Travel Behaviour and Society 35 (2024) 100724

Contents lists available at ScienceDirect

Travel Behaviour and Society

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

Mixed land use has opposite associations with subjective well-being through social capital: Spatial heterogeneity in residential and workplace neighborhoods

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ARTICLE INFO

Keywords:
Built environment
Land use diversity
Life satisfaction
Social capital
Spatial heterogeneity

ABSTRACT

Mixed land use (MLU) is recognized as a crucial means for urban planners to facilitate residents' subjective well-being (SWB). However, prior research has rarely explored the mediating effect of social capital on the MLU-SWB association and has overlooked the possibility that this association may be subject to spatial heterogeneity between residential and workplace neighborhoods. Based on a sample of 1028 survey participants in Shanghai from 2018 to 2019, a structural equation model is used to investigate the associations among MLU, social capital, and SWB in residential and workplace neighborhoods. We find that MLU has a negative and indirect association with SWB by decreasing social capital in residential neighborhoods, while it has a positive and indirect association with SWB by enhancing social capital in workplace neighborhoods with adjustments for other built environmental and sociodemographic attributes. That is, MLU has opposite associations with SWB mediated by social capital. Therefore, policymakers need to adopt different strategies to optimize MLU in residential and workplace neighborhoods to facilitate social capital and SWB.

1. Introduction

Subjective well-being (SWB) is defined by people's experience and assessment of their whole lives (Diener et al., 2018a; Wang & Wang, 2016). Higher SWB not only improves individuals' job performance (Tenney et al., 2016) and health status (Diener & Chan, 2011) but is also beneficial to the sustainable development of cities and the entire society (Geropanta et al., 2021; Tay et al., 2015). Hence, enhancing citizens' SWB is a key part of Sustainable Development Goal 3 (United Nations, 2021a) and has attracted increasing attention from both academia and governments (Chen & Smallwood, 2022; Vik & Carlquist, 2017). To improve people's SWB, urban planners and policymakers often rely on improving the urban physical environment, which is considered an upstream determinant of SWB (Mouratidis, 2022; Nathan et al., 2018). This strategy is consistent with Sustainable Development Goal 11, which explains the necessity of building sustainable cities and communities (United Nations, 2021b).

Mixed land use (MLU) stresses the diversity of buildings for various uses on the layout (Hoppenbrouwer & Louw, 2005; Nabil & Eldayem, 2015), which is one of the most essential elements of compact neighborhoods (Ewing & Cervero, 2010) as well as a key intervention in promoting Sustainable Development Goal 11. Previous research has shown that residents of mixed-use neighborhoods are likely to have higher SWB (Mouratidis, 2021; Trudeau, 2013). One possible reason is that MLU improves access to various facilities and services that meet residents' diverse needs for daily activity participation (e.g., work and shopping) (Grant, 2002; Jabareen, 2006). This is conducive to increasing neighborhood satisfaction, which is a key contributor to SWB (Sun et al., 2022a). However, some scholars have found differing results that suggest that MLU tends to reduce residents' SWB (Mouratidis, 2021; Pfeiffer & Cloutier, 2016) because of noise and air pollution (Mouratidis, 2019). Yang (2008) found that MLU has a positive association with

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https://doi.org/10.1016/j.tbs.2023.100724
Received 12 April 2023; Received in revised form 12 October 2023; Accepted 20 November 2023

neighborhood satisfaction in the compact context, while it has a negative relationship with neighborhood satisfaction in the sprawl context; hence, the effect of MLU depends on the context. In the Minneapolis–Saint Paul metropolis, Cao (2016) found both of these mechanisms and MLU had a null effect on SWB. He argued that this was because the benefit of better accessibility is offset by the negative effect of nuisances.

Social capital refers to potential resources that can become available through people's social interactions and social networks (Kawachi et al., 2008), characterized by familiarity, trust, and reciprocity (Putnam, 2000), which may be another mediator of the association between MLU and SWB. However, this mediator is often ignored by the literature. First, MLU is linked with social capital. Jacobs (1961) highlighted that a mixture of diverse uses contributes to social interaction. Studies have suggested that people residing in mixed-use neighborhoods are likely to have more social interactions and social integration because they have a higher likelihood of traveling by active modes (e.g., on foot) and encountering neighbors (Leyden, 2003; Nabil & Eldayem, 2015; Xia & Lu, 2023). However, other studies have found that residents' social capital may be hindered by MLU due to increasing feelings of insecurity (Wood et al., 2010; Wood et al., 2008) and fear of crime (Inlow, 2021; Wo, 2019; Zahnow, 2018). Second, social capital is a substantial contributor to SWB (Diener et al., 2018b; Leung et al., 2013). Therefore, MLU may affect SWB by influencing social capital. However, to our knowledge, only Guo et al. (2021) have empirically explored this mechanism. These authors focused on elderly residents in Hong Kong, China, and found that MLU was positively correlated with SWB by enhancing the sense of community. Considering that older adults are retired and their daily lives and SWB mainly rely on social networks in residential neighborhoods (Padeiro et al., 2021), the findings from older adults often cannot be transferred to other populations. Therefore, more evidence is needed to determine whether social capital plays a mediating role in the MLU-SWB association in the labor force population.

