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# Urban Containment Policies and Physical Activity

## A Time-Series Analysis of Metropolitan Areas, 1990–2002

Semra A. Aytur, PhD, Daniel A. Rodriguez, PhD, Kelly R. Evenson, PhD, Diane J. Catellier, DrPH

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**Background:** Urban containment policies attempt to manage the location, character, and timing of growth to support a variety of goals such as compact development, preservation of greenspace, and efficient use of infrastructure. Despite prior research evaluating the effects of urban containment policies on land use, housing, and transportation outcomes, the public health implications of these policies remain unexplored. This ecologic study examines relationships among urban containment policies, state adoption of growth-management legislation, and population levels of leisure and transportation-related physical activity in 63 large metropolitan statistical areas from 1990 to 2002.

**Methods:** Multiple data sources were combined, including surveys of urban containment policies, the Behavioral Risk Factor Surveillance System, the U.S. Census of Population, the National Resources Inventory, and the Texas Transportation Institute Urban Mobility Study. Mixed models were used to examine whether urban containment policies and state adoption of growth-management legislation were associated with population levels of leisure-time physical activity (LTPA) and walking/bicycling to work over time.

**Results:** Strong urban containment policies were associated with higher population levels of LTPA and walking/bicycling to work during the study period. Additionally, residents of states with legislation mandating urban growth boundaries reported significantly more minutes of LTPA/week compared to residents of states without such policies. Weak urban containment policies showed inconsistent relationships with physical activity.

**Conclusions:** This study provides preliminary evidence that strong urban containment policies are associated with higher population levels of LTPA and active commuting. Future research should examine potential synergies among state, metropolitan, and local policy processes that may strengthen these relationships.

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### Introduction

Relationships between the built environment and public health have received increasing attention in light of escalating trends in obesity, diabetes, and related medical expenditures in the U.S. Despite the recognized health benefits of physical activity, 25% of Americans do not engage in any leisure-time physical activity (LTPA), such as walking or bicycling.<sup>1,2</sup> Prior cross-sectional research has examined whether micro-level (neighborhood scale) features of the built environment may promote activity-friendly communities.<sup>3–12</sup> However, there is a paucity of research examining whether macro-level (e.g., state and metropolitan) policies are associated with physical

activity. By influencing important attributes of urban form such as density, land-use mix, and transportation investments, macro-level policies may complement micro-level planning efforts to influence both leisure-time and transportation-related physical activity. Urban containment policies, in particular, may support activity-friendly environments by managing the location, character, and timing of growth. Implemented at the state, metropolitan, county, or municipal levels, urban containment policies attempt to direct development within designated urban areas,<sup>6,7</sup> encourage efficient use of infrastructure,<sup>7,8</sup> promote social equity,<sup>9,10</sup> preserve farmland,<sup>7,8,11</sup> and set aside land for public greenspace.<sup>13</sup> Despite this prior research evaluating the effects of urban containment policies on land use, housing, and transportation outcomes, the public health implications of these policies remain unexplored.

Urban containment policies include a variety of implementation tools, ranging from urban growth boundaries and urban service areas to the delineation of greenbelts that curtail development outside a designated boundary.<sup>14</sup> Similarly, growth management is

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defined as the deliberate and integrated use of the planning, regulatory, and fiscal authority of state and local governments to influence the pattern of growth in order to meet projected needs.<sup>13–19</sup>

Nelson et al.<sup>20,21</sup> proposed that urban containment involves the preparation and implementation of growth-management plans to designate urban and rural land uses, direct the demand for urban development toward specific locations, and orchestrate infrastructure investments (A Nelson, unpublished survey, 1999). Although state involvement in growth management is expected to directly influence local adoption of urban containment policies, states also determine other factors that affect land markets (e.g., by funding road improvements and transit expenditures). Therefore, state policies may exert independent effects that transcend local containment-policy influences.

Premised on the socioecologic framework,<sup>22–24</sup> this hypothesis-generating study examines relationships among urban containment policies, state growth-management legislation, and population physical activity levels in 63 large U.S. metropolitan statistical areas (MSAs) from 1990 to 2002 (Figure 1).

## Methods

The study sample included MSAs from 31 states from which data could be reconstructed longitudinally from the sources listed in Table 1.

## Measures

**State growth-management legislation.** Analyses were restricted to policies adopted by 1998 to ensure several years of post-adoption observation time. The sample includes ten states classified as having state growth-management legislation in place by 1998 (Table 2). States were categorized as follows: (1) states that mandate the adoption of urban growth boundaries; and (2) states that enable (encourage, rather than require) local jurisdictions to engage in some form of

urban containment, broadly defined. For example, in Oregon and Washington, metropolitan areas are required by state law to prepare local land-use plans that implement urban growth boundaries. In contrast, statutes in Florida and Maryland encourage compact development primarily through infrastructure provisions such as urban service limits, concurrency requirements, and adequate public facilities ordinances.

