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How Community-Built Environment and Social Capital Are Jointly Associated with Multidimensional Health in China: A Compensatory–Synergy Perspective

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Abstract

Community social capital (CSC) and the community-built environment (CBE) are key resources associated with residents' health, yet their combined associations with multidimensional health and well-being remain insufficiently understood. Drawing on large-scale data from the 2018 China Labor-force Dynamics Survey, this study analyzed a filtered sample of 14,127 respondents nested within 326 communities and employed multilevel models to examine the direct, interactive, and combined associations of CSC and CBE on four outcomes: residents' self-rated health, subjective well-being, loneliness, and mental health. The results identified two CSC indicators: neighborhood mutual support and resident relationship quality, and two CBE indicators: community type and residential density, as key factors associated with multidimensional health, each showing significant associations with multiple health outcomes, with CSC indicators demonstrating relatively stronger and more consistent effect sizes than CBE indicators. The study further identified a dual mechanism involving key indicators of CSC (relationship quality and neighborhood mutual support) and CBE (community type and residential density). When one dimension was constrained, the other was associated with compensatory patterns in residents' health, whereas high levels of both social and physical resources were associated with synergistic advantages. Stratified analyses revealed that individuals with low external social engagement appeared more sensitive to these environmental associations. This study emphasizes that sustainable community planning and governance should consider key social and physical indicators to support both social sustainability and built-environment sustainability. Depending on the level of community resources, it may be beneficial to leverage the compensatory and synergistic patterns among different community attributes to support improvements in residents' health benefits. Particular attention may be warranted for individuals with low social engagement to build healthier and more sustainable communities. This research advances an integrated resource configuration framework that contributes to a shift in urban health governance from isolated environmental interventions toward an adaptive, balanced approach.

Keywords: community social capital; community-built environment; multidimensional health; synergy mechanisms; social engagement heterogeneity

Academic Editor: Gianpiero Greco

Received: 19 January 2026
Revised: 1 April 2026
Accepted: 2 April 2026
Published: 5 April 2026

1. Introduction

In recent years, improving population health has become a central concern of the United Nations Sustainable Development Goals (SDGs) [1]. Health is a multidimensional

 https://doi.org/10.3390/su18073564

construct, encompassing not only physical conditions but also mental well-being and social relationships [2]. Amidst growing global health challenges, the influence of residential environments on health has gained prominence [3]. In rapidly urbanizing China, in particular, issues such as health disparities, community transformation, and urban–rural heterogeneity have drawn widespread attention to residents' health status and the determinants of community resources [4,5]. How to improve multidimensional health through community-level resource allocation and governance has therefore emerged as a key question in urban sustainability and public health research [6], particularly in the context of building inclusive, resilient, and sustainable communities.

Among the multiple determinants of health, community social capital (CSC) and the community-built environment (CBE) stand out as two essential yet qualitatively distinct resources. Social capital refers to neighborhood support, social cohesion, mutual aid networks, and collective efficacy [7], which foster cooperation and reciprocity and in turn generate health benefits [8]. Existing studies examine social capital across different levels—individual, family, community, city, and national [9]—with level-specific measurement and analytical strategies. At the community-aggregate level, collective social capital captures the structural and relational resources embedded in communities [10]. This includes platforms for social participation (e.g., local organizations, community events), the quality of interpersonal relations, and overall community cohesion, reflecting the provision of "soft" social resources at the aggregation level [11].

Empirical evidence links higher CSC to better health through multiple mechanisms. Social networks provide emotional support and health information, thereby alleviating psychological and cognitive stress [12,13]. Furthermore, community cohesion and mutual trust facilitate collective action that enhances public services and safety, indirectly improving health outcomes [14,15]. Numerous studies associate CSC with improved physical functioning [5], greater well-being [16], lower levels of depression [17] and loneliness [18]. Conversely, disorganized communities, lack of social cohesion, or community poverty are often associated with poorer health [19].

In contrast to this "soft" environment, the CBE functions as the "hard" environment, directly shaping residents' lifestyles and health opportunities. The CBE typically encompasses factors such as population density, facility diversity, and accessibility of public spaces [20]. A high-quality built environment fosters health-promoting behaviors—for example, increasing opportunities for physical activity [21,22], ensuring convenient access to medical, commercial, and public facilities [8,23], and improving air quality and noise conditions [24]. Moreover, well-designed public spaces and infrastructure create physical platforms for social interaction, thereby fostering social connectedness and psychological well-being [25,26].

Nevertheless, several gaps remain. Most studies examine CSC and CBE separately in relation to health, while systematic investigations of their interactive and joint effects are still limited. Even in the limited body of research that considers both social and built environments, the typical design is to include them in parallel, with little attention paid to whether and how they work together to influence health [27–29]. Building on the buffering theory of social support [30,31] and prior empirical evidence [32,33], this study propose a set of expectations that when the physical environment is constrained, CSC may compensate for health risks through support, mutual aid, or social networks; when social capital is insufficient, a high-quality built environment (e.g., appropriate density and accessible public spaces) may offset the lack of social ties by providing alternative opportunities for interaction and restorative experiences. When both are at high levels, synergistic effects may emerge. Given the distinct roles of the built and social environments, as well as the potential complexity of their impacts on health outcomes, a comprehensive assessment is needed to advance a fuller understanding of this gap.

At the same time, most studies on community environments focus on single-dimensional health outcomes, such as depressive symptoms [34], obesity [35], or physical frailty [36]. Yet health is inherently multidimensional, encompassing physical health, mental well-being, and social connectedness [37]. Concentrating on a single outcome may limit our understanding of how social and material resources jointly shape overall health and well-being, and may partly overlook critical indicators that simultaneously affect multiple dimensions of health [38]. For example, certain environmental resources may have only limited effects on physical health but play a vital role in mental status, subjective well-being, or loneliness [39]. Therefore, adopting a multidimensional perspective to examine how CSC and CBE separately and jointly influence residents' health is needed to provide a more comprehensive understanding of environment–health relationships. To address the inherent complexity of human health, this study adopts a multidimensional framework that aligns with the WHO's definition of health as a state of complete physical, mental, and social well-being [2]. By integrating four metrics (self-rated health, well-being, loneliness, mental health), the study ensures that the impacts of community resources are not assessed in isolation, but rather across the full spectrum of an individual's life experience, allowing for a more robust evaluation of how CSC and CBE jointly shape health outcomes.

In addition, research on the relationship between community environments and residents' health has predominantly focused on demographic factors (e.g., age [40], gender [41], household income [42]) or macro-level contexts (e.g., urban–rural differences [35], urbanization levels [43]) as moderators, while residents' social behaviors receive little attention. Existing studies suggest that social participation improves cognitive function, quality of life, and physical functioning [44]. It is therefore reasonable to expect that differences in individuals' external social engagement may also shape their reliance on community resources, thereby modifying the "community environment–health" relationship [45]. For instance, residents with high levels of external social engagement may rely more on individual or cross-community resources to maintain health, making them less dependent on community-level social capital and the built environment, whereas those with lower external engagement may show the opposite pattern. However, systematic empirical evidence on this issue remains limited. This limitation constrains our understanding of the mechanisms linking community environments and health and hampers targeted policy design.

Based on these theoretical underpinnings, this study proposes three hypotheses: (H1) CSC and CBE are significantly associated with multidimensional health; (H2) CSC and CBE exhibit compensatory and synergistic associations in relation to health outcomes; and (H3) these associations are moderated by individuals' external social engagement. This study offers three primary incremental contributions. First, it investigates the complex interplay between "soft" and "hard" community resources, revealing mechanisms of compensation and synergy. Second, it adopts a holistic multidimensional health perspective, ensuring a robust evaluation across physical, mental, and social dimensions. Third, by introducing external social engagement as a moderator, it provides a more nuanced understanding of how individual behavioral patterns shape environmental health impacts. These insights aim to inform more targeted and inclusive community sustainability governance.