Previous studies have mainly focused on MLU in residential neighborhoods and have not considered that the impacts of MLU may have spatial heterogeneity. In addition to neighborhoods where people live, neighborhoods where people work also matter to citizens' daily lives (Gong et al., 2020) because most employees spend approximately half of their waking time at worksites on weekdays (Zhu et al., 2020). Research on both travel behavior and public health has revealed that MLU in workplace neighborhoods has important effects on commuting behavior (Ding et al., 2018; Yang et al., 2022) and physical activity (Carlson et al., 2018). Hence, the environment surrounding worksites may also influence people's social capital as well as SWB (Sun et al., 2022b). On the one hand, employees inevitably join social networks around workplaces because they share the same spatial location with residents and other employees in workplace neighborhoods (Johnston & Pattie, 2011). For example, people have many opportunities to conduct social interactions with others (e.g., during mealtime or while waiting for the bus). People can also build trust and reciprocity by alerting other people that their shoelaces are untied or that they have dropped their wallet. On the other hand, high social capital in workplace neighborhoods helps people develop positive moods and reduce their fear of crime (Adams & Serpe, 2000; Giamo et al., 2012), which can promote their satisfaction with their workplace and contribute to higher SWB (Sun et al., 2022b). However, evidence comparing the effects of MLU in residential and workplace neighborhoods on social capital and SWB remains scant.

In addition to MLU, other built environmental attributes play important roles in shaping social capital and SWB and may be confounders of the association between MLU, social capital, and SWB. People who live in neighborhoods with higher population and road densities, shorter distances to the city center, and greater accessibility to public transportation are more likely to travel by active modes (Ewing & Cervero, 2010; Forsyth & Oakes, 2014; Giehl et al., 2016; Yin et al., 2022), which may provide more opportunities for informal social interactions with neighbors and lead to a higher level of social capital (Leyden, 2003; Mouratidis, 2018; Utsunomiya, 2016). Green and blue spaces provide space for social interaction and social activities, which are important to strengthen social capital (Liu et al., 2019; Wang et al., 2023). By enhancing social capital, promoting physical activity, and improving convenience, these built environmental elements can further improve SWB (Mouratidis, 2021; Wang et al., 2023; White et al., 2016; Yin et al., 2020). However, high population and road densities are often accompanied by crowdedness and traffic congestion, resulting in a decrease in SWB (Cao, 2016). In the Chinese context, proximity to the city center means more environmental pollution and higher housing prices, which have been found to be negatively related to SWB (Li et al., 2018). These negative effects were especially evident during the COVID-19 pandemic (Mouratidis & Yiannakou, 2022). People who travel by transit, particularly by bus, often have lower travel satisfaction than those who travel by automobile and on foot (Wang et al., 2021; Zhu & Fan, 2018), which may lead to lower SWB. Overall, the built environment has complex associations with social capital and SWB. This study focuses on MLU with the aim of disentangling the link between MLU, social capital, and SWB.

Inspired by these gaps in the literature, we use a structural equation model (SEM) to investigate whether social capital is a mediator of the association between MLU and SWB in different neighborhood contexts using data from Shanghai, China. In particular, we intend to address two questions: 1) Does social capital mediate the association between MLU and SWB? 2) If so, does this mediation effect differ in residential and workplace neighborhoods?

We develop a conceptual framework to guide this study (Fig. 1). In this framework, we focus on the effect of MLU on SWB and treat other built environmental elements and sociodemographic information as control variables. SWB is affected by individuals' sociodemographics, social capital and built environments (including MLU and others) in residential and workplace neighborhoods. Moreover, residential and workplace social capital are affected by the corresponding built environment and sociodemographics. Social capital can mediate the association between MLU and SWB because it is a result of MLU and a cause of SWB. Therefore, the effect of MLU on SWB consists of direct and indirect effects. The former is defined by the effect of MLU on SWB excluding the effect of social capital. The latter refers to the effect of MLU on SWB through social capital, which provides an answer to the first question. By comparing the indirect effects of MLU in residential and workplace neighborhoods on SWB by the corresponding social capital, we can obtain the answer to the second question.

2. Methods

2.1. Data

Shanghai is one of the largest Chinese cities. In 2018, it had a population of almost 25 million within an administrative area of 6340.5 km^2 (Shanghai Municipal Statistics Bureau, 2019). Its built-up area consisted of 13 districts, mainly around and within the outer ring highway, covering approximately 1238 km^2.

We used a self-administered survey collected from 2018 to 2019 in Shanghai that was approved by the Ethics Board of East China Normal University (No. HR080-2021). This survey collected data based on strict sampling processes that have been introduced in detail in other studies (Sun et al., 2022b; Yin et al., 2023a). Briefly, the 13 districts within the built-up area were first divided into ten groups, and 30 subdistricts within these groups were randomly selected. Next, approximately 35 households were randomly chosen from one or two neighborhoods within each subdistrict to complete the questionnaire. Household heads or their spouses aged 18–60 years with stable jobs were invited to participate in face-to-face interviews, and a total of 1127 questionnaires were collected. Investigators asked the participants to report the full addresses of their residential and workplace locations, but 99 participants were reluctant to provide this information. Hence, the final sample with valid georeferenced residential and workplace addresses in this

