Health & Place 47 (2017) 80–89

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Healthy urban living: Residential environment and health of older adults in Shanghai

Yafei Liu[a], Martin Dijst[a], Jan Faber[b], Stan Geertman[a], Can Cui[c,*]

[a] Department of Human Geography and Planning, Utrecht University, The Netherlands
[b] Copernicus Institute of Sustainable Development, Utrecht University, The Netherlands
[c] The Center for Modern Chinese city Studies & School of Urban and Regional Science, East China Normal University, Shanghai 200241, China

ARTICLE INFO

Keywords:
Health
Residential environment
Older adults
Physical and social activities
Subjective well-being
Shanghai

ABSTRACT

A healthy residential environment, especially for older adults, has emerged as an important issue on political and planning agenda in China. This paper aims to investigate the direct and indirect impact of residential environment on the health of older adults in Shanghai, taking into account health-related behaviours, subjective well-being and socio-demographic factors in one comprehensive conceptual model. Our results show that the residential environment is associated with older adults' health directly, and also indirectly through a series of significant behavioural (physical and social activities) and perceptual (subjective well-being) factors. After combining the direct and indirect association, the results show that good housing and neighbourhood quality and a safe social environment contribute to better subjective, physical and mental health conditions of older adults. In addition, access to cultural facilities is positively related to older adults' mental and physical health and subjective well-being, while a higher proportion of older adults in a neighbourhood appears to promote physical and social activities but not health.

1. Introduction

Despite economic prosperity achieved since market-oriented reforms from 1970s, Chinese cities are facing increasing social and environmental problems (e.g. socio-economic inequality and environmental deterioration) (Bian, 2002; He et al., 2012). To address the environmental problems, shaping a healthy and liveable urban environment has been placed high on the agenda of China's central government (National New-Type Urbanization Plan 2014–2020, 2014). Rapid population ageing is also becoming a serious social challenge for Chinese megacities. Older adults' health is especially vulnerable to the negative impacts of residential environment (Dujardin et al., 2014). This research therefore in particular focuses on the impact of residential environment on the health of older adults.

Research in public health, urban planning and environmental psychology has shown that health, in both its physical and mental dimensions, is associated with various facets of the physical and social environment (Barahmand et al., 2013; Cagney, 2006; de Vries et al., 2003; Ellen et al., 2001; Renalds et al., 2010; Ross and Mirowsky, 2008; Thomas et al., 2007). For instance, high housing quality, green spaces, good accessibility to cultural and leisure facilities, social cohesion and safety are positively related to a person's physical and mental health. Studies also suggest that health-related behaviours such as physical activities (e.g. walking, exercise and leisure) and social activities are important intermediate factors in the effects of the residential environment on health (Carlson et al., 2012; Frank and Engelke, 2001; Soltani and Hoseini, 2014). Physical spaces and facilities and the social environment provide people with opportunities to participate in physical activities and socialise with each other, which in turn affect their physical and mental health. Other perceptual factors such as subjective well-being (SWB) (Diener and Ryan, 2009) and individual socio-demographic factors are also associated with the residential environment and health.

However, empirical studies so far have focused primarily on partial and discipline-specific issues such as particular kinds of residential environment, health conditions, activities, perceptions and socio-demographic factors. Hardly any empirical effort has been made to integrate these insights into a more comprehensive understanding of the relationships between residential environment and health (Carlson et al., 2012; Northridge et al., 2003). Moreover, most studies to date have only investigated the direct association between residential environment, health and other relevant factors. There is scant empirical evidence on the indirect relationships between residential environmental and health variables (Franzini et al., 2005; Kruger et al., 2007).

* Corresponding author.
E-mail addresses: y.liu@uu.nl, arthurliu.lyf@gmail.com (Y. Liu), m.j.dijst@uu.nl (M. Dijst), j.faber1@uu.nl (J. Faber), s.c.m.geertman@uu.nl (S. Geertman), giscuican@gmail.com (C. Cui).

http://dx.doi.org/10.1016/j.healthplace.2017.07.007
Received 26 June 2016; Received in revised form 20 April 2017; Accepted 6 July 2017

This makes it difficult to fully understand the indirect and total effects of the residential environment on health (Carlson et al., 2012; Renalds et al., 2010).

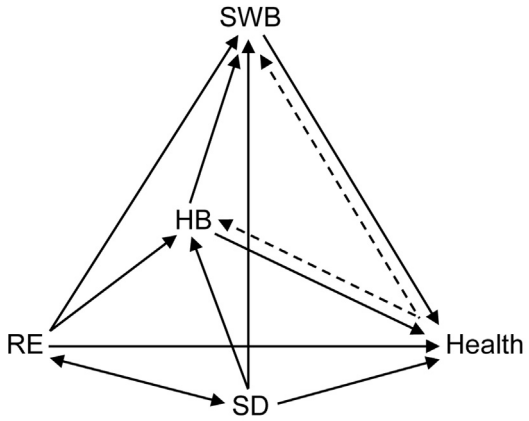
The limitations mentioned above also apply to the studies on environment-health relationships for older adults. As age advances, older adults are more likely to experience health-related changes and challenges, such as declining immunity, muscle strength, mobility and cognition, and increasing incidence of chronic illness (Day, 2008). These functional as well as mental declines make older adults more sensitive and susceptible to the negative characteristics of the residential environment than other age groups (Dujardin et al., 2014). Studies have shown that the health of older adults is particularly associated with their physical and social environment, such as housing quality, accessibility, neighbourhood socio-economic and age composition, safety and social supports, in addition to health-related behaviours and personal attributes (Clarke and Nieuwenhuijsen, 2009; Kerr et al., 2012; Lehning et al., 2014; Roh et al., 2011; Sugiyama and Thompson, 2007). However, the complex direct and indirect relationships between the residential environment and health of older adults have rarely been studied in an integrative way.

This paper therefore aims to investigate the direct and indirect association between residential environment and the health of older adults by applying structural equation modelling, which takes into account health-related behaviours, subjective well-being and socio-demographic factors. Shanghai, one of the rapidly ageing megacities in China, is selected as our study area. In 2015, the ageing population in Shanghai was 4.4 million (accounted for 30.2% of the total population), and this number is expected to reach 5 million by 2018 (Shanghai Government, 2016). This research proposes a comprehensive conceptual model to understand the relationships between residential environment and health. Moreover, the empirical findings will provide valuable implications for policies and practices seeking to promote healthy aging in cities.

2. Theoretical framework

The concepts of both health and the residential environment are rather broad and may have various meanings for different people. The health of older adults is multifaceted and covers several inter-correlated elements such as diagnosed chronic diseases (e.g. arthritis, diabetes and depression), symptoms (e.g. pain and discomfort), functional capacity (e.g. mobility and cognition) and mortality risk. These elements are usually separated into two interlinked categories: physical health and mental health, which reflect a person's somatic and psychological conditions respectively (Barahmand et al., 2013; Yen et al., 2009). Meanwhile, health not only involves these objective health conditions, but also the individuals' perception and evaluation of their own health status (Smith et al., 2002). The residential environment of older adults refers to the physical and social neighbourhood characteristics that particularly affect older people's lives. The physical characteristics consist of the interior housing qualities and exterior neighbourhood qualities (e.g. street conditions, walkability and amenities), and the accessibility of essential facilities and services outside the neighbourhood (e.g. medical, leisure and shopping facilities) (Clarke and Nieuwenhuijsen, 2009; Lehning et al., 2014). The social characteristics comprise the socio-demographic attributes of a neighbourhood (e.g. socio-economic, racial, ethnic and age compositions) and interpersonal relationships (e.g. social cohesion, trust, safety, networks and social support) (Norstrand et al., 2012; Seeman and Crimmins, 2001).

