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The Associations of Code Reform Zoning and Activity-Oriented Zoning with Neighborhood Social Connectedness in the U.S., including Mediation by Walkability and Park Coverage

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Abstract

Objective: Zoning codes influence the built environments of communities in the United States (U.S.), which in turn have potential to promote social connections. This study assessed associations between code reform zoning (CRZ) and activity-oriented zoning (AOZ) exposure and perceived neighborhood social connectedness and whether these associations were mediated by walkability and park coverage.

Methods: Data from the Current Population Survey September 2019 Volunteering and Civic Life Supplement were linked to U.S. county-level data on (1) population-level exposure to CRZ and an index of 10 AOZ measures as of 2010, (2) EPA's 2021 National Walkability

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This work was deemed not to be human subjects research by the institutional review board at the University of Illinois Chicago.

Declaration of conflicting interest

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Neither generative AI nor AI-assisted technologies were used in the writing process.

Index, and (3) proportion of area devoted to parks from the 2018 National Neighborhood Data Archive (n=21,616). Multivariable logistic regression models with robust standard errors examined associations between CRZ and AOZ exposure and three perceived neighborhood social connectedness measures and mediation analyses examined mediation by walkability and park coverage.

Results: CRZ (OR: 1.22, 95% CI: 1.08–1.36) and each additional AOZ measure (OR: 1.03, 95% CI: 1.01–1.05) were associated with having conversations or spending time with neighbors. CRZ (OR: 1.22, 95% CI: 1.10–1.35) was also associated with neighbors doing favors for each other, as was AOZ (OR: 1.03, 95% CI: 1.01–1.04). None of these associations were mediated by walkability or park coverage. CRZ (OR: 1.29, 95% CI: 1.14–1.46) and AOZ (OR: 1.04, 95% CI: 1.02–1.06) were associated with neighbors getting together to do something positive; both associations were mediated by walkability but not park coverage.

Conclusion: Zoning is a policy lever that can promote neighborhood social connectedness.

Keywords

built environment; zoning; social connectedness; social infrastructure

1. Introduction

Neighborhoods provide important opportunities for supporting the health and well-being of residents through the provision of both physical and social infrastructures. The built environment encompasses the human-made, physical features of a community,[1] whereas social infrastructure refers to the physical places and spaces that provide opportunities for social interactions, building and maintaining relationships and engaging within the community.[2] The social infrastructures of neighborhoods are heavily influenced by opportunities provided through the built environment.[2, 3]

Neighborhoods thus have an important potential role in promoting social connections.[4] Social connectedness is a multi-component construct which includes the structure, function and quality of one's social relationships and the extent to which these relationships meet an individual's social needs.[5] Strong social connectedness is associated with positive mental, cognitive and physical health outcomes and overall well-being across the lifecourse.[6–9] Social connectedness is a particularly important protective factor against social isolation and loneliness, [10] distinct but closely related experiences,[11–13] that organizations including the World Health Organization and national governments have deemed emerging public health priorities that require prompt response to ameliorate the associated negative health consequences.[14–17] Strong neighborhood social ties have been shown to reduce loneliness and social isolation while promoting a sense of belonging and psychological well-being.[4, 18, 19]

Neighborhood social connections can take different forms. Among them are social interactions, social capital and civic engagement.[20] Neighborhoods provide opportunities for formal and informal social interactions, such as having regular conversation or spending time with neighbors, that can help build a sense of familiarity and belonging among

neighbors.[3] Greater rates of contact with neighbors have been shown to reduce loneliness.[18]

Neighborhood social capital refers to the ways in which people residing in the same area help and support each other, often reflecting trust and social cohesion.[21] The majority of studies examining the association between social capital and loneliness have found that increased social capital reduces experiences of loneliness, with some studies finding no association.[18] Close physical proximity to neighbors can promote mutual assistance, or reciprocal helping behaviors among neighbors, a form of social capital.[18] Such assistance can range from small favors to providing emotional or tangible support during times of crisis. Experiences with mutual assistance among neighbors, whether on the giving or receiving end, can strengthen feelings of trust and dependability among neighbors.[22] Civic engagement, which includes participation in organizations or activities for the betterment of the neighborhood, is another form of social capital. Civic engagement can promote a shared sense of purpose and identity among neighbors who are invested in their community.[23]

Several characteristics of the built environment have been studied in association with loneliness and social isolation. These studies have largely found that neighborhood environments that are safe, aesthetically pleasing and provide access to foundational resources or a range of destinations and amenities are associated with lower rates of loneliness and higher rates of social capital.[24–26] However, findings have not been completely uniform, with some studies suggesting that social context and resident demographic factors are important considerations. Several studies have specifically examined neighborhood walkability as a built environment indicator. Greater walkability has generally been associated with reduced rates of loneliness, with more consistent associations observed in studies assessing subjective measures of walkability compared to objective measures.[18] Neighborhoods that promote walking through provisions such as safe streets, sidewalks, and access to places such as restaurants and community centers provide opportunities for planned and incidental social engagement.[1, 2] Walkable neighborhoods are also associated with higher levels of social capital among residents.[27]

Access to parks and green space is potentially important for providing opportunities for social interactions in neighborhoods. Two systematic reviews found that most studies assessing the relationship between exposure to green space exposure and loneliness observed a protective effect, with studies using subjective measures of green space more consistently demonstrating this association than those using objective measures.[18, 28] Astell-Burt and colleagues propose three evidence-informed potential pathways through which access to green space can protect against loneliness: providing opportunities for connections with other people, bringing a sense of belonging and connection with nature and reducing exposure to harmful environments characterized by violence or other destructive behaviors.[28] They conversely posit that unintended consequences can emerge when green space is of low quality, not aesthetically pleasing or inaccessible to residents.

