Published in final edited form as:

Cancer Epidemiol Biomarkers Prev. 2017 April ; 26(4): 578–586. doi:10.1158/1055-9965.EPI-16-0331.

Exploring the Linkage between Activity-Friendly Zoning, Inactivity, and Cancer Incidence in the United States

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Abstract

Background—Physical activity (PA) protects against cancer and enhances cancer survivorship. Given high inactivity rates nationwide, population-level PA-facilitators are needed. Several authoritative bodies have recognized that zoning and planning helps create activity-friendly environments. This study examined the association between activity-friendly zoning, inactivity, and cancer in 478 of the most populous U.S. counties.

Methods—County geocodes linked county-level data: cancer incidence and smoking (State Cancer Profiles), inactivity (Behavioral Risk Factor Surveillance System), 11 zoning measures (compiled by the study team), and covariates (from the American Community Survey and NAVTEQ). For each zoning measure, single mediation regression models and Sobel tests examined whether activity-friendly zoning was associated with reduced cancer incidence, and whether inactivity mediated those associations. All models were clustered on state with robust standard errors and significance at the $P < .05$ level.

Results—Zoning for crosswalks, bike-pedestrian connectivity, and bike-pedestrian trails/paths were associated with reduced cancer incidence (β between -0.71 and -1.27 , $P < .05$), about one case per 100,000 for each 10 percentage point increase in county population exposure to zoning. Except for crosswalks, each association was mediated by inactivity. However, county smoking attenuated these results, with only crosswalks remaining significant. Results were similar for males (with zoning for bike-pedestrian connectivity, street connectivity, and bike-pedestrian trails/paths), but not females, alone.

Conclusion—Zoning can help to create activity-friendly environments that support decreased inactivity, and possibly reduced cancer incidence.

Impact—Given low PA levels nationwide, cross-sectoral collaborations with urban planning can inform cancer prevention and public health efforts to decrease inactivity and cancer.

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Disclosure of Potential Conflicts of Interest

None of the authors have any potential conflicts of interests to disclose.

Disclaimer

The findings and conclusions of this report are those of the authors and do not necessarily represent the official positions of the NIH or NCI.

Keywords

Cancer incidence; physical activity; policy; zoning; public health

Introduction

Cancer incidence continues to rank among one of the top 10 leading causes of death in the United States and accounts for 23% of all deaths (1,2), but cancer-related deaths are declining. The age-adjusted cancer death rate decreased by 15% between 2003 and 2013, from 190.9 to 163.2 deaths per 100,000 population (1). Although year-to-year changes over the last 5 years in cancer death rates have remained stable among women and decreased slightly among men (1.8%) (2), longer time trends suggest that all cause death rates are decreasing faster for women (11% decrease), compared to 6% among men aged 55–64 due to lower cancer and heart disease related deaths (1). Additionally, the number of cancer survivors is continuing to grow, with the number of people who have lived 5 years or more after their cancer diagnosis projected to increase approximately 37% to 11.9 million (3). These simultaneous trends of increasing cancer incidence and decreasing cancer mortality have contributed to a need for more focused research on modifiable lifestyle factors, including physical activity (PA) levels, that can protect against cancer and improve post-diagnostic quality of life.

Current research supports PA as a protective factor against cancer development and as a factor in improved prognosis for cancer survivors. Cancer and PA research are of critical importance for the general population since approximately one third of adults worldwide are currently inactive, with the trend starting early in life (4,5). Current research supports an association between PA and a reduction in risk of certain cancers in the general population (6,7). Leisure time physical activity (LTPA) has been related to reductions in postmenopausal breast cancer (6,8–10), colon (6,11,12), and endometrial cancers (13,14). Mixed results support associations between moderate levels of PA (higher metabolic levels than LTPA) and pancreatic (15–17) and rectal cancer (6,11) risk reductions. One recent systematic review and meta-analysis also found an association between LTPA and an 11% reduction in pancreatic cancer risk, with the strongest effects in younger populations (18). A recent study also found significant reductions in esophageal adenocarcinoma, liver, lung, kidney, myeloid leukemia, myeloma, gastric cardia, bladder, breast, colon, rectal, endometrial, and head and neck cancers, but increased risk in prostate and malignant melanoma associated with LTPA (6). Increased PA, especially after cancer treatment, has been related to improved prognosis, better physical functioning, reduced fatigue and bodily pain, and overall quality of life (7,19–22), underscoring the need for PA promotion among cancer survivors (5,23).