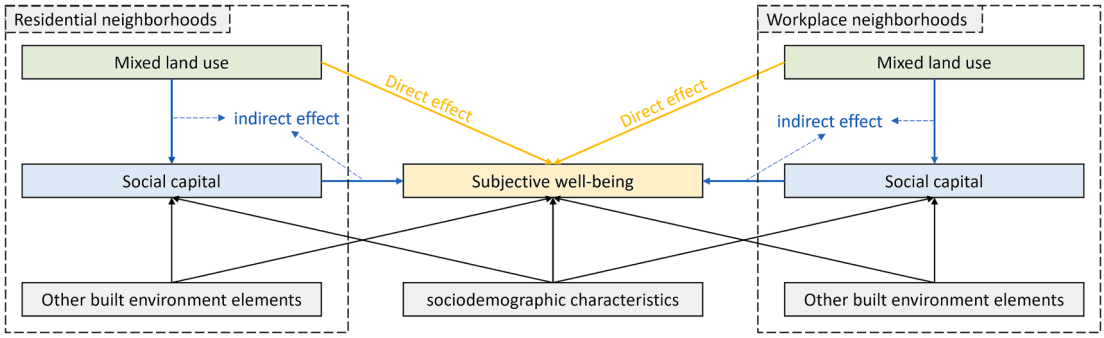


Fig. 1. The conceptual framework of this study.

study consisted of 1028 participants (Fig. 2).

2.2. Variables

Subjective well-being (SWB). We measured SWB by the Satisfaction with Life Scale (SWLS) (Diener et al., 1985). This scale included five items based on a 7-point Likert scale from "extremely disagree" (1) to "extremely agree" (7). A latent variable of SWB was generated by confirmatory factor analysis (Fig. 3). The Cronbach's alpha of SWB was larger than 0.8 and the coefficients of all the items were significant, indicating that the latent variable of SWB had good reliability (Kjell & Diener, 2021; Yin et al., 2021).

Social capital. Following previous research (Sun et al., 2022b; Vemuri et al., 2009), we measured participants' social capital in their residential and workplace neighborhoods. The measurement of social capital consisted of three items on a 5-point Likert scale from "strongly disagree" (1) to "strongly agree" (5). We generated the latent variables of residential and workplace social capital. Fig. 4 illustrates the latent variables of social capital in residential and workplace neighborhoods. They had good reliability since their Cronbach's alphas were greater than 0.9 (Gliem & Gliem, 2003).

MLU and other built environmental variables. Built environmental variables were measured based on 1000-m circular buffers surrounding the participants' residences and worksites (i.e., residential neighborhoods and workplace neighborhoods). The reasons for selecting this buffer size were as follows. First, the 1000-m circular buffer roughly corresponds to the area of 15-minute community-life circles, which are people's main daily activity spaces (Shanghai Urban Planning and Land Resources Administration Bureau, 2016). Second, the 1000-m circular buffer is often used in the literature, which is beneficial for comparing results across studies (Barnett et al., 2020; Liu et al., 2020a; Yin et al., 2023b).

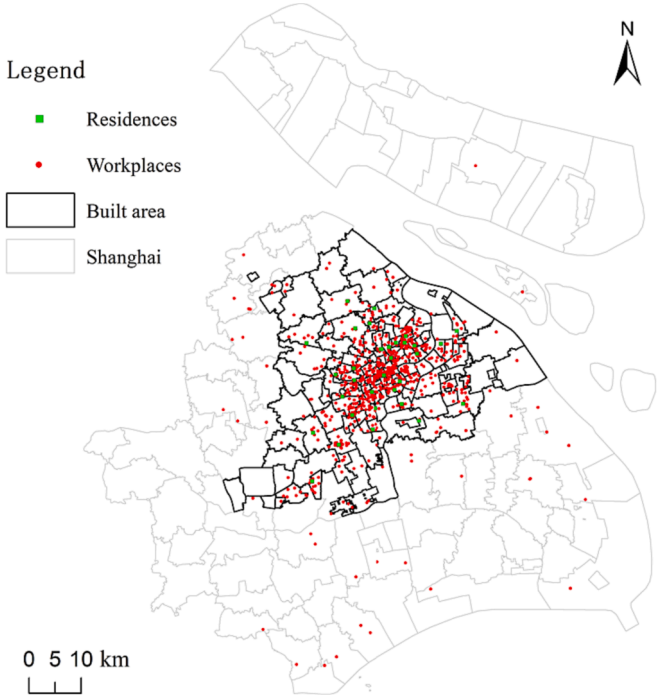


Fig. 2. Participants' residential and workplace locations in Shanghai, China.

MLU was the key independent variable, which was measured by the land-use entropy index. Specifically, the land-use entropy index was calculated by the following formula (Brown et al., 2009; Hino et al., 2014):

$$LUE = \sum_{j=1}^{k} P_j * \ln(P_j)/\ln(k) \quad (1)$$

where *LUE* indicates the land-use entropy, *P* refers to the number of land-use facilities *j* within the buffer, and *k* refers to the number of land-use facility types within the buffer. Seventeen types of land-use facilities were extracted based on points of interest from the 2018 Amap, including catering facilities, tourist attractions, parks and squares, public facilities, firms, shopping centers, transportation infrastructure, financial services, educational institutions, residential buildings, high-tech industrial parks, life services, sports facilities, entertainment facilities, healthcare facilities, government agencies, and hotels. The value of land-use entropy was between 0 and 1. The higher the value, the higher the degree of MLU.

Following previous studies (Cao, 2016; Liu et al., 2021; Sun et al., 2022a), density, street connectivity, proximity to the city center, access to transit stops, and green and blue spaces were controlled in the model to exclude their confounding effects. Density was measured by two variables: population density and floor area ratio. Population density used the 2018 LandScan dataset to measure the population size within the buffer divided by the buffer size. Based on the Chinese building height at 10-m resolution, which is the most detailed and refined open-source dataset of Chinese building footprints (Wu et al., 2023), we measured the floor area ratio by the ratio of the total floor area of all buildings relative to the land area within the buffer. Road density was a proxy of street connectivity, which used the 2018 Open Street Map dataset to capture the street length divided by the buffer size within the buffer. Distance to the city center was calculated by the nearest street network distance from the respondents' residences/workplaces to People Square. Within the buffer, we counted the number of subway stations and bus stops using the points of interest from Amap in 2018. Green space was measured by the number of parks and the green area within the buffer. Blue space was calculated by the water area within the buffer.