Zoning is the primary tool by which by local governments in the U.S. regulate land use and spatial organization of communities.[29, 30] Traditional Euclidean zoning originally developed in part as a means to separate residential areas from public health threats

associated with pollution and communicable diseases.[31] However, they emerged to focus on residential neighborhoods and protection of property rights, which resulted in separation of residential, commercial and civic areas of communities[32] and worsened geographic-based inequities according to race, ethnicity and income due to intentional misuse designed to create segregated communities.[33–35] These zoning codes additionally have resulted in sprawling communities and reinforced automobile dependency.[30, 36]

In recent decades, there has been a growing commitment to new approaches to zoning that attempt to mitigate the negative consequences of Euclidean zoning across many communities in the U.S. These newer approaches prioritize creating communities that are more physically connected across residential, commercial and civic sectors.[36] These include code reform zoning, such as form-based codes, transit-oriented development and the SmartCode, which is pedestrian-oriented by design,[37–39] and activity-oriented zoning measures for specific features such as sidewalks, street connectivity and mixed use development. These approaches prioritize mixed land uses, pedestrian-oriented street design and public gathering spaces, offering potential opportunities for social interaction and building a sense of community. Consistent with their intent to be pedestrian-oriented, residents of communities with code reform zoning and activity-oriented zoning features have demonstrated higher rates of physical activity.[40–43]

However, significant gaps remain in our understanding of the relationship between zoning policies and social connectedness. This includes whether code reform and activity-oriented zoning promote social connectedness across a range of indicators. There is also a lack of understanding of the potential mechanisms through which code reform zoning and activity-oriented zoning may impact social connectedness, with walkability and green space playing potentially important roles. Understanding these relationships may provide important insight into whether and how zoning policies designed to positively impact physical connections (i.e., more walkable or pedestrian-oriented, access to destinations) in communities also influence social connections that are known to ameliorate loneliness and social isolation.

The purpose of this manuscript was to assess the association between zoning exposure and social connectedness. We specifically examined the associations of code reform zoning and activity-oriented zoning measures with three measures of perceived neighborhood social connectedness among a sample of U.S. adults. The extent to which these associations were mediated by walkability and park coverage was also explored.

2. Methods

2.1. Data sources and measures

2.1.1. Current Population Survey: Data on perceived neighborhood social connectedness were obtained from the September 2019 Current Population Survey (CPS) Volunteering and Civic Life Supplement.[44] CPS is a labor force survey conducted by the U.S. Census Bureau that has been ongoing for over 50 years and obtains interviews from approximately 50,000 households each month. While CPS focuses on labor statistics, it regularly includes supplements to collect data on other topics.[45] The present study did not involve human subjects and was exempt from human subjects committee oversight.

2.1.1.1. Perceived neighborhood social connectedness: Three questions assessed perceived neighborhood social connectedness. The first asked, “In the past 12 months, how often did [you/[NAME]] have a conversation or spend time with [your/his/her] neighbors?” The second asked, “In the past 12 months, how often did [you/[NAME]] and [your/his/her] neighbors do favors for each other such as house sitting, watching each other’s children, lending tools, and other things to help each other.” Response options to both questions included “not at all,” “less than once a month,” “once a month,” “a few times a month,” “a few times a week,” and “basically every day.” Both questions were dichotomized as either yes (any response other than “not at all”) or no. The third question asked, “In the past 12 months, did [you/[NAME]] get together with other people from [your/his/her] neighborhood to do something positive for [your/his/her] neighborhood or the community?” Response options were limited to yes and no.

2.1.1.2. Individual covariates: Data were obtained on individual-level characteristics: sex (female or male), age, self-reported race and ethnicity (Hispanic or non-Hispanic American Indian/Alaskan Native, Asian, Black, Hawaiian/Pacific Islander, multiracial, or White), whether employed, education (high school or less, some college, Bachelor’s degree or more), family income in the last 12 months (<\$50,000, ≥\$50,000-<\$100,000, ≥\$100,000), household size, whether married, whether have children <18 years old, and whether living quarters were owned or being bought by a household member.

2.1.2. County-level sociodemographic characteristics: County-level population size and Census region were obtained from the 2020 Census. County-level percentage non-Hispanic White, percentage non-Hispanic Black, percentage Hispanic, and median household income were obtained from the 2017–2021 American Community Survey 5-year estimates. Population size and median household income were categorized into tertiles for analyses. County-level urbanicity was obtained from the 2013 National Center for Health Statistics Urban-Rural Classification Scheme for Counties,[46] which classifies counties as: large central metro, large fringe metro, medium metro, small metro, micropolitan, and non-core.

