on designing neighborhood landscapes and facilities which can further contribute to aging in place policies.

Keywords: Objective built environment; perceived built environment; older adults; mental health; structural equation model

1 Introduction

Rapid population aging is becoming a serious social challenge for Chinese cities (Wu and Ren, 2021). The health problems of the elderly, especially mental health, are now receiving growing attention (Guo et al., 2021; Liu et al., 2021; Pelgrims et al., 2021; Zhou et al., 2020). The "Healthy Aging" concept emphasized the role of environmental factors for the health of older adults (Kerr et al., 2012). Compared with the individual's own resources and socio-economic characteristics, the built environment is a factor that is regulated more easily by governments and urban planning professionals, which can be used as a means of preventing and improving psychological conditions besides medical treatments (Sarkar et al., 2014). The neighborhood built environment is especially essential for older adults, who spend more time in residential communities than other age groups due to decreased mobility (Burton et al., 2011; Clarke and Nieuwenhuijsen, 2009; Kerr et al., 2012; Van Dyck et al., 2015). Therefore, research about the impact of the built environment on older adults' mental health is of practical significance, and can provide important theoretical support for the "aging in place" policy.

The built environment is a broad concept that includes man-made material aspects of the environment such as homes, buildings, streets, open spaces, and infrastructure, all of which can affect individual physical and mental health as well as health on a neighborhood level (Kerr et al., 2012; Núñez-González et al., 2020; Shen, 2014). The majority of studies has concentrated on the built environment at the neighborhood level, which is the layer closest to inhabitants under ecological systems theory since it comprises the built environment characteristics with which residents have direct interaction (Bronfenbrenner, 1979; Gao et al., 2016; Guo et al., 2020). The neighborhood built environment is the spatial carrier of most material facilities and activities related to the mental wellbeing in older adults (Liu et al., 2016).

Compared to younger adults, older adults seem more vulnerable to changes in the neighborhood built environment. Their social interactions and social networks shrink because of deterioration of physical functioning and retirement, so they spend more time in neighborhood interactions and their daily activities are often confined to the geographic space of the neighborhood (Burton et al., 2011). As reliance on neighborhood grows, the convenience and comfort of material conditions of their neighborhood built environment become more relevant to their mental health (Cagney et al., 2013; Kitchen et al., 2012). Moreover, with rapid aging in China, the number of older adults living alone is gradually rising. These older adults are frequently more dependent on the neighborhood's resources and services (Liu and Guo, 2008). These highlight the importance of both the physical and functional aspects of the neighborhood built environment in the quality of life and mental health of older adults.

The associations of physical and functional aspects of the built environment with older adults' mental health are preliminarily acknowledged. Regarding physical-environment aspects, associations with mental health parameters in older adults have been found for housing and neighborhood qualities. For instance, previous studies indicated that qualities of residential buildings, exercise and leisure facilities, cleanliness and peacefulness in neighborhoods had positive associations with specific parameters of older adult' mental health (Liu et al., 2021; Phillips et al., 2005; Sarkar et al., 2013; Ziegler and Schwanen, 2011). Regarding functional aspects related to the environment, accessibility to local services (e.g., hospitals, supermarkets, parks and restaurants) (Besser et al., 2017; Nordbakke and Schwanen, 2015), and convenience and comfort of facilities (Costa-Font, 2012) have been positively associated with older adults' mental health indicators. In addition, older adults' mental health is at higher risk of exposure to unfriendly built environments compared to adults. Poor accessibility, for example, involves that overcoming the spatial separation will require more physical strength and energy, financial resources, and time for older adults than for adults, which will worsen the wellbeing of older adults who already suffer from declining physical strength and mobility (Liu et al., 2016).

Notably, the objective and perceived built environment showed certain discrepancies in their associations with mental health in the available studies (Barros et al., 2019; Hoisington et al., 2019; Núñez-González et al., 2020). Specifically, the objective built environment is mostly measured with the help of geographic information system (GIS) technology (Nordbø et al., 2018). Some studies revealed that objective residential density and street connectivity were positively associated with mental wellbeing (Guo et al., 2020), whereas others have indicated negative associations (Sullivan and Chang, 2011; Van Dyck et al., 2011; Woodbridge et al., 2018). More specifically, Sullivan and Chang (2011) found that higher residential density had negative associations with residents' psychological states, while Van Dyck et al. (2011) found a negative association with neighborhood satisfaction. Objectively-assessed greenspace measures have been shown to be beneficial for mental health and subjective well-being (Wang et al., 2019a; Wang et al., 2019b; Wang et al., 2020; Yue et al., 2022); nevertheless, this is more likely to be found in more highly urbanized areas (Arnberger and Eder, 2012). Other studies have also suggested that these associations could be non-linear. The conclusions of previous studies are diverse, and further empirical research is needed to have a better understanding of such relationships (Jiang et al., 2014). In terms of the perceived built environment, self-reported data is the primary source for assessing factors like walkability, security, and aesthetics, with usually positive associations with mental health indicators (Cleary et al., 2019; Gao et al., 2016; Leslie and Cerin, 2008).

Inconsistent findings previously reported on the impacts of objective and perceived built environment characteristics on mental health indicators suggest that some mismatch between the two may have been overlooked. The mismatch probably is more pronounced in older adults as they in particular have a more profound perceptual experience of the neighborhood built environment than other age groups (Burton et al., 2011; Kerr et al., 2012). Indeed, Campbell et al. (1976) identified this conundrum, stating that individuals may perceive similar environmental conditions differently (Campbell et al., 1976). In addition, some other studies have attempted to combine the objective and perceived built environment in the same model (Koohsari et al., 2015). The ecological model of active living categorizes spatial elements of the objective built environment, such as home, leisure, work and transport, into five corresponding aspects of the perceived built environment, i.e. accessibility, convenience, comfort, amenity and safety, to explore the environmental impact on individuals' behavior, psychology and family (Sallis et al., 2006; Sallis and Owen, 2015). Sarkar et al. (2014) constructed a conceptual healthy city model, which describes direct and indirect effects of the objective built environment on psychological wellbeing through psychosocial stress (pollution, congestion, crime, etc.) and psychosocial resources (social capital, support, interaction, neighborhood satisfaction, etc.) (Sarkar et al., 2014). Other empirical studies have revealed that when subjective elements such as perceptions of walkability or service accessibility are controlled for, the association between objective built environment and mental health weakens, implying that the perceived built environment may play a mediating role in the objective built environment-mental health relationship (Guo et al., 2021; Zhang and Zhang, 2017).

For the purpose of this paper, we developed a theoretical framework based on the ecological model of active living that treats the perceived built environment as the mediator in the objective built environment-mental wellbeing association. Through receptive senses such as seeing, hearing, smelling, and touching, the perceived built environment represents an individual awareness of the built environment (Sallis et al., 2006). These sensory inputs are combined to create the environment's emotional feeling (Connors, 2012). As the healthy city model points out, planning strategies may not provide the desired results if residents are unable to perceive the benefits of the planner's so-called age-friendly environment (Sarkar et al., 2014). As a result, it is critical to understand the relationship of the objective and perceived built environment with mental health, which has been largely overlooked in earlier research.