Sociodemographic covariates. To improve the model estimation, sociodemographic characteristics were treated as covariates in the model, as in the literature (Chng et al., 2016; Sun et al., 2022b). Sociodemographic covariates included sex, age, hukou status, years of education, marital status, household size, number of employees, number of

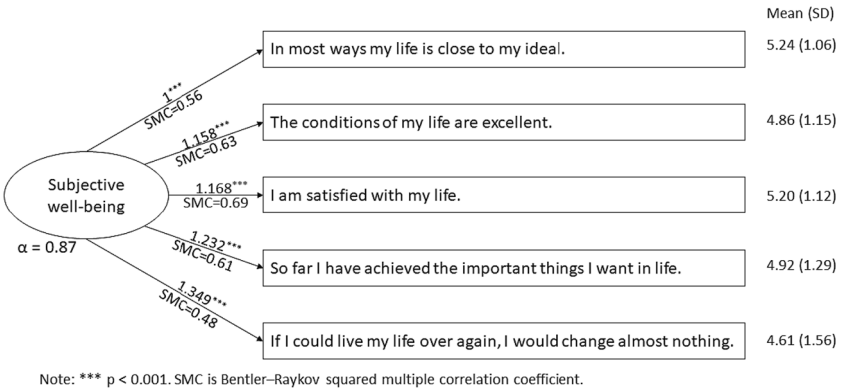


Fig. 3. The latent variable of SWB.

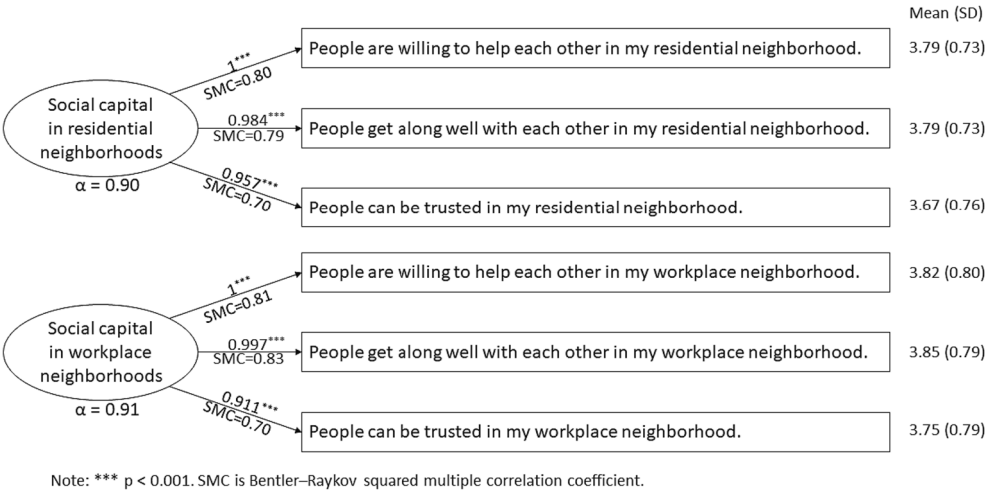


Fig. 4. The latent variables of residential and workplace social capital.

children, household annual income, housing tenure, years at current residence, work type, years at current workplace, working hours per week, and commuting distance.

2.3. Analysis approach

We employed a structural equation model (SEM) to explore the associations among MLU, social capital, and SWB. SEM consists of measurement models and structural models. The former were used to obtain latent variables of social capital and SWB by confirmatory factor analysis. The latter were applied to explore the pathways from MLU to SWB via social capital. The structural models are as follows:

$$SC_{r,i} = \alpha_{r,i} MLU_{r,i} + \sum \alpha_{be,r,i} BE_{r,i} + \sum \alpha_{sd,r,i} SD_i + \varepsilon_{r,i} \quad (2)$$

$$SC_{w,i} = \alpha_{w,i} MLU_{w,i} + \sum \alpha_{be,w,i} BE_{w,i} + \sum \alpha_{sd,w,i} SD_i + \varepsilon_{w,i} \quad (3)$$

$$SWB_i = \beta_{r,i} MLU_{r,i} + \beta_{w,i} MLU_{w,i} + \beta_{scr,i} SC_{r,i} + \beta_{scw,i} SC_{w,i} + \sum \beta_{be,n,i} BE_{n,i} + \sum \beta_{sd,m,i} SD_{m,i} + \varepsilon_i \quad (4)$$

where SWB_i is the dependent variable and indicates participant i's subjective well-being. SC is the mediator, and the subscripts r and w indicate the variables measured in residential and workplace neighborhoods, respectively. MLU_r and MLU_w are key independent variables and indicate MLU in residential and workplace neighborhoods, respectively. BE and SD represent other built environmental and sociodemographic attributes, respectively. α and β are the regression coefficients, and ε is the residual error. All exogenous variables are assumed to be correlated with each other in SEM.