2.1.3. Code reform zoning and activity-oriented zoning: Zoning codes as of 2010 were obtained in a previous nationwide study.[41, 43] Briefly, zoning codes for over 4000 municipalities and unincorporated areas were compiled from each jurisdiction and evaluated using systematic methods and a detailed zoning code audit tool developed specifically for this project.[47] Codes were assessed by two or more urban planners with a high rate of inter-coder reliability (≥90%); all complex or large jurisdictions were double-coded and a consensus coding was generated. For purposes of this study, we coded for the presence or absence of 10 zoning measures that were developed based on scientific evidence documenting features of the built environment (i.e., sidewalks, crosswalks, bike-pedestrian connectivity, street connectivity, bike lanes, bike parking, bike/pedestrian trails/paths, mixed use, active recreation, and passive recreation) associated with recreational and/or transit-related physical activity including walking and biking.[31, 41, 43, 48, 49] We also included a dichotomous measure of code reform zoning. Unlike traditional zoning provisions which govern community design based on use and density (e.g., commercial,

residential), code reform zoning aims to create pedestrian-supportive built environments that include a mix of land uses, higher density, open space, transportation infrastructure, and traditional neighborhood structures that are designed to support walking.[29, 31, 37, 39] Examples of zoning code reforms in the U.S. include, but are not limited to, the SmartCode, form-based codes, transit-oriented development zoning, and pedestrian-oriented development zoning.[37, 41, 43]

For this study, we examined any code reform zoning (yes/no) and a continuous activity-oriented zoning index. The index was comprised of 10 binary (yes/no) zoning measures, as described above, that were summed into an index (range 0–10). To facilitate linkages with CPS, for which only county-level FIPS codes were available, county-aggregated zoning measures were computed reflecting the proportion of each county's population exposed to the given zoning measure. For code reform zoning, the county-aggregated measure reflected the proportion of the county exposed to any code reform zoning. The county-aggregated version of the activity-oriented zoning index was equal to the sum of the county-aggregated versions of the 10 specific zoning measures, and ranged from a minimum possible value of 0 to a maximum possible value of 10 if 100% of a county's population was exposed to each of the 10 measures. For example, suppose a county included (1) jurisdiction A that included 30% of the county's population and did not have code reform zoning, (2) jurisdiction B that included 20% of the county's population, and did have code reform zoning, and (3) jurisdiction C that included 50% of the county's population and did not have code reform zoning. Then the county-aggregated measure of code reform zoning for this county would be 0.20, reflecting the 20% of the county's population exposed to code reform zoning in jurisdiction B. Similarly, if jurisdiction A addressed all 10 measures in the activity-oriented zoning index while jurisdictions B and C addressed none of the 10 measures, the county-aggregated activity-oriented zoning index would be 3.

2.1.4. Walkability index: Walkability was measured using the EPA's 2021 National Walkability Index, which is calculated based on measures of street intersection density, diversity of land uses and proximity to transit.[50] Elements of this Index are presented in Appendix Table A. This was aggregated from the block group level to the county level to facilitate data linkages by first averaging from the block group level to the jurisdiction level and then aggregating from the jurisdiction level to the county level by taking a population-weighted average across jurisdictions in each county.

2.1.5. Park coverage: Data on land area devoted to open parks in 2018 was obtained at the tract level from the National Neighborhood Data Archive.[51] To facilitate data linkages, park coverage was computed at the jurisdiction level as the proportion of area devoted to open parks and then aggregated to the county level by taking a population-weighted average across jurisdictions in each county.

2.2. Analytical sample

Datasets were linked based on county Federal Information Processing Standards (FIPS) codes. A total of 56,130 adult civilian household members completed the Volunteering and Civic Life Supplement. Of those, zoning data could not be linked for 34,024 respondents

because the FIPS code for their county was suppressed in the CPS data and for 397 respondents because zoning data were not available for the given county because the county was not included in the frame of the previous study for which those data were obtained. Of the remaining 21,709 respondents, 93 were in counties with missing data on the mediators of interest. This left 21,616 respondents in 259 counties in 40 states and DC. The 259 counties spanned all four U.S. census regions and were predominantly in metropolitan areas (36 large central metro, 97 large fringe metro, 73 medium metro, 48 small metro), with 5 micropolitan counties. Appendix Table B compares the characteristics of the 259 counties compared to other counties throughout the U.S. As the data indicate, the sample is predominantly comprised of large urban counties with a higher median household income and higher percentages of non-Hispanic Black and Hispanic individuals compared to all other U.S. counties. Appendix Figure A shows a map of the 259 counties across the U.S. Due to missing item-specific outcome data, analytical sample sizes ranged from 20,406 to 20,461 individuals. Because of cases lost when linking data, analyses were not able to account for CPS survey weights or sample design.