By integrating conceptual ideas with empirical evidence from other studies (Ellen et al., 2001; Frank and Engelke, 2001; Franzini et al., 2005; Hill and Maimon, 2013; Kruger et al., 2007; Seeman and Crimmins, 2001; Villanueva et al., 2013), we come up with a comprehensive conceptual model specifying the direct as well as the indirect relationships between the residential environment and health conditions of older adults (Fig. 1). The direct effects of the residential environment (RE) on health (the arrow from RE to Health in Fig. 1) are widely acknowledged. Various physical and social characteristics of the residential environment can function as resources or stressors for an older person's health (Clarke and Nieuwenhuijsen, 2009; Ellen et al., 2001; Lehning et al., 2014). Physical resources include good quality housing, health care facilities and green spaces, which have direct positive effects on older adults' health (Yeo and Heshmati, 2014). By contrast, physical stressors such as air pollution, noise, poor street lighting, heavy traffic and uneven pedestrian paths can influence older adults' health negatively (Day, 2008). Social resources include social networks, trust and support. These resources can provide older adults with physical assistance (e.g. while encountering emergent health problems), health-related information, and financial and emotional support, and hence contribute to a better health outcome (Norstrand et al., 2012). Conversely, social stressors such as crime, violence and unsafety may negatively affect mental and physical health by exacerbating hypertension and other stress-related disorders, and by weakening the immune system and increasing vulnerability to disease and disability (Ellen et al., 2001; Roh et al., 2011).



Note: HB = Health-related behaviours, RE = Residential environment, SD = Socio-demographics, SWB = Subjective well-being.

Fig. 1. Conceptual model for the direct and indirect association between residential environment and health.

The residential environment can also affect health indirectly. The intermediate role of health-related behaviours (HB), including physical and social activities, has received increasing attention (the arrows from RE to HB to Health in Fig. 1) (Clarke and Nieuwenhuijsen, 2009; Frank and Engelke, 2001; Seeman and Crimmins, 2001; Villanueva et al., 2013). Physical activities such as walking, cycling, exercise, sports and some leisure activities can exert a direct beneficial effect on older adults' physical and mental health (Kerr et al., 2012). At the same time, these activities are inevitably influenced by the physical and social environment. The availability, quality and accessibility of relevant facilities (e.g. sports and recreational centres), infrastructures (e.g. walkways) and spaces (e.g. parks and plazas), and the safety conditions of the residential environment can directly influence the intensity, duration and frequency of physical activities, and hence indirectly affect health (Frank and Engelke, 2001; Villanueva et al., 2013). A study in the UK, for example, showed that older adults who live in an environment that supports physical activity tend to engage in more of the outdoor activities that lead to higher probability of being in better health (Sugiyama and Thompson, 2007). By means of social activities (e.g. meeting, chatting and socialising), the residential environment also indirectly affects older adults' mental and physical health (Clarke and Nieuwenhuijsen, 2009). Specifically, the physical environment may facilitate (e.g. good accessibility, high street connectivity) or discourage (e.g. long distance) social interaction (Yen et al., 2009). The social environment, such as the compositional (proportion of older adults,

socio-economic status), collective (social norms) and relational (safety, trust) environment, influences the characteristics of the neighbours an older person may interact with, and the norms and frequencies of social behaviours (Sugiyama and Thompson, 2007). The frequencies and qualities of social activities further influence older adults' functional status and mental health (Sugiyama and Thompson, 2007; Yen et al., 2009).

Another intermediate factor in the health effects of the residential environment is subjective well-being (SWB) (the arrows from RE to SWB to Health in Fig. 1). SWB refers to self-appraisals of individuals' overall life situations, encompassing both cognitive judgments of life satisfaction and affective evaluations of feelings (Diener, 2009; Ormel et al., 1999). A growing body of evidence shows that individuals with a higher level of SWB tend to have stronger immune systems, better cardiovascular health, fewer life-style diseases (e.g. addictions to alcohol or drugs), lower cancer mortality and greater longevity (Diener and Chan, 2011; Diener and Ryan, 2009). Studies have also shown that older adults tend to experience a reduction in the size of their activity space and relational networks with advancing age, and therefore their immediate residential environment can have a substantial impact on their SWB (Costa-Font, 2013; Rojo-Pérez et al., 2007). Older people, who live in a neighbourhood with, for instance, better housing quality, better access to local amenities, better safety and social cohesion conditions and a higher socio-economic status, are more likely to experience higher SWB (Rojo-Pérez et al., 2007; Wahl et al., 2007). This indicates that residential environment could also influence older adults' health indirectly through SWB.

In addition to the behavioural and perceptual factors, personal attributes such as socio-demographics (SD) also play an intermediate role in the health effects of the residential environment (the arrows from RE to SD to Health in Fig. 1) (Clarke and Nieuwenhuijsen, 2009; Seeman and Crimmins, 2001). Taking age as an example, the older elderly are more likely than the younger elderly to suffer from the stressors in their neighbourhoods, such as poor housing quality, poor accessibility and unsafety, and so have poorer health. In addition, the familial and social networks of older adults, represented by household size and social ties, could serve as sources of social support to reduce and buffer the physical and psychological consequences of detrimental neighbourhood conditions (Hill and Maimon, 2013). Similarly, individuals with lower socio-economic status tend to be more vulnerable to the negative characteristics of neighbourhoods. Those possessing higher economic, educational and occupational status are more likely to attenuate and buffer these negative effects by using their wealth, knowledge and capabilities. Moreover, socio-demographics can affect the intermediate factors of health-related behaviours and SWB in environment-health relationships (the arrow from SD to HB and the arrow from SD to SWB in Fig. 1). For instance, the older elderly are generally less capable than their younger counterparts of performing physical and social activities. Due to the direct negative effect of age on activities, the indirect positive health effect of residential environment via activities could be weakened. There are two dashed arrows in Fig. 1, which mean that health, besides being considered as an outcome, can also function as a resource and a cause affecting a person's present and future behaviours and SWB (Lindenberg, 1996; Nieboer et al., 2005; Northridge et al., 2003; Ormel et al., 1997, 1999; Sugiyama and Thompson, 2007).

So far, the existing research has only focused on particular kinds of residential environment, health conditions, activities, perceptions and socio-demographic factors. And most studies have only investigated the direct effects of residential environment on health, leaving the indirect effects poorly explored. In this paper, based on the existing literature, we propose a comprehensive conceptual model (Fig. 1) to examine the effects of residential environment on the health of older adults in Shanghai, taking health-related behaviours, subjective well-being and socio-demographic factors into account. We hypothesize that not only the physical residential environment but also the social aspects of the residential environment play a significant role in affecting older adults' health. Specifically, a good social environment, with a higher share of older adults and better safety conditions, is assumed to contribute to a higher probability of being in better health. More importantly, we pay particular attention on the indirect effects of residential environment on the health. It is hypothesized that the indirect effects are mainly exerted through health-related behaviours including physical and social activities. The residential environment, through facilitating (e.g. good accessibility, good safety conditions) or hindering (e.g. long distance, poor safety conditions) physical activities (e.g. walking, cycling, exercise) and social activities (e.g. meeting, chatting, socialising), benefits or impairs older adults' physical and mental health indirectly.