Studies vary widely in both the examination of and findings on gender differences in the relationship between PA and cancer risk. One study found a positive dose-response between age and inactivity among men, who in general had higher levels of activity, but not among women (24). However, many studies find consistent results for both men and women, particularly for colon cancer (12). Although the link between PA and cancer risk has

received increasing attention, virtually all published studies indicate a need for additional research on ways to encourage PA among those affected by cancer and increase LTPA among healthy adults and gender-specific targeted programs may be most effective in some cases.

The implementation of policies to improve infrastructure for PA have been shown to be an effective means for improving PA, which is critically important among the general population where PA remains stagnant and among cancer survivors where only 4.5% are meeting PA recommendations of 150 minutes/week (25). Community and street-scale urban design policies have been shown to impact people's lifestyles and PA levels (26–30). Such policies are typically incorporated into a community's zoning code and design standards. Examples of the types of activity-friendly infrastructure that is typically included in zoning codes are requirements for more compact development with a mix of residential, commercial, retail, and recreational destinations; traditional neighborhood design that provides street and sidewalk connectivity; transportation infrastructure; and proximity to recreational areas/facilities (26). A previous study conducted by the current study team found that all of the activity-friendly zoning measures examined here, except crosswalks, were associated with reduced physical inactivity among adults 18–64 (31). Reductions ranged from 11–16% for the individual zoning measures after adjusting for a variety of individual and county characteristics using multivariate generalized linear models. This was consistent with other previous studies by the study team finding positive associations between activity-friendly zoning and adult walking/biking (32) and active travel to work (33,34).

Materials and Methods

This study is the first to our knowledge to examine the associations among activity-friendly zoning provisions, physical inactivity, and cancer incidence. It was conducted between May 2012 and August 2016. The University of Illinois at Chicago (UIC) Institutional Review Board deemed that this study did “not involve human subjects” (research protocol #2011-0880). The study design is cross-sectional and links 2010 zoning code data, aggregate 2009–2013 data on cancer incidence, inactivity, and county characteristics, aggregate 2008–2010 data on smoking, and aggregate 2007–2011 data on walkability.

Study sample

The initial sample frame for this study included a purposeful sample of the 496 most populous U.S. counties for which zoning data were compiled, which collectively represented approximately 74.26% of the U.S. population based on 2010 Census estimates. County-level data on cancer incidence were not available for the states of Kansas, Minnesota, and Nevada, which eliminated 16 counties, and data from Michigan may have been limited but was not excluded (did not include cases diagnosed in other states). The final analytic sample (N=478 counties in 46 states and DC), male-only sample (N=432 counties in 46 states and DC) and female-only sample (N=395 counties in 42 states and DC) excluded counties with missing childhood cancer data, as it was impossible to compute adult cancer incidence for those counties. Analyses controlling for smoking excluded one additional county due to missing

data, which reduced state coverage by one. Excluded counties were similar to those included in the analytic sample in terms of race, income, poverty, median age, and walkability, with the exception that excluded counties for the combined-gender analyses had a significantly lower percentage of non-Hispanic blacks, and excluded counties for the female-only analyses had significantly higher percentages of non-Hispanic whites, lower percentages of non-Hispanic blacks and Hispanics, and lower walkability scales. The analytic sample covered 68–72% of the U.S. population, depending on the specific analysis being conducted.

Data sources and measures

Cancer incidence—Pooled, age-adjusted annual cancer incidence rates per 100,000 for years 2009–2013 at the county level were obtained from the State Cancer Profiles website, a collaboration of the National Cancer Institute (NCI) and the Centers for Disease Control and Prevention (CDC) (35). These rates included invasive cancer only (except bladder cancer, which was invasive or in situ) at all sites. Cancer incidence rates for adults age 20 and older were computed by subtracting incidence of childhood cancers from incidence rates for all ages. The time period for the incidence data was the only one available through our data source, and the most current publicly available data. These county-aggregated incidence rates are based on non-publicly available individual-level incidence data from the CDC’s National Program of Cancer Registries Cancer Surveillance System (NPCR-CSS) and the NCI’s Surveillance, Epidemiology, and End Results (SEER) Program. The NPCR and SEER jointly collect data for the entire U.S. population (36). Medical facilities such as hospitals report cancer cases to their local registry, which reports to central state cancer registries that in turn submit data annually to NPCR and SEER. Data collected included the type, extent, and location of the cancer, the type of initial treatment, and outcomes, together with demographic information. Information regarding primary or secondary site was not available. Additionally, due to the low incidence of specific cancers by county, all cancers were combined for the primary analysis. Sensitivity analysis detailed below describe cancer type specific results, as a secondary analysis. Age-adjusted incidence rates were calculated using SEER*Stat with population counts for denominators based on Census populations as modified by NCI.