2. Methods

2.1. Data and Study Sample

The data from the most recent wave (2018) of the China Labor-force Dynamics Survey (CLDS) (http://css.sysu.edu.cn/Data, accessed on 5 December 2025) was used for this study. The CLDS is a nationally representative survey of China's labor force conducted by the Center for Social Science Survey at Sun Yat-sen University. It covers both urban and rural areas nationwide, and employs a stratified, multistage sampling design to systematically monitor and construct data at multiple levels, including individuals, households, and communities. CLDS's survey weights were not applied in this analysis since the primary objective was to estimate associations rather than population-level parameters, and the multilevel modeling framework already accounts for clustering at the community level. For this study, 791 participants under the age of 18 and 1274 cases lacking community-level social or physical environment data were firstly excluded. Also, 345 cases without essential demographic or health information were further excluded. The final analytic sample consisted of 14,127 participants with complete information. The analytic sample was drawn from 326 communities across 130 Chinese cities. On average, there were 43.47 respondents per community (SD = 17.32) and 108.67 respondents per city (SD = 69.75). Detailed descriptive statistics at both the community and individual levels are reported in Table 1.

Table 1. Variable system and sample statistical characteristics.

Dimensions	Variables/Indicators	Description	Mean (SD)/n (%)
-	Multidimensional health outcome		
	Self-rated health	5-point Likert scale, score range: 1–5	3.616 (0.999)
	Subjective well-being		3.787 (0.874)
	Loneliness	4-point Likert scale, score range: 1–5	3.670 (0.628)
	Mental health	Total score of 20 items (based on 4-point Likert scale), score range: 20–80	52.408 (9.157)
Social participation	Community social capital		
	Total number of social organizations		2.516 (7.703)
	Total number of annual community activities		16.333 (23.670)
Social networks	Community resident relationship quality	5-point Likert scale, score range: 1–5	4.145 (0.663)
Social support	Neighborhood mutual support	Calculated the average of all individual responses within a community, score range: 1–5	4.532 (0.593)
Public safety	Community public security status	4-point Likert scale, score range: 1–4	3.667 (0.415)
	Community-built environment		
Community spatial context	Community type		
	Urban community, n (%)	Rural community = 0, urban community = 1	4497 (31.833%)
	Rural community, n (%)		9630 (68.167%)
Density	Community residential density	Unit: persons per square kilometer	6.511 (26.171)
Diversity	Community facility diversity	Based on ten types of community public facilities	5.701 (2.320)
Destination accessibility	Distance to the nearest square/park	Unit: kilometer	7.376 (16.331)
Environmental burden	Community air pollution level	5-point Likert scale, score range: 1–5	2.985 (0.450)
	Community noise pollution level		3.067 (0.445)

Table 1. *Cont.*

Dimensions	Variables/Indicators	Description	Mean (SD)/n (%)
-	External social engagement level (Eating-out frequency)		
	Low external social engagement group	Mean < 3	12,104 (85.680%)
	High external social engagement group	Mean ≥ 3	2023 (14.320%)
-	Covariates		
	Age		53.556 (14.367)
	Gender		
	Female	Female = 0, male = 1	7431 (52.601%)
	Male		6696 (47.399%)
	Local household registration (Hukou)		
	Local household registration, n (%)	Local household registration = 0	12,599 (89.184%)
	Non-local household registration, n (%)	Non-local household registration = 1	1528 (10.816%)
	Annual household income	Unit: Chinese yuan	69,026.994 (111,647.372)
	Marital status		
	Married, n (%)	Married = 0, unmarried = 1	11,778 (83.372%)
	Unmarried, n (%)		2349 (16.628%)
	Educational level		
	No formal education		1528 (10.816%)
	Basic education	Primary school, traditional private school, junior high school	8296 (58.724%)
	Secondary education	General high school, vocational high school, technical school, secondary technical school	2419 (17.123%)
	Higher vocational education	Junior college	874 (6.187%)
	Higher education	Bachelor's, master's, doctorate	1010 (7.149%)
	BMI		22.748 (3.437)
	Household size		4.547 (2.072)
	Smoking status		
	Not smoking	Not smoking = 0, smoking = 1	10,864 (76.902%)
	Smoking		3263 (23.098%)
	Drinking status		
	Not Drinking	Not drinking = 0, drinking = 1	9339 (66.107%)
	Drinking		4788 (33.893%)
	Regular physical exercise status		
	No regular exercise	No regular exercise = 0, exercise regularly = 1	11,808 (83.585%)
	Exercise regularly		2319 (16.415%)
	Household internet access status		
	No network access	No network access = 0, network access = 1	3096 (21.915%)
	Network access		11,031 (78.085%)
	Car ownership in the household		
	No car	No car = 0, owns car(s) = 1	9657 (68.358%)
	Owns car(s)		4470 (31.642%)
	Secondhand smoke exposure status		
	No exposure to secondhand smoke	No exposure to secondhand smoke = 0, exposure to secondhand smoke = 1	6503 (46.032%)
	Exposure to secondhand smoke		7624 (53.968%)

2.2. Variables

As described earlier, four outcome variables—self-rated health, mental health, subjective well-being, and loneliness—were analyzed to capture individuals' multidimensional health and well-being across the physical, psychological, and social domains [2,46]. In this study, self-rated health indicates overall health, including physical and mental conditions and chronic disease status. Mental health was measured using a 20-item CLDS scale (see Supplementary Material S2). The internal consistency of the scale in the present sample was high (Cronbach's $\alpha = 0.89$). Loneliness reflects the perceived quality and satisfaction of social interactions. Subjective well-being assesses life satisfaction. All outcome variables were coded in the same direction, with higher scores indicating better health and well-being. Supplementary Material S2 provides detailed information on the wording and coding of the four individual-level outcomes, as well as all community-level variables described below from the CLDS questionnaire.

Community-level explanatory variables were primarily drawn from the CLDS community questionnaire (see Table 1). Following the '3D' built environment framework and based on data availability, this study considered five domains of the CBE: community spatial context, density, diversity, destination accessibility, and environmental burden. Specifically, the community type indicates whether a community is in an urban or rural context. Residential density was calculated as the ratio of population to land area. To measure facility diversity, ten common public facilities (kindergarten, primary school, middle school, sports facilities, senior activity rooms, libraries or reading rooms, squares or parks, playgrounds, hospitals or private clinics, and banks or credit cooperatives) were included. Each facility was coded as 1 if present and 0 if absent, and the total score represented the diversity of facilities in a community. Distance to the nearest square/park captured accessibility to public space. In addition, air and noise pollution levels were considered as an indicator of environmental burden.

Correspondingly, CSC was assessed as the community's capacity to provide a "soft" environment. Following established frameworks [33,47], CSC was measured across four dimensions: social participation, social support, social networks, and public safety. Specifically, the total number of social organizations reflected the number of organizations located or active within the community. The total number of annual community activities captured both volunteer-based and community-led activities open to residents. The resident relationship quality reflected the harmony of interpersonal ties among residents. The neighborhood mutual support indicator captured the extent of mutual assistance among residents in the community and was operationalized as a community-level measure by averaging individual responses within each neighborhood. To validate the aggregation approach, intraclass correlation coefficients (ICC) were calculated for aggregated variables. The ICC value was 0.18, indicating adequate between-community variation and justifying the aggregation of individual perceptions to the community level.