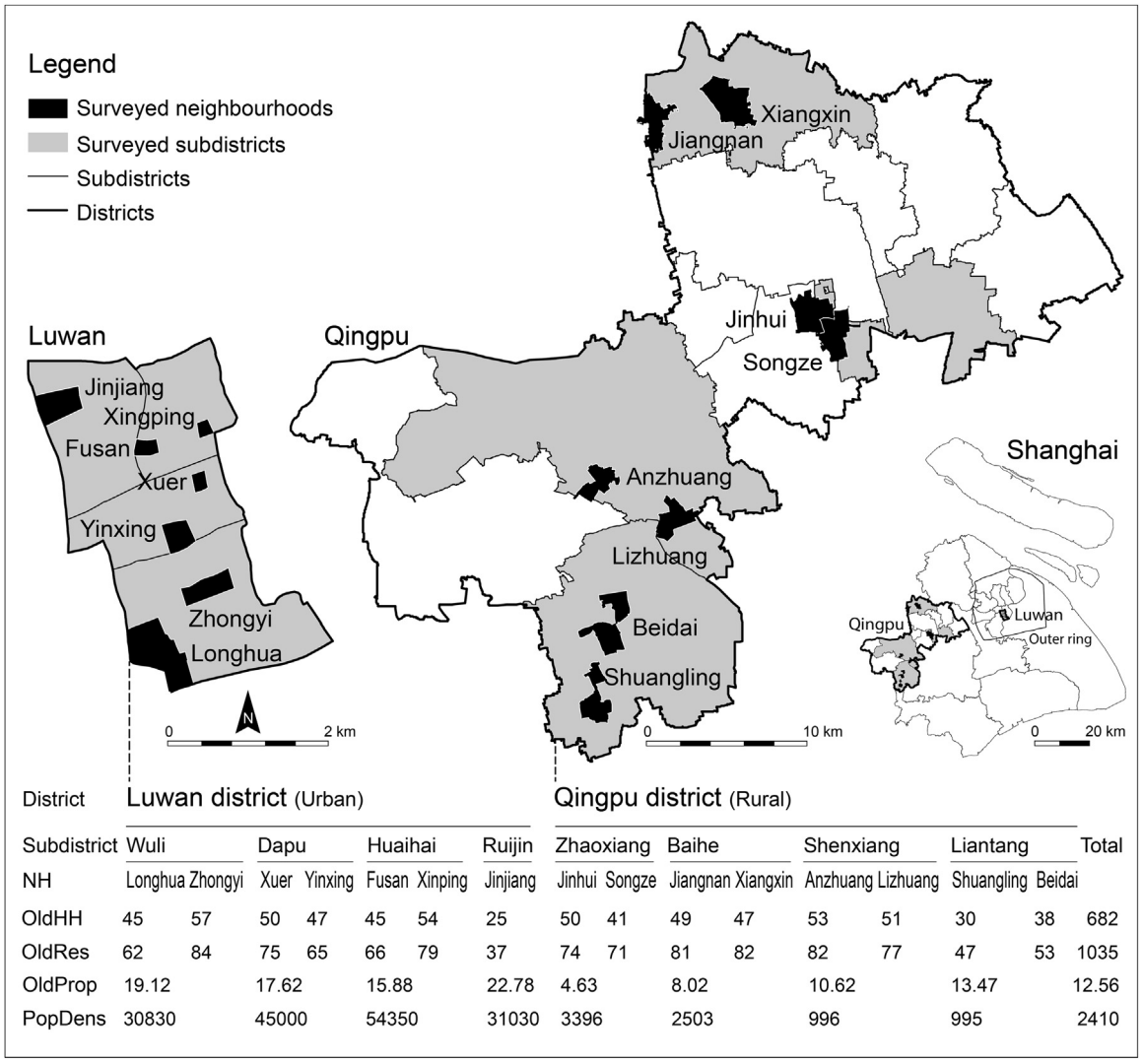
3. Research design

3.1. Data collection

The 'China - Study on Global Ageing and Adult Health (SAGE) – 2007/10, WAVE 1′ dataset comes from a survey designed by the World Health Organization, focusing on older adults' health (SAGE team, 2013). SAGE comprises detailed individual-level information on the health conditions, health-related behaviours, SWB and quality of life, housing and socio-demographic characteristics of Chinese older adults. For Shanghai, this dataset covers one randomly selected district in an urban area (Luwan) and one randomly selected county in a rural area (Qingpu). Each district/county contains four randomly selected sub-districts/townships, each of which further contains one or two neighbourhoods (Fig. 2). In each neighbourhood 70 households (aged 50+) were randomly selected. Ultimately, 1035 elderly people aged over 60 years participated in the Shanghai survey in 2010. Two other datasets, the 2010 Shanghai Population Census and the 2008 Shanghai Economic Census, provide information on the social and physical characteristics of the residential environment respectively. The Population Census contains information on the compositional socio-demographic characteristics (e.g. socio-economic and age compositions). The contextual characteristics of various facilities and institutions relevant to older adults (e.g. cultural facilities, hospitals and parks) were drawn from the 2008 Economic Census. As facilities and institutions are relatively stable, we suppose there were little changed between 2008 and 2010. The 2010 digital street network database of Shanghai and the 2010 Google satellite images of Shanghai provide additional information on the neighbourhoods' street networks and types of building.

3.2. Operationalisation and measurement of key concepts

The key concepts of our research contain several latent dimensions and subdimensions. They were operationalised and measured as latent variables and sublevel latent variables on the observed indicators from the SAGE dataset and the Census (Table 1). To specify the health effects, we have used three (rather than one) health concepts: physical health (PH), mental health (MH) and subjective overall health (SH). While physical and mental health mainly reflect objective health, subjective overall health refers to a self-rated general health status, taking into account personal values, preferences and motivations (Smith et al., 2002). To better understand the specific impact of various residential environments (RE), we used four sublevel variables to represent the residential environment. Housing quality and access to cultural facilities were chosen to reflect the physical residential environment. Housing quality was measured by high-rise and mid-rise residential buildings, because such buildings in Shanghai are equipped with much better housing facilities (e.g. kitchen and bathroom), better sanitation and better-equipped neighbourhood facilities (e.g. food-related and medical facilities) than low-rise traditional and rural houses. Access to cultural facilities, including culture centres, univer-



District	Luwan district (Urban)							Qingpu district (Rural)								
Subdistrict	Wuli		Dapu		Huaihai		Ruijin	Zhaoxiang		Baihe		Shenxiang		Liantang		Total
NH	Longhua	Zhongyi	Xuer	Yinxing	Fusan	Xinping	Jinjiang	Jinhui	Songze	Jiangnan	Xiangxin	Anzhuang	Lizhuang	Shuangling	Beidai	
OldHH	45	57	50	47	45	54	25	50	41	49	47	53	51	30	38	682
OldRes	62	84	75	65	66	79	37	74	71	81	82	82	77	47	53	1035
OldProp	19.12		17.62		15.88		22.78	4.63		8.02		10.62		13.47		12.56
PopDens	30830		45000		54350		31030	3396		2503		996		995		2410

Note: NH = Neighbourhood, OldHH = Number of surveyed households of older adults,
OldRes = Older respondents aged above 60,
OldProp = Proportion (%) of older adults in total population at subdistrict level,
PopuDen = Population density (N/km2) at subdistrict level.

Fig. 2. Study areas in Shanghai.

sities for seniors and libraries, was evaluated by potential accessibility measure, which takes the cumulative opportunities and distance decay coefficient into consideration (Liu et al., 2014). The proportion of older adults in and the perceived safety of a neighbourhood were used to reflect the compositional and relational characteristics of the social environment respectively. Likewise, we used the latent variables of physical activities (PA) and social activities (SA) to represent the concept of health-related behaviours (HB). Subjective well-being (SWB) was operationalized by life satisfaction, happiness and subjective quality of life (Camfield and Skevington, 2008). Lastly, to reflect socio-demographic characteristics (SD), we used age and gender to represent the basic socio-demographic variables, and used household size and household income to reflect the social and economic resources of older adults.