2.3. Statistical analyses

Multivariable logistic regression models with robust standard errors were computed to separately assess the association of code reform zoning and the activity-oriented zoning index with each of the three outcome measures, controlling for individual- and county-level characteristics (i.e., estimated total effect). As noted above, only county-level FIPS codes were available in CPS, so county-aggregated, population-weighted zoning measures were used. The odds ratios from these models can be interpreted as associations with 100% versus 0% county-level exposure to code reform zoning, or 100% versus 0% county-level population exposure to one additional indicator in the activity-oriented zoning index. For example, an odds ratio of 1.03 for code reform zoning would indicate 3% higher odds of the given outcome with 100% versus 0% county-level exposure to code reform zoning. Adjusted prevalence estimates were computed from the logistic regression models comparing no exposure to zoning (0% county-level exposure to code reform zoning or to all 10 items in the activity-oriented zoning index) to maximal exposure to zoning (100% county-level exposure to code reform zoning or to all 10 items in the activity-oriented zoning index). Similar multivariable linear regression models with robust standard errors were computed to assess the association of the zoning exposure measures with the walkability and park coverage mediators.

To assess mediation by walkability and park coverage, mediation analyses under a counterfactual framework[52] were conducted with robust standard errors, with linear models for the potential mediators and probit models for the outcomes, allowing for treatment-mediator interactions. This methodology is used in other recent literature analyzing cross-sectional data.[53, 54] Importantly, by using a counterfactual framework, it is possible to obtain correct inferences with dichotomous outcomes, such as the dichotomous social connectedness outcomes used in this study. As noted in previous literature,[55–57] traditional mediation approaches do not give valid estimates of direct or indirect effects for dichotomous outcomes when treatment-mediator interactions are present (which we allow for in the current study), and estimates for some commonly used models are not

valid when the dichotomous outcomes are not rare (as they are not in the current study). Directed acyclic graphs showing the hypothesized relationships between the independent, mediator, and outcome variables are shown in Figure 1. Separate mediation analyses were conducted for the two potential mediators, which produced estimates of the natural indirect effect (NIE), natural direct effect (NDE), total effect, and proportion mediated comparing no and maximal exposure to zoning. These estimates are interpretable as differences in the probability of the outcome. For instance, a NIE for mediation of the activity-oriented zoning index by park coverage of 0.003 indicates that the zoning index is associated via park coverage with 0.3 percentage points higher probability of the given outcome. The presence of mediation was assessed based on whether a 95% confidence interval for the NIE included zero. Analyses were conducted in Stata/MP 18.0, using the mediate command for mediation analyses.

3. Results

3.1. Sample description

More than half of the sample lived in large central (35.3%) or fringe (27.5%) metro counties (Table 1). Individuals were predominantly non-Hispanic White (64.1%), with about half (53.5%) female and average age of 50.2 years. They were predominantly employed (60.9%), with less than a college degree (59.5% some college or less).

3.2. Zoning exposure, walkability and park coverage

On average, individuals lived in counties where 36% of the county population was exposed to code reform zoning, exposure to the items in the activity-oriented zoning index was 5.4 out of 10, the walkability index was 10.9 out of a range of 1–20, and park coverage was 0.1 out of 1.

3.3. Prevalence of perceived neighborhood social connectedness outcomes

The prevalence of the outcome measures varied: 72.8% of the sample had conversations or spent time with their neighbors, 53.4% and their neighbors did favors for each other, and 22.1% got together with others from their neighborhood to do something positive.

3.4. Association of zoning exposure with walkability, park coverage, and perceived neighborhood social connectedness outcomes

Code reform zoning was positively associated with both walkability and park coverage (Table 2), with exposure to 100% versus 0% county-level exposure to code reform zoning associated with about a 1-point increase in the walkability index (out of 20) and a 0.01 increase in the park coverage measure (out of 1). Further, code reform zoning was positively associated with all three perceived neighborhood social connectedness outcomes, with an adjusted prevalence (not shown in tables) of 75.0% versus 71.5% for having conversations or spending time with neighbors with 100% versus 0% county-level exposure to code reform zoning (OR: 1.22, 95% CI: 1.08, 1.36), 56.2% versus 51.8% for individuals and their neighbors doing favors for each other (OR: 1.22, 95% CI: 1.10, 1.35), and 24.8% versus 20.6% for individuals getting together with others from their neighborhood to do something positive (OR: 1.29, 95% CI: 1.14, 1.46).

The activity-oriented zoning index was positively associated with both walkability and park coverage, with 100% versus 0% county-level exposure to one additional indicator in the activity-oriented zoning index associated with a 0.23 increase in the walkability index (out of 20) and a 0.003 increase in park coverage (out of 1). The zoning index was also associated with all three perceived neighborhood social connectedness outcomes, including having conversations or spending time with their neighbors (OR: 1.03, 95% CI: 1.01, 1.05; adjusted prevalence of 75.2% with 100% county-level exposure to all of the zoning measures in the index and 69.6% with no county-level exposure to any of the zoning measures), individuals and their neighbors doing favors for each other (OR: 1.03, 95% CI: 1.01, 1.04; adjusted prevalence of 56.1% versus 50.1%), and with getting together with others from their neighborhood to do something positive (OR: 1.04, 95% CI: 1.02, 1.06; adjusted prevalence of 25.4% versus 18.6%).

Table 3 presents adjusted associations of code reform zoning and the activity-oriented zoning index with neighborhood social connectedness when controlling for walkability and park coverage.