In terms of research methodology, the association of built environment with mental health may have a bias due to residential self-selection, meaning that individuals are influenced by their own preferences and habits when choosing where to live (McCormack and Shiell, 2011). Although this mechanism has been confirmed in previous studies (Wang and Lin, 2014; Zhang, 2014), it is difficult to exclude residential self-selection from cross-sectional studies (Kärmeniemi et al., 2018). However, the unique urban housing system in China has provided a possibility to address this problem. Residents who are living in the welfare housing and the *Danwei* housing from the government or state were passively allocated to houses with little possibility to select housing on their own preference (Wang and Zhou, 2017). Selecting these groups as participants makes it possible to circumvent the issue of residential self-selection to a large extent, although not completely, to test the robustness of results.

Moreover, most previous studies have been conducted within a Western context, such as Ghent (Van Dyck et al., 2011) and Brussels (Pelgrims et al., 2021), Belgium; Brisbane (Cleary et al., 2019), Australia; Szeged (Kothencz et al., 2017), Hungary; Metro Vancouver (Engel et al., 2016), Canada; Catalonia (Triguero-Mas et al., 2015), Spain and South Wales (Sarkar et al., 2013), UK, etc. Dalian, a typical second-tier hilly city in China, is undergoing rapid population aging. The city's prevalence of mental diseases in older adults is considerably high (25%) (Sun and Lu, 2022). Dalian's high population density, in contrast to many other developed cities in Western countries, leads to efficient transportation and relatively close proximity to public services. As a result, the environmental effects on older adults may differ from those shown in Western countries with lower population density. Also, various types of slopes can be found in more than half of the residential neighborhoods in urban areas. Low hills, with altitudes ranging from 50 to 200 meters and an inclination of 5 to 10 degrees, are common in urban areas, and they have an impact on older adults' outdoor activities and mental health in Dalian (Sun and Lu, 2022). Therefore, there is a need to explore the specific associations of the objective and perceived built environment with older adults' mental health in Dalian to guide strategic planning for a livable city that promotes health in older populations in similar countries and cities.

Inspired by the ecological model of active living and current research gaps, the associations of built environment characteristics with mental health in older adults in Dalian were studied by integrating measures of the objective and perceived built environment. Specifically, we address the following research questions: 1) Do the objective and perceived built environment have different associations with mental wellbeing? 2) Do perceived built environmental attributes mediate the relationship between the objective built environment and mental wellbeing in older adults in Dalian? 3) Do the relationships change after excluding participants with potential residential self-selection? This research can provide guidelines on the selection of environment planning indicators and design of neighborhood environments and facilities which can further contribute to aging in place policies and evidence-based planning strategies.

2 Methods

2.1 Study area and survey data

This is a cross-sectional study, conducted in residential areas in Dalian, China, from May to October 2019 (Fig. 1). The geographical scope of this study was limited to central administrative districts of the urban area (Zhongshan District, Xigang District, Shahekou District, Ganjingzi District). There are 39 sub-administrative units with large geographic differences in the jurisdiction, including 1799 residential areas (Sun and Lu, 2022). The recruitment procedure was based on a two-stage stratified sampling design. In the first stage, 1-2 residential areas were randomly selected from each sub-administrative unit. In total, 61 residential areas (neighborhoods) were chosen, accounting for 3.39% of all residential areas. Selected residential areas range from 0.03 to 1.12 km^2 (0.28 km^2; SD±0.24). Then, in each residential area, 12-18 older adults over 60 were randomly selected as respondents.

Preliminary home interviews were conducted to determine whether the selected older adults were willing to participate in the survey. Among the total of 986 randomly selected older adults (conformity with criteria), 900 of them from different households finally agreed to participate in the interview (response rate 91.3%). Survey data were collected during an interview that was conducted face-to-face at respondents' homes. All of the interviewers participated in a training course before conducting survey data collection. Questionnaires with incomplete answers, apparently contradictory answers, and regular answers (e.g., all the same options) were deleted. 879 participants with valid data were included in further data analyses. Through detailed individual interviews, participants' mental wellbeing, environmental perceptions and socio-economic attributes were assessed. The study protocol was approved by the Dalian University of Technology Research Ethics Committee, and all participants completed informed consent before enrollment.

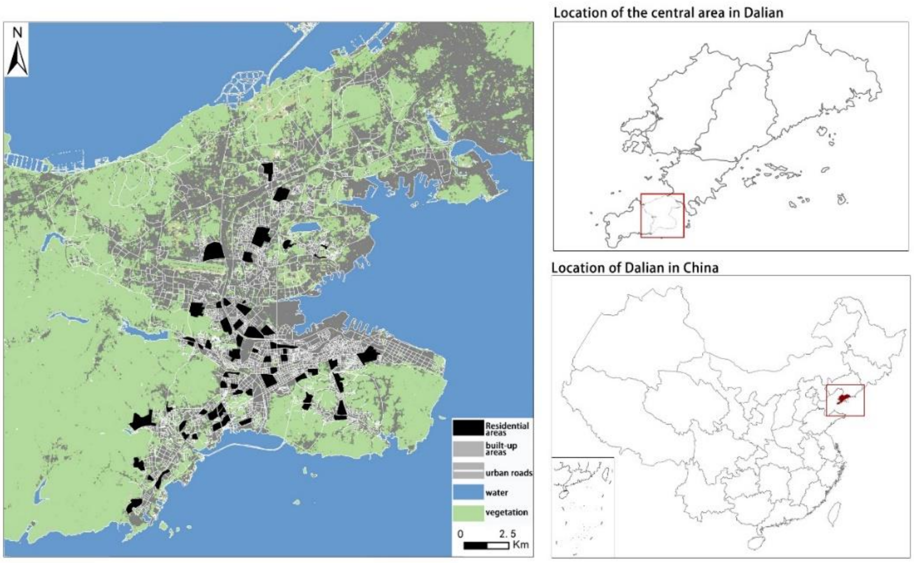

Fig. 1 Location of the study area and neighborhood

2.2 Measures

2.2.1 The objective and perceived built environment

The theory of social production function (SPF) proposed by Lindenberg, integrated concepts including mental wellbeing, goals, needs, activities and resources hierarchically (Lindenbenberg, 1996; Liu et al., 2016; Nieboer et al., 2005; Ormel et al., 1999). The goal of improving mental wellbeing can be attained by five instrumental approaches or basic needs: comfort (physiological needs; pleasant and safe environment), stimulation (optimal level of arousal), status (control over scarce resources), behavioral confirmation (approval for 'doing the right things'), and affection (positive inputs from caring others) (Nieboer et al., 2005). These five basic needs can be met in turn by lower-level activities and resources. According to this theory, older adults' mental wellbeing correlates to the satisfaction level of the five basic needs as well as to the availability and quality of residential environmental resources. For example, food is obtained from supermarkets and grocery stores as a necessary resource to satisfy comfort; most recreational activities for physical and mental stimulation take place in leisure facilities and urban open spaces; satisfaction of status is usually associated with superior residence quality and location. Therefore, based on SPF theory, we can select the description indicators of environmental resources that are closely related to psychological wellbeing.

The material conditions (distinguished from social relationships) of residential environmental resources often include physical and functioning aspects of the built environment (Bonaiuto, 2004; Crowe, 2010; Mao et al., 2015). The objective and perceived built environment is respectively defined as objective measurement (e.g., distance to facilities and street density) and subjective measurement (e.g., perception for convenience and aesthetics) for physical and functioning conditions of the built environment (Zhang and Zhang, 2017).