Inactivity—Average inactivity rates across the 5-year period 2009–2013 (to correspond with the available cancer incidence data) were computed based on yearly data on age-adjusted LTPA level prevalence among adults age 20 and older at the county level obtained from the CDC Diabetes Data and Statistics County Data Indicators (37). These data were model-based estimates derived from data from the CDC’s Behavioral Risk Factor Surveillance System (BRFSS) and the U.S. Census Bureau’s Population Estimates Program (38). The BRFSS is a state-based monthly telephone survey of adults designed to collect data on behavioral health risks and use of preventive health services which collects data in all 50 states, the District of Columbia, and three U.S. territories, completing more than 400,000 interviews per year (39). BRFSS respondents were counted as inactive if they answered no to the question “During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?”

A systematic review supported the findings of BRFSS with substantial ($k > 0.6$) agreement found when assessing reliability among persons who were categorized at the vigorous level of physical activity (40). And although there was some variation in validity as assessed by different data collection methods, trends were similar when comparing survey results over time (40).

Smoking—Rates of current smoking among adults age 18+ at the county level were obtained from the State Cancer Profiles (41). Model-based estimates were obtained at the county level based on 2008–2010 BRFSS and National Health Interview Survey (NHIS) data.

Zoning codes—Zoning codes were collected as part of a larger project to examine the association between zoning code reforms and activity-friendly zoning provisions nationwide and adult LTPA and commuting-related PA (32,33). Zoning codes were collected by Master's level urban planners via Internet research with 100 percent verification via telephone and/or electronic mail with all jurisdictions of interest. To allow an implementation lag for the larger study for which these data were collected (32), we obtained the version in effect as of 2010 if the zoning code had been updated more recently. Although the effective date was 2010, a review of the zoning codes suggests that the vast majority of the provisions examined herein were effective at least several years prior to 2010. Zoning codes were compiled for all municipal jurisdictions and unincorporated areas in the 478 counties in the sample, excluding only those areas representing less than 0.5% of the given county population. The 0.5% population restriction reduced the sample from 6,515 municipal jurisdictions and unincorporated areas to 4,344. However, only very small jurisdictions were excluded that represented 2.12% of the initial sample population, and that would make little difference in the population-weighted county-aggregated measures used in this analysis. We could not obtain 151 municipal zoning codes and 2 county zoning codes (applicable to unincorporated areas), again generally in places with very small populations, so our final set of zoning data covered 4,191 municipal jurisdictions and unincorporated areas representing 97.63% of the population of the 478 counties in the sample.

Master's level urban planners assessed the zoning codes using an audit tool (see the Supplementary Material) and detailed coding protocol developed by the study team to evaluate the zoning codes for the presence of the following 11 markers of activity-friendly infrastructure across eight types of districts/zones within each jurisdiction's zoning code: sidewalks; crosswalks; bike lanes; bike parking; bike-pedestrian trails/paths; bike-pedestrian connectivity; street connectivity; mixed use; active recreation (e.g., playgrounds, athletic fields, recreation facilities); passive recreation (e.g., open space, parks); and other general walkability provisions (e.g., traffic calming or pedestrian measures). Coders were tested for inter-rater reliability and were not allowed to code independently until reaching at least a 90 percent rate of agreement. Two Research Electronic Data Capture (REDCap) databases were developed to record policy collection and coding (42). For this analysis, 11 dichotomous (yes/no) measures were created to reflect the presence of each of the activity-friendly markers across ANY district/zone.

Jurisdiction-level zoning data were aggregated to the county level in order to link with the other data. Each jurisdiction-level zoning variable was multiplied by the proportion of the county population represented by the jurisdiction, and then these weighted measures were summed across each county to produce the county-aggregated measures (32). The measures were multiplied by 10 so that a one-unit increase would correspond to a 10 percentage point increase in population exposure to the zoning measure. For instance, if 25% of a given county's population lived in a jurisdiction with zoning for bike-pedestrian connectivity, then the bike-pedestrian connectivity zoning variable would equal 2.5 for that county. Jurisdictions for which the zoning code could not be obtained were not included in the county population denominator for purposes of this computation.