3.5. Mediation of the associations between zoning exposure and perceived neighborhood social connectedness outcomes by walkability and park coverage

There was no evidence for mediation of the associations between code reform zoning and individuals having conversations or spending time with their neighbors or individuals and their neighbors doing favors for each other by either walkability or park coverage (Table 4). The association between code reform zoning and individuals getting together with others from their neighborhood to do something positive was partially mediated by walkability. Code reform zoning was associated with 1.0 percentage points higher probability of this outcome through walkability, while it was directly associated with 3.2 percentage points higher probability of the outcome, for a proportion mediated of 24.2% (95% CI: 0.2%, 48.2%). This association was not mediated by park coverage.

Similarly, the associations between the activity-oriented zoning index and individuals reporting having conversations or spending time with their neighbors or individuals and their neighbors doing favors for each other were not mediated by either walkability or park coverage. However, again, the association between the zoning index and individuals getting together with others from their neighborhood to do something positive was separately found to be partially mediated by walkability, with 100% county-level exposure to each of the zoning measures included in the activity-oriented zoning index versus no county-level exposure to any of the measures included in the index associated with 2.8 percentage points higher probability of the outcome through walkability and 4.7 percentage points higher probability directly, for a proportion mediated of 37.5% (95% CI: 14.5%, 60.5%). This association was not mediated by park coverage.

4. Discussion

Leading health authorities have called for interventions that promote social connectedness to address loneliness and social isolation.[16, 17, 58, 59] Built environments designed according to principles of code reform zoning and activity-oriented zoning have potential

to provide a social infrastructure that allows for engagement. This study is the first to our knowledge to examine the associations between these zoning approaches and indicators of perceived neighborhood social connectedness.

In this national sample of U.S. adults, we found that both code reform zoning and activity-oriented zoning facilitate engagement with neighbors. The 2023 U.S. Surgeon General's report titled "Our Epidemic of Loneliness and Isolation" includes strengthening the social infrastructure in local communities as one its pillars and specifically recommends built environments that promote social connections.[17] Neighborhoods are a critical part of the social infrastructure, allowing proximity to places and spaces that provide opportunities for social engagement.[60] This study suggests that modern approaches to zoning that attempt to mitigate the segregation and harms caused by traditional Euclidean zoning are important policy tools to promote social connections in neighborhoods.

Social connectedness is a multi-component construct that is influenced by the structure, function and quality of one's relationships.[5] Social relationships can have positive and negative aspects and occur on a continuum, from casual encounters to deeper relationships. The indicators examined in this study included: (1) having conversations and spending time with neighbors, a measure of social contact, [3, 18] (2) doing favors for each other, a measure of mutual assistance and form of social capital,[18, 22] and (3) getting together with neighbors to do something positive for the neighborhood, an indicator of civic engagement and also a form of social capital.[18, 23] These indicators represent varying degrees of engagement with neighbors. The zoning indicators examined in this study were associated with each type of social connectedness examined. These results suggest that built environment changes associated with these zoning reforms can promote a range of positive social interactions among neighbors, consistent with their goal of providing human-centric communities that promote both physical and social connections. Holt-Lunstad and colleagues have defined three components of social connectedness: structure, function and quality.[5] All the indicators examined in the current study are indicators of function, with the getting together with neighbors to do something positive also touching upon quality. Future research with more comprehensive measures is needed to further determine how zoning influences social connectedness.

Walkability and access to parks are key features of built environments that support physical activity.[48, 49] In our analyses, zoning was associated with both walkability and park coverage, suggesting that zoning provisions were being implemented in practice. We hypothesized that these features would mediate the associations between code reform and activity-oriented zoning and social connectedness because of their potential to provide opportunities for both planned and unplanned social interactions. However, findings exploring the mediating roles of walkability and park coverage were mixed. None of the associations were found to be mediated by park coverage. Walkability did partially mediate the associations between both code reform and activity-oriented zoning measures and getting together with neighbors to do something positive for the neighborhood. This represents a measure of civic engagement and a deeper level of involvement with neighbors than the other two measures and focuses on neighborhood improvement, rather than traditional neighborly interactions. Thus, zoning-directed improvements to neighborhood

walkability may be more likely to lead to civic engagement-oriented social interactions that involve being out in the neighborhood. Future research should explore the mediating role of zoning-directed changes to other infrastructure components (e.g., transit stops, community centers) that can support social interactions.

4.1. Study strengths and limitations

Study strengths include the large national sample, comprehensive zoning indicators and adjustment for individual-level covariates. Limitations include the cross-sectional design, which precludes causal inferences, and limited generalizability due to inability to account for CPS weighting because of the large proportion of the sample that could not be linked to zoning data; however, the study still included individuals from 259 counties located in 40 states and the District of Columbia and the rates of zoning exposure were comparable to those in a larger nationwide sample of individuals from the most populous 495 counties located in 48 states and the District of Columbia.[41] Only county-level indicators of zoning, walkability and park coverage could be examined due to inability to link to CPS at a lower geographic level, resulting in possible misclassification of exposure to zoning reforms which are more common at the municipal (rather than the county) level, which could over or under-estimate the observed findings. There was also considerable missing data that resulted when linking zoning data to CPS data due to suppression of FIPS codes in the CPS. This may have resulted in bias in the representativeness of the sample included in the study. Of note, the final sample included individuals from 40 states and the District of Columbia. Analyses comparing all eligible CPS participants to those who could be included in the analyses indicated the analytical sample had lower prevalence of all three social connectedness outcomes, was less non-Hispanic White, less likely to be married, more educated, higher-income, more likely to be employed, more likely to have children, less likely to own their living quarters, and younger. The included zoning measures assess policies that have been adopted or are on-the-books, which do not necessarily reflect implementation of the policies through changes to the built environment in practice. However, the analyses included a 9+ year lag between the latest year of zoning adoption and the CPS outcomes, which allows for on-the-ground implementation. (Additionally, we know that many jurisdictions in our zoning sample had adopted their zoning codes even earlier than 2010, which allows for an even longer implementation lag.).[47] This analysis was limited to perceived neighborhood social connectedness measures available in CPS. Finally, mediation analyses including both walkability and park coverage simultaneously were not possible.