We performed four robustness checks to examine whether the main findings were stable. In the first robustness model, we changed the radius of buffers from 1000 m to 1500 m to address the potential modifiable areal unit problem. The 1500-m circular buffer was selected because it roughly corresponded to the area of a 20-min neighborhood (Gower & Grodach, 2022). In the second robustness model, we removed participants with a commuting distance of less than 2 km, which ensured that the participants' residential and workplace neighborhoods did not overlap. In the third robustness model, we removed participants who had resided/worked in residential/workplace neighborhoods for less than one year, which helped to address the self-selection issue. In the fourth robustness model, we recalculated MLU by recategorizing the 17 types of POIs into three types (i.e., live, work, and visit) (Dovey & Pafka, 2017; Nabil & Eldayem, 2015), which helped to reduce biases from measurement.

The data had a nested and cross-classified structure because the participants were nested within the same residential neighborhood or workplace neighborhood. However, the null and cross-classified multilevel model showed that the intraclass correlation coefficients (ICCs) in both residential and workplace neighborhoods were less than 0.06 ($ICC_r = 0.02$, $ICC_w = 0.03$), suggesting that the problem of individual spatial dependency had trivial effects on the estimations (Snijders & Bosker, 2011). Hence, we did not employ cross-classified multilevel SEM.

3. Results

3.1. Descriptive statistics

As presented in Table 1, we illustrate the built environmental characteristics in residential and workplace neighborhoods. Compared to workplace neighborhoods, residential neighborhoods had higher degrees of MLU and shorter distances to the city center. However, residential neighborhoods had a lower population density and floor area ratio, fewer subway stations, bus stops, and parks, and smaller green and water areas. We did not find significant differences in road density between residential and workplace neighborhoods.

Figs. 3 and 4 illustrate the mean of each item of SWB and social capital. The mean score of SWB items was approximately 5 points, which suggested that on average, participants somewhat agreed with these SWB-related statements. The average values of social capital items around residential neighborhoods were between 3.6 and 3.8, slightly lower than the values for workplace neighborhoods, which were between 3.7 and 3.9. On average, participants' workplace social capital was slightly higher than their residential social capital.

Table 2 describes the participants' sociodemographic characteristics. Males accounted for 46 % of the total participants. The participants were 39 years old on average with 14 years of education. They were mainly local and married, accounting for 76 % and 77 %, respectively. On average, each household had three people, including two employees and one child. The participants' average household income was approximately 182,200 yuan per year. On average, the participants had resided in residential neighborhoods for 12 years, and 79 % of the participants were house owners. In terms of the participants' type of work, technicians and professionals, clerks and leaders of organizations, business and service workers, and agriculture and manufacturing staff accounted for 20 %, 33 %, 35 %, and 12 %, respectively. The participants had worked in their workplace neighborhoods for an average of 11 years and spent approximately 43 h working per week. The average one-way commuting distance was approximately 6.87 km.

Table 2
Participants' sociodemographic characteristics.

Variable	Mean/%	Std. Dev.
Male (vs. female)	46 %	—
Age (years old)	39.45	10.18
Local hukou (vs. others)	76 %	—
Years of education (years)	13.99	2.56
Married (vs. others)	77 %	—
Household size (count)	2.95	1.02
Number of employees (count)	2.03	0.70
Number of children (count)	0.81	0.60
Household income (10,000 yuan)	18.22	12.25
House owner (vs. renter)	79 %	—
Years at current residence (years)	12.34	9.80
Work type		
Technicians and professionals	20 %	—
Clerks and leaders of organizations	33 %	—
Business and service workers	35 %	—
Agriculture and manufacture staffs (reference group)	12 %	—
Years at current workplace (years)	10.69	9.85
Working hours (h)	42.76	11.07
Commuting distance (km)	6.87	8.16

3.2. Model results

Table 3 presents the standardized coefficients of SEM adjusted by other built environmental and sociodemographic characteristics. The goodness-of-fit indices showed that the SEM had a good model fit. Specifically, the CFI was greater than 0.9, the SRMR was smaller than 0.08, and the RMSEA was smaller than 0.08 (Gana & Broc, 2019).

In residential neighborhoods, MLU was the only significant built environmental variable that was negatively associated with social capital. Females and married participants were likely to have higher residential social capital. The number of years at the current workplace had a positive association with residential social capital.

In workplace neighborhoods, MLU was also the only significant built environment variable and was positively correlated with social capital, which was opposite to the finding in residential neighborhoods. Household size was positively related to workplace social capital. The number of years at the current residence and commuting distance had negative relationships with workplace social capital.

Both residential and workplace social capital were positively associated with SWB, but residential social capital had approximately triple the effect size of workplace social capital. After controlling for social capital, workplace MLU still had a positive and direct association with SWB, but residential MLU had a nonsignificant and direct relationship with SWB. Moreover, longer distances from residential neighborhoods to the city center had a negative association with SWB, whereas longer distances from workplace neighborhoods to the city center had a positive relationship with SWB. Fewer parks and larger water areas in residential neighborhoods were positively associated with SWB, while larger water areas in workplace neighborhoods were negatively correlated with SWB. Additionally, males tended to have lower SWB than females. Participants who had fewer years of education and higher household income reported higher SWB. Households with a higher number of employees had a positive relationship with SWB. A longer commuting distance was detrimental to SWB.

Fig. 5 presents the direct, indirect, and total associations of residential and workplace MLU with SWB. In residential neighborhoods, MLU had a negative correlation with social capital, and social capital had a positive relationship with SWB. Hence, residential social capital was a mediator between residential MLU and SWB, and its effect size was −0.250 ($-0.250 = -0.854*0.293, p < 0.05$). The direct relationship between residential MLU and SWB was also negative ($\beta = -0.540$) but

Table 1
Built environmental characteristics between residential and workplace neighborhoods.