The validity of these operationalisations was tested using principal factor analysis (PFA) and confirmatory factor analysis (CFA) in LISREL 8.8 (Jöreskog and Sörbom, 2001), based on a polychoric correlation matrix built in PRELIS 2 (Jöreskog and Sörbom, 1996). Polychoric correlations are the Pearson correlations of the normally distributed standardised latent variables underlying the observed categorical variables as their realisation (Olsson, 1979; Olsson et al., 1982). PFA examines whether the observed indicators belong to one underlying latent variable (i.e. an eigenvalue > 1 indicates a valid latent construct). CFA tests whether sublevel latent variables belong to the same latent construct (i.e. standardised Cronbach's Alpha above .7 indicates a valid latent construct), and only the valid latent constructs are kept in the model. The estimated factor loadings of the concepts on the latent variables, the sublevel latent variables and observed indicators are presented in Table 1 (shown between brackets, all with $p < .01$), together with the eigenvalues of the lowest-level latent variables. The estimated correlations among these selected latent and observed variables constitute the input correlation matrix for the structural model to be estimated.

3.3. Structural equation modelling

After operationalising the key concepts, the conceptual model has been specified in the structural model estimating the direct and indirect

Table 1
Operationalization and measurement of concepts based on observed variables in SAGE dataset, and the population and economic censuses.

Concept	Latent variable[c]	Sublevel latent variable[c]	Observed indicator[c]	Eigen value
Subjective overall health (SH)[a]	Self-rated health (1.000)		In general, how would you rate your health today? (1.000)	
Physical health (PH)[a]	Physical functioning (1.000)	Mobility (.900)	Overall in the last 30 days, how much difficulty did you have ... ... with moving around? (1.000) ... in vigorous activities? (.567)	1.595
		Self-care (1.000)	Overall in the last 30 days, how much difficulty did you have ... ... with self-care, such as bathing/washing or dressing yourself? (.928) ... in taking care of and maintaining your general appearance (for example, grooming, looking neat and tidy)? (.927) ... in staying by yourself for a few days 3–7 days)? (1.000)	2.941
		Pain and discomfort (.667)	Overall in the last 30 days, ... how much of bodily aches or pains did you have? (1.000) ...how much bodily discomfort did you have? (.962)	1.924
		Vision (.467)	In the last 30 days, how much difficulty did you have ... ... in seeing and recognising an object or a person you know across the road (from a distance of about 20 m)? (1.000) ... in seeing and recognising an object at arm's length (for example, reading)? (.912)	1.843
	Chronic physical conditions (.371)	Chronic lung disease (1.000)	During the last 12 months, have you experienced any ... ... shortness of breath at rest? (while awake) (1.000) ... coughing or wheezing for ten minutes or more at a time? (.896) ... coughing up sputum or phlegm for most days of the month for at least 3 months? (.880)	2.838
		Asthma (.502)	During the last 12 months, have you experienced any of the following: ... ... attacks of wheezing or whistling breathing? (.968) ... attack of wheezing that came on after you stopped exercising or some other physical activity? (.876) ... a feeling of tightness in your chest? (.859) ... have you woken up with a feeling of tightness in your chest in the morning or any other time? (.750) ... have you had an attack of shortness of breath that came on without obvious cause when you were not exercising or doing some physical activity? (1.000)	4.604
Mental health (MH)[a]	Mental functioning (1.000)	Cognition (.685)	Overall in the last 30 days, how much difficulty ... ... did you have with concentrating or remembering things? (1.000) ... did you have in learning a new task (for example, learning how to get to a new place, learning a new game, learning a new recipe)? (.803)	1.820
		Interpersonal activities (1.000)	Overall in the last 30 days, how much difficulty did you have ... ... with personal relationships or participation in the community? (.862) ... in dealing with conflicts and tensions with others? (.763) ... with making new friendships or maintaining current friendships? (1.000) ... with dealing with strangers? (.618)	3.564
		Sleep and energy (.480)	Overall in the last 30 days, how much of a problem did you ... ... have with sleeping, such as falling asleep, waking up frequently during the night or waking up too early in the morning? (.961) ... have due to not feeling rested and refreshed during the day (for example, feeling tired, not having energy)? (1.000)	1.931
		Affect (.809)	Overall in the last 30 days, how much of a problem did you have ... ... with feeling sad, low or depressed? (1.000) ... with worry or anxiety? (.990)	1.992
	Chronic mental conditions (.804)	Depression (1.000)	During the last 12 months, have you had a period lasting several days when you ... ... felt sad, empty or depressed? (.966) ... lost interest in most things you usually enjoy such as personal relationships, work or hobbies/recreation? (1.000) ... have been feeling your energy decreased or that you are tired all the time? (.707)	2.747
Residential environment (RE)[b]	Physical environment	Housing quality	High- and middle-rise building (1.000)	
		Access to cultural facilities	Access to cultural facilities (1.000)	
	Social environment	Proportion	Proportion of older adults (1.000)	
		Safety	Safety at home (1.000) Safety on street (.626)	1.587
Health-related behaviours (HB)[a]	Physical activities (PA)	Leisure activities	In a typical week, how much time do you spend doing moderate intensity sports, fitness or recreational (leisure) activities? (1.000)	
	Social activities (SA)	Meetings (.843)	How often in the last 12 months have you ... ... attended any public meeting in which there was discussion of local or school affairs? (1.000)	2.309
		Social groups (1.000)	... attended any group, club, society, union or organizational meeting? (1.000)	
		Neighbours (.465)	... worked with other people in your neighbourhood to fix or improve something? (1.000)	

(continued on next page)

Table 1 *(continued)*

Concept	Latent variable[c]	Sublevel latent variable[c]	Observed indicator[c]	Eigen value
		Friends (.446)	... had friends over to your home? (1.000)	
Subjective well-being (SWB)[a]	Life satisfaction (.980)		How satisfied are you with your life as a whole these days? (1.000)	2.505
	Happiness (.877)		How happy do you feel these days? (1.000)	
	Subjective QoL (1.000)		How would you rate your overall quality of life? (1.000)	
Socio-demographics (SD)[a]	Age		Age (1.000)	
	Gender		Gender (1.000)	
	Household size		Household size (1.000)	
	Household Income		Household income (1.000)	

[a] Note: Data source is SAGE.
[b] Note: There are four sublevel latent variables for residential environment (RE). 'Housing quality' was measured based on the types of building, shown on the 2010 Google satellite images. 'Access to cultural facilities' was measured based on the data from Economic Census. Data about 'Proportion' were derived from Population Census. 'Safety' refers to perceived safety at home and on street, which were obtained from two rating questions with 5-point scale in SAGE.
[c] Note: The numbers in the brackets are the standardised factor loadings in the confirmatory factor analysis (CFA).

relationships between the latent and observed variables. Since structural equation modelling (SEM) allows dependent variables to be both outcome variables and explanatory variables simultaneously, we were able to estimate not only the regression effects of the independent variables on the dependent variables, but also the regression effects of the dependent variables on each other. This enabled us to analyse the complex direct and indirect relationships between multiple variables. Moreover, SEM estimates the effects between all the variables simultaneously, which avoids biases in the estimates of the effects induced by traditional step-wise regression analyses and captures all the effects in a more accurate way.