External social engagement, which in this study refers to residents' participation in activities outside the community, was assessed using three items from the CLDS 2018 questionnaire that captured the frequency of eating out in different contexts: (1) inviting others for a meal, (2) being invited to eat out, and (3) accompanying friends to eat out. Each item was rated on a five-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = very often). This operationalization is based on the assumption that dining-out activities represent a common and observable form of informal social interaction in daily life, reflecting individuals' engagement in face-to-face social exchanges beyond the community. The wording of these items and response options is provided in Supplementary Material S2. For each participant, the mean of the three items (excluding missing or "not applicable" responses) was calculated. Based on the scale semantics, an average score of 3 ("sometimes") was used as an a priori cut-off point to distinguish relatively infrequent social engagement ("never" or "rarely") from more regular engagement ("sometimes," "often," or "very often"). The three items demonstrated excellent internal consistency

(Cronbach's α = 0.962) [48]. In addition, exploratory factor analysis (EFA) supported a clear single-factor structure (Eigenvalue = 2.631), with all items loading strongly on one factor, indicating good unidimensionality. All three items exhibited exceptionally strong factor loadings on this latent construct, ranging from 0.929 to 0.948. These results support the reliability and construct validity of using these items as a composite proxy for external social engagement.

Participants with an average score < 3 were classified into the low external social engagement group, while those with an average score ≥ 3 were classified into the high social engagement group. In the analytic sample, 85.7% of respondents were classified into the low engagement group, reflecting the generally low frequency of dining-out activities in the survey population. In addition, a series of covariates relevant to residents' health and well-being, covering socioeconomic status, family environment, and health-related behavioral characteristics, was included. Details are provided in Table 1. Explanatory variables and covariate indicators were standardized using the Z-score before being included in the model.

2.3. Analytical Framework and Models

Respondents were nested within communities, and members of the same community shared the same CSC and CBE values. Given this hierarchical structure, two-level multilevel models with individuals (Level 1) nested in communities (Level 2) were estimated. This framework allows community-specific baselines (random intercepts), includes individual- and community-level covariates, and accommodates interaction terms to assess within- and cross-level moderation and joint effects. To test for the presence of group clustering effects, we first calculated the ICC based on the null model. The ICC values for self-rated health, subjective well-being, loneliness, and mental health were 0.195, 0.253, 0.157, and 0.155, respectively, all greater than 0.1. This indicates that individual health outcomes exhibit intra-group clustering at the community level, thereby justifying the use of a two-level model for analysis [43,49].

A three-step strategy was used to identify the effects of CSC and CBE on residents' multidimensional health and to test tolerance–synergy mechanisms (Figure 1). First, direct associations were examined to identify significant factors; interaction effects indicated possible synergy or antagonism; and joint effects revealed how specific combinations of CSC and CBE jointly produced patterns of tolerance and synergy. Specifically, in this step, the multilevel model included all CSC and CBE indicators simultaneously to identify their direct associations with residents' multidimensional health and well-being. Second, we added interaction terms between significant CSC and CBE indicators to test for synergy or antagonism in their combined effects. Third, although continuous interaction terms can capture overall effect modification, they do not directly indicate which specific exposure combinations drive the associations. To address this limitation, we applied a joint classification approach that enables direct estimation and comparison of effect sizes across meaningful exposure groups. To more intuitively illustrate the synergistic patterns between CSC and CBE, each significant indicator was dichotomized at its sample median (low vs. high), which ensures balanced group sizes and avoids arbitrary threshold selection. Based on this, four joint exposure groups were constructed: low CSC–low CBE (reference group), low CSC–high CBE, high CSC–low CBE, and high CSC–high CBE. This approach is commonly used in environmental health and epidemiological research to examine joint exposure effects and interaction patterns, as it facilitates clear comparisons across different exposure combinations [50]. In addition, all key findings from the joint exposure analyses were interpreted alongside the results from the continuous models to ensure robustness and consistency. In addition, stratified analyses by external social engagement level (high vs. low) were conducted to further explore whether the relationships among CSC, CBE, and multidimensional health outcomes varied depending on individuals' social participation outside the community.

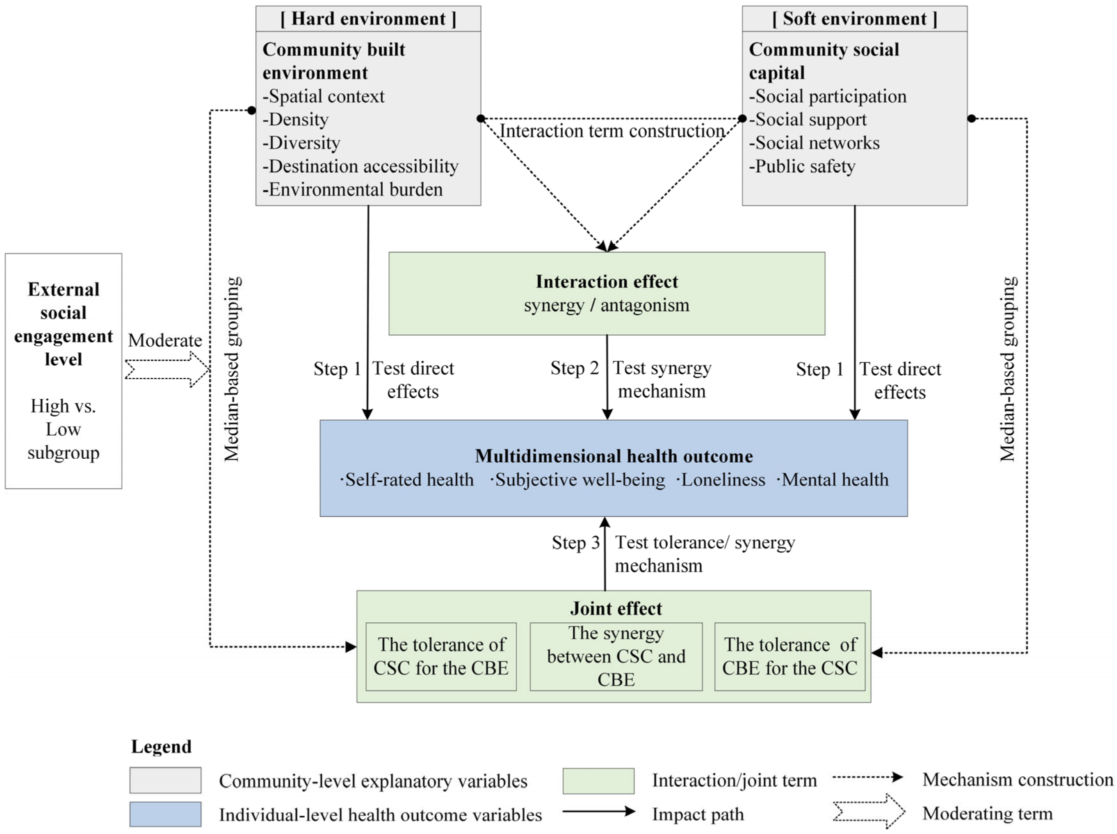

Figure 1. Conceptual framework.

Step 1. Examination of direct associations

For the three ordinal outcome variables (self-rated health, subjective well-being, and loneliness), this study applied a two-level ordinal logistic model to assess the direct associations of CSC and CBE with individual-level outcomes:

$$logit\ P(Y_{ij} \leq c) = \alpha_c + \sum_{p=1}^{P} \beta_p SC_{pj} + \sum_{q=1}^{Q} \gamma_q BE_{qj} + \sum_{r=1}^{R} \delta_r X_{rij} + u_{0j} \quad (1)$$

Here, $logit\ P(Y_{ij} \leq c)$ is the log-odds that individual i in community j attains outcome category c or above. α_c is the intercept at threshold c. $\sum_{p=1}^{P} \beta_p SC_{pj}$ represents the overall associations of P CSC indicators (SC_{pj}), with each coefficient β_p indicating the change in log-odds associated with a one-unit increase in the corresponding indicator. $\sum_{q=1}^{Q} \gamma_q BE_{qj}$ represents the overall effects of Q community-level CBE indicators, with each coefficient γ_q capturing its corresponding effect. $\sum_{r=1}^{R} \delta_r X_{rij}$ reflects the overall effects of R individual-level covariates X_{rij}, with coefficient δ_r indicating its effect size. Finally, u_{0j} is the random intercept at the community level. Effect direction was determined by odds ratio (OR) values with 1 as the cutoff.