5. Conclusions

Reducing loneliness and social isolation through interventions that promote social connectedness is a public health priority. This study supports code reform and activity-oriented zoning as policy-based approaches to promote social connections. Future research and evaluation is needed to further delineate the social benefits of zoning reform and to determine mechanisms through which zoning influences opportunities for social connections.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability statement

The zoning data and supporting documentation used in this study are available through the University of Michigan's Inter-university Consortium for Political and Social Research (ICPSR) openICPSR data archive (<https://www.openicpsr.org/openicpsr/project/242779/version/V1/view>). The 2019 Current Population Survey (CPS) Volunteering and Civic Life Supplement is publicly available from the U.S. Census Bureau. The 2021 National Walkability Index is publicly available from the U.S. Environmental Protection Agency. Park coverage data as of 2018 are available from the National Neighborhood Data Archive, accessible through ICPSR. County-level urbanicity was obtained from the 2013 National Center for Health Statistics Urban-Rural Classification Scheme for Counties, which is publicly available from the U.S. Centers for Disease Control and Prevention.

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Highlights:

- Code reform and activity-oriented zoning are associated with social connections with neighbors, including indicators of having conversations or spending time with neighbors, neighbors doing favors for each other and neighbors getting together to do something positive
- Code reform and activity-oriented zoning are associated with walkability and park access
- Walkability mediates code reform and activity-oriented zoning and doing positive things with neighbors
- Park coverage does not mediate observed associations

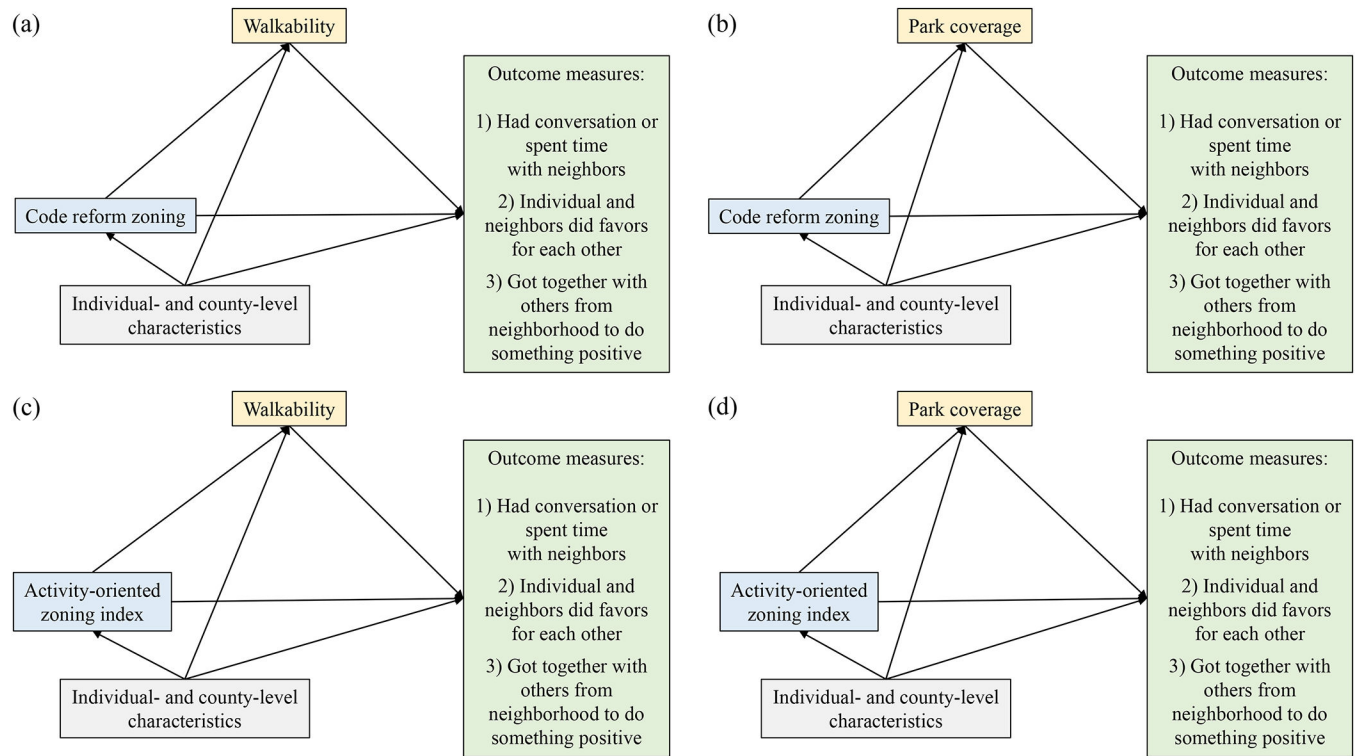


Figure 1. Directed acyclic graphs showing hypothesized relationships between the independent, mediator, and outcome variables. The four panels (a)-(d) of this figure show the four primary models examined.