American Community Survey (ACS)—County controls were obtained from the Census Bureau's American Community Survey (ACS) 2009–2013 5-year estimates (again to correspond to the time frame for the cancer data). The 5-year estimates are the most precise available (43). ACS controls included tertiles of median household income (computed separately for each analytic sample), the percentage of households in poverty, percent non-Hispanic White, percent non-Hispanic Black, percent Hispanic, median age, and region.

NAVTEQ—ArcGIS 9.1 software was used to access NAVTEQ 2011 data with 3rd quarter updates. NAVTEQ data provided county-level totals of 4-way intersections as well as all street level intersections. A standardized walkability scale was constructed using NAVTEQ 2011 and ACS 2007–2011 data. The walkability scale is standardized and adjusted by a factor of one to decrease negative scale values and is a summated scale of four density measures: the ratio of four-way intersections to all intersections (NAVTEQ), intersection density or the total number of intersections in the county divided by the county land area (NAVTEQ), housing unit density (ACS), and population density (ACS). The walkability scale is based on the scale created by Slater and colleagues (44) which was adapted from the scale created and updated by Reid Ewing and colleagues (45).

Statistical analysis

Using county-level Federal Information Processing Standards (FIPS) geocodes, data on cancer (2009–2013), inactivity (2009–2013), zoning (2010), ACS (2009–2013), smoking (2008–2010), and NAVTEQ (2011) were merged. The 2010 effective date for the zoning data was the only available data on activity-friendly zoning. Since this analysis is cross-sectional and only intended to explore correlations rather than causation, we felt that the data periods were sufficient, particularly given our anecdotal knowledge that many of our jurisdictions' zoning provisions had been “on-the-books” for a number of years prior to our collection effective date of 2010.

Single mediation regression models were used to test whether activity-friendly zoning provisions were associated with reduced cancer incidence, and whether those associations were mediated by inactivity. Models were run separately for each zoning measure. Mediation was tested using two approaches: (1) causal steps (46) and (2) the Sobel test (47). Testing the causal steps requires three separate regressions: a regression of inactivity on the zoning measure, a regression of cancer incidence on the zoning measure without controlling

for inactivity, and a regression of cancer incidence on the zoning measure and inactivity. Additionally, the magnitude of the coefficient relating the zoning measure to cancer incidence must be larger in the model that does not control for inactivity than in the model that does control for inactivity. For those zoning measures that met the causal steps criteria, the Sobel test was incorporated, which tests whether the indirect association of the independent variable of interest with the dependent variable through the mediator is significant. To explore the gender-cancer-activity connections, we also examined the mediation models using gender-specific cancer and inactivity measures. Also, due to the important role of smoking in cancer incidence, all models were run with and without controlling for gender-specific smoking.

For all models, coefficients on the zoning variables correspond to a 10 percentage point increase in county-level population exposure to the zoning measure. All models were clustered on state with robust standard errors. Statistical significance was determined at the $P < .05$ level. All analyses were conducted in Stata/SE 13.1 (48).

Results

Table 1 shows descriptive statistics for the analytic sample. Average cancer incidence was nearly 435 cases per 100,000, with an average of just over one-fifth of the population being inactive and about one-fifth currently smoking. Average county-level population exposure to the zoning measures ranged from 17% for bike lanes to 81% for active and passive recreation. On average, counties were comprised of mostly non-Hispanic White individuals (68%) with only 13% of households in poverty, and a median age of 37 years. Slightly more than 40% of the counties were located in the South, with the other counties being almost equally distributed across the West (19%), Midwest (20%), and Northeast (21%).

First, analyses examined the separate association between each individual zoning measure and cancer rates adjusting for county controls, but without controlling for inactivity, and these results are displayed in Table 2. Without the smoking control, zoning for crosswalks ($\beta = -1.27$, 95% CI = $-2.33, -0.22$), bike-pedestrian connectivity ($\beta = -0.88$, 95% CI = $-1.73, -0.03$), and bike-pedestrian trails/paths ($\beta = -0.71$, 95% CI = $-1.41, -0.01$) were significantly associated with reduced cancer incidence. These results were attenuated once county smoking was included in the model. Only zoning for crosswalks ($\beta = -1.14$, 95% CI = $-2.25, -0.03$) remained significantly associated with reduced cancer incidence.