Mental health, as a continuous dependent variable, was modeled using a two-level linear regression model:

$$Y_{ij} = \alpha + \sum_{p=1}^{P} \beta_p SC_{pj} + \sum_{q=1}^{Q} \gamma_q BE_{qj} + \sum_{r=1}^{R} \delta_r X_{rij} + u_{0j} + \varepsilon_{ij} \quad (2)$$

where α represents the overall intercept, ε_{ij} denotes the individual-level residual, and the coefficient β_p is directly interpreted as the linear effect, the average change in the dependent variable associated with a one-unit change in the independent variable. The remaining symbols are consistent with those used in the above ordinal logistic model. Effect direction was determined by β coefficient with 0 as the cutoff.

Step 2: Testing the interaction

$$logit\ P(Y_{ij} \leq c) = \alpha_c + \sum_p \beta_p SC_{pj} + \sum_q \gamma_q BE_{qj} + \sum_p \sum_q \theta_{pq} (SC_{pj} \times BE_{qj}) + \sum_r \delta_r X_{rij} + u_{0j} \quad (3)$$

where an additional term $\sum_p \sum_q \theta_{pq} (SC_{pj} \times BE_{qj})$ was introduced into the model to capture the interaction between community-level social capital and built environment indicators. Each coefficient θ_{pq} quantifies how the relationship between a given CSC indicator and the outcome variable varies across different levels of the CBE. Specifically, a statistically significant interaction term with an odds ratio greater than 1 was interpreted as a synergistic interaction, whereas a statistically significant interaction term with an odds ratio less than 1 was interpreted as an antagonistic interaction. Furthermore, due to functional similarity, the two-level linear regression model for continuous dependent variables is not listed separately in Step 2 and Step 3.

Step 3: Testing the joint associations

For each significant CSC–CBE pair, four joint groups were constructed as described above. These joint variables were incorporated into the two-level models to estimate the effect values (OR or regression coefficients) of each group relative to the reference group (low CSC–low CBE). This enabled direct comparisons across different combinations. The specific formula is as follows:

$$logit\ P(Y_{ij} \leq c) = \alpha_c + \lambda_{HL} D_{HL,j} + \lambda_{LH} D_{LH,j} + \lambda_{HH} D_{HH,j} + \sum_r \delta_r X_{rij} + u_{0j} \quad (4)$$

where the community-level predictors are represented by dummy variables $D_{HL,j}$, $D_{LH,j}$ and $D_{HH,j}$, corresponding to the combinations of high CSC–low CBE, low CSC–high CBE, and high CSC–high CBE, respectively. The coefficients λ_{HL}, λ_{LH} and λ_{HH} indicate the effects of each combination relative to the reference group (low CSC–low CBE). For ordinal outcomes, exponentiating the coefficients yields the corresponding OR; for continuous outcomes, the coefficients are interpreted as linear effects.

Additionally, multicollinearity was assessed using the variance inflation factor (VIF). All variables had VIF values less than 5, with a mean VIF of 1.50, indicating that multicollinearity was not a concern in the model (Supplementary Material S1, Table S1). All models were estimated using Stata 18.0. Parameters were estimated using maximum likelihood with adaptive Gaussian quadrature. Random intercepts at the community level were specified. We additionally tested models allowing random slopes for the main CSC and CBE predictors. Likelihood-ratio tests indicated that the inclusion of random slopes did not significantly improve model fit; therefore, the more parsimonious fixed-slope specification was retained.

3. Results

3.1. Direct Associations of Community Social Capital and Built Environment with Multidimensional Health

As shown in Table 1, in the overall sample, community resident relationship quality (OR = 1.273, 95% CI: 1.170–1.385), neighborhood mutual support (OR = 1.256, 95% CI: 1.116–1.414), and community type (OR = 1.308, 95% CI: 1.021–1.676) were significantly and positively associated with higher levels of residents' self-rated health. The same pattern held for subjective well-being. Distance to the nearest square/park (shorter distance) (OR = 1.076, 95% CI: 1.025–1.130) was also associated with higher subjective well-being. Moreover, neighborhood mutual support (OR = 1.209, 95% CI: 1.152–1.443), community type (OR = 1.340, 95% CI: 1.091–1.646), and community residential density (OR = 1.097, 95% CI: 1.003–1.199) significantly increased the likelihood of residents' loneliness being in a better category. Furthermore, the total number of social organizations (β = 0.396, 95% CI: 0.071–0.720), community resident relationship quality (β = 0.407, 95% CI: 0.077–0.736), neighborhood mutual support (β = 0.999, 95% CI: 0.532–1.465), and community residential density (β = 0.365, 95% CI: 0.016–0.713) were all positively associated with residents' mental health. Overall, the magnitude of associations varied between CSC and CBE indicators. Key CSC indicators, particularly community resident relationship quality and neighborhood mutual support, showed moderate effect sizes (ORs generally above 1.20), corresponding to approximately 20–30% higher likelihoods of better health outcomes. In contrast, most CBE indicators (e.g., residential density and distance to parks) exhibited more modest associations (ORs closer to 1.05–1.10), indicating smaller but still meaningful contributions.

The stratified analysis by external social engagement (Figure 2) was generally consistent with the overall results. Furthermore, for each outcome variable, the number of significant predictors was greater in the low subgroup than in the high subgroup. Specifically, in the low subgroup, community type (urban context) (OR = 1.287, 95% CI: 1.001–1.655) was significantly associated with higher levels of self-rated health in the low subgroup; community resident relationship quality (OR = 1.085, 95% CI: 1.008–1.168), community type (OR = 1.343, 95% CI: 1.081–1.669), and distance to the nearest square/park (OR = 1.084, 95% CI: 1.030–1.142) were positively associated with higher levels of subjective well-being; number of social organizations (OR = 1.095, 95% CI: 1.002–1.197), and community residential density (OR = 1.102, 95% CI: 1.002–1.212) significantly increased the likelihood of loneliness being in a higher category in the low subgroup; and community resident relationship quality (β = 0.418, 95% CI: 0.077–0.758) and community residential density (β = 0.391, 95% CI: 0.027–0.755) were significantly and positively associated with mental health in the low subgroup. In contrast, the high external social engagement subgroup was influenced only by CSC indicators (community resident relationship quality and neighborhood mutual support), while none of the CBE indicators showed significant effects for this group.

3.2. Compensatory and Synergy Patterns Between Community Social Capital and Built Environment

Adding interaction terms (Table S2), the interaction between community type and neighborhood mutual support exhibited significant antagonistic associations with self-rated health (OR = 0.678, 95% CI: 0.533–0.863) and subjective well-being (OR = 0.768, 95% CI: 0.632–0.935) in the pooled sample. In contrast, the interaction between community type and the total number of social organizations (OR = 1.241, 95% CI: 1.058–1.457), as well as the interaction between distance to the nearest square/park and neighborhood mutual support (OR = 1.071, 95% CI: 1.012, 1.133), showed significant synergistic associations with higher levels of subjective well-being.