Using LISREL 8.8 (Jöreskog and Sörbom, 2001), we estimated the structural model that best represented our conceptual model. The effects that were not specified in our conceptual model were not estimated and were set at zero. Furthermore, since the indicators in the SAGE dataset and Census were collected at different moments, the effects that were inconsistent with the chronological sequence of indicators were likewise not estimated and set at zero. Three goodness-of-fit measures were selected to assess the fit of the estimated SEM model to the input correlation matrix: the root mean square error of approximation (RMSEA), the comparative fit index (CFI) and the adjusted goodness-of-fit index (AGFI). For a good model, RMSEA should be below .05, and CFI and AGFI should be above .95.

4. Results

This section presents the estimated direct association of the residential environment with the health of older adults, as well as the indirect association of the residential environment on health through health-related behaviours, subjective well-being specified in the SEM model (Fig. 3). Insignificant effects between the dependent variables have been set at zero (and are not reported) for reasons of identification of the SEM model which is unnecessary for the independent variables (Johnston and DiNardo, 1997). In general, the SEM model fits quite well to the data, as indicated by RMSEA = .000, well below the critical value of .05, and CFI = 1.000 and AGFI = .992, well above the critical value of .95 (Table 2).

4.1. Direct association of residential environment with health

Regarding the direct impact of the residential environment, housing quality exhibits relatively strong positive associations with physical health (.355***) and mental health (.590***). Elderly people with better access to cultural facilities (including culture centres, universities for seniors and libraries) appear to have better mental health (e.g. better cognitive abilities such as concentrating and learning, and they are less depressive) (.189*). As expected, social aspects of the residential environment also play a significant role in influencing older adults' health. However, contrary to the positive influence we assumed in our first hypothesis, the proportion of older adults in a neighbourhood turns out to be negatively related to physical health (–.164**). Safety, another social environmental variable, reflects the level of social stresses in a neighbourhood. The results show that better safety conditions lead to better physical health (.199***). It has to be noted that the three measurements of health are closely related. Physical health has a strong direct and positive effect on mental health (.627***) and subjective overall health (.643***). As a result, the residential environment's impact on mental health and subjective overall health are enhanced through physical health.

4.2. Indirect association of residential environment with health

In line with our second hypothesis, the residential environment also indirectly associated with health. As shown in Fig. 3, the two most important mediators are health-related behaviours (including physical and social activities) and SWB. To clearly present the paths through which residential environment affects health indirectly, we made Table 3 based on Fig. 3 summarizing the total indirect association of residential environment variables (housing quality, access to cultural facilities, proportion of older adults and safety) with health (subjective overall health, physical health and mental health).

4.2.1. The intermediate role of health-related behaviours (physical and social activities)

Health-related behaviours, including both physical and social activities, are significantly and positively related to older adults' physical health (.150*** and .235***). Besides, social activities are also significantly and positively associated with mental health (.255***). Although physical and social activities do not show direct association with subjective overall health (SH), considering the path from PH to SH (.643***), significant positive total impact of physical and social activities on subjective overall health appear (.104*** and .162***). Similarly, considering the path from PH to MH (.627***), physical and social activities' total impact on mental health become significant and stronger respectively (.094*** and .403***).

Residential environment affects the frequency of older adults' physical and social activities, and thereby influence their health indirectly. Housing quality shows a direct weak negative impact on social activities (–.109**). Living in high quality neighbourhoods, notably high-rise and mid-rise building, could imply a vertical spatial and psychological barrier to the elderly residents reaching outdoor activity spaces and meeting other people, and a higher probability of being socially isolated (Chile et al., 2014). In general, housing quality's indirect associations with health (subjective overall health, physical health and mental health) through physical and social activities are weak. As expected, elderly people with more accessible cultural facilities participate in social activities more frequently (.302***), leading to better physical and mental health, and consequently

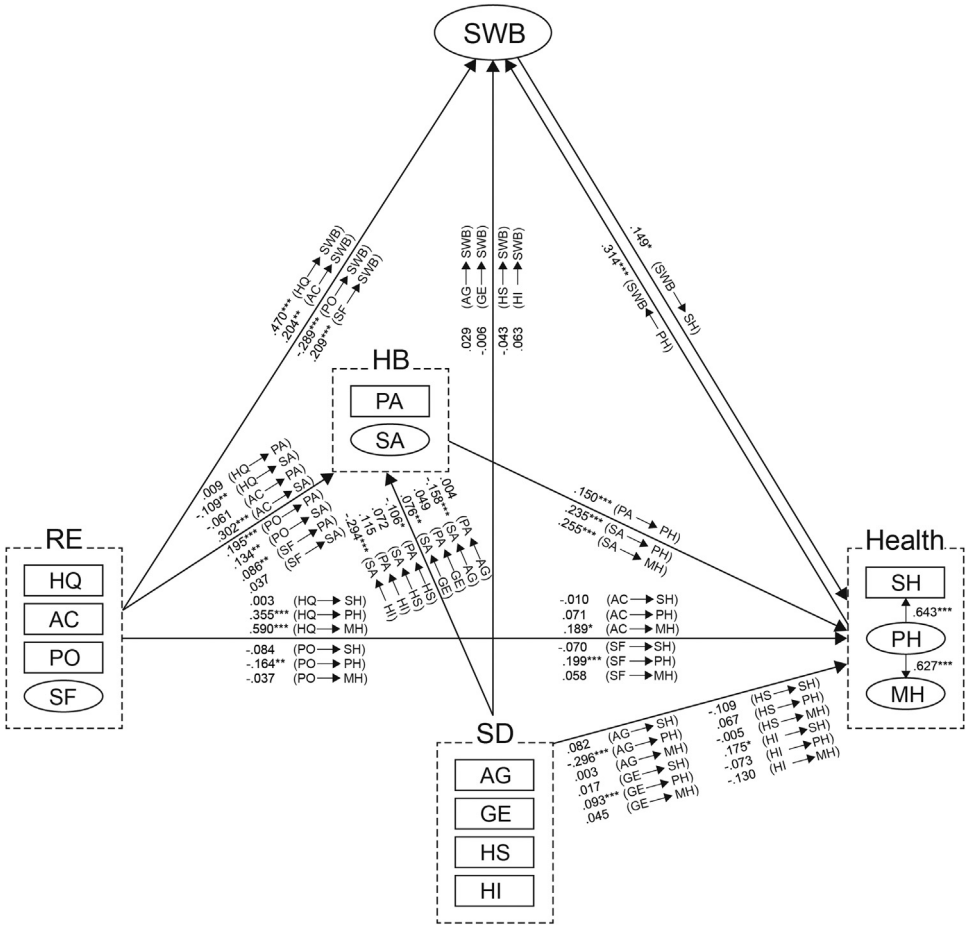


Fig. 3. Results of structural equation model: relationships between RE (residential environment), SD (socio-demographics), SWB (subjective well-being), HB (heath-related behaviours) and health.

improved subjective overall health. The proportion of older adults in a neighbourhood has a positive impact on participation in both physical and social activities (.195*** and .134***). Through these activities, the proportion of older adults affects physical health, mental health and subjective overall health indirectly and positively. Expectedly, a higher level of safety leads to more physical activities (.086**), and safety's

Table 2
Structural equation model for residential environment and health of older adults (standardised regression weight).