	Residential neighborhood		Workplace neighborhood		Difference
	Mean	Std. Dev.	Mean	Std. Dev.	T test
Mixed land use	0.79	0.07	0.75	0.11	0.04***
Population density (10,000 people/km^2)	1.61	0.95	1.68	1.02	−0.07*
Floor area ratio	4.31	0.85	4.39	1.10	−0.08*
Road density (km/km^2)	1.95	0.82	1.98	0.80	−0.03
Distance to the city center (km)	11.00	6.12	11.50	9.31	−0.50+
Number of subway stations (count)	4.47	4.95	5.74	6.61	−1.27***
Number of bus stops (count)	23.21	8.24	25.27	11.49	−2.06***
Number of parks (count)	3.38	3.43	3.76	3.57	−0.38**
Green space area (km^2)	0.08	0.09	0.11	0.12	−0.02***
Water area (km^2)	0.08	0.06	0.10	0.13	−0.02***

Note: $^{+}\ p < 0.1$, $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

Table 3
The standardized results of SEM.

	RSC	WSC	SWB
Mediators			
Residential social capital			0.293***
Workplace social capital			0.090*
Mixed land use			
Residential mixed land use	−0.854*		−0.540
Workplace mixed land use		0.718**	0.521+
Built environmental attributes			
In residential neighborhoods			
Population density	−0.005		−0.059
Floor area ratio	0.001		−0.085
Road density	0.039		−0.010
Distance to the city center	0.013		−0.024*
Number of subway stations	0.004		0.001
Number of bus stops	0.006		0.010
Number of parks	−0.007		−0.033*
Green space area	−0.161		0.495
Water area	0.122		1.098*
In workplace neighborhoods			
Population density		−0.050	0.055
Floor area ratio		0.003	−0.018
Road density		0.035	−0.064
Distance to the city center		0.009	0.013*
Number of subway stations		0.008	−0.001
Number of bus stops		−0.004	0.003
Number of parks		0.010	0.007
Green space area		−0.239	−0.134
Water area		0.301	−0.349+
Sociodemographic attributes			
Male	−0.082+	−0.064	−0.104*
Age	−0.001	0.000	−0.006
Local hukou	−0.080	0.052	0.113
Years of education	−0.006	−0.002	−0.029*
Married	0.134+	0.086	0.055
Household size	0.003	0.054+	−0.035
Number of employees	−0.009	−0.054	0.077+
Number of children	−0.029	−0.049	0.023
Household income	−0.002	−0.003	0.007**
House owner	−0.043	−0.084	0.111
Years at current residence	0.000	−0.007*	−0.002
Technicians and professionals	−0.066	−0.040	0.107
Clerks and leaders of organizations	0.062	0.030	−0.011
Business and service workers	−0.012	−0.023	−0.032
Years at current workplace	0.005+	0.003	0.000
Working hours	0.002	0.001	−0.002
Commuting distance	−0.004	−0.018***	−0.015***
N	1028		
CFI	0.913		
SRMR	0.044		
RMSEA	0.042		

Note: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. RSC: residential social capital; WSC: workplace social capital; SWB: subjective well-being.

was nonsignificant after controlling for the mediating effects of residential social capital. In workplace neighborhoods, MLU had a positive correlation with social capital, and social capital had a positive relationship with SWB. Therefore, workplace social capital was also a mediator between workplace MLU and SWB, and its mediation effect size was 0.065 (0.065 = 0.718*0.090, $p < 0.1$). However, this mediation effect size was much lower than the direct effect size of workplace MLU on SWB. Regarding the total effects, workplace MLU was positively related to SWB, whereas residential MLU was negatively but nonsignificantly correlated with SWB ($p = 0.102$).

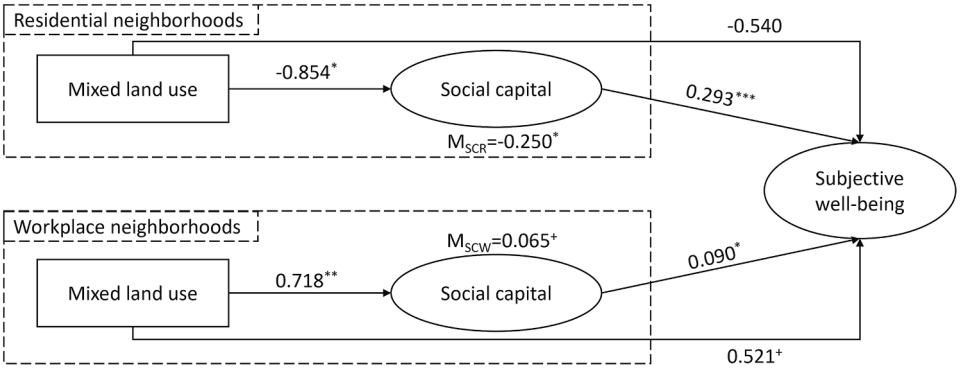
3.3. Robustness checks

We conducted four robustness models to test whether the main findings were robust (Table 4). The results of these robustness models confirmed that social capital mediated the associations between MLU and SWB. In particular, residential MLU had a negative association with residential social capital, leading to lower SWB. However, workplace MLU was positively related to workplace social capital, resulting in higher SWB. These results were in line with the findings in the baseline model, suggesting that our findings were robust.