The detailed objective built environment characteristics are described in terms of services facilities (nodes), street networks (paths), and neighborhood blocks (districts), which have connections to different basic needs in SPF theory. The specific indicators were selected from the 5D concepts (density, diversity, design, distance to transit, destination access) proposed by Cervero et al. (2009) (Fig. 2).

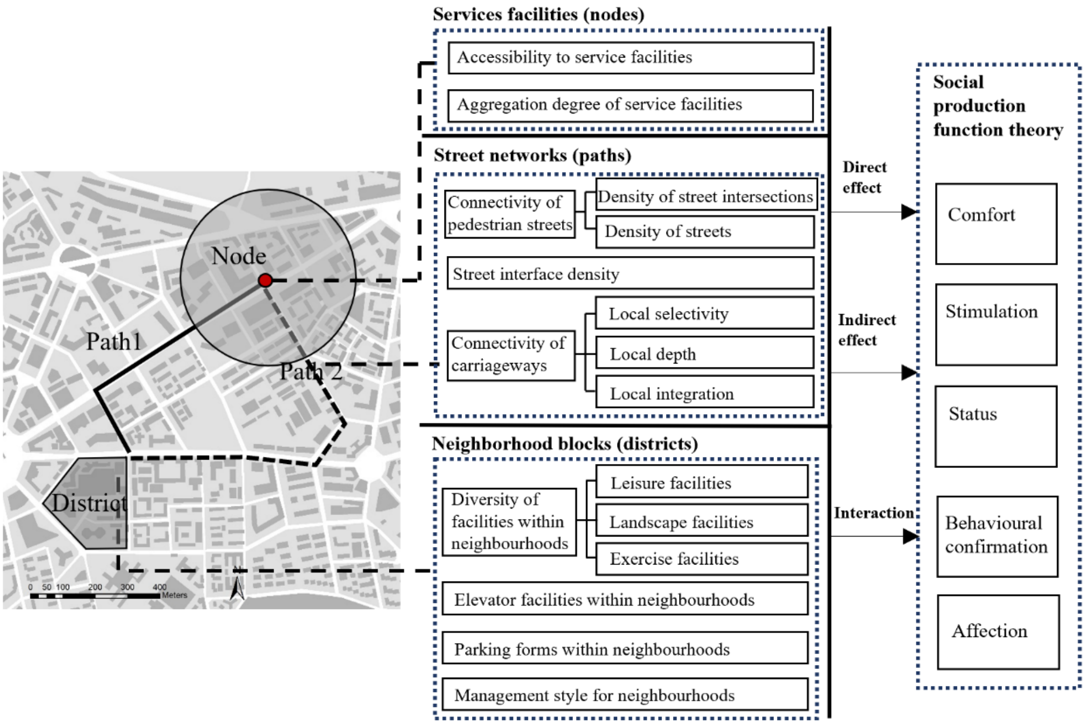

Fig. 2 Objective built environment characteristics

Some objective built environment characteristics were derived from Google Maps and Open Street Maps (OSM) in 2019 and corrected through on-site observations. Indicators such as the diversity of residential facilities are obtained through on-site observations. The daily activities of older adults after retirement are mainly concentrated in and around the neighborhood, so partial indicators were calculated by averaging the scores for all sampling points within a circular buffer around the respondents' residence. There is still no consensus regarding the most appropriate definition of neighborhood size when studying associations of environmental factors with mental health and related behaviors. Buffers with radii ranging from 0.4 km to 1.0 km have been frequently used, with some evidence suggesting that smaller buffers may be more appropriate for older adults given their reduced physical capacity (Barnett et al., 2018; Burton et al., 2011; Cerin et al., 2014). Depending on the study focus (e.g., whether related to physical or mental health responses to environments) different buffer distances seem to be used in previous research. For example, mental health studies were more likely to select buffer distances less than or equal to 300 m (Labib et al., 2020). Consequently, we conducted the analyses using 300 m buffers and tested results robustness using 500 m buffers.

At nodes level, accessibility to service facilities was obtained by calculating the minimum street network distance to facilities that meet the daily living needs of older adults, such as supermarkets, banks, restaurants and hairdressers; the aggregation degree was acquired by calculating the sum of types and numbers of commercial facilities (e.g. supermarkets and shopping malls), leisure facilities (e.g. parks and squares), educational facilities (e.g. primary and secondary schools), medical facilities (e.g. clinics and hospitals) and transport facilities (e.g. bus and metro stations) in the 300m-buffers. At paths level, the street interface density is the average ratio of the width of projection plane of street-facing building to the length of the street within the buffer area calculated by Geographic information system (GIS), which describes the distribution of open spaces along the street. The connectivity of carriageways is calculated by the spatial syntax using Depthmap software. At districts level, the auxiliary and supporting facilities, parking forms and management style within neighborhoods are captured through on-site observations. Details of the calculation methods are shown in Table 1.

The perceived built environmental attributes included perceptions of noise, travel fluency, security, and landscape aesthetics based on the ecological model of active living. These perceived elements were assessed through a questionnaire (Table 1). The questions were informed by relevant literature (Chen et al., 2009; Irvine et al., 2009; Kothencz et al., 2017; Krajter Ostoić et al., 2017; Mansor et al., 2012; Szeremeta and Zannin, 2009). Each element was scored on a 5-point Likert scale. The final score of perceived built environmental attributes was measured by factor analysis in Structural Equational Model (SEM). The reliability and validity of the perceived built environment questionnaire were tested using the composite reliability coefficient and average of variance extracted respectively by confirmatory factor analysis in SEM.

2.2.2 Mental wellbeing

The questions used to assess mental wellbeing originate from the WAVE 1' dataset, which is a survey designed by the World Health Organization (WHO). The WAVE survey was used in a longitudinal study of aging and adult health with nationally representative samples of adults from 6 low- and middle-income countries including China (Arokiasamy et al., 2017). We selected questions to assess older adults' mental wellbeing from the Chinese version of the questionnaire (SAGE team, 2013). Three aspects of mental wellbeing were assessed: Residence wellbeing (Burton et al., 2011); travelling wellbeing (Burton et al., 2011; Liu et al., 2017b) and evaluative wellbeing (Steptoe et al., 2015). Residence wellbeing was assessed with one item (I have been satisfied with the neighborhood as a place to live in the past 30 days). Travelling wellbeing was assessed with one item (I have been attracted by trips in the neighborhood in the past 30 days), and evaluative wellbeing with one item (I have been satisfied with my life as a whole in the past year). Each item was scored on a 5-point Likert scale and the total score ranged from 3 to 15. Greater values indicate better mental wellbeing. The reliability and validity of the mental wellbeing questionnaire were tested using the composite reliability coefficient and average of variance extracted respectively by confirmatory factor analysis in SEM.