	Direct association						Total association					
	SH	PH	MH	SWB	PA	SA	SH	PH	MH	SWB	PA	SA
Dependent variables												
Subjective overall health (SH)												
Physical health (PH)	.643***		.627***	.314***			.690***		.627***	.314***		
Mental health (MH)												
Subjective well-being (SWB)	.149*						.149*					
Physical activities (PA)		.150***					.104***	.150***	.094***	.047***		
Social activities (SA)		.235***	.255***				.162***	.235***	.403***	.074***		
Independent variables												
Residential environment												
Housing quality (HQ)	.003	.355***	.590***	.470***	.009	−.109**	.301***	.330***	.770***	.574***	.009	−.109**
Access to cultural facilities (AC)	−.010	.071	.189*	.204**	−.061	.302***	.113	.133*	.350***	.246***	−.061	.302***
Proportion of older adults (PO)	−.084	−.164**	−.037	−.289***	.195***	.134**	−.198***	−.103	−.067	−.321***	.195***	.134**
Safety (SF)	−.070	.199***	.058	.209***	.086**	.037	.113***	.221***	.207***	.278***	.086**	.037
Socio-demographics												
Age (AG)	.082	−.296***	.003	.029	.004	−.158***	−.144***	−.333***	−.247***	−.076**	.004	−.158***
Gender (ref.=female) (GE)	.017	.093***	.045	−.006	.049	.076**	.097***	.118***	.138***	.031	.049	.076**
Household size (HS)	−.109	.067	−.005	−.043	−.106*	.072	−.068	.069	.056	−.021	−.106*	.072
Household income (HI)	.175*	−.073	−.130	.063	.115	−.294***	.099	−.125	−.283***	.023	.115	−.294***
Model quality												
R-squared	.527	.341	.999	.521	.068	.220	.527	.341	.999	.521	.068	.220
RMSEA / CFA / AGFI	.000 / 1.000 / .992											

Significance levels: *p < .10, **p < .05, ***p < .01.
Note: MH=Mental health, PA=Physical activities, PH=Physical health, SA=Social activities, SH=Subjective overall health, SWB=Subjective well-being.

Table 3
Indirect relationship between residential environment and health (standardised regression weight).

	Health					
	SH		PH		MH	
Residential environment						
Housing quality (HQ)	.298***	.070 HQ → SWB → SH .017 HQ → PH → SWB → SH .000 HQ → PA → PH → SWB → SH −.001 HQ → SA → PH → SWB → SH .228 HQ → PH → SH .001 HQ → PA → PH → SH −.016 HQ → SA → PH → SH	−.024	.001 HQ → PA → PH −.026 HQ → SA → PH	.180***	.223 HQ → PH → MH .001 HQ → PA → PH → MH −.016 HQ → SA → PH → MH −.028 HQ → SA → MH
Access to cultural facilities (AC)	.122**	.030 AC → SWB → SH .003 AC → PH → SWB → SH −.000 AC → PA → PH → SWB → SH .003 AC → SA → PH → SWB → SH .046 AC → PH → SH −.006 AC → PA → PH → SH .046 AC → SA → PH → SH	.062**	−.009 AC → PA → PH .071 AC → SA → PH	.160***	.045 AC → PH → MH −.006 AC → PA → PH → MH .044 AC → SA → PH → MH .077 AC → SA → MH
Proportion of older adults (PO)	−.114**	−.043 PO → SWB → SH −.008 PO→PH → SWB → SH .001 PO→PA → PH → SWB → SH .001 PO→SA → PH → SWB → SH −.105 PO→PH → SH .019 PO→PA → PH → SH .020 PO→SA → PH → SH	.061***	.029 PO→PA → PH .031 PO→SA → PH	−.031	−.103 PO→PH → MH .018 PO→PA → PH → MH .020 PO→SA → PH → MH .034 PO→SA → MH
Safety (SF)	.183***	.031 SF → SWB → SH .009 SF→PH → SWB → SH .001 SF→PA → PH → SWB → SH .000 SF→SA → PH → SWB → SH .128 SF→PH → SH .008 SF→PA → PH → SH .006 SF→SA → PH → SH	.022*	.013 SF→PA → PH .009 SF→SA → PH	.148***	.125 SF→PH → MH .008 SF→PA → PH → MH .005 SF→SA → PH → MH .009 SF→SA → MH

Significance levels: *p < .10, **p < .05, ***p < .01.
Note: MH=Mental health, PA=Physical activities, PH=Physical health, SA=Social activities, SH=Subjective overall health, SWB=Subjective well-being.
(The significance of the estimates in the brackets are not reported by LISREL).

indirect influence on physical and mental health via physical and social activities seem to be significant and positive.

4.2.2. The intermediate role of SWB

The relationship between SWB and the three measurements of health (PH, MH and SH) is more complicated. SWB has a direct significant effect on the subjective overall health of the elderly (.149*), meanwhile, SWB is directly determined by physical health (.314*), suggesting that SWB could be the outcome as well as the cause of health. Owing to SWB acting as a mediator, physical health indirectly affects subjective overall health, and as a result, the total effect of physical health on subjective overall health is higher than its direct effect. SWB also interacts with other mediators, the health-related behaviours (physical and social activities). Although there is no direct link between them, physical and social activities affect SWB indirectly via physical health (.047*** and .074***)

It seems that residential environment could have indirect relation with subjective overall health through SWB. Housing quality is strongly and positively related to SWB (.470***), but its indirect association with subjective overall health via SWB is comparatively weak. As expected, the elderly with better access to cultural facilities exhibits a higher level of SWB (.204**). However, the access to cultural facilities has very weak indirect impact on subjective overall health via SWB. The proportion of older adults turns out to negatively associated with the SWB of the elderly (−.289***), whereas its association with subjective overall health via SWB is not obvious. Better safety conditions contribute to higher SWB (.209***), but it does not lead to better subjective overall health. To conclude, residential environment does not affect health so much through SWB. Health-related behaviours are the stronger mediators between the residential environment and health.

4.3. Total association of residential environment with health

Combining the direct and indirect association through both health-related behaviours and SWB, the right part of Table 2 demonstrates the total association of the residential environment with health. Housing quality's total association with subjective overall health becomes significant (.301***), and its total association with mental health become stronger (.770***). The total impact of the accessibility to cultural facilities on physical health become significant (.133*), and, similarly, its total association with mental health become stronger (.350***). After adding the direct and indirect association, the total association of the proportion of older adults with subjective overall health become negatively significant and stronger (−.198***). Its total negative association with physical health turns out to be insignificant (.103). Safety's total association with subjective overall health become significantly positive (.113***), and its total association with physical health are enhanced (.221***), while its total association with mental health become significant (.207***).

With regard to the socio-demographic variables, age shows a significant direct, moderate and negative impact on physical health and social activities. After taking into account the indirect path via social activities and physical health, age is shown to have a significant total negative impact on subjective overall health, mental health and SWB. Elderly males have slightly better physical health compared to elderly females, and are more active in participating social activities. The total association show that elderly males have better physical, subjective and mental health than elderly females. Contrary to our expectations, household size, as a representation of social/familial resources, does not significantly related to health, but only negatively related to physical activities. Household income, which represents economic resources, directly and positively associated with the subjective overall health of

older adults. Furthermore, low household income appears to discourage older adults participating in social activities. After considering all the indirect relationship, the total association of household income with subjective overall health and mental health become insignificant and negatively significant, respectively.

5. Conclusions and discussion

5.1. Main findings

With deteriorating environmental conditions and a rapidly ageing population in Chinese megacities, a healthy residential environment – especially for older adults – has emerged as an important issue on political and planning agenda. Existing empirical research on public health, urban planning and environmental psychology suggests that many residential environmental, behavioural, perceptual and individual factors can affect older adults' health. However, these studies primarily focus on partial and discipline-specific issues and their direct association only. By integrating these insights into a more comprehensive conceptual model, this paper aims to investigate both the direct and indirect association of the residential environment with the health of older adults in Shanghai, paying particular attention on the indirect relationship. Two major conclusions, which correspond to our two hypotheses, contribute to the existing knowledge about the influence of residential environments on health.