Next, for the zoning measures that were significantly associated with cancer rates, mediation analyses tested for potential mediation of these associations by inactivity. With the smoking control, there were no significant mediations, and zoning for crosswalks was not significantly associated with cancer incidence when also controlling for inactivity. Models that had significant results for both causal steps and Sobel tests without the smoking control are displayed in Figures 1A–1B. Without the smoking control, zoning for crosswalks had a significant direct association with reduced cancer incidence even when controlling for inactivity ($\beta = -1.09$, 95% CI = $-2.15, -0.03$), but since it was not significantly associated with inactivity it failed the first of the causal steps criteria for testing mediation. Figures 1A–1B show mediation analysis path diagrams for the remaining two zoning provisions that were

significantly associated with cancer (bike-pedestrian connectivity and bike-pedestrian trails/paths). For each figure, path *a* shows the association of the zoning measure with inactivity; path *b* shows the association of inactivity with cancer; path *c* shows the direct association of the zoning measure with cancer incidence; and path *c'* shows the association of the zoning measure with cancer incidence after accounting for inactivity. In both cases, the remaining three causal steps are satisfied and the Sobel test confirmed significant mediation. Bike-pedestrian connectivity and bike-pedestrian trails/paths were indirectly associated with reduced cancer incidence through an association with inactivity. In both instances, inactivity fully mediated the relationship between zoning and cancer as shown with a significant *c* path but non-significant *c'* path. In each case, the total association was about one fewer case of cancer per 100,000 for a 10 percentage point increase in county-level population exposure to the zoning measure.

Gender-specific analyses were also conducted. Table 3 presents the results of regressions of cancer incidence on the zoning measures and county controls, excluding inactivity, separately by gender. Among males, bike-pedestrian connectivity, street connectivity, and bike/pedestrian trails and paths were associated with reduced cancer incidence. Mediation by inactivity was found for all three zoning measures, as shown in Figures 2A–2C. However, these findings were completely attenuated by the inclusion of county smoking. Among females, interestingly, although no zoning measures were originally associated with cancer, once county smoking was included in the model, bike parking, other walkability, mixed use, and passive recreation was positively associated with cancer incidence, although mediation by inactivity was not established. Sensitivity analysis conducted by cancer type revealed an increased risk of melanoma associated with LTPA. It is possible that zoning directed at increasing outdoor types of LTPA, while reducing some types of cancers (our sensitivity analysis found reduced incidence of cervical, colon, kidney, and lung associated with LTPA), may also increase exposure to the sun and risk of melanoma. This finding is consistent with Moore et al. 2016 (6), which found a positive association between LTPA and melanoma.

Discussion

To our knowledge, this was the first nationwide study to examine the associations among activity-friendly zoning provisions, physical inactivity, and cancer incidence. Our findings for both genders combined suggest that zoning for crosswalks was associated with reduced cancer incidence, although mediation by inactivity could not be established, while two other zoning provisions, for bike-pedestrian connectivity and bike-pedestrian trails/paths, were associated with reduced cancer incidence with full mediation by inactivity. Although the overall reduction was small at the county level, about one fewer case of cancer per 100,000 for each 10 percentage-point increase in county-level population exposure to the zoning measure, summated across all U.S. counties this could correspond to a significant change in population level cancer rates. Results were substantially attenuated after county smoking was included in the model, but zoning for crosswalks remained significant.

Additionally, analyses were examined separately by gender and results were similar for males compared to the gender combined models, but results were insignificant for females alone. One possible explanation is that the zoning provisions associated with reduced

inactivity and cancer were primarily focused on infrastructure that would support bicycling. Several studies have documented that men cycle for recreational and active travel purposes significantly more than women (24,49,50). Relatedly, while zoning permits specific types of retail outlets (e.g., commercial gyms, studios, etc.), this study focused specifically on the physical infrastructure that would be conducive for activity. Thus, it could be speculated that the zoning measures captured herein largely focused on outdoor exercise which may be more likely to decrease inactivity levels among males, whereas females may be more inclined to choose indoor LTPA that is not covered by the type of zoning measures captured for this study. It is also possible that the female cancers captured in our combined cancer measure were not as strongly associated with PA as the male cancers examined. Our study supports previous research that reducing cancer through PA may need to tailor programs to gender-specific needs (24).