**Urban containment policies in metropolitan areas.** To measure the presence of urban containment policies, secondary data from a national survey (A Nelson, unpublished survey, 1999) of metropolitan planning organizations conducted by Nelson et al.<sup>33,34</sup> and subsequent work examining the predominant urban containment frameworks<sup>20</sup> were utilized. The survey asked planning directors to identify jurisdictions with urban containment policies, and to report the year that the earliest policy was adopted. Urban containment was defined as the presence of a formally adopted containment policy (e.g., urban growth boundary, urban service limit, or greenbelt) in one or more jurisdictions within the MSA, as well as the presence of at least one policy to limit development outside the boundary.

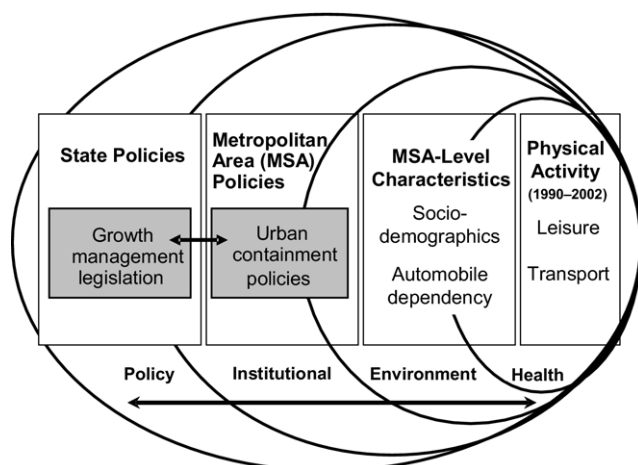
Nelson and Dawkins<sup>20</sup> describe four types of urban containment policy frameworks, derived from extensive content evaluation and cluster analyses: (1) weak-restrictive (infrastructure-based policy emphasis, few policies to contain the outward spread of development, weak intergovernmental coordination); (2) weak-accommodating (infrastructure and land-supply policy emphasis, urban growth boundaries or urban service limits but few tools to manage development outside the boundaries, moderate intergovernmental coordination); (3) strong-restrictive (infrastructure and open-space policy emphasis, implementation tools to direct growth into designated urban areas, moderate intergovernmental coordination); (4) strong-accommodating (emphasis on containment of urban-scale development within a growth boundary, strong policies to preserve rural and open space, and strong intergovernmental coordination).

To ensure adequate sample sizes, weak-restrictive and weak-accommodating categories were combined, as were strong-restrictive and strong-accommodating categories. Although this classification collapses the original four categories into two, it preserves key distinguishing features hypothesized to influence physical activity: Strong plans tend to have more land conservation policies to protect open space and restrict growth outside the boundary, as well as stronger implementation tools to encourage compact development and manage infrastructure within the boundary.<sup>20</sup>

Details pertaining to the policy measures, physical activity outcomes, and sociodemographic covariates are provided in Table 1. For the policy variables, the reference group is “no policy.” Covariates were coded as deciles centered at the median value, so that coefficients represent the difference in the outcome variable for every 10% deviation from the median. All covariates were examined both as baseline (1990) and time-varying variables representing the incremental annual change from 1990 to 2002.

## Statistical Analysis

Linear mixed models using SAS PROC MIXED, version 8.2, were used to estimate the proportion of the population in each MSA that reported being physically active, given the



**Figure 1.** Conceptual model: relationships of urban containment policies to physical activity.

**Table 1.** Measures and data sources

| Measure  | Data source  | Variable(s)/coding  | Data quality/comments   |
|--|--|---|---|
| <b>DEPENDENT VARIABLES</b>                       |  |   |   |
| <b>MSA-level physical activity</b>               |  |   |   |
| Percentage walking/bicycling to work (1990–2000) | U.S. Census of Population, Summary File 3, <sup>25,26</sup> 1990 and 2000  | Percentage of the population reporting walking or bicycling as their mode of transportation to work (among workers aged 16 and over). Coded as a time-varying variable; values between 1990 and 2000 were imputed assuming a constant average rate of change.   | To maintain a consistent unit of analysis over time, metropolitan areas were defined according to the 1990 Census of Population definition for the PMSA or NECMA. <sup>27</sup><br>A limitation of this approach is that it does not permit examination of the effects of containment policies on new counties added to MSAs at the urban fringe.   |
| Percentage no LTPA in the last month (1990–2002) | BRFSS, a population-based, random-digit-dialed telephone survey of the civilian, non-institutionalized population aged 18 years and older. <sup>28</sup> | Respondents were asked whether they participated in any physical activities, other than their regular job, in the last month (1=Yes, 0=No). Individual responses were aggregated to the MSA level for each year, and the percentage no leisure-time physical activity was derived by dividing all “No” responses by the total number of responses (excluding refusals and “don’t know”). Coded as a time-varying continuous variable.   | Median BRFSS sample sizes for the sampled MSAs were 120 in 1990 and 515 in 2000 (minimum sample size for inclusion=30). To ensure that the BRFSS samples matched the MSA boundaries defined by the Census, <sup>27</sup> the county components of each MSA in each year were verified, and only the BRFSS data from the appropriate counties were included in the analysis. Physical activity measures from the BRFSS have shown acceptable reliability. <sup>29–32</sup> |
| Mean minutes LTPA/week (1990–2000)               | BRFSS  | BRFSS respondents reported the frequency and duration of activity, and the two most commonly performed activities per week or per month. The total minutes of leisure-time physical activity per week was calculated using a formula previously derived by the CDC. Data were aggregated by averaging the individual responses in each MSA (excluding refusals and “don’t know”). The denominator includes all respondents, not just physically active respondents.<br>This variable is available annually from the BRFSS from 1990 to 1992, and then in alternate years for 1994, 1996, 1998, and 2000.<br>Coded as a time-varying continuous variable. No imputation was performed for missing years, as the mixed models can handle arbitrary spacing of measurements. |   |