Not only physical aspects but also the social aspects of the residential environment affect older adults' health. In line with the existing literature (Ellen et al., 2001; Northridge et al., 2003; Parra et al., 2010; Phillips et al., 2005), physical residential environment, including housing quality and the access to cultural facilities, is positively associated with older adults' physical and mental health; additionally, better housing quality leads to better subjective overall health. As one of the social aspects of residential environment, the proportion of older adults in a neighbourhood appears to promote their participation in physical and social activities, but, unexpectedly, is negatively associated with their health. This might be related to the unique compositional and occupational characteristics of those neighbourhoods with a higher proportion of older adults in Shanghai. Such neighbourhoods are mostly previous work-unit/*danwei* (state-owned enterprises) communities located in the central city. Many elderly residents living there, according to the SAGE survey, used to work as skilled manual workers in the factories, so that they are more likely to exposed to industrial pollution and physical injury, resulting in poorer health conditions. Meanwhile, a higher proportion of older adults can also imply a greater likelihood of experiencing negative events such as someone's illness and death, which could exert negative impact on SWB and thereby affects health in a negative way. This result suggests that living in a more vibrant and lively social environment, in which multiple age groups live together, may promote older adults' health. Safety, the other indicator of the social quality of the residential environment, is significantly and positively related to older adults' physical, mental and subjective health conditions.

In line with our second hypothesis, a series of behavioural and perceptual factors, especially physical activities (e.g. sports, fitness and leisure activities) and social activities (e.g. attending social meetings and groups, and socialising with neighbours and friends), play crucial intermediate roles in the relationship between residential environment and health. For instance, when the intermediate role of social activities is taken into account, the impact of the access to cultural facilities (a characteristic of the residential environment) on physical health changes dramatically from insignificant to significant. In addition, by taking into account the intermediate role of physical activities, the impact of the safety of the residential environment on physical health becomes stronger. These findings enhance our understanding of the significant intermediate role of physical and social activities in the relationship between residential environment and health.

5.2. Future research directions and policy implication

All these findings add to the growing literature documenting the relationship between the residential environment and older adults' health, and also go beyond previous findings by comprehensively exploring the direct and indirect association of residential environments with health. Future research should also focus on both the direct and indirect influence of additional physical and social characteristics of the residential environment, such as neighbourhood quality and neighbourhood socio-economic status. Moreover, considering the crucial intermediate role of physical and social activities in the relationship between residential environment and health, further research should pay more attention to activity-supportive characteristics of the residential environment. These characteristics include, for instance, walkability, cyclability, street connectivity, accessibility and activity spaces that support physical activities, as well as social cohesion, social networks and public spaces that support social activities. The type and intensity of these health-related activities may vary between different age groups (e.g. younger, mid-aged and older adults) and different geographical and social contexts (e.g. Chinese and Western contexts), and hence future research needs to take these variations explicitly into account.

Over the past few decades, Chinese policies have largely focused on economic growth, but have paid little attention to a healthy urban living environment. The findings of this study have several important implications for policies and practices regarding a healthy living environment. Given the importance shown by this study of the indirect impact of the residential environment on health, it is crucial for planners, designers and local governments to pay more attention to the development of residential environments which support health and health-related behaviours, not least for vulnerable groups such as older adults. Such environments should incorporate attributes such as physical activity facilitation (e.g. physical activity-supportive facilities and spaces such as accessible parks, plazas, barrier-free housing and pedestrian streets for fitness, sports and leisure activities); social interaction facilitation (e.g. attractive social activity-supportive places and a good atmosphere for meeting and socialising); good housing and neighbourhood quality (e.g. good sanitation and medical facilities); good accessibility to cultural and leisure facilities (e.g. a good public transport system); and sufficient safety (e.g. streets with social surveillance and crime control). Additionally, neighbourhoods composed of diverse age groups might also promote the SWB and health of older adults. After several decades of pro-economic development, it is now time for China to shift its focus to urban planning and to the rapidly ageing population and health conditions of the country's older adults. Much more can be done to promote a healthier residential environment for older adults in China's megacities.

5.3. Limitations

Limitations of the study should also be noted. The estimation in this paper is based on a cross-sectional design (that is, the variables are measured once in time). This implies that causal effects cannot be assessed and that the estimated relationships can only be interpreted in causal terms based on plausibility. Another limitation is that health conditions may not have been fully captured in the model. Although SAGE provides more data concerning health, we only kept the health conditions, which are able to validly construct an upper-level latent variable. For instance, we have tested arthritis, diabetes, and other chronic physical conditions, but they do not load on the upper-level latent variable, and thereby have not been included in the model.

Additionally, the results presented in this study should, however, be regarded as tentative. As the sample of 1035 older adults has been obtained by random sampling 70 older respondents within 15 neighbourhoods, the measurements of the variables analysed might not be fully independent from each other and be affected by unspecified

neighbourhood effects. This implies that although the estimates of the unknown parameters in the SEM model are consistent, their estimated standard errors should be corrected for possible biases induced by those neighbourhood effects. However, methods for such corrections, hierarchical linear modelling and clustered standard errors, have been developed for variables measured on continuous interval and ratio scales but not for variables measured (mostly) on ordinal scales as in this study. Treating ordinal variables as continuous variables and applying the correction methods mentioned would result in seriously underestimated values of the unknown parameters in the SEM model but with correctly estimated standard errors (Jöreskog and Sörbom, 1996). Therefore, we have chosen to present correctly estimated parameters with potentially underestimated standard errors but admit that this problem should be given further attention in future research.

References

Barahmand, U., Shahbazi, H., Shahbazi, Z., 2013. Implications of perceived physical and social aspects of the environment for self-reported physical and mental health. Int. J. Environ. Health Res. 23, 31–45.

Bian, Y., 2002. Chinese social stratification and social mobility. Annu. Rev. Sociol. 28, 91–116.

Cagney, K.A., 2006. Neighborhood age structure and its implications for health. J. Urban Health 83, 827–834.

Camfield, L., Skevington, S.M., 2008. On subjective well-being and quality of life. J. Health Psychol. 13, 764–775.

Carlson, C., Aytur, S., Gardner, K., Rogers, S., 2012. Complexity in built environment, health, and destination walking: a neighborhood-scale analysis. J. Urban Health 89, 270–284.

Chile, L.M., Black, X.M., Neill, C., 2014. Experience and expression of social isolation by inner-city high-rise residents. Hous. Care Support 17, 151–166.

Clarke, P., Nieuwenhuijsen, E.R., 2009. Environments for healthy ageing: a critical review. Maturitas 64, 14–19.

Costa-Font, J., 2013. Housing-related well-being in older people: the impact of environmental and financial influences. Urban Stud. 50, 657–673.

Day, R., 2008. Local environments and older people's health: dimensions from a comparative qualitative study in Scotland. Health Place 14, 299–312.

Diener, E., 2009. Subjective well-being. In: Diener, E. (Ed.), The Science of Well-Being. Springer, New York.

Diener, E., Chan, M.Y., 2011. Happy people live longer: subjective well-being contributes to health and longevity. Appl. Psychol.: Health Well-Being 3, 1–43.

Diener, E., Ryan, K., 2009. Subjective well-being: a general overview. S. Afr. J. Psychol. 39, 391–406.

Dujardin, C., Lorant, V., Thomas, I., 2014. Self-assessed health of elderly people in Brussels: does the built environment matter? Health Place 27, 59–67.

Ellen, I.G., Mijanovich, T., Dillman, K.-, 2001. Neighborhood effects on health: exploring the links and assessing the evidence. J. Urban Aff. 23, 391–408.

Frank, L.D., Engelke, P.O., 2001. The built environment and human activity patterns: exploring the impacts of urban form on public health. J. Plan. Lit. 16, 202–218.