Table 1 The latent variables and observable variables in models and measurement methods

Latent variables	Observed variables	Calculating methods
Accessibility to service facilities	Supermarket	The nearest street network distance from respondent's residence to supermarket
	Bank	The nearest street network distance from respondent's residence to bank
	Restaurant	The nearest street network distance from respondent's residence to restaurant
	Hairdresser	The nearest street network distance from respondent's residence to hairdresser
Aggregation degree of service facilities	The number of facilities	The total number of service facilities in the 300m-buffer area
	The number of facilities types	The total number of service facilities types in the 300m-buffer area
Connectivity of pedestrian streets	Density of street intersections	The average density of street intersections in the 300m-buffer area

	Density of streets	The average density of street in 300m-buffer area
Connectivity of carriageways	Local selectivity	Local selectivity of street nearest to respondent's residence calculated by the Spatial syntax
	Local depth	Local depth of street nearest to respondent's residence calculated by the Spatial syntax
	Local integration	Local integration of street nearest to respondent's residence calculated by the Spatial syntax
Diversity of facilities within neighborhoods	Leisure facilities	The number of leisure facilities types within the neighborhood
	Landscape facilities	The number of landscape facilities types within the neighborhood
	Exercise facilities	The number of exercise facilities types within the neighborhood
Perceived built environmental attributes	Noise	Noise within the neighborhood: 1 (very noisy) to 5 (very quiet)
	Travel fluency	Traffic condition within the neighborhood: 1 (very congested) to 5 (very smooth)
	Security	Security condition within the neighborhood: 1 (very poor) to 5 (very good)
	Landscape aesthetics	Aesthetics condition within the neighborhood: 1 (very poor) ~ 5 (very good)
Physical health	Impact on activities	Effect of current physical condition on participation in regular outdoor activities: 1 (affect largely) to 5 (not affect at all)
	Medicine usage	Frequency of taking medicine: 1 (almost daily) to 5 (rarely)
	Satisfaction	Satisfaction with the current physical condition: 1 (very dissatisfied) ~ 5 (very satisfied)
Mental wellbeing	Residence wellbeing	Satisfaction with the neighborhood as a place to live in the past 30 days: 1 (very dissatisfied) to 5 (very satisfied)
	Travelling wellbeing	Attraction from trips in the neighborhood in the past 30 days: 1 (unattractive) to 5 (very attractive)
	Evaluative wellbeing	Satisfaction with life as a whole in the past year: 1 (very dissatisfied) to 5 (very satisfied)
—	Street interface density	the average of street interface density in the 300m-buffer area
—	Elevator facilities within neighborhoods	Dummy variables: with elevators = 1, without elevator = 0
—	Parking forms within neighborhoods	Dummy variables: On-ground parking = 1, underground parking = 0
—	Management style for neighborhoods	Dummy variables: closed = 1, open = 0
—	Neighborhood cohesion	Frequency of activities held in the neighborhood mainly for older adults (such as calligraphy contests, tea parties, dancing competitions, etc.): 1 (never) to 5 (often)

2.2.3 Socio-demographics

Socio-demographic characteristics can affect residents' mental wellbeing (Dong and Qin, 2017; Triguero-Mas et al., 2015), so data regarding multiple covariates on an individual level were obtained through the survey. We controlled for the factors suggested by previous studies, including age, gender, educational level, monthly income level, and years of living at the current address (Besser et al., 2017). Moreover, pre-retirement occupation and residential property rights are important (Zock et al., 2018); lacking the latter was found a risk factor for mental wellbeing disorders in the Chinese context (Liu et al., 2017a). We also considered the number of co-occupants in a household, as single older adults are high-risk groups (Tsai et al., 2016). Given that physical health affects mental wellbeing (Steptoe et al., 2015), we controlled for the respondent's rating of their physical health. We selected questions to assess older adults' physical health from the Chinese version of the questionnaire originating from the WAVE 1' dataset (SAGE team, 2013). Three aspects of physical health were assessed: impact of physical health on activities, medicine usage and satisfaction with current physical-health condition. Each item was scored on a 5-point Likert scale and the total score ranged from 3 to 15. Greater values indicate better physical health. Pre-retirement occupation, number of co-occupants and residential property rights were included as dummy variables in the models.

2.3 Statistical analysis

In the research of environment-mental health, there are conceptual variables such as perceptions and psychological factors, which are difficult to measure directly and accurately. These latent variables can only be measured indirectly with some observable variables. SEM can process latent variables and their observable variables simultaneously. SEM is a comprehensive statistical method based on the covariance matrix of variables to analyze the relationship between variables. The model is divided into two parts: the measurement model and the structural model. The measurement model reflects the compositional relationships between latent variables and observed variables; the structural model reflects the associations between latent variables (Hox and Bechger, 1998).

First, confirmatory factor analysis (CFA) was performed on all latent variables and corresponding observed variables to test standardized factor loadings (Std. β), composite reliability (CR) and average of variance extracted (AVE). Std. β represent correlation coefficients between the observed variables and explained latent variables. Second, Pearson correlation tests were conducted between all endogenous and exogenous variables to determine whether there was a problem of multicollinearity. Third, hierarchical models were set to test the associations. Only covariates were included as independent variables in model 1a. Objective built environment characteristics and covariates were included as independent variables in model 1b. Perceived environmental attributes and covariates were included as independent variables in model 1c. In model 1d, the perceived built environmental attributes were treated as mediating variables, and the direct effect of the objective built environment, the indirect effect through perceived built environmental attributes and the total effect on mental wellbeing were calculated respectively. 5000 Bootstraps were performed in all models to obtain robust results. The significance of the mediating effect was determined by the z-value (z = standardized coefficient/standard error). In the case of $z \geq |1.96|$ and when bias-corrected confidence intervals did not contain 0, the mediating effect was considered to be significant (Hox and Bechger, 1998).

The existence of residential self-selection may affect the accuracy of results regarding the relationship between the built environment and mental wellbeing (McCormack and Shiell, 2011). Neighborhoods in Dalian are mainly divided into four types: *Danwei* communities, commodity housing communities, social welfare housing communities and self-built housing communities (Wang and Lin, 2014). Housing in *Danwei* communities is bought from the state or provided by work units before 1998. Social welfare housing is bought or rented from the government or state with a subsidy. The older adults living in *Danwei* and social welfare housing were largely constrained in their residential choice. Their houses are passively allocated and there is little possibility of choosing housing and surrounding environment according to their preferences (Wang and Lin, 2014; Zhao et al., 2010). Also, a small group of urban migrants who have no access to welfare housing live with their adult children help to take care of grandchildren and to do household chores after their adult children buy houses in the city. These older adults also had no opportunities to choose housing and residential locations based on their own preferences (Wang and Zhou, 2017). The majority of these above-mentioned older adults can be considered as non-residential self-selection samples, although we are aware that this method is not conclusive. Therefore, we repeated all analyses after excluding the residential self-selection sample to test the robustness of results.

Also, we first conducted all analyses using 300 m buffers. Then, we repeated our analyses using 500 m buffers as a robustness test. Statistical analyses were carried out in Amos software.

3 Results

3.1 Descriptive statistics

Table 2 shows the individual socio-demographics and objective built environment variables (non-latent variables). At individual level, slightly more females than males participated in the study and the average age was 73.2 years. 34.7% of the respondents had high school education or higher and approximately 12.9% possessed a college-level education. Almost 80% of the participants had a monthly income of more than 2000RMB (> USD 314.70). In total, 61.8% of the respondents had been living at their current address for more than 20 years. In our sample, 72.1% of the older adults were aged 65 and over, compared to 68.28% in Dalian census data. Furthermore, 46.19% of our sample was male, compared to 47.56% in the census data (Dalian Municipal Bureau of Statistics, 2021). This indicates that regarding age and gender, our study sample is representative for the older population in Dalian. The average physical health score for all participants was 10.77 (range: 3-15, SD: 3.26). The average mental wellbeing score was 10.62 (range: 3-15, SD: 2.04). The overall physical health and mental health were both moderately high.