Table 1.

Descriptive Characteristics of the Included Sample, Current Population Survey September 2019 Volunteering and Civic Life Supplement, n=21,616.

	% or Mean (SD)
Individual-level characteristics	
Female	53.5%
Age	50.2 (18.5)
Race and ethnicity	
American Indian/Alaskan Native, non-Hispanic	0.55%
Asian, non-Hispanic	7.2%
Black, non-Hispanic	10.6%
Hawaiian/Pacific Islander, non-Hispanic	0.40%
Hispanic	15.7%
Multiracial, non-Hispanic	1.5%
White, non-Hispanic	64.1%
Employed	60.9%
Education	
High school or less	33.9%
Some college	25.6%
Bachelor's degree or more	40.5%
Family income in last 12 months	
<\$50,000	35.8%
≥\$50,000-<\$100,000	31.3%
≥\$100,000	32.9%
Married	51.5%
Have own children <18 years old	22.8%
Household size	2.6 (1.4)
Living quarters owned or being bought by household member	67.2%
County-level characteristics	
Population size	
Small (116,530–456,781)	33.5%
Medium (>456,781–1,016,508)	35.1%
Large (>1,016,508–10,014,009)	31.4%
% non-Hispanic White	54.9 (21.7)
% non-Hispanic Black	12.5 (12.3)
% Hispanic	20.6 (17.4)
Median household income	
Low (36,736–65,656)	33.5%
Medium (>65,656–82,894)	33.2%
High (>82,894–156,821)	33.3%
Census region	
West	31.2%
Midwest	13.2%

	% or Mean (SD)
Northeast	25.9%
South	29.7%
Urbanicity	
Large central metro	35.3%
Large fringe metro	27.5%
Medium metro	25.1%
Small metro	11.0%
Micropolitan	1.1%
Zoning exposure (county-aggregated)	
Code reform zoning exposure (0–1)	0.36 (0.37)
Activity-oriented zoning index (0–10)	5.4 (2.7)
Potential mediators	
Walkability index (range: 1–20)	10.9 (2.5)
Park coverage (range: 0–1)	0.08 (0.07)
Neighborhood social connectedness measures	
Had conversation or spent time with neighbors ^a	72.8%
Individual and neighbors did favors for each other ^b	53.4%
Got together with others from neighborhood to do something positive ^c	22.1%

N=21,616 individuals in 259 counties in 40 states and DC.

^aN=20,461 due to item-specific missing data.

^bN=20,406 due to item-specific missing data.

^cN=20,435 due to item-specific missing data.

Table 2.

Adjusted Associations of Code Reform Zoning and Activity-Oriented Zoning Index with Walkability, Park Coverage, and Neighborhood Social Connectedness.

	Had conversation or spent time with neighbors ^a	Individual and neighbors did favors for each other ^b	Got together with others from neighborhood to do something positive ^c
	Coefficient or Odds Ratio (95% CI)	Coefficient or Odds Ratio (95% CI)	Coefficient or Odds Ratio (95% CI)
<i>Exposure: Code reform zoning^d</i>			
Association of exposure with walkability	1.43 (1.36, 1.49)	1.43 (1.36, 1.49)	1.42 (1.36, 1.48)
Association of exposure with park coverage	0.01 (0.01, 0.01)	0.01 (0.01, 0.01)	0.01 (0.01, 0.01)
Association of exposure with outcome	1.22 (1.08, 1.36)	1.22 (1.10, 1.35)	1.29 (1.14, 1.46)
<i>Exposure: Activity-oriented zoning index^e</i>			
Association of exposure with walkability	0.23 (0.23, 0.24)	0.23 (0.23, 0.24)	0.23 (0.22, 0.24)
Association of exposure with park coverage	0.003 (0.003, 0.004)	0.003 (0.003, 0.004)	0.003 (0.003, 0.004)
Association of exposure with outcome	1.03 (1.01, 1.05)	1.03 (1.01, 1.04)	1.04 (1.02, 1.06)

Note: Statistically significant results at $p < .05$ are shown in **bold**. Each estimate shown is from a separate multivariable model (coefficients from linear regressions for associations with walkability and park coverage and odds ratios from logistic regressions for associations with outcomes). Each model adjusts for individual sex, age, race, ethnicity, employment, education, family income, marital status, having children under 18, household size, housing ownership and county-level population size tertiles, percentage non-Hispanic White, percentage non-Hispanic Black, percentage Hispanic, median household income tertiles, Census region, and urbanicity. All models were estimated with robust standard errors.

^a $n=20,461$

^b $n=20,406$

^c $n=20,435$

^d Coefficients and odds ratios show associations with 100% versus 0% county-level exposure to code reform zoning.

^e Coefficients and odds ratios show associations with 100% versus 0% county-level exposure to one additional indicator in the activity-oriented zoning index.