4. Discussion

Our study is one of the first to explore the mediating effects of social capital on the relationship between MLU and SWB in residential and workplace neighborhoods. It contributes to current knowledge by providing a new pathway from MLU to SWB and a new perspective to understand the MLU-SWB association in different spatial contexts. The SEM results showed several interesting findings. First, in residential and workplace neighborhoods, MLU had opposite associations with social capital. Second, social capital in both residential and workplace neighborhoods was positively related to SWB, although the former had a larger effect size. Third, social capital was a mediator of the MLU-SWB relationship.

In residential neighborhoods, we observed that MLU had a negative correlation with social capital. This result contradicts some new urbanism studies that have suggested that MLU is conducive to shaping formal or informal social capital by promoting active travel (Lund, 2003; Mazumdar et al., 2017). However, our result is in accordance with some previous findings in the U.S. (Kamruzzaman et al., 2014), Australia (Wood et al., 2008), and China (Sun et al., 2022a), which argued that MLU could promote more facilities that curb residents' social interactions (Kamruzzaman et al., 2014; Sun et al., 2022a; Wood et al., 2008). For example, more alcohol outlets were found to have a negative correlation with the perception of neighborhood safety, leading to lower social capital in residential neighborhoods (Theall et al., 2009).



Note: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The model is adjusted for other built environments and sociodemographic characteristics. Full results of direct effects are in line with Table 3.

Fig. 5. Direct and indirect effects of mixed land use in residential and workplace neighborhoods on subjective well-being.

Table 4
The results of robustness models.

	Model 1			Model 2			Model 3			Model 4		
	RSC	WSC	SWB	RSC	WSC	SWB	RSC	WSC	SWB	RSC	WSC	SWB
Mediators												
RSC			0.297***			0.308***			0.279***			0.291***
WSC			0.078+			0.093+			0.113*			0.091*
Mixed land use												
Residential mixed land use	−1.490**		−0.342	−1.533**		−0.701	−0.981*		−0.491	−0.376+		−0.372
Workplace mixed land use		0.875**	0.484		0.694*	0.318		0.710**	0.521+		0.471***	0.310*
Residential built environment	Yes		Yes	Yes		Yes	Yes		Yes	Yes		Yes
Workplace built environment		Yes	Yes		Yes	Yes		Yes	Yes		Yes	Yes
Sociodemographic attributes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1028			730			871			1028		
CFI	0.913			0.916			0.912			0.913		
SRMR	0.044			0.046			0.042			0.044		
RMSEA	0.042			0.042			0.043			0.042		

Note: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. RSC: residential social capital; WSC: workplace social capital; SWB: subjective well-being. Model 1 changed the radius of buffers from 1000 m to 1500 m. Model 2 excluded participants with a commuting distance of less than 2 km. Model 3 excluded participants who had resided/worked in residential/workplace neighborhoods for less than one year. Model 4 recalculated the mixed land use index by recategorizing the 17 types of POIs into three types.

Industrial land use around residential neighborhoods often induces health hazards (Nabil & Eldayem, 2015), which hinder social capital (Brown, 2022). Moreover, MLU is often accompanied by more nuisances, such as crowdedness and noise (Cao, 2016), which are another cause of lower social capital (Churchman, 1999; Honold et al., 2014). Furthermore, many visitors outside the residential neighborhood may come to use amenities in mixed-use neighborhoods and leave the neighborhood after their visit, which might be detrimental to residents' sense of neighborhood belonging and familiarity by reducing their privacy and safety (Nabil & Eldayem, 2015; Wood et al., 2010). This may lead to more impersonal social ties and lower social capital (Mouratidis & Poortinga, 2020).

However, MLU had a positive correlation with social capital in workplace neighborhoods. This suggests that the proposition of increasing land use diversity by new urbanism may be more effective in workplace neighborhoods. This may be because people's needs for residential and workplace neighborhoods are different. In contrast to people's needs for safety and leisure in residential neighborhoods, the accessibility of destinations is most favored by people in workplace neighborhoods (Sun et al., 2022b). People who work in mixed-use neighborhoods have a higher likelihood of walking to surrounding destinations (Yang et al., 2022), such as clubs, bars, recreational areas, and other "third places," which play an important role in forming informal social interactions and social ties (Svendsen, 2010). Moreover, MLU in workplace neighborhoods is related to less sedentary behavior and more physical activity (Lin et al., 2020), which may also be important to facilitate socializing with people around workplaces (Hassmén et al., 2000).

Social capital, whether in residential or workplace neighborhoods, was positively related to SWB, which was in line with the literature (Hoogerbrugge & Burger, 2018; Sun et al., 2022b). Stronger residential social capital indicates more social ties with neighbors and a higher degree of social cohesion, leading to higher levels of SWB (Hommerich & Tiefenbach, 2018; Huppert et al., 2004). Stronger workplace social capital may help workers unwind from busy working hours and relieve their stress and fatigue, which is beneficial to SWB (Ilies et al., 2015). Notably, residential social capital played a more important role in promoting SWB than workplace social capital, as supported by a previous study (Sun et al., 2022b). This may be because people's daily activities mainly occur in residential neighborhoods (Li & Tong, 2016).