Table 2 Descriptive statistics for individual and objective built environmental variables

Variables	Mean (SD) / N (%)
Individual-level variables	
Age	
60-70	394(44.82%)
71-80	293(33.33%)
81+	192(21.84%)
Gender	
Male	406(46.19%)
Female	473(53.81%)
Pre-retirement occupation	
Brain work	314(35.72%)
Manual labor	505(57.45%)
Other	60(6.83%)
Education level	
Primary school or lower	300(34.13%)
Middle school	274(31.17%)
High school	192(21.84%)
College/university	113(12.86%)
Number of co-occupants	
1	116(13.20%)
2	388(44.14%)
3+	375(42.66%)
Monthly income level	
RMB 0-1000 (USD 0-157.35)	116(13.20%)
RMB1001-2000 (USD 157.51-314.70)	63(7.17%)
RMB2001-3000 (USD 314.86-472.05)	242(27.53%)

RMB3001-4000 (USD 472.21-629.41)	242(27.53%)
RMB4000+ (USD 629.41+)	216(24.57%)
Residential property rights	
Owned	571(64.96%)
Kinsfolk	261(29.69%)
Tenancy	47(5.35%)
Years of living at current address	
10 ＜ 15	169(19.23%)
15 ≤ 20	167(19.00%)
20+	543(61.77%)
objective built environmental variables (non-latent variables)	
Street interface density (range=0-1)	0.38 (0.10)
Elevator facilities within neighborhoods (0 or 1)	0.53 (0.48)
Parking forms within neighborhoods (0 or 1)	0.23 (0.56)
Management style for neighborhoods (0 or 1)	0.43 (0.50)
Neighborhood cohesion (range=0-4)	2.41 (0.99)

Fig. 3 describes the distribution characteristics of supermarkets, hairdressers and restaurants as examples for service facilities. Fig. 4 demonstrates the local integration, local selectivity and local depth of carriageways. After confirmatory factor analysis, all observed variables corresponding to latent variables met the requirements of well-fitting model. Their Std. β were between 0.55 and 0.95 which were acceptable, as some latent variables in the model were not directly derived from validated scales (Hox and Bechger, 1998; Ko and Stewart, 2002). All latent variables met reliability requirements for CR (>0.5) and validity requirements for AVE (>0.7) (Table 3) (Hox and Bechger, 1998).

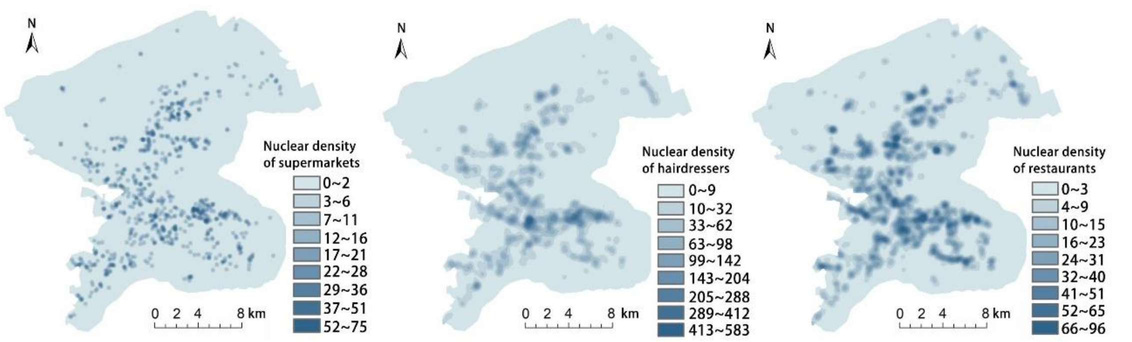

Fig. 3 Nuclear density of supermarkets, hairdressers and restaurants

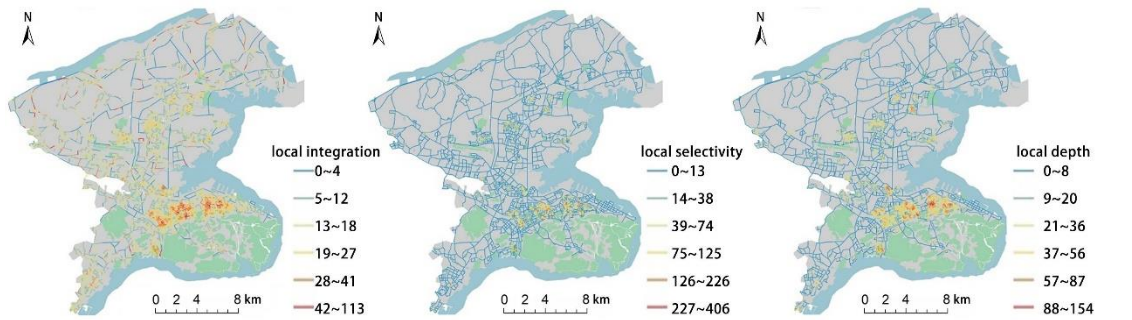

Fig. 4 Local integration, local selectivity and local depth with a radius of 300m

Table 3 The results of confirmatory factor analysis

Latent variables	Observed variables	Std. β	CR/AVE
Accessibility to service facilities	Supermarket	0.610	0.832 / 0.563
	Bank	0.583	

	Restaurant	0.816	
	Hairdresser	0.934	
Aggregation degree of service facilities	The number of facilities	0.843	—
	The number of facilities types	0.931	
Connectivity of pedestrian streets	Density of street intersections	0.950	—
	Density of streets	0.938	
Connectivity of carriageways	Local selectivity	0.601	0.778 / 0.542
	Local depth	0.801	
	Local integration	0.790	
Diversity of facilities within neighbourhoods	Leisure facilities	0.892	0.779 / 0.548
	Landscape facilities	0.718	
	Exercise facilities	0.576	
Perceived built environmental attributes	Noise	0.820	0.801 / 0.506
	Travel fluency	0.761	
	Security	0.653	
	Landscape aesthetics	0.587	
Physical health	Impact on activities	0.829	0.821 / 0.605
	Medicine usage	0.753	
	Satisfaction	0.748	
Mental wellbeing	Residence wellbeing	0.943	0.814 / 0.602
	Travelling wellbeing	0.753	
	Evaluative wellbeing	0.591	

3.2 Structural equation analysis with the full sample

The connectivity of pedestrian streets, connectivity of carriageways, and management style for neighborhoods were not significantly related to mental wellbeing and therefore were not included in the SEM. The correlations between the six exogenous variables were below 0.7 (Table 4), fulfilling the model requirements (Hox and Bechger, 1998).