*(continued on next page)*

**Table 1.** (continued)

| Measure   | Data source  | Variable(s)/coding   | Data quality/comments   |
|---|--|--|---|
| <b>INDEPENDENT VARIABLES</b>                    |  |  |   |
| <b>Main Exposures</b>                           |  |  |   |
| Presence of UCPs in metropolitan areas          | Planning literature and prior planning surveys, <sup>13-21,33-37</sup> (A Nelson, unpublished survey, 1999)  | <b>Weak UCP</b> (Weak-Accommodating and/or Weak-Restrictive <sup>20</sup> )<br>1=Present<br>0=Absent (Referent)<br><b>Strong UCP</b> (Strong-Accommodating and/or Strong-Restrictive <sup>20</sup> )<br>1=Present<br>0=Absent (Referent)<br>Coded as two time-varying categoric variables. | Information on containment policies was cross-checked with data from other studies, reports, and primary documents from the planning literature (A Nelson, unpublished survey, 1999). <sup>13-21,33-37</sup> MSAs that contained mixed policy types were classified according the predominant type reported by the majority of jurisdictions or by the largest geographical unit (e.g., region versus municipality).  |
| Presence of state growth-management legislation | Planning literature <sup>13-17,38-48</sup>   | <b>Enabling Legislation</b><br>1=Present<br>0=Absent (Referent)<br><b>Legislation Mandating Urban Growth Boundaries (UGBs)</b><br>1=Present<br>0=Absent (Referent)<br>Coded as two time-varying categoric variables.   | For the states of Georgia <sup>a</sup> and California <sup>b</sup> there is some ambiguity in the planning literature regarding whether these states should be classified as having a growth-management program. For the purposes of this study, Georgia was classified as a weak (enabling) growth-management state, and California was classified as not having a state growth-management program. This classification was used because it was expected to provide a more conservative estimate of the relationship between state policies and physical activity outcomes (estimates biased toward the null). |
| <b>Covariates</b>                               |  |  |   |
| Daily VMT/capita                                | TTI Urban Mobility Report, <sup>49</sup> a national study of mobility and traffic congestion on freeways and major streets for 75 urbanized areas. | Daily VMT for freeways and principal arterial streets was obtained from TTI. Daily VMT per capita was derived by dividing VMT by population. <sup>50</sup><br>Coded as a time-varying variable, deciles, centered at the median value.   | Methodology and data quality are summarized in the Annual Urban Mobility Report. <sup>49</sup>  |
| MSA population size                             | U.S. Census <sup>27</sup>  | U.S. Census of Population data for each MSA/PMSA were used to determine population size for each year.<br>Coded as a time-varying variable, deciles, centered at the median value.   | The population of each county component in each MSA was cross-checked for accuracy to ensure that the appropriate counties were included.   |

(continued on next page)

**Table 1.** Measures and data sources (*continued*)

| Measure  | Data source  | Variable(s)/coding  | Data quality/comments   |
|--|--|---|---|
| Net density  | NRI <sup>51,52</sup>   | Net density was calculated as population (10,000) divided by the amount of built land area, <sup>52</sup> excluding water bodies. The NRI measures of built land area are derived from surveys conducted every five years (estimates for 1987, 1992, and 1997 were obtained, and intervening years were imputed assuming a constant average rate of change). Coded as a time-varying variable, deciles, centered at the median value. | Because the NRI data are estimates, as a quality control we checked the error (standard deviation) for all MSAs in the sample, and found them to be within 2% of the mean estimate. |
| Percentage black, percentage nonwhite                      | U.S. Census of Population, Summary File 3 (SF-3), <sup>25,26</sup> 1990 and 2000 | Two separate variables were derived, one for the percentage of the population in each MSA reporting black or African-American race, and one for the percentage of the population reporting a race other than white. Values between the decennial census were imputed assuming a constant average rate of change. Coded as two time-varying variables, deciles, centered at the median value.  | In the analyses, percentage black and percentage nonwhite were examined separately as potential covariates, and the more significant variable was retained in the models.           |
| Percentage of population aged 65 or older                  | U.S. Census of Population, Summary File 3 (SF-3), <sup>25,26</sup> 1990 and 2000 | Estimates were obtained from the census. Values between the decennial census were imputed assuming a constant average rate of change.   |   |
| Percentage of population with $\geq$ high school education |  | Coded as separate time-varying variables, deciles, centered at the median value.  |   |
| Median household income                                    |  |   |   |

<sup>a</sup>Georgia's program is not considered a true growth-management program according to some scholars,<sup>14,41</sup> who view the approach as weak and pro-development. However, Georgia's program is considered a state-sponsored, growth-management strategy by several other researchers.<sup>39,40,44</sup>

<sup>b</sup>California has had a comprehensive planning mandate since 1963; however, its planning framework emphasizes a locally oriented approach through the creation of "local agency formation commissions" (LAFCOs) rather than a regionally coordinated approach, and is therefore not considered a true growth-management state by most planning researchers.<sup>39,41,46</sup> BRFSS, Behavioral Risk Factor Surveillance System; LTPA, leisure-time physical activity; MSA, metropolitan statistical area; NECMA, New England consolidated metropolitan area; NRI, national resources inventory; PMSA, primary metropolitan statistical area; TTI, Texas Transportation Institute; UCP, urban containment policy; VMT, vehicle miles traveled.