Table 3. Adjusted Associations of Code Reform Zoning and Activity-Oriented Zoning Index with Neighborhood Social Connectedness when Controlling for Walkability and Park Coverage.

	Had conversation or spent time with neighbors ^a	Individual and neighbors did favors for each other ^b	Got together with others from neighborhood to do something positive ^c
	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)
<i>Exposure: Code reform zoning^d</i>			
Association of exposure with outcome controlling for walkability	1.11 (0.99, 1.25)	1.15 (1.03, 1.28)	1.22 (1.07, 1.39)
Association of exposure with outcome controlling for park coverage	1.20 (1.07, 1.35)	1.21 (1.09, 1.34)	1.28 (1.13, 1.45)
<i>Exposure: Activity-oriented zoning index^e</i>			
Association of exposure with outcome controlling for walkability	1.02 (1.00, 1.04)	1.02 (1.00, 1.03)	1.03 (1.01, 1.05)
Association of exposure with outcome controlling for park coverage	1.03 (1.01, 1.05)	1.03 (1.01, 1.04)	1.04 (1.02, 1.06)

Note: Statistically significant results at p<.05 are shown in **bold**. Each estimate shown is from a separate multivariable logistic regression model. Each model adjusts for individual sex, age, race, ethnicity, employment, education, family income, marital status, having children under 18, household size, housing ownership and county-level population size tertiles, percentage non-Hispanic White, percentage non-Hispanic Black, percentage Hispanic, median household income tertiles, Census region, and urbanicity, as well as either walkability or park coverage as noted in the row header. All models were estimated with robust standard errors.

^a n=20,461

^b n=20,406

^c n=20,435

^d Odds ratios show associations with 100% versus 0% county-level exposure to code reform zoning.

^e Odds ratios show associations with 100% versus 0% county-level exposure to one additional indicator in the activity-oriented zoning index.

Table 4.

Results of Mediation Analyses Linking Code Reform Zoning and Activity-Oriented Zoning Index with Neighborhood Social Connectedness through Walkability and Park Coverage.

	Mediator: Walkability			Mediator: Park Coverage		
	Natural Indirect Effect (95%CI)	Natural Direct Effect (95%CI)	Total Effect (95%CI)	Natural Indirect Effect (95%CI)	Natural Direct Effect (95%CI)	Proportion Mediated (95%CI)
<i>Exposure: Code reform zoning^a</i>						
<u>Outcome</u>						
Had conversation or spent time with neighbors ^b	0.004 (-0.005, 0.013)	0.029 (0.007, 0.051)	0.033 (0.013, 0.053)	0.000 (-0.003, 0.002)	0.037 (0.017, 0.057)	--
Individual and neighbors did favors for each other ^c	0.001 (-0.010, 0.011)	0.041 (0.016, 0.066)	0.042 (0.019, 0.065)	-0.002 (-0.004, 0.001)	0.047 (0.024, 0.071)	--
Got together with others from neighborhood to do something positive ^d	0.010 (0.001, 0.019)	0.032 (0.010, 0.053)	0.042 (0.021, 0.062)	0.001 (-0.001, 0.003)	0.040 (0.019, 0.060)	3.11% (-2.36%, 8.58%)
<i>Exposure: Activity-oriented zoning index^e</i>						
<u>Outcome</u>						
Had conversation or spent time with neighbors ^b	0.005 (-0.011, 0.020)	0.043 (0.009, 0.077)	0.047 (0.015, 0.080)	0.002 (-0.005, 0.009)	0.053 (0.021, 0.085)	3.58% (-9.23%, 16.39%)
Individual and neighbors did favors for each other ^c	0.005 (-0.012, 0.023)	0.047 (0.009, 0.085)	0.053 (0.016, 0.089)	0.002 (-0.006, 0.010)	0.057 (0.021, 0.093)	3.86% (-9.58%, 17.31%)
Got together with others from neighborhood to do something positive ^d	0.028 (0.013, 0.043)	0.047 (0.015, 0.078)	0.075 (0.044, 0.106)	0.004 (-0.003, 0.012)	0.065 (0.034, 0.095)	6.49% (-4.09%, 17.07%)

Note: Statistically significant results at $p < .05$ are shown in **bold**. Estimates with 95% confidence intervals shown from separate mediation analyses for the two potential mediators adjusting for individual sex, age, race, ethnicity, employment, education, family income, marital status, having children under 18, household size, housing ownership and county-level population size tertiles, percentage non-Hispanic White, percentage non-Hispanic Black, percentage Hispanic Black, percentage Hispanic, median household income tertiles, Census region, and urbanicity. All models were estimated with robust standard errors. The natural indirect effect is the estimate of interest for assessing whether mediation was present. The proportion mediated is equal to the natural indirect effect divided by the total effect (i.e., the sum of the natural indirect effect and the natural direct effect) and is not shown where the natural indirect effect and natural direct effect are of different signs.

^a Estimated effects compare 100% county-level exposure to code reform zoning to no county-level exposure to code reform zoning.

^b $n = 20,461$

^c $n = 20,406$

^d $n = 20,435$

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Estimated effects compare 100% county-level exposure to each of the zoning measures included in the activity-oriented zoning index to no county-level exposure to any of the measures included in the index.