Table 4 The results of the Pearson correlation

		01	02	03	04	05	06	07	08
01	Accessibility to service facilities	1							
02	Aggregation degree of service facilities	-0.034	1						
03	Street interface density	-0.067*	0.110**	1					
04	Diversity of facilities	0.281***	-0.367***	-0.074**	1				
05	On-ground parking	-0.035	0.294***	0.006	-0.531***	1			
06	With elevators	0.135***	-0.313***	-0.207***	0.303***	-0.476***	1		
07	Perceived built environmental attributes	0.112**	-0.403***	-0.112**	0.420***	-0.262***	0.304***	1	
08	Mental wellbeing	0.173***	-0.148**	-0.086**	0.343***	-0.125***	0.193***	0.673***	1

Note: *** P<0.001, ** P<0.05, * P<0.1

We found that the model fit of Model 1c (GFI (Goodness-of-fit index)=0.967) was slightly better than that of Model 1b (GFI=0.961), indicating that the associations of perceived built environmental attributes with older adults' mental wellbeing were stronger, relative to the associations of objective built environment characteristics (Table 5). We obtained a sufficiently well-fitting final model with the full sample (Model 1d): GFI = 0.954 (>0.9), RMSEA (Root Mean Square Error of Approximation) = 0.038 (<0.05). Table 5 and Fig. 5 describe the associations of objective built environment characteristics with older adults' mental wellbeing and the mediating effects of perceived built environment. It indicated that most objective built environment characteristics had associations with both perceived built environmental attributes and mental wellbeing, and the mediating effects of perceived built environment attributes were significant in some pathways. Meanwhile, perceived built environmental attributes were positively related to older adults' mental wellbeing with a much larger coefficient than most of the objective built environment characteristics' coefficients. Specifically:

At the service facilities (nodes) level, there were significant differences in associations with older adults' mental wellbeing between service facilities' accessibility and aggregation degree. Accessibility to service facilities had a positive association with older adults' mental wellbeing mainly through the mediating effect of the perceived built environment. Regarding the association between aggregation degree of service facilities and mental wellbeing, the negative indirect effect of the perceived built environment offset the positive direct effect of aggregation degree of service facilities with mental wellbeing. Consequently, the total effect of aggregation degree on mental wellbeing was not significant.

At the street networks (paths) level, the connectivity of pedestrian streets and carriageways both had no association with older adults' mental wellbeing. The street interface density which described the condition of street-facing buildings or open spaces along the street was negatively associated with mental wellbeing mainly through the mediating effect of the perceived built environment.

At the neighborhood blocks (districts) level, the diversity of facilities within neighborhoods had a positive association with older adults' mental wellbeing, both directly and through the mediating effect of the environmental perceptions. Also, compared to underground parking, on-ground parking was negatively related to older adults' mental wellbeing directly. The elevator facilities within neighborhoods had a positive association with mental wellbeing through the mediating effect of the perceived built environment.

Adding variables of the built environment did not alter the significance levels of the covariates almost (Model 1a-1d), although the coefficients changed slightly. Some of socio-demographics were statistically significant. Older age was positively related to mental wellbeing. Years of living at current address had a negative association with mental wellbeing. Moreover, physical health and neighborhood cohesion also had a strong positive association with older adults' mental wellbeing.

Table 5 Unstandardized estimates in the association of built environmental attributes with older adults' mental wellbeing (full sample)

	Model 1a		Model 1b		Model 1c		Model 1d					
							Direct effect		Indirect effect		Total effect	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Accessibility to service facilities			**0.031***	0.018			0.009	0.014	**0.020***	0.015	**0.029***	0.018
Aggregation degree of service facilities			-0.006	0.016			**0.072****	0.019	**-0.079****	0.018	-0.006	0.016
Street interface density			**-0.024****	0.009			-0.004	0.008	**-0.020****	0.008	**-0.023****	0.009
With elevators (ref. without elevators)			**0.086****	0.019			0.017	0.018	**0.069*****	0.019	**0.085*****	0.019
On-ground parking (ref. underground parking)			**-0.052****	0.019			**-0.040****	0.017	-0.010	0.017	**-0.050****	0.019
Diversity of facilities			**0.072****	0.017			**0.025***	0.015	**0.044****	0.015	**0.069****	0.017
Perceived built environmental attributes					**0.365****	0.046					**0.392****	0.052
Age	**0.007****	0.002	**0.008****	0.002	0.002	0.002					**0.008****	0.002
Brain work (ref. non-brain work)	-0.001	0.022	0.002	0.021	0.012	0.021					0.002	0.021
Education level	0.008	0.013	0.006	0.012	-0.002	0.011					0.006	0.012
Number of co-occupants	**0.018***	0.010	0.007	0.010	-0.002	0.008					0.009	0.010
Monthly income level	-0.003	0.012	-0.012	0.012	-0.008	0.011					-0.011	0.011
Having residential property rights (ref. having not residential property rights)	0.017	0.026	0.034	0.026	**0.075****	0.023					0.034	0.026

Years of living at current address	**-0.004****	0.001	**-0.002***	0.001	-0.001	0.001					**-0.002****	0.001
Neighborhood cohesion	**0.084****	0.015	**0.062****	0.014	**0.048****	0.012					**0.062****	0.014
Physical health	**0.110****	0.028	**0.107****	0.027	**0.029***	0.022					**0.106****	0.027

Note: *** P<0.001, ** P<0.05, * P<0.1; 5000 bootstraps; N=879; Chi-square=657.271, df=293, χ^2/df=2.243, AGFI=0.922, GFI=0.954, CFI=0.950, TLI=0.920, RMSEA=0.038 in Model 1d.

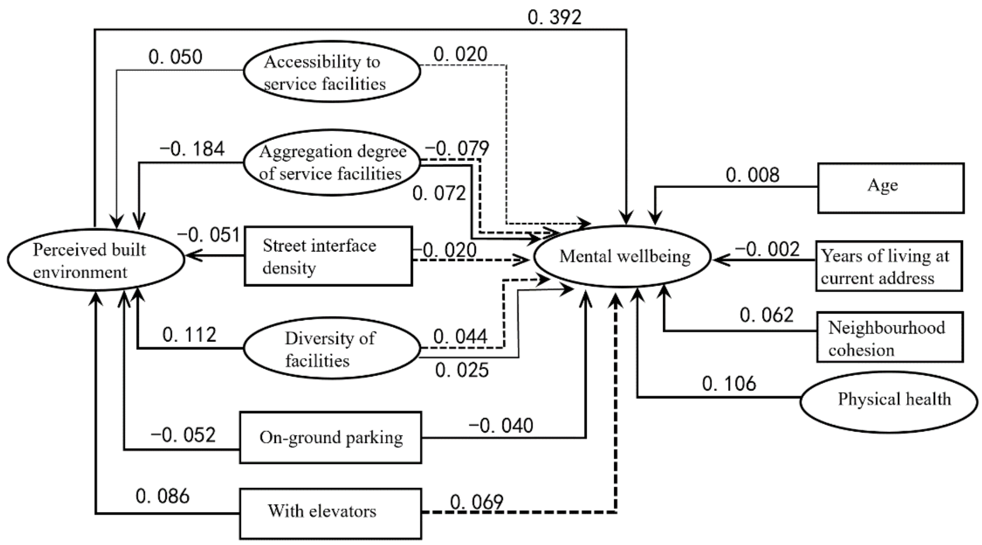

Fig. 5 Unstandardized regression coefficients in the associations of the built environment with older adults' mental wellbeing (full sample)

Note: Ovals refer to latent variables and rectangles refer to observed variables; the arrow forms ↑↑ indicate positive and negative associations respectively; the solid and dashed lines indicate direct and indirect effects respectively; the width of the lines ❙ ❙ ❘ reflects the 0.001, 0.05 and 0.1 levels of significance respectively; the values are unstandardized regression coefficients.