**Table 2.** Classification of state growth-management legislation and urban containment policies

| MSA UCP <sup>b</sup> | State growth-management legislation <sup>a</sup>  |  | Mandate UGB                              |
|----------------------|---|--|--|
|                      | None  | Enabling   |  |
| <b>None</b>          | Albany/<br>Schenectady/<br>Troy<br>Bakersfield<br>Beaumont<br>Boston<br>Brownsville<br>Buffalo<br>Chicago<br>Cincinnati<br>Cleveland<br>Colorado Springs<br>Columbus<br>Corpus Christi<br>Dallas<br>Detroit<br>El Paso<br>Fort Worth<br>Houston<br>Indianapolis<br>Kansas City<br>Laredo<br>Las Vegas<br>Los Angeles<br>Louisville<br>Milwaukee<br>New York<br>New Orleans<br>Oklahoma City<br>Omaha<br>Pittsburgh<br>Rochester<br>Salt Lake City<br>San Antonio<br>St. Louis | Atlanta<br>Hartford/<br>Middleton<br>Memphis<br>Nashville<br>Providence<br>Phoenix | None                                     |
| <b>Weak</b>          | Austin<br>Albuquerque<br>Charlotte<br>Denver<br>Norfolk<br>Philadelphia   | Minneapolis<br>Tucson  | None                                     |
| <b>Strong</b>        | Riverside/<br>San Bernardino<br>Sacramento<br>San Diego<br>San José<br>San Francisco<br>Washington DC   | Baltimore<br>Miami<br>Ft. Lauderdale<br>Miami<br>Jacksonville<br>Orlando<br>Tampa  | Portland<br>Seattle<br>Tacoma<br>Spokane |

<sup>a</sup>Years of adoption for state legislation are as follows: Oregon (1973); Florida (1985); Rhode Island (1988); Georgia (1989); Washington (1990); Maryland (1992); Minnesota (1996); Connecticut (1997); Tennessee (1998); Arizona (1998).

<sup>b</sup>We inferred the policy classification for four MSAs that were not evaluated by Nelson and Dawkins by obtaining information from other sources and matching MSA characteristics to the criteria described. Additionally, because Nelson and Dawkins' survey<sup>33,34</sup> asked about current containment policies, it is possible that a few jurisdictions had a policy in the past but did not report having one currently. Although we cross-checked the dates against other literature, it is possible that our data misclassify certain jurisdictions as not ever having a containment policy. Similarly, jurisdictions that may have terminated their policies at a later date may be misclassified as currently having policies (we are aware of only two cases for which some ambiguity existed).

MSA, metropolitan statistical area; UCP, urban containment policy; UGB, urban growth boundary.

presence or absence of policies from 1990 to 2002. Because measurements were derived from repeated cross-sectional surveys in which different individuals were sampled at each time-point from each MSA, the data were considered to have a hierarchic structure, with repeated aggregate values (Level 1) nested within each MSA (Level 2). This nested structure suggests the use of multilevel modeling techniques that allow any pattern of measurements (i.e., arbitrary spacing or number of observations) while accounting for the correlation between repeated measurements over time within a geographic unit, and preventing underestimation of standard errors.<sup>53–56</sup> Following the approach of Singer et al.,<sup>54,55</sup> each model included a random-intercept term, allowing the intercept for each MSA to vary. Random-slope terms were retained in the final models only if significant variation in the slopes was observed, or if adding a random slope significantly improved the model fit, using an unstructured covariance matrix. The final adjusted models predicted the average change in physical activity between 1990 and 2002 as a function of policy classification and MSA-level covariates.

A full model including all covariates was first examined for each outcome (not shown). Initial exploratory models included a term for the number of years since policy enactment, but this term was not significant and thus was not retained in final models. As sample sizes were limited, the final adjusted models retained only those covariates that remained statistically significant ( $\alpha=0.10$ ) or were considered theoretically important. Multiplicative interactions were not assessed due to limited power. Trends in physical activity with respect to specific policy classifications were also examined graphically using SAS PROC LOESS.

## Results

Forty-seven percent of MSAs were classified as having either state growth-management legislation or urban containment policies in place during the study period. Of those with urban containment policies, 83% had adopted policies by 1990, and 17% adopted them between 1991 and 1998. Sociodemographic characteristics of the MSAs are presented in Table 3.

## Overall Physical Activity Trends

Overall, trends in the percentage of the urban sample reporting no LTPA were similar to national trends,<sup>57</sup> decreasing slightly from 29% in 1990 to 26% in 2002. The mean minutes of LTPA/week remained relatively constant during the study period, while the percentage of workers walking or bicycling to work decreased from 3.8% in 1990 to 2.9% in 2000.