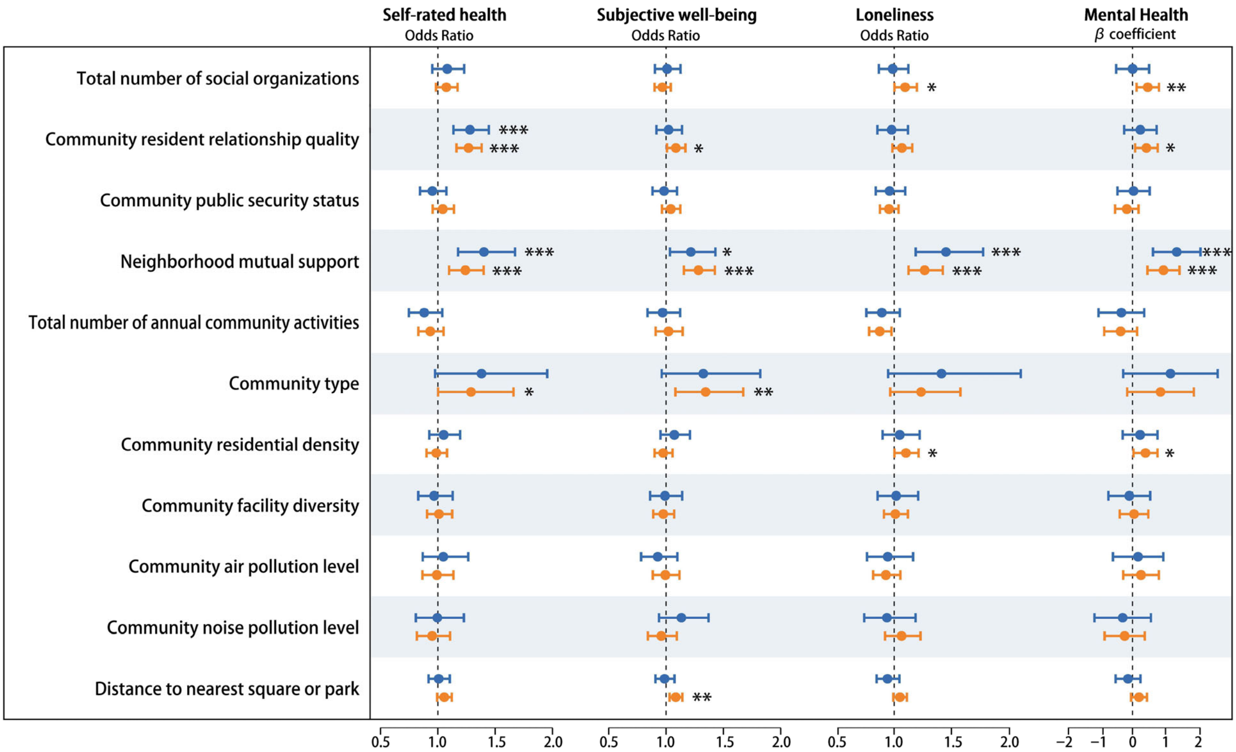

Figure 2. The effects of community social capital and built environment on multidimensional health in different subgroups stratified by external social engagement (low subgroup in orange, high subgroup in blue; the significance results are based on the adjusted p-values). Note: Bold values indicate significance after Benjamini-Hochberg false discovery rate correction: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

For the low external social engagement subgroup, the results of self-rated health, subjective well-being, and mental health were consistent with the pooled sample. For the high subgroup, the interaction between community residential density and community resident relationship quality showed significant synergistic associations with higher levels of self-rated health (OR = 1.349, 95% CI: 1.084–1.679), loneliness (OR = 1.425, 95% CI: 1.088–1.868), and mental health (OR = 1.317, 95% CI: 0.427–2.207). In addition, the interaction between distance to the nearest square/park and neighborhood mutual support exhibited a synergistic positive association with mental health in this subgroup (β = 0.479, 95% CI: 0.042–0.916). The magnitude of these interaction effects suggests that the 'soft' and 'hard' environments do not merely add up but function as meaningful modifiers of each other, where the presence of one resource can significantly alter the health-protective value of the other.

The joint effects of the three CSC indicators (total number of social organizations, community resident relationship quality, and neighborhood mutual support) and the three CBE indicators (community type, community residential density, and distance to the nearest square/park) were examined, which showed significant positive direct effects. The results for the pooled sample are presented in Figure 3 and Table S3, in terms of the tolerance (compensatory) effects of CSC on CBE, when community type was at a disadvantaged level, the total number of social organizations showed a significant compensatory association with residents' self-rated health (OR = 1.328, 95% CI: 1.029–1.713); community resident relationship quality exhibited tolerance patterns across all outcomes: self-rated health (OR = 2.115, 95% CI: 1.669–2.680), subjective well-being (OR = 1.339, 95% CI: 1.096, 1.634), loneliness (OR = 1.346, 95% CI: 1.080–1.679), mental health (β = 1.350, 95% CI: 0.410, 2.290); and neighborhood mutual support compensated for self-rated health (OR = 1.632, 95% CI: 1.283–2.077), subjective well-being (OR = 1.520, 95% CI: 1.254–1.844), and mental health (β = 1.068, 95% CI: 0.148–1.989). When community residential density was limited, the total number of social organizations demonstrated a tolerance association with self-rated health (OR = 1.332, 95% CI: 1.016–1.749); community resident relationship quality exerted compensatory associations with self-rated health (OR = 2.061, 95% CI: 1.587–2.675) and subjective well-being (OR = 1.368, 95% CI: 1.094–1.709); and neighborhood mutual support compensated for subjective well-being (OR = 1.404, 95% CI: 1.141–1.725) and mental health (β = 1.416, 95% CI: 0.440, 2.391). When the distance to the nearest square/park was at a lower level, community resident relationship quality compensated for residents' self-rated health (OR = 1.592, 95% CI: 1.093–2.321), subjective well-being (OR = 1.420, 95% CI: 1.049–1.923), and mental health (β = 1.638, 95% CI: 0.209–3.068). Across these joint-exposure models, combinations involving CSC indicators (particularly relationship quality and mutual support) often yielded relatively large effect sizes (with several ORs exceeding 1.50), indicating substantial differences in health outcomes across exposure groups.