3.3 Structural equation analysis excluding the residential self-selection sample

After excluding participants with residential self-selection, 308 older adults were included in the analyses (35.04% of the full sample). We obtained a reasonably moderate-fitting final model: GFI = 0.929 (>0.9), RMSEA = 0.049 (<0.05). Table 6 showed that the relationships were broadly consistent with those in the model with the full sample. The main differences were as follows. The accessibility to service facilities was no longer positively associated with older adults' mental wellbeing. We speculate that the welfare housing and the *Danwei* housing were used for a longer period of time mostly with high accessibility to daily living service facilities. And the tiny difference in accessibility to services between neighborhoods had not enough statistical power to detect associations (Kothencz et al., 2017). Also, the association of the perceived built environment with mental wellbeing was weaker than that in the model with the full sample. Similar environments in the welfare housing communities or the *Danwei* housing communities led to relatively homogenous environmental perceptions. Consistent with accessibility, limited variations in the perceived built environment between neighborhoods weakened the associations with mental wellbeing.

Table 6 Unstandardized estimates in the association of built environmental attributes with older adults' mental wellbeing (excluding the residential self-selection sample)

	Model 2a		Model 2b		Model 2c		Model 2d					

							Direct effect		Indirect effect		Total effect	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Accessibility to service facilities			0.001	0.027			0.020	0.028	-0.022	0.020	-0.002	0.027
Aggregation degree of service facilities			-0.016	0.016			**0.040****	0.023	**-0.054****	0.021	-0.014	0.016
Street interface density			**-0.026****	0.013			-0.014	0.013	-0.010	0.009	**-0.024****	0.013
With elevators (ref. without elevator)			**0.048****	0.024			-0.009	0.024	**0.051****	0.024	**0.042****	0.023
On-ground parking (ref. underground parking)			**-0.045****	0.026			-0.028	0.025	-0.010	0.025	**-0.038****	0.025
Diversity of facilities			**0.063****	0.026			**0.034***	0.024	0.025	0.022	**0.059****	0.025
Perceived built environmental attributes					**0.267****	0.073					**0.326****	0.099
Age	**0.003***	0.002	**0.004***	0.002	**0.003***	0.002					**0.003***	0.002
Brain work (ref. non-brain work)	-0.040	0.035	-0.027	0.033	0.004	0.033					-0.027	0.032
Education level	0.012	0.016	0.009	0.015	0.005	0.014					0.009	0.015
Number of co-occupants	-0.002	0.013	0.009	0.014	-0.014	0.011					-0.009	0.014
Monthly income level	0.002	0.014	-0.002	0.014	-0.019	0.012					-0.001	0.013
Years of living at current address	**-0.005****	0.002	**-0.004****	0.002	-0.001	0.001					**-0.004****	0.002
Neighborhood cohesion	**0.040****	0.018	**0.028***	0.018	**0.024****	0.015					**0.027***	0.018
Physical health	**0.125****	0.048	**0.120****	0.045	**0.044***	0.032					**0.109*****	0.043

Note: *** P<0.001, ** P<0.05, * P<0.1; 5000 bootstraps; N=308; Chi-square=488.306, df=280, χ^2/df=1.744, AGFI=0.895, GFI=0.929, CFI=0.934, TLI=0.908, RMSEA=0.049 in Model 2d.

3.4 Robustness checks on the 500 m buffer

The results of the analyses using 500 m buffers were overall consistent with what is displayed in Table 4-6 (results available in the supplementary file). The main difference was that street interface density within 500 m buffers was not associated with older adults' mental wellbeing, while it had a negative association in the 300 m buffer. The above shows that overall, our findings are robust.

4 Discussion

4.1 The built environment and mental wellbeing

We found that accessibility to daily living service facilities was positively associated with older adults' mental wellbeing. The higher accessibility to these frequently used facilities, such as supermarkets, banks, restaurants and hairdressers, were associated with more positive environmental perceptions (i.e., of noise, travel fluency, security, landscape aesthetics), which are related to the comfort need of the SPF theory, thus increasing psychological satisfaction and wellbeing. Wang et al. (2021) also found that accessibility to those shopping services that are important for older adults' daily life, such as convenience stores, markets, and supermarkets, was positively associated with their psychological wellbeing. This conclusion is consistent with other studies (Adams et al., 2011; Mazumdar et al., 2018).

The aggregation degree of daily living services had no association with older adults' mental wellbeing overall in our study. Sarkar et al. (2014) found that the concentration of services at the regional level was detrimental to the psychological wellbeing of older adults, although it was in contrast to common sense. It is mostly likely due to the fact that the basic service facilities within usual walking distance could meet the daily needs of older adults. Although a higher concentration of services enhanced the convenience of living and contributes to mental wellbeing of older adults to a certain extent, it could also add to perception of insecurity and chaos which offsets positive effects. Meanwhile, the perception of excessive noise, low aesthetics and air pollution from dining facilities could have a negative impact on psychological wellbeing. Wang et al. 2021 also drew a similar conclusion that health services, although were needed by older adults, in the immediate area may negatively impact emotion, because too many hospitals/clinics may induce more stress or anxiety (Corrigan, 2004; Wang et al., 2021).

At the street network (paths) level, the connectivity of pedestrian streets and carriageways had no association with older adults' mental wellbeing. In previous studies, the evidence for relationships of the connectivity of streets with mental health was not straightforward. Engel et al. (2016) clarified that for older adults, a higher intersection density might inhibit active living and mental health because of lack of road safety while crossing streets (Engel et al., 2016). Wang et al. (2017) found that the negative association of street connectivity with mental health were only identified in the 300-meter buffer. Some studies suggested that older adults could benefit from moderate-level street connectivity, as appropriate walkable design could facilitate older adults' mobility and further improve their mental health (Guo et al., 2021; Sarkar et al., 2015). We speculate the reason for finding no association in our study could be that older adults spent the majority of their day in their residential neighborhood (Burton et al., 2011; Liu et al., 2019; Su et al., 2019), which resulted in mostly short distance travel. Consequently, the structure of streets may have limited effect on older adults' psychological state (Barnett et al., 2018; Burton et al., 2011).

The street interface density was negatively associated with older adults' wellbeing mainly through the mediating effects of the environmental perceptions. This indicates that compared to open spaces and greenery which is rather perceived as tranquil and pleasant, extensive walls or excessive service facilities along the street are rather accompanied by depressing walking spaces (Galea et al., 2005), views without nature, and sometimes parking chaos, increasing the uncomfortable experience and safety risks of older adults, which is detrimental to their psychological wellbeing.