## Analysis of Policy Classifications

**Percentage walking or bicycling to work.** Table 4 presents relationships between policy classifications and the percentage of the population walking or bicycling to work. In models examining state legislation (Model 1), enabling legislation was inversely associated with walking or bicycling to work. However, strong MSA

**Table 3.** Sociodemographic characteristics of 63 U.S. metropolitan areas

| Characteristic (% unless otherwise noted)      | Median   | SE     | Range             |
|--|----------|--------|-------------------|
| <b>≥High school education</b>                  |          |        |                   |
| 1990   | 78.6     | 7      | 48–88             |
| 2000   | 82.3     | 7      | 52–91             |
| <b>Black</b>                                   |          |        |                   |
| 1990   | 10.2     | 8      | 0–45              |
| 2000   | 10.0     | 9      | 1–43              |
| <b>Nonwhite</b>                                |          |        |                   |
| 1990   | 19.8     | 9      | 5–43              |
| 2000   | 25.8     | 10     | 9–48              |
| <b>Median household income</b>                 |          |        |                   |
| 1990   | \$30,882 | \$5417 | \$17,336–\$48,115 |
| 2000   | \$44,782 | \$7124 | \$26,155–\$62,024 |
| <b>≥Aged 65</b>                                |          |        |                   |
| 1990   | 16.0     | 3      | 10–28             |
| 2000   | 16.8     | 3      | 11–28             |
| <b>Population size<sup>a</sup></b>             |          |        |                   |
| 1990   | 130.2    | 170.9  | 13.3–886.3        |
| 2000   | 163.3    | 185.1  | 17.2–950.2        |
| <b>Net density<sup>b</sup></b>                 |          |        |                   |
| 1990   | 0.8049   | 0.1587 | 0.1134–11.7200    |
| 2000   | 0.8644   | 0.1614 | 0.1226–11.9124    |
| <b>Daily vehicle miles traveled per capita</b> |          |        |                   |
| 1990   | 21.0     | 3.6    | 12–29             |
| 2000   | 22.9     | 5.3    | 12–40             |

<sup>a</sup>Population × 10,000.

<sup>b</sup>Net density was calculated as population (10,000) divided by the amount of built land area,<sup>52</sup> excluding water bodies.

urban containment policies showed positive associations with active commuting (Model 2). Coefficients for weak urban containment policies were not statistically significant. Both enabling state legislation and strong urban containment policies remained independently associated with walking or bicycling to work in the final model (Model 3). Density was positively related to active commuting, while vehicle miles traveled (VMT)/capita showed an inverse association with this outcome.

**Percentage of no LTPA in the last month.** Metropolitan Statistical Areas with state legislation mandating urban growth boundaries had significantly lower average percentages of no LTPA from 1990 to 2002 compared with MSAs without policies (Table 5, Model 1). Similarly, strong urban containment policies were associated with lower percentages of no LTPA (Model 2). Strong urban containment policies remained independently associated with no LTPA (Model 3), while the coefficient for state legislation mandating growth boundaries was rendered insignificant once MSA-level policies were accounted for. However, enabling state legislation was associated with higher percentages of no LTPA in Model 3. Density and VMT/capita were not statistically significant and were not retained in the final models.

One objective of *Healthy People 2010*<sup>58</sup> is to reduce population levels of no LTPA to ≤20%. Figure 2 illustrates trends for various policy classifications relative to this target. Metropolitan areas with strong urban containment policies in states mandating urban growth

boundaries showed the steepest decline in the percentage of no LTPA relative to other policy classifications, surpassing the target by the middle of the study period.

**Mean minutes of leisure-time physical activity per week.** Relationships between policy classifications and the mean minutes of LTPA/week from 1990 to 2000 are presented in Table 6. Residents of MSAs with state legislation mandating urban growth boundaries reported approximately 53 additional minutes of LTPA/week, compared with residents of states without policies (Model 1). Strong MSA-level urban containment policies were associated with approximately 24 additional minutes of LTPA/week (Model 2). In Model 3, state legislation mandating urban growth boundaries and strong MSA policies remained independently associated with more minutes of LTPA/week, suggesting an additive effect.

## Discussion

This study provides preliminary evidence that strong urban containment policies are associated with LTPA and active commuting. As this research is exploratory, the findings are intended to be hypothesis-generating rather than elucidating causal mechanisms through which policies affect physical activity. Recent research suggests that residents of communities with higher density, greater connectivity, and more mixed land use report higher rates of walking and bicycling compared with residents of low-density, poorly connected, and