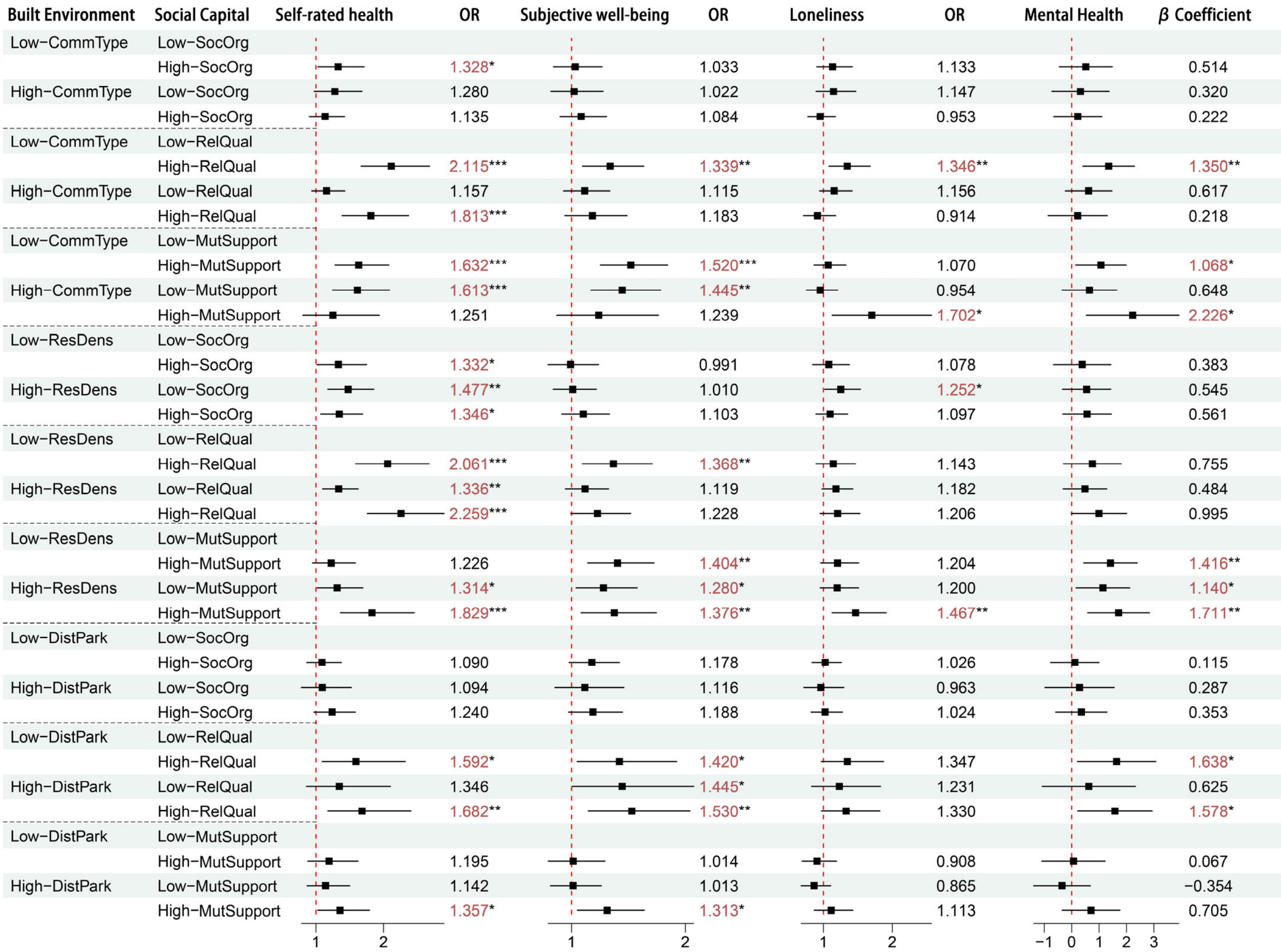

Figure 3. Joint associations of community social capital and community-built environment with multidimensional health and well-being in the pooled sample. The reference group represents communities with low levels of both CSC and CBE. Black squares represent odds ratios or β coefficients, and horizontal lines denote the corresponding 95% confidence intervals. Red labels with asterisks indicate statistically significant results (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). All models were adjusted for the full set of covariates. Detailed numerical estimates corresponding to this figure are reported in Table S3 in the Supplementary Materials. Abbreviations: OR, odds ratio; CI, confidence interval; CommType, community type; ResDens, community residential density; DistPark, distance to the nearest square or park; SocOrg, total number of social organizations; RelQual, community resident relationship quality; MutSupport, neighborhood mutual support.

Regarding the tolerance effects of CBE on CSC, when neighborhood mutual support was insufficient, community type exhibited significant tolerance associations with residents' self-rated health (OR = 1.613, 95% CI: 1.247–2.088) and subjective well-being (OR = 1.445, 95% CI: 1.171–1.782); community residential density demonstrated tolerance associations with self-rated health (OR = 1.314, 95% CI: 1.019–1.696), subjective well-being (OR = 1.280, 95% CI: 1.040–1.576), and mental health (β = 1.140, 95% CI: 0.162–2.119). When the total number of social organizations was at a low level, community residential density provided compensation effects for self-rated health (OR = 1.477, 95% CI: 1.176–1.855) and loneliness (OR = 1.252, 95% CI: 1.020–1.537). When community resident relationship quality was at a disadvantaged level, community residential density exerted a tolerance association with self-rated health (OR = 1.336, 95% CI: 1.100–1.624); distance to the nearest square/park showed a tolerance association with subjective well-being (OR = 1.445, 95% CI: 1.007–2.073).

Some indicators also exhibited synergistic enhancement associations with residents' health outcomes. Specifically, when both community type and community resident relationship quality were at high levels, they jointly exerted a synergistic association with residents' self-rated health (OR = 1.813, 95% CI: 1.388–2.370). A similar effect was observed for the combination of high community residential density and a high total number of social organizations (OR = 1.813, 95% CI: 1.388–2.370), as well as for the combination of high community residential density with self-rated health (OR = 1.813, 95% CI: 1.388–2.370). A high community type combined with a high neighborhood mutual support produced synergistic associations with loneliness (OR = 1.702, 95% CI: 1.129–2.568) and mental health (β = 2.226, 95% CI: 0.537–3.914). When both community residential density and neighborhood mutual support were at high levels, they jointly demonstrated synergistic enhancement effects across all four health and well-being outcomes: self-rated health (OR = 1.829, 95% CI: 1.362–2.455), subjective well-being (OR = 1.376, 95% CI: 1.083–1.745), loneliness (OR = 1.476, 95% CI: 1.126–1.912), mental health (β = 1.711, 95% CI: 0.586–2.837). In addition, the combination of a short distance to the nearest square/park and a high community resident relationship quality yielded a synergistic advantage for self-rated health (OR = 1.682, 95% CI: 1.177–2.404), subjective well-being (OR = 1.530, 95% CI: 1.147–2.040), and mental health (β = 1.578, 95% CI: 0.220–2.936). Finally, the combination of a short distance to the nearest square/park and a high neighborhood mutual support showed synergistic associations with self-rated health (OR = 1.357, 95% CI: 1.027–1.791) and subjective well-being (OR = 1.313, 95% CI: 1.051–1.639). Notably, synergistic combinations of CSC and CBE tended to produce the largest effect sizes observed in the analysis, often exceeding those of single-factor and compensatory associations, highlighting their greater practical relevance.

In addition, the joint effects for the low and high external social engagement subgroups are presented in Tables S4 and S5, respectively. A comparison shows that, whether in the tolerance effects or synergistic effects between CSC and CBE, the number of significant indicators related to the four types of health and well-being outcomes is consistently much larger in the low subgroup than in the high subgroup. This indicates that the low subgroup is more sensitive to the joint effects. This difference is also reflected in effect size, with the low-engagement subgroup consistently exhibiting larger and more frequent moderate-to-strong associations across models compared to the high-engagement subgroup.

4. Discussion

4.1. Main Findings

(1) Several key CSC and CBE indicators exerted fundamental associations with multi-dimensional health

This study found that within CSC, community resident relationship quality and neighborhood mutual support were the most robust indicators, each showing significant and relatively strong associations with three (self-rated health, subjective well-being, and mental health) to four health outcomes (Table 1). Within CBE, community type and community residential density demonstrated more moderate associations, influencing three outcomes (self-rated health, subjective well-being, and loneliness) and two outcomes (loneliness and mental health), respectively. In addition, indicators with significant associations with a single health outcome included: the total number of annual community activities (loneliness only), the number of social organizations (mental health only), and the distance to the nearest square/park (subjective well-being only). These findings indicate that both the social and built environments play critical roles in multidimensional health, though their breadth of influence and underlying mechanisms differ. Specifically, the relationship quality, neighborhood mutual support, community type, and residential density emerged as the key factors.

The identification of these key indicators is consistent with the existing literature. Numerous studies have highlighted that trust, mutual support, and cohesion at the community level was associated with better self-rated health and psychological well-being by enhancing social support, facilitating the sharing of health-related information, and strengthening emotional regulation capacities [51]. This study extends this evidence with empirical evidence across multiple health dimensions, including subjective well-being and mental health. At the same time, residential density and community type within CBE also demonstrated significant associations consistent with [52] the idea that higher residential density and rational community functional layouts may increase opportunities for neighborhood interaction, thereby indirectly improving psychological health and social connectedness.

In addition, this study underscores the differentiated patterns of the social and built environments in health promotion. The impact of CSC appeared to be more universal and robust, both in terms of the number of significant associations and the magnitude of estimated effects, whereas the effects of CBE exhibited stronger conditional dependence and generally smaller effect sizes. This implies that social capital factors such as relationship quality and cohesion may serve as the most direct and enduring health resources, while the contributions of the built environment may need to be combined with other social factors to fully realize their value [53].