The findings in this study are subject to several limitations. First, this study is cross-sectional and findings should be interpreted as associations rather than causation. Secondly, the aggregate nature of the data at the county level allows for the possibility of an ecological fallacy and future studies will need to examine these pathways with individual level analysis as well. Third, although we attempted to include a policy lag it was not possible to tease out timing of the individual elements. Fourth, while self-reported data are typically deemed less reliable, that was less of a concern here given that our outcome measure, inactivity, is less likely to lead to respondent bias (40); however population level results need to be considered with some caution (51). Fifth, although our sample of counties spans the United States, it focused entirely on the most populous counties that cover approximately 72% of the U.S. population and therefore results cannot be generalized beyond the counties studied. Sixth, due to the small incidence of individual cancers by county and the ecological nature of the study we were unable to completely examine the relationships among zoning, LTPA, and specific cancer, although these secondary results do suggest similar findings on the inactivity-cancer relationship to a recent study (6) with respect to colon, kidney, and lung cancers, and melanoma. Lastly, although we controlled for community walkability infrastructure using proven and reliable methods (44), we did not have objective measures of the built environment directly corresponding to each zoning measure.

Yet, this study is the first of its kind to examine a linkage between zoning provisions, inactivity levels, and cancer. We found that living in a county with a higher proportion of population-level exposure to more activity-friendly zoning (especially for crosswalks, bike-pedestrian connectivity and bike-pedestrian trails/paths) was associated with reduced inactivity levels, and in turn, may reduce cancer, especially among males. Given the low PA level in the U.S., these findings identify an opportunity for the public health and cancer communities to work with urban planners to design communities to be more activity-friendly.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors would like to gratefully acknowledge the research and zoning coding assistance provided by Emily Thrun, MUPP, Haytham Abu Zayd, MAPSS, Anthony Pelikan, MUPP, Sunny Bhat, MUPP, Erika Strauss, MUPP, Brad Gregorka, MUPP, April Jackson, PhD, MUPP, Nija Fountano, Carmen Aiken, MUPP, and Jennifer Nalbantyan, MUPP.

Financial Support

J.F. Chiriqui received a grant from the National Cancer Institute, National Institutes of Health (grant number R01CA158035), and the REDCap databases used for policy collection and coding were funded by the University of Illinois at Chicago Center for Clinical and Translational Science located within the Institute for Health Research and Policy at UIC (grant number UL1RR029879).

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Figure 1.
Mediation analysis path diagrams showing separate regression coefficients for each model.

Figure 2. Mediation analysis path diagrams for males only showing separate regression coefficients for each model.

Table 1Characteristics of the study sample^a

Variable	% (or mean)	SD	Minimum	Maximum
<i>Outcome and Mediator Variables</i>				
Cancer incidence ^b (mean)	434.91	38.78	268.20	522.90
Male cancer incidence (mean)	488.56	49.58	328.80	606.30
Female cancer incidence (mean)	398.56	34.15	280.40	468.80
Inactivity	22.51	4.24	10.10	35.30
Male inactivity	20.79	3.83	9.32	31.86
Female inactivity	24.02	4.72	10.80	38.38
<i>Zoning Provisions Addressed</i>				
Sidewalks	69.48	32.52	0	100
Crosswalks	25.87	33.48	0	100
Bike-pedestrian connectivity	42.50	37.54	0	100
Street connectivity	40.35	37.32	0	100
Bike lanes	16.64	29.14	0	100
Bike parking (proxy for street furniture)	40.42	38.62	0	100
Bike-pedestrian trails/paths	56.82	37.97	0	100
Other walkability (e.g. pedestrian plazas)	67.71	33.29	0	100
Mixed use	64.81	33.99	0	100
Active recreation	81.22	28.83	0	100
Passive recreation	81.10	29.11	0	100
<i>County Controls</i>				
West	18.62	38.97		
Midwest	20.08	40.10		
Northeast	20.92	40.72		
South	40.38	49.12		
Median Household Income Tertiles:				
Low (\$29,806.00–\$48,450.00)	33.05	47.09		
Middle (>\$48,450.00–\$58,745.00)	33.47	47.24		
High (>\$58,745.00–\$122,238.00)	33.47	47.24		
% Households in Poverty	13.41	4.71	3.18	31.67
% non-Hispanic White	67.62	19.15	3.57	95.65
% non-Hispanic Black	12.04	12.70	0.27	69.45
% Hispanic	13.44	14.74	0.87	95.50
Median age (mean)	37.40	4.22	24.40	56.70
Walkability scale (mean)	1.00	1.02	0.72	18.04
Current smoking rate	20.17	5.16	1.80	41.60
Male current smoking rate	22.61	5.25	6.70	44.50
Female current smoking rate	18.12	5.37	0.90	38.30

^aN=478 counties, except 477 for smoking, 432 for male cancer, and 395 for female cancer.