**Table 4.** Percentage walking or bicycling to work 1990–2000, by policy classification<sup>a</sup>

|   | Model 1.<br>State<br>legislation |                |         | Model 2.<br>MSA<br>containment<br>policy |      |                | Model 3.<br>State<br>legislation and<br>MSA policy |                |         |
|---|----------------------------------|----------------|---------|--|------|----------------|--|----------------|---------|
|   | SE                               | <i>p</i> value | SE      | <i>p</i> value                           | SE   | <i>p</i> value | SE   | <i>p</i> value |         |
| Intercept (percentage walking/<br>bicycling to work, 1990)  | 3.20                             | 0.16           | <0.0001 | 3.21                                     | 0.16 | <0.0001        | 3.18   | 0.16           | <0.0001 |
| Year  | -0.09                            | 0.01           | <0.0001 | -0.09                                    | 0.01 | <0.0001        | -0.09  | 0.01           | <0.0001 |
| <b>State growth-management<br/>legislation (ref=none)</b>   |                                  |                |         |  |      |                |  |                |         |
| Enabling  | -0.10                            | 0.02           | <0.0001 |  |      |                | -0.09  | 0.02           | 0.0002  |
| Mandate growth boundary<br>(UGB)                            | 0.65                             | 0.49           | 0.1890  |  |      |                | 0.59   | 0.49           | 0.2275  |
| <b>Metropolitan containment policy<br/>(UCP) (ref=none)</b> |                                  |                |         |  |      |                |  |                |         |
| Weak UCP  |                                  |                |         | 0.09                                     | 0.06 | 0.0978         | 0.06   | 0.06           | 0.3135  |
| Strong UCP  |                                  |                |         | 0.09                                     | 0.03 | 0.0028         | 0.08   | 0.03           | 0.0031  |
| <b>MSA-level SES factors</b>                                |                                  |                |         |  |      |                |  |                |         |
| Percentage ≥ High school <sup>b</sup>                       | 0.17                             | 0.05           | 0.0006  | 0.17                                     | 0.05 | 0.0003         | 0.16   | 0.05           | 0.0009  |
| Percentage nonwhite in 1990                                 | 0.10                             | 0.05           | 0.0684  | 0.07                                     | 0.05 | 0.1562         | 0.16   | 0.05           | 0.0944  |
| Median household income <sup>b</sup>                        | 0.01                             | 0.01           | 0.0028  | 0.01                                     | 0.01 | 0.0397         | 0.01   | 0.01           | 0.0029  |
| Percentage ≥ aged 65 in 1990                                | 0.11                             | 0.05           | 0.0205  | 0.10                                     | 0.05 | 0.0397         | 0.10   | 0.05           | 0.0248  |
| Daily VMT per capita in 1990                                | -0.14                            | 0.04           | 0.0010  | -0.15                                    | 0.04 | 0.0007         | -0.14  | 0.04           | 0.0011  |
| Net density <sup>b</sup>                                    | 0.39                             | 0.07           | <0.0001 | 0.40                                     | 0.07 | <0.0001        | 0.40   | 0.07           | <0.0001 |
| <b>Percentage of between-MSA<br/>variance explained</b>     | 60                               |                |         | 60                                       |      |                | 60   |                |         |
| <b>Model fit: AIC</b>                                       | -1490.9                          |                |         | -1485.5                                  |      |                | -1496.7  |                |         |

<sup>a</sup>Models include random intercepts as well as a random slope for *YEAR*, utilizing an unstructured covariance matrix. Because the walk/bike to work percentages were calculated by imputation between 1990 and 2000, assuming a constant rate of change, a simplified general linear model (GLM) without imputation was run for comparison. The dependent variable was the proportion walking/biking to work in 2000, and independent variables were the baseline (1990) policy variables and any significant sociodemographic factors. These models produced similar results to the models presented in Table 4 (for example, the GLM Model 3 showed significant coefficients for state enabling legislation (estimate = -1.04, *p*=0.0110) and for Strong UCPS (estimate=0.86, *p*=0.0249).

<sup>b</sup>Time-varying covariate, deciles, centered at the median.

AIC, Akaike Information Criterion; MSA, metropolitan statistical area; UCP, urban containment policy; UGB, urban growth boundary; VMT, vehicle miles traveled.

single land use areas.<sup>7,59–63</sup> Additionally, relationships between travel behavior and urban form<sup>64–68</sup> with respect to mode choice,<sup>69–71</sup> street networks,<sup>72–74</sup> and accessibility to activity centers<sup>71,75–77</sup> have been examined. Missing from this debate, however, has been a discussion of the potential impacts of urban containment policies on physical activity.

Results from the present study suggest that different types of state and MSA containment policies may differentially affect physical activity. For example, a lower percentage of no LTPA was associated with the presence of strong urban containment policies. State enabling legislation, however, showed a positive relationship with no LTPA, once MSA policies were accounted for. There are several possible explanations for this somewhat contradictory finding. First, the “enabling” category comprises states with diverse historic contexts and variations in their implementation approaches. Second, some states that adopted enabling legislation in the late 1980s or early 1990s may have been reacting to growth-related problems such as worsening traffic congestion, and the study period may not be long enough to reflect the full effects of these

policies. Third, some researchers suggest that certain types of urban containment policies may actually contribute to sprawl by constraining market mechanisms that facilitate higher densities,<sup>35,78,79</sup> shifting sprawl to areas with weaker land-use controls. Critics also argue that urban containment policies decrease housing affordability,<sup>80–83</sup> disrupt land markets,<sup>84,85</sup> and may be economically inefficient relative to pricing and taxing incentives.<sup>86</sup>