The diversity of leisure, landscape, and exercise facilities within neighborhoods was positively associated with older adults' mental wellbeing, both directly and through the mediating effect of the perceived built environment. The ratio of the mediating effect to total effect reached 63.8%. The potential reason for this has been well established. The areas with more recreational services can provide more opportunities for older adults to undertake physical and social activities, which can further enhance their social network, attachment to the neighborhood, and physical and mental health (Adams et al., 2011; Mazumdar et al., 2018). From the predominant mediating role of the perceived built environment in our study, we can also infer that leisure, landscape, and exercise facilities, as auxiliary and supporting facilities within neighborhoods, can meet the older adults' needs for privacy, security, pleasure and a sense of belonging (Liu et al., 2021), thus effectively promoting their wellbeing. The variety of these facilities in neighborhoods can enrich the activities of older adults within their limited travel range, functioning at the stimulation need of the SPF theory to improve their quality of life.

We found that on-ground parking within neighborhoods was negatively related to older adults' mental wellbeing. Previous European studies also reported that areas with large parking spaces and high traffic (Tuckett et al., 2018; Zhao and Chung, 2017) were usually associated with a reduced sense of community and unwanted social contacts. It is comprehensible that compared to underground parking, on-ground parking in residential neighborhoods causes mixed traffic and occupied pedestrian pathways so as to increase travel risks, which has a negative association with older adults' wellbeing.

The presence of elevators in neighborhoods was positively associated with older adults' psychological wellbeing mainly through the mediating effect of the perceived built environment.

No studies have been conducted on the association of elevators with psychological wellbeing in old adults within Chinese urban neighborhoods before. Only two studies found that narrow, dark staircases and elevators spaces were likely to inhibit the formation of social ties and social interactions, and were detrimental to adults' psychological wellbeing in western cities (Barros et al., 2019; Ho et al., 2017). The reasons for the different conclusions may be that the elevators in Chinese neighborhoods greatly increase the convenience and safety for older adults going up and down stairs (Zhao and Fu, 2017), due to the decline of their physical functions. In the interviews with older adults, we were also informed that most of their social interaction took place outside the high-rise buildings and elevators were rather a travel method than places for interaction for them.

4.2 Socio-demographic characteristics and mental wellbeing

The roles of several socio-demographic variables in mental wellbeing of older adults are notable. First, physical health was a very robust factor related to mental wellbeing. This finding is consistent with previous studies (Pinquart and Sörensen, 2000; Steptoe et al., 2015; Zhang and Zhang, 2015, 2017). This shows that the physical health status is one of the most important prerequisites for maintaining individual wellbeing and mental health (Angner et al., 2013; Tomaszewski, 2013). Second, social cohesion was positively associated with psychological wellbeing, probably because it can enhance neighborhood belonging and participation and improve mental wellbeing through the behavioral confirmation need of the SPF theory (Liu et al., 2016). Firdaus (2016) also found that social support promoted emotional calmness and stability in older adults.

It is generally accepted that a longer stay at a residence can result in an increase of emotional connection and attachment to the residential neighborhood, enhance individual positive evaluation of the residential environment and consequently, promote mental wellbeing. However, correlation analyses indicated that the number of years someone lived at the current address was negatively associated with mental wellbeing in our study. This finding contradicts the conclusion of several previous studies (Crowe, 2010; Tartaglia, 2006; Zhang, 2014). Moreover, Mak et al. (2009) found that length of living time in a neighborhood was not associated with residents' wellbeing in Hong Kong. We speculate that a negative effect of more years of living in a specific neighborhood may counteract or exceed the positive effect on mental wellbeing and sense of community (Zhang and Zhang, 2017). The primary negative factor is the deterioration of amenities, the declined living environment and housing conditions because of the lack of maintenance in old neighborhoods, which probably result in lower mental wellbeing. The associations of neighborhood quality with older adults' mental health have been verified in previous studies (Barros et al., 2019; Liu et al., 2016; Tomaszewski, 2013). In the interviews with respondents, we also learned that many of them were unsatisfied with and felt frustrated by the deterioration of facilities in old neighborhoods, especially perceiving a gap with the surrounding new residential neighborhoods with better greenery, auxiliary and supporting facilities.

4.3 Implications

Although accessibility to daily living service facilities was positively associated with older adults' mental wellbeing, the aggregation degree of these services had no association with mental wellbeing overall. The excessive concentration of services brings convenience but also increases the sense of disorder, noise and insecurity of older adults (Guo et al., 2020; Sarkar et al., 2014; Wang et al., 2021), which was verified by the negative mediating effect of perceived built environment in the model. Therefore, how to boost older adults' experiential comfort and avoid negative perception with services, rather than simply offering more services, may be crucial aspects when considering the layout of services in the city. Also, it is worth noting that the diversity of exercise, leisure and landscape facilities within neighborhoods can promote psychological wellbeing through perceived pathways such as sensation of security, belonging and pleasure (Adams et al., 2011; Mazumdar et al., 2018). So, the arrangement and layout of services and facilities need to be differentiated by considering their function and type during neighborhood planning and the construction phase.

Our results also showed that other objective built environmental characteristics are more likely to be positively related to mental wellbeing. For example, more open spaces along streets, underground parking forms and the presence of elevators within neighborhoods might be of importance to older adults. These findings have implications for landscape and urban planning policy and can provide an empirical contribution to the theoretical foundation of aging in place. Moreover, although this study focused on the role of objective and perceived built environment, many important socio-economic variables, including physical health, income level, pre-retirement occupation, number of co-occupants and residential property rights, were incorporated into the analyses. This helps to comprehensively understand the determinants of mental wellbeing and the independent role of each factor.

4.4 Strengths and Limitations

From a theoretical perspective, we used the ecological model of active living to guide the research exploring the associations of objective built environment characteristics with mental wellbeing through the mediating effect of the perceived built environment. We selected the characteristics of built environment based on the SPF theory. From a methodological perspective, we innovatively 1) distinguished the associations of the objective and perceived built environment with older adults' mental health indicators; 2) tested the robustness of the study results by excluding participants with potential residential self-selection; 3) integrated diverse specific characteristics of the objective built environment such as parking forms and elevators within neighborhoods into the models.

Nevertheless, this study has several limitations. First, this is a cross-sectional study that can provide an understanding of the associations, but is unable to establish robust causation (Zhang, 2014), although we excluded participants with potential residential self-selection in the analyses. Second, we only employed a 300-meter buffer as the research scope, ignoring the Uncertain Geographic Context Problem (UGCoP) which is a fundamental issue with static studies. The 300-meter buffer was selected since it adequately represented older adults' daily activity space. However, this is a common assumption and was not examined confirmatory with our data (Liu et al., 2019; Su et al., 2019; Wang et al., 2017). Future research should adopt a dynamic strategy to investigate real-time person-environment interactions. Third, each attribute of the perceived built environment such as safety, noise, etc. was measured with only one item and this may be somewhat unreliable due to self-reporting bias.

5 Conclusions

This study explored the association of the objective and perceived built environment with older adults' mental wellbeing and the mediating role of the perceived built environment based on the ecological model of active living. The findings in Dalian which is a typical Chinese second-tier city, have some differences with results in Western contexts with lower population density. It is worth to note that the perception of noise, insecurity and confusion related to the excessive clustering of daily living service facilities, such as supermarkets, restaurants etc., was negatively associated with older adults' mental wellbeing. This study increased our understanding of how specific objective and perceived built environmental attributes are connected to mental wellbeing, which has previously been overlooked (Zhang and Zhang, 2017). The results of this study have significant implications for the selection of environmental planning indicators, layout of services and neighborhood design for city planners, policymakers and program managers working to support older adults in neighborhoods.

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