(2) Evidence supports both compensatory and synergy effects

Same-level interaction analyses revealed coexisting synergetic and antagonistic patterns (Table 2). Overall, these findings confirm that "physical–social" resources are not merely additive. Antagonism may arise when their functions overlap or marginal effects diminish, while synergy is more likely when the two are complementary, such as when the built environment provides accessibility and spaces, and the social environment activates participation and trust. This aligns with public policy frameworks that regard social and material environments as co-factors and emphasize their interactions [54].

Further joint exposure analyses provided clearer insights into the mechanisms of tolerance and synergy (Figure 3) and confirmed the stability of heterogeneous effects across subgroups stratified by social engagement (Tables S4 and S5). When "hard" environmental factors such as community type, residential density, and park proximity were at unfavorable levels, improvements in resident relationship quality and neighborhood mutual support were significantly associated with reduced disadvantage for self-rated health, subjective well-being, mental health, and loneliness. Importantly, the relatively larger effect sizes associated with CSC indicators suggest that social resources demonstrated a more direct and substantial association with health outcomes compared with physical environmental factors. This finding aligns with the “social support buffering hypothesis”, which posits that under adverse conditions, social resources may potentially buffer the negative stress–health pathway [30]. Notably, resident relationship quality may function as an “all-around buffer,” and was associated with reduced disadvantages under adverse conditions of disadvantaged community type, constrained residential density, and low park accessibility on all four health outcomes. One possible explanation is that resident relationship quality represents a form of bonding social capital characterized by “close proximity and high interaction frequency” [55]. For example, strong neighborhood ties may partially substitute for formal services (e.g., mutual caregiving) and compensate for limited outdoor space via low-threshold indoor activities [56].

Table 2. Direct associations of community social capital and built environment with multidimensional health.

	Self-Rated Health		Subjective Well-Being		Loneliness		Mental Health	
	OR (95% CI)	***p* (Adjust *p*)**	**OR (95% CI)**	***p* (Adjust *p*)**	**OR (95% CI)**	***p* (Adjust *p*)**	**β Coef. (95% CI)**	***p* (Adjust *p*)**
Community social capital								
Total number of social organizations	1.075 (0.988, 1.169)	0.091 (0.143)	0.972 (0.908, 1.040)	0.410 (0.564)	1.067 (0.983, 1.158)	0.121 (0.190)	**0.396 * (0.071, 0.720)**	**0.017 (0.047)**
Total number of annual community activities	0.995 (0.878, 1.128)	0.942 (0.797)	1.006 (0.910, 1.112)	0.903 (0.710)	0.874 (0.781, 0.979)	0.012 (0.066)	−0.317 (−0.811, 0.177)	0.208 (0.254)
Community resident relationship quality	**1.273 *** (1.170, 1.385)**	**0.000 (0.000)**	**1.078 * (1.005, 1.155)**	**0.020 (0.044)**	1.062 (0.983, 1.148)	0.128 (0.176)	**0.407 * (0.077, 0.736)**	**0.013 (0.048)**
Community public security status	1.022 (0.937, 1.115)	0.627 (0.627)	1.042 (0.969, 1.119)	0.267 (0.420)	0.957 (0.883, 1.038)	0.290 (0.319)	−0.123 (−0.463, 0.218)	0.480 (0.440)
Neighborhood mutual support	**1.256 *** (1.116, 1.414)**	**0.000 (0.000)**	**1.271 *** (1.151, 1.403)**	**0.000 (0.000)**	**1.290 *** (1.152, 1.443)**	**0.000 (0.000)**	**0.999 *** (0.532, 1.465)**	**0.000 (0.000)**
Community-built environment								
Community type	**1.308 * (1.021, 1.676)**	**0.026 (0.048)**	**1.340 * (1.091, 1.646)**	**0.005 (0.014)**	**1.272 * (1.006, 1.608)**	**0.014 (0.039)**	0.900 (−0.072, 1.872)	0.070 (0.128)
Community residential density	1.003 (0.919, 1.095)	0.943 (0.741)	0.999 (0.927, 1.076)	0.975 (0.715)	**1.097 * (1.003, 1.199)**	**0.013 (0.048)**	**0.365 * (0.016, 0.713)**	**0.021 (0.046)**
Community facility diversity	1.005 (0.904, 1.118)	0.920 (0.843)	0.978 (0.896, 1.067)	0.613 (0.613)	1.007 (0.912, 1.111)	0.893 (0.756)	0.038 (−0.377, 0.453)	0.857 (0.725)
Community air pollution level	0.996 (0.872, 1.138)	0.956 (0.701)	0.978 (0.877, 1.092)	0.697 (0.639)	0.931 (0.824, 1.052)	0.252 (0.308)	0.254 (−0.265, 0.773)	0.337 (0.371)
Community noise pollution level	0.953 (0.821, 1.107)	0.530 (0.583)	0.977 (0.863, 1.105)	0.710 (0.601)	1.046 (0.911, 1.201)	0.522 (0.479)	−0.259 (−0.843, 0.324)	0.384 (0.384)
Distance to nearest square or park	1.053 (0.992, 1.119)	0.104 (0.143)	**1.076 * (1.025, 1.130)**	**0.003 (0.011)**	1.045 (0.990, 1.103)	0.114 (0.209)	0.159 (−0.073, 0.391)	0.179 (0.246)

Note: Bold values indicate significance after Benjamini–Hochberg false discovery rate correction: * $p < 0.05$, *** $p < 0.001$.

Conversely, residential density emerged as the most critical buffer. It was associated with weaker negative associations linked to low neighborhood mutual support, few social organizations, and poor resident relationship quality on three health outcomes: self-rated health, subjective well-being, and mental health. This is likely because residential density is directly associated with the probability of daily encounters among residents—even in communities lacking organizations, support, or neighborhood trust, the frequent contacts generated in high-density settings can establish a minimal level of social connection, which is associated with more favorable self-rated health outcomes, subjective well-being, and mental health [57]. Secondly, community type was associated with reduced disadvantage for the lack of neighborhood mutual support, likely because higher-quality urban communities, compared with rural ones, are equipped with more adequate public spaces and housing conditions. These features may, to some extent, substitute for cohesion among neighbors and are associated with better self-rated health and subjective well-being [58].

When both CSC and CBE were at high levels, the synergistic patterns reflected a "1 + 1 > 2" association pattern in health outcomes. Among these, the combination of high residential density and high neighborhood mutual support exhibited synergistic effects across all four health outcomes, making it the most broadly effective pairing. A possible explanation is that high density provides a spatial foundation for frequent interactions, while high cohesion offers an emotional foundation for positive interactions; together, they corresponded to the highest observed health scores in the sample regarding community engagement [59]. Other typical combinations, such as high accessibility to squares/parks together with high resident relationship quality, also demonstrated synergistic associations with three health outcomes. This is supported by related studies suggesting that green space–social connectedness linkages can create a virtuous cycle that enhances health [60].

From an economic perspective, the compensation mechanism reflects resource substitutability—when one type of community resource is scarce, the other can partially offset its absence, being associated with relatively stable health outcomes. This aligns with the economic principle of diminishing marginal returns: when one resource is abundant, additional units provide smaller incremental benefits, making the alternative resource relatively more valuable. Conversely, the synergy mechanism embodies resource complementarity—the two types of resources enhance each other's effectiveness when both are present, being associated with stronger combined associations than either factor alone. This suggests non-linear production functions in health generation, where optimal outcomes may be associated with more balanced investment in both social and physical infrastructure. However, this compensation has its boundaries; our data suggests that while social capital acts as a robust 'buffer', it may not fully replace physical infrastructure in cases of severe environmental deprivation (e.g., extreme lack of green space), where the associations of social factors with health outcomes may weaken. Furthermore, this compensatory relationship is most 'sufficient' for residents with low external social engagement—the community-dependent group—whereas high-engagement residents are less sensitive to such trade-offs due to their ability to draw on external resources.