Nevertheless, strong urban containment policies were positively associated with both LTPA and walking/bicycling to work in the present study. Additionally, strong urban containment policies and state legislation mandating urban growth boundaries were independently associated with more minutes of LTPA/week. Compared to residents of MSAs without policies, residents of MSAs with strong urban containment policies in states that also mandated growth boundaries averaged 62 additional minutes of LTPA/week. Because this type of state legislation requires local governments to include a variety of implementation tools to manage growth, preserve open space, and coordinate land use and transportation planning across jurisdictions, this

**Table 5.** Percentage no LTPA in the last month, 1990–2002, by policy classification<sup>a</sup>

|   | Model 1.<br>State<br>legislation |                |         | Model 2.<br>MSA<br>containment<br>policy |      |                | Model 3.<br>State<br>legislation and<br>MSA policy |                |         |
|---|----------------------------------|----------------|---------|--|------|----------------|--|----------------|---------|
|   | SE                               | <i>p</i> value | SE      | <i>p</i> value                           | SE   | <i>p</i> value | SE   | <i>p</i> value |         |
| <b>Intercept (Proportion no LTPA in 1990)</b>           | 25.35                            | 1.07           | <0.0001 | 25.86                                    | 1.07 | <0.0001        | 25.74  | 1.06           | <0.0001 |
| <b>Year</b>   | 0.94                             | 0.25           | 0.0002  | 0.95                                     | 0.25 | 0.0002         | 0.98   | 0.25           | 0.0001  |
| <b>Year Sq</b>  | -0.07                            | 0.02           | <0.0001 | -0.07                                    | 0.02 | <0.0001        | -0.08  | 0.02           | <0.0001 |
| <b>State growth-management legislation (ref=none)</b>   |                                  |                |         |  |      |                |  |                |         |
| Enabling  | 1.13                             | 0.78           | 0.1491  |  |      |                | 2.03   | 0.78           | 0.0096  |
| Mandate growth boundary (UGB)                           | -3.28                            | 1.43           | 0.0254  |  |      |                | -1.81  | 1.44           | 0.2156  |
| <b>Metropolitan containment policy (UCP) (ref=none)</b> |                                  |                |         |  |      |                |  |                |         |
| Weak UCP  |                                  |                |         | -1.25                                    | 0.99 | 0.2114         | -1.80  | 0.94           | 0.0590  |
| Strong UCP  |                                  |                |         | -2.12                                    | 0.74 | 0.0043         | -2.40  | 0.79           | 0.0024  |
| <b>MSA-level SES factors</b>                            |                                  |                |         |  |      |                |  |                |         |
| Percentage ≥ high school <sup>b</sup>                   | -0.65                            | 0.15           | 0.0001  | -0.64                                    | 0.15 | <0.0001        | -0.55  | 0.15           | 0.0004  |
| Median household income <sup>b</sup>                    | -0.75                            | 0.18           | <0.0001 | -0.76                                    | 0.18 | <0.0001        | -0.79  | 0.17           | <0.0001 |
| Percentage black in 1990                                | 0.60                             | 0.13           | 0.0002  | 0.59                                     | 0.13 | <0.0001        | 0.55   | 0.12           | <0.0001 |
| Percentage ≥ aged 65 in 1990                            | 0.26                             | 0.12           | 0.0323  | 0.26                                     | 0.12 | 0.0281         | 0.17   | 0.11           | 0.1312  |
| <b>Percentage of between-MSA variance explained</b>     | 75                               |                |         | 77                                       |      |                | 78   |                |         |
| <b>Model fit: AIC</b>                                   | 2842.7                           |                |         | 2842.7                                   |      |                | 2837.2   |                |         |

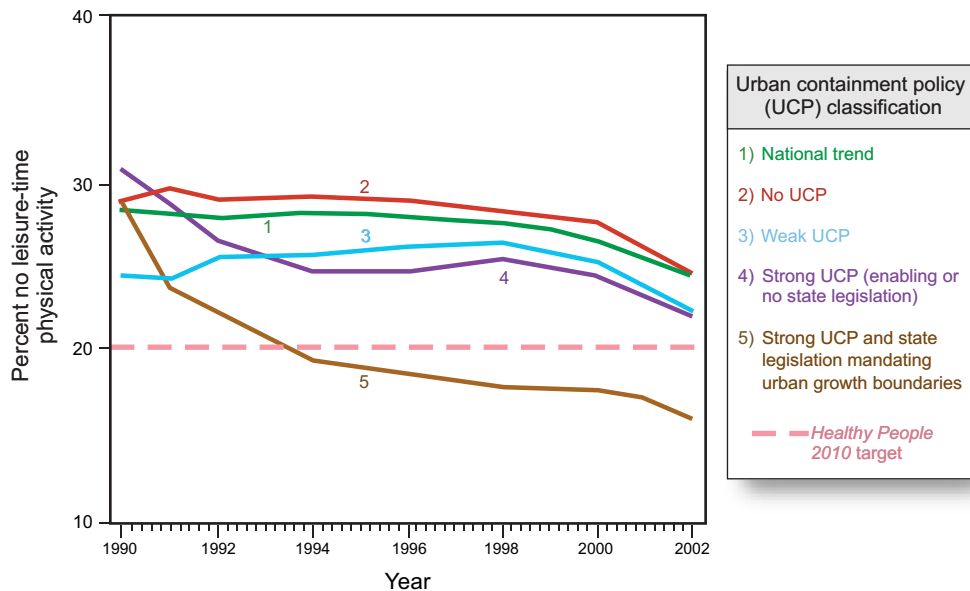
<sup>a</sup>Models include random intercepts as well as a random slope for *YEAR*, utilizing an unstructured covariance matrix.