Franzini, L., Caughy, M., Spears, W., Fernandez Esquer, M.E., 2005. Neighborhood economic conditions, social processes, and self-rated health in low-income neighborhoods in Texas: a multilevel latent variables model. Soc. Sci. Med. 61, 1135–1150.

He, C., Pan, F., Yan, Y., 2012. Is economic transition harmful to China's urban environment? Evidence from industrial air pollution in Chinese cities. Urban Study 49, 1767–1790.

Hill, T.D., Maimon, D., 2013. Neighborhood context and mental health. In: Aneshensel, C., Phelan, J., Bierman, A. (Eds.), Handbook of the Sociology of Mental Health. Springer, Netherlands, 479–501.

Johnston, J., DiNardo, J., 1997. Econometric Methods. McGraw-Hill, New York.

Jöreskog, K.G., Sörbom, D., 1996. PRELIS 2: User's Reference Guide. Scientific Software International, Lincolnwood, USA.

Jöreskog, K.G., Sörbom, D., 2001. LISREL 8: User's Reference Guide. Scientific Software International, Lincolnwood, USA.

Kerr, J., Rosenberg, D., Frank, L., 2012. The role of the built environment in healthy aging: community design, physical activity, and health among older adults. J. Plan. Lit. 27 (1), 43–60.

Kruger, D.J., Reischl, T.M., Gee, G.C., 2007. Neighborhood social conditions mediate the association between physical deterioration and mental health. Am. J. Community Psychol. 40, 261–271.

Lehning, A.J., Smith, R.J., Dunkle, R.E., 2014. Age-friendly environments and self-rated health: an exploration of Detroit elders. Res. Aging 36, 72–94.

Lindenberg, S., 1996. Continuities in the theory of social production functions. In: Ganzeboom, H., Lindenberg, S. (Eds.), Verklarende Sociologie: Opstellen Voor Reinhard Wippler. Thela Thesis, Amsterdam.

Liu, Y., Dijst, M., Geertman, S., 2014. Residential segregation and well-being inequality between local and migrant elderly in Shanghai. Habitat Int. 42, 175–185.

National New-Type Urbanization Plan 2014–2020, 2014. ⟨http://politics.people.com.cn/n/2014/0317/c1001-24649809.html⟩ (Accessed 21 December 2016).

Nieboer, A., Lindenberg, S., Boomsma, A., Van Bruggen, A.C., 2005. Dimensions of well-being and their measurement: the Spf-Il scale. Soc. Indic. Res. 73, 313–353.

Norstrand, J.A., Glicksman, A., Lubben, J., Kleban, M., 2012. The role of the social environment on physical and mental health of older adults. J. Hous. Elder. 26, 290–307.

Northridge, M.E., Sclar, E.D., Biswas, P., 2003. Sorting out the connections between the built environment and health: a conceptual framework for navigating pathways and planning healthy cities. J. Urban Health 80, 556–568.

Olsson, U., 1979. Maximum likelihood estimation of the polychoric correlation coefficient. Psychometrika 44, 443–460.

Olsson, U., Drasgow, F., Dorans, N.J., 1982. The polyserial correlation coefficient. Psychometrika 47, 337–347.

Ormel, J., Lindenberg, S., Steverink, N., Vonkorff, M., 1997. Quality of life and social production functions: a framework for understanding health effects. Soc. Sci. Med. 45, 1051–1063.

Ormel, J., Lindenberg, S., Steverink, N., Verbrugge, L.M., 1999. Subjective well-being and social production functions. Soc. Indic. Res. 46, 61–90.

Parra, D.C., Gomez, L.F., Sarmiento, O.L., Buchner, D., Brownson, R., Schimd, T., Gomez, V., Lobelo, F., 2010. Perceived and objective neighborhood environment attributes and health related quality of life among the elderly in Bogotá, Colombia. Soc. Sci. Med. 70, 1070–1076.

Phillips, D.R., Siu, O.-, Yeh, A.G.O., Cheng, K.H.C., 2005. The impacts of dwelling conditions on older persons' psychological well-being in Hong Kong: the mediating role of residential satisfaction. Soc. Sci. Med. 60, 2785–2797.

Renalds, A., Smith, T.H., Hale, P.J., 2010. A systematic review of built environment and health. Fam. Community Health 33, 68–78.

Roh, S., Jang, Y., Chiriboga, D.A., Kwag, K.H., Cho, S., Bernstein, K., 2011. Perceived neighborhood environment affecting physical and mental health: a study with Korean American older adults in New York City. J. Immigr. Minor. Health 13, 1005–1012.

Rojo-Pérez, F., Fernández-Mayoralas, G., Rodríguez-Rodríguez, V., Rojo-Abuín, J., 2007. The environments of ageing in the context of the global quality of life among older people living in family housing. In: Mollenkopf, H., Walker, A. (Eds.), Quality of Life in Old Age. Springer, Dordrecht, 123–150.

Ross, C.E., Mirowsky, J., 2008. Neighborhood Socioeconomic Status and Health: context or Composition? City Community 7, 163–179.

SAGE team, 2013. China - Study on Global Ageing and Adult Health-2007/10, WAVE 1. 2014.

Seeman, T.E., Crimmins, E., 2001. Social environment effects on health and aging: integrating epidemiologic and demographic approaches and perspectives. Ann. N. Y. Acad. Sci. 954, 88–117.

Shanghai Government, 2016, Release of Information on Shanghai Population Aging and its Development in 2015. ⟨http://www.shanghai.gov.cn/nw2/nw2314/nw2315/nw4411/u21aw1118419.html⟩ (Accessed 28 December 2016).

Smith, J., Borchelt, M., Maier, H., Jopp, D., 2002. Health and well-being in the young old and oldest old. J. Soc. Issues 58, 715–732.

Soltani, A., Hoseini, S.H., 2014. An analysis of the connection between built environment, physical activity and health: comparing three urban neighbourhoods from Shiraz, Iran. Int. J. Urban Sci. 18, 19–30.

Sugiyama, T., Ward Thompson, C., 2007. Older people's health, outdoor activity and supportiveness of neighbourhood environments. Landsc. Urban Plan. 83, 168–175.

Thomas, H., Weaver, N., Patterson, J., Jones, P., Bell, T., Playle, R., Dunstan, F., Palmer, S., Lewis, G., Araya, R., 2007. Mental health and quality of residential environment. Br. J. Psychiatry 191, 500–505.

Villanueva, K., Pereira, G., Knuiman, M., Bull, F., Wood, L., Christian, H., Foster, S., Boruff, B.J., Beesley, B., Hickey, S., Joyce, S., Nathan, A., Saarloos, D., Giles-Corti, B., 2013. The impact of the built environment on health across the life course: design of a cross-sectional data linkage study. BMJ Open 3.

de Vries, S., Verheij, R.A., Groenewegen, P.P., Spreeuwenberg, P., 2003. Natural environments - Healthy environments? An exploratory analysis of the relationship between greenspace and health. Environ. Plan. A 35, 1717–1731.

Wahl, H., Mollenkopf, H., Oswald, F., Claus, C., 2007. Environmental aspects of quality of life in old age: conceptual and empirical issues. In: Mollenkopf, H., Walker, A. (Eds.), Quality of Lifein Old Age. Springer, Dordrecht, 101–122.

Yen, I.H., Michael, Y.L., Perdue, L., 2009. Neighborhood environment in studies of health of older adults. A systematic review. Am. J. Prev. Med. 37, 455–463.

Yeo, M., Heshmati, A., 2014. Healthy residential environments for the elderly. J. Hous. Elder. 28, 1–20.