(3) The "high sensitivity" of the low social engagement residents

First, stratified analyses indicated that the low external social engagement group was more sensitive to both the direct effects of CSC and CBE (Table 1) and their joint effects (Tables S4 and S5). This finding supports the interpretation that residents with low levels of external social engagement are more "community-dependent," so their health showed a higher sensitivity to the associations involving combinations of CSC and CBE; conversely, residents with high external social engagement are able to buffer the limitations of community-level resources by drawing on external social resources [61]. This pattern also highlights potential inequalities in the distribution of health benefits: individuals with fewer social interactions may rely more heavily on community-level social and built resources to obtain support, connection, and restorative experiences, and therefore exhibited stronger positive associations with neighborhood greenery, community activities, and high-quality neighbor relations [62,63]. In other words, community social and built resources showed a stronger positive linkage to health for this vulnerable subgroup. Moreover, in the direct-effect analyses, the high external social engagement group showed lower dependence on the physical environment: their health outcomes were primarily associated with CSC, while CBE showed no significant associations. A plausible explanation is that access to abundant external social resources may reduce their reliance on the physical environment; several studies have suggested that social relationships can substitute for some material conditions, particularly with respect to emotional well-being [45,64].

4.2. Implications for Sustainability Governance

This study provides new insights into how social and physical community environments jointly shape multidimensional health through the lens of resource configuration. The findings reveal two fundamental mechanisms—compensation and synergy—under which soft (social) and hard (physical) resources interact. Rather than focusing on isolated environmental factors, this integrated perspective highlights how the adaptive balance between social cohesion and spatial resources can enhance resilience and inclusivity in community planning. Moreover, the moderating effect of social engagement underscores the need to consider behavioral heterogeneity in community design, suggesting that environmental planning should account for diverse social participation patterns. These insights inform a more holistic and adaptive approach to community resource planning, paving the way for inclusive and health-oriented urban governance.

(a) Key indicator identification and prioritized investment

Building on the above resource configuration insights, we recommend that community physical environment planning prioritize the key CBE (community type and residential density) and CSC (neighborhood cohesion and quality of resident relations) indicators identified in this study. Specifically, moderately increase residential density in both urban and rural communities, while advancing the modernization and quality improvement of rural communities. In parallel, community governance should emphasize enhancing residents' cohesion through improvements in neighbor familiarity, mutual trust, and mutual support, with particular attention to the quality of resident relations. Such planning and governance efforts may be likely to maximize health benefits across multiple outcomes.

(b) Dynamic complementary governance strategies based on resource availability

Second, environmental managers and planning practitioners may consider focusing on dynamic complementarity between community social and built environments. In settings where the built environment is constrained (e.g., high-density communities with limited public space), targeted strengthening of CSC may play a compensatory role. This may be achieved by supporting community organizations, collective activities, and trust-building initiatives (e.g., neighborhood festivals, volunteering, or small mutual aid groups) to offset loneliness and improve both mental and physical health as well as subjective well-being. Conversely, when the social environment is weak, selective physical interventions may be associated with substantial benefits. For instance, moderately increasing residential density or improving the accessibility and quality of parks and squares can create low-threshold opportunities for interaction and restorative experiences, thereby promoting social connections. In resource-rich communities, policy should aim to leverage the "high–high" combinations of CBE and CSC, where dual investments are more likely to yield synergistic health and well-being benefits and foster a virtuous cycle of social and material resources.

(c) Targeted interventions for high-vulnerability groups

Finally, residents with low external social engagement, as a vulnerable group, require targeted governance and interventions. Because these individuals are most sensitive to changes in community support and spatial environments, policies should aim to reduce barriers to participation in order to expand their social connections. Examples include introducing easily accessible neighborhood activities in public spaces or providing more flexible and informal venues for social interaction to gradually encourage engagement. At the same time, community planning should consider ensuring the accessibility and usability of facilities for vulnerable groups, thereby enhancing their actual participation and maximizing their health benefits.

4.3. Limitations and Future Research

This study has several limitations. First, the analysis was based on cross-sectional data, which restricts causal inference. Potential endogeneity issues may arise because unobserved community-level factors (e.g., historical or cultural characteristics) could simultaneously influence both social capital and residents' health outcomes, and reverse causality cannot be ruled out (e.g., healthier individuals may participate more actively in community activities). Therefore, the findings should be interpreted as robust associations rather than definitive causal relationships. Future research could employ longitudinal data, instrumental variable approaches, or propensity score matching to further address these concerns. Second, due to data availability, the multidimensional health outcomes relied mainly on self-reported indicators, which may be subject to common method bias. Subsequent studies could incorporate objective health measures or leverage big data sources for validation. Third, community-level environments may not fully capture more fine-grained patterns of social interaction or spatial configuration. For instance, community facilities or green spaces lack information on spatial quality, maintenance conditions, design features and walkway continuity. In addition, some CSC indicators are aggregated from individual-level data to the community level, which may introduce perceptual bias. Future research should integrate multiple data sources and novel measurement tools—such as remote sensing, social media, and street-view imagery—to deepen understanding of the underlying mechanisms. Fourth, the external social engagement measure, operationalized through dining-out frequency, is a creative proxy but may not fully capture the breadth of social participation (e.g., religious activities, interest clubs, online social networks). Finally, the findings may be shaped by the national context of the sample. Cross-city comparative studies under different planning paradigms and cross-cultural analyses can clarify how cultural differences might shape the effects of social capital.

5. Conclusions

This study clarifies how CSC and the CBE are jointly associated with residents' multidimensional health. The findings indicate that both CSC and CBE show independent associations with health outcomes, while also interacting through two primary patterns: compensation and synergy. Notably, CSC indicators, particularly community resident relationship quality and neighborhood mutual support, demonstrated relatively stronger and more consistent associations across multiple health outcomes, whereas CBE indicators generally exhibited more modest and outcome-specific associations. Specifically, stronger social ties (e.g., relationship quality and cohesion) are associated with reduced health disadvantages in less favorable physical environments, whereas certain physical attributes (e.g., residential density and community type) correspond to weaker negative associations linked to limited social connections. When both domains are favorable, their combination corresponds to stronger health and well-being outcomes.

These results highlight that sustainable community governance should move beyond single-dimensional interventions and consider the coordinated development of both social and physical resources. In practice, the relatively stronger associations observed for CSC suggest that investments in social cohesion and neighborhood relationships are associated with broader and more consistent health advantages, particularly in resource-constrained settings. Meanwhile, improvements in the built environment, although generally exhibiting smaller effect sizes, may still play an important complementary role, especially when aligned with existing social resources. Furthermore, the higher sensitivity observed among residents with low external social engagement indicates the importance of targeted strategies aimed at reducing potential health inequalities. By identifying these "social–spatial–health" interrelationships, this study contributes to the understanding of how community environments are linked to population health and well-being.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su18073564/s1, Table S1: Multicollinearity Diagnostics; Table S2. Interactive effects of community social capital and built environment on multidimensional health; Table S3. Joint effects of community social capital and built environment on multidimensional health and well-being among pooled sample; Table S4. Joint effects of community social capital and built environment on multidimensional health and well-being among the low external social engagement subgroup; Table S5. Joint effects of community social capital and built environment on multidimensional health and well-being among the high external social engagement subgroup.

Author Contributions: Conceptualization, K.Z. and R.D.S.; methodology, K.Z.; software, K.Z.; validation, K.Z., R.D.S., and P.D.; formal analysis, K.Z.; investigation, K.Z.; resources, K.Z. and P.D.; data curation, K.Z.; writing—original draft preparation, K.Z.; writing—review and editing, R.D.S., and P.D.; visualization, K.Z.; supervision, P.D.; project administration, P.D.; funding acquisition, K.Z. and P.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by [JST SPRING] grant number [JPMJSP2136]. And The APC was funded by [JST SPRING].

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: The authors thank the editor and the anonymous reviewers for their insightful comments and constructive feedback.

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

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https://doi.org/10.3390/su18073564