^b Cancer incidence rates are annual rates per 100,000.

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Table 2Multivariate regressions of cancer incidence on zoning provisions addressed^a

Zoning Provision Addressed	Without Smoking Control		With Smoking Control	
	Coefficient	95% CI	Coefficient	95% CI
Sidewalks	-0.24	-1.41,0.93	0.00	-1.21,1.21
Crosswalks	-1.27 *	-2.33,-0.22	-1.14 *	-2.25,-0.03
Bike-pedestrian connectivity	-0.88 *	-1.73,-0.03	-0.73	-1.65,0.18
Street connectivity	-0.68	-1.50,0.13	-0.59	-1.41,0.23
Bike lanes	-0.60	-1.80,0.60	-0.40	-1.62,0.82
Bike parking	0.13	-0.84,1.11	0.40	-0.58,1.38
Bike-pedestrian trails/paths	-0.71 *	-1.41,-0.01	-0.49	-1.23,0.25
Other walkability	0.05	-0.97,1.06	0.30	-0.68,1.29
Mixed use	0.46	-0.63,1.55	0.74	-0.35,1.83
Active recreation	0.89	-0.51,2.29	1.09	-0.37,2.55
Passive recreation	0.98	-0.43,2.40	1.23	-0.24,2.70

^aN=478 counties without smoking control and N=477 counties with smoking control containing 72% of the U.S. population located in 46 states (45 with the smoking control) and the District of Columbia. Cancer incidence rates are annual rates per 100,000. Each row corresponds to two separate regression models, with and without a smoking control, but including all other county controls except inactivity. Coefficients correspond to a 10 percentage point increase in county-level population exposure to the given zoning provision. All models were clustered on state with robust standard errors.

* $P < .05$

Table 3

Multivariate regressions of cancer incidence on zoning provisions addressed, separately by gender^a

Zoning Provision Addressed	Males			Females		
	Without Smoking		With Smoking	Without Smoking		With Smoking
	Coefficient	95% CI	Coefficient	Coefficient	95% CI	Coefficient
Sidewalks	-0.90	-2.59,0.78	-0.50	0.03	-1.10,1.17	0.14
Crosswalks	-1.25	-2.66,0.15	-1.01	-0.29	-1.15,0.56	-0.24
Bike-pedestrian connectivity	-1.30*	-2.40,-0.20	-1.09	-0.06	-0.88,0.77	0.02
Street connectivity	-1.22*	-2.31,-0.12	-1.08	-0.03	-0.87,0.81	0.00
Bike lanes	-0.93	-2.68,0.81	-0.69	0.18	-0.88,1.25	0.30
Bike parking	-0.32	-1.61,0.97	0.02	0.79	-0.05,1.64	0.95*
Bike-pedestrian trails/paths	-1.11*	-2.19,-0.03	-0.73	-0.13	-0.78,0.53	-0.05
Other walkability	-0.60	-2.20,1.00	-0.28	0.84	-0.03,1.71	0.95*
Mixed use	-0.39	-1.94,1.17	0.00	0.89	-0.08,1.86	1.06*
Active recreation	-0.38	-2.38,1.62	0.02	1.18	-0.06,2.42	1.26
Passive recreation	-0.23	-2.26,1.80	0.25	1.22	-0.02,2.46	1.31*

^a N=432/431 counties for males without and with smoking control, and N=395/394 counties for females with and without smoking control, containing 68–70% of the U.S. population located in 41–46 states and the District of Columbia. Cancer incidence rates are annual rates per 100,000. Each row corresponds to four separate regression models, by gender, including all county controls except inactivity. Models were run separately using cancer incidence, inactivity, and smoking among males and females, respectively. Coefficients correspond to a 10 percentage point increase in county-level population exposure to the given zoning provision. All models were clustered on state with robust standard errors.

* $P < .05$