Social capital has been found to mediate the association between MLU and SWB since MLU is related to social capital and social capital is related to SWB. Mixed-use residential neighborhoods were negatively and indirectly associated with SWB because they reduced residents' social capital. Mixed-use workplace neighborhoods were positively and indirectly correlated with SWB because they improved workers' social capital. Moreover, MLU in workplace neighborhoods had a total positive correlation with SWB, in line with empirical findings in Beijing (Wu et al., 2022). This indicates that MLU and various facilities in workplace neighborhoods are important for workers' perceived quality of life. However, we did not observe a significant and total association of residential MLU with SWB, as supported by a study in Beijing (Dong & Qin, 2017). One possible reason is that the opposite effects of MLU in residential and workplace neighborhoods cancel each other out (Cao, 2016).

Other than MLU, we did not find that built environmental attributes were associated with social capital in residential and workplace neighborhoods. After controlling for social capital, distance to the city center had opposite relationships with SWB in residential and workplace neighborhoods. In particular, people who lived closer to the city center reported higher levels of SWB, while people who worked farther from the city center tended to have lower levels of SWB. This could be attributed to the Chinese context, which is characterized by higher residential quality in the inner city but better workplace environments away from the city center (Han et al., 2018; Xu et al., 2022). Water areas also had opposite relationships with SWB in residential and workplace neighborhoods. More water areas in residential neighborhoods promoted SWB, consistent with the literature (Cheng et al., 2021; White et al., 2021). However, more water areas in workplace neighborhoods reduced SWB. This may be because water areas are natural obstacles to destination accessibility in workplaces, leading to lower SWB. Additionally, more parks in residential neighborhoods were negatively associated with SWB, which is counterintuitive. A possible reason is that a higher number of parks in residential neighborhoods is positively related to housing prices (Wu et al., 2017), which is unfavorable for SWB due to housing debt (Liu et al., 2020b).

Our findings may enlighten policymakers in other countries with contexts similar to China in planning livable and sustainable cities and achieving sustainable development goals. First, given that social capital is a mediator between MLU and SWB, policymakers need to create more places to facilitate social interactions, which will also improve people's happiness and contribute to achieving Sustainable Development Goal 3. Second, urban planners need to realize that MLU is a double-edged sword: it may promote inhabitants' SWB by enhancing their social capital in workplaces but decrease their SWB by reducing social capital in residences. Therefore, policymakers should pay more attention to local contexts rather than simply advocating or discouraging intervention in MLU. In neighborhoods with mainly employment functions, particularly suburban workplaces, it is necessary to increase MLU because it is conducive to improving destination accessibility and

reducing travel duration, which is beneficial to developing local social capital and enhancing employees' quality of life. With the increasing degree of mixed land use, planners need to pay close attention to the negative effects of mixed land use. In neighborhoods with mainly residential functions, a moderate MLU should be adopted to avoid the negative effect of mixed land use, and planners need to focus on whether the positive effect of mixed land use remains effective. This is supported by the current planning guidelines in Shanghai, which highlight the relocation of noncore functions in some neighborhoods. Moreover, in neighborhoods with mixed residences and workplaces, policymakers should find suitable thresholds of MLU to promote residents' SWB and avoid ineffective interventions in land use mixes for the population as a whole.

The limitations of this study are as follows. First, we cannot infer causality from a cross-sectional design. It is recommended that longitudinal data should be collected to identify causal relationships between MLU and SWB. Second, we focused only on the mediating effect of social capital and ignored other potential mediators. Future studies may examine more pathways from MLU to SWB and identify the net effect of MLU. Third, our findings in the high-density context of China may not be generalizable to other contexts. Evidence from other countries is needed to cross-validate our findings. Fourth, our findings based on the linear assumption can only identify the general trend of MLU on social capital and SWB but cannot identify the appropriate threshold of MLU. Future studies may seek more evidence on the appropriate threshold and identify whether the appropriate threshold of MLU differs in spatial contexts. Finally, the measurement of social capital in the workplace neighborhood is directly transformed from the scale of social capital in the residential neighborhood, which may be biased and may omit some types of workplace social capital. Considering that limited research has focused on social capital in workplace neighborhoods, we encourage scholars to develop a more appropriate scale to measure social capital in workplace neighborhoods to cross-validate our findings.

5. Conclusions

To accomplish the Sustainable Development Goals and the thriving development of cities and society, urban planners aim to enhance citizens' SWB through built environment interventions. We explore the relationship between MLU and SWB and identified the mediating effect of social capital considering the spatial heterogeneity in residential and workplace neighborhoods. Based on the Shanghai sample, we find that MLU has opposite associations with SWB in residential and workplace neighborhoods through the mediating effect of social capital. Residential MLU hinders SWB by decreasing residential social capital, while workplace MLU improves SWB by enhancing workplace social capital. Moreover, after controlling for social capital, workplace MLU has a direct and positive correlation with SWB, but residential MLU is not significantly directly related to SWB. These findings indicate that social capital mediates the relationship between MLU and SWB and that MLU has different effects on social capital and SWB in different spatial contexts (i.e., residential and workplace neighborhoods). Therefore, intervening in neighborhood land use and enhancing social capital are important strategies to build livable cities, although MLU is not a panacea for building happy neighborhoods in all contexts.

Funding

This work was supported by the [National Natural Science Foundation of China] under Grant [No. 42071210 and No. 42101184], the [Chenguang Program of Shanghai Education Development Foundation and Shanghai Municipal Education Commission] under Grant [No. 22CGA27], and the [Fundamental Research Funds for the Central Universities] under Grant [No. 2022ECNU-XWK-XK001].

CRediT authorship contribution statement

Chun Yin: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Jiahang Liu:** Formal analysis, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Shaoqing Dai:** Data curation, Investigation, Methodology. **Bindong Sun:** Data curation, Funding acquisition, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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