<sup>b</sup>Time-varying covariate, deciles, centered at the median.

AIC, Akaike Information Criterion; LTPA, leisure-time physical activity; MSA, metropolitan statistical area; UCP, urban containment policy; UGB, urban growth boundary; VMT, vehicle miles traveled.

approach may stimulate more compact development patterns supportive of physical activity. States that mandate growth boundaries may also provide stronger incentives to facilitate regionally coordinated growth management. For example, Oregon was one of the first states to adopt growth-management legislation in 1973,

subsequently electing a regional metropolitan planning organization in 1978 to coordinate land use and transportation planning in Portland. It is also possible that state-level variables are acting as a proxies for other unmeasured characteristics associated with physical activity.



**Figure 2.** Percentage of no leisure-time physical activity, 1990–2002, by type of urban containment policy in large U.S. metropolitan areas.

*Note:* To facilitate comparison with *Healthy People 2010* population-wide targets, trends are not adjusted for sociodemographics.

**Table 6.** Mean minutes LTPA per week, 1990–2000, by policy classification

|  | <b>Model 1.</b>          |           |                | <b>Model 2.</b>               |           |                | <b>Model 3.</b>                         |           |                |
|--|--------------------------|-----------|----------------|-------------------------------|-----------|----------------|---|-----------|----------------|
|  | <b>State legislation</b> | <b>SE</b> | <b>p value</b> | <b>MSA containment policy</b> | <b>SE</b> | <b>p value</b> | <b>State legislation and MSA policy</b> | <b>SE</b> | <b>p value</b> |
| <b>Intercept (Mean minutes LTPA per week in 1990)</b>        | 178.20                   | 11.19     | <0.0001        | 177.90                        | 11.20     | <0.0001        | 175.86                                  | 10.72     | <0.0001        |
| <b>Year</b>  | 0.92                     | 1.24      | 0.4551         | 0.79                          | 1.24      | 0.5239         | 0.7625                                  | 1.20      | 0.5265         |
| <b>State growth-management legislation (ref=none)</b>        |                          |           |                |                               |           |                |   |           |                |
| Enabling   | -4.26                    | 8.25      | 0.6207         |                               |           |                | -12.47                                  | 8.86      | 0.1608         |
| Mandate growth boundary (UGB)                                | 53.45                    | 15.50     | 0.0011         |                               |           |                | 41.16                                   | 16.07     | 0.0132         |
| <b>Metropolitan containment policy (UCP) (referent=none)</b> |                          |           |                |                               |           |                |   |           |                |
| Weak UCP   |                          |           |                | 13.33                         | 10.49     | 0.2090         | 18.36                                   | 9.87      | 0.0681         |
| Strong UCP   |                          |           |                | 24.00                         | 7.98      | 0.0029         | 21.09                                   | 8.86      | 0.0181         |
| <b>MSA-level SES factors</b>                                 |                          |           |                |                               |           |                |   |           |                |
| Percentage black in 1990                                     | -3.95                    | 1.41      | 0.0069         | -4.70                         | 1.38      | 0.0012         | -4.09                                   | 1.30      | 0.0027         |
| Percentage ≥ high school <sup>a</sup>                        | 2.49                     | 1.49      | 0.1008         | 2.64                          | 1.49      | 0.0827         | 1.42                                    | 1.44      | 0.3309         |
| Median household income <sup>a</sup>                         | -0.40                    | 2.04      | 0.8440         | -0.47                         | 2.04      | 0.8196         | -0.24                                   | 1.95      | 0.9002         |
| Percentage ≥ aged 65 in 1990                                 | -1.22                    | 1.29      | 0.3471         | -1.33                         | 1.26      | 0.2964         | -0.83                                   | 1.21      | 0.4961         |
| Daily VMT per capita in 1990                                 | 3.79                     | 2.19      | 0.0883         | 3.54                          | 2.22      | 0.1162         | 3.96                                    | 2.12      | 0.0674         |
| Daily VMT per capita <sup>a</sup>                            | -4.50                    | 2.15      | 0.0373         | -3.99                         | 2.18      | 0.0686         | -4.21                                   | 2.11      | 0.0475         |
| Population size <sup>a</sup>                                 | 1.45                     | 1.48      | 0.3300         | 0.68                          | 1.47      | 0.6466         | 1.06                                    | 1.38      | 0.4423         |
| <b>Percentage of between-MSA variance explained</b>          | 61                       |           |                | 61                            |           |                | 69                                      |           |                |
| <b>AIC</b>   | 3255.3                   |           |                | 3258.7                        |           |                | 3252.7                                  |           |                |

<sup>a</sup>Time-varying covariate, deciles, centered at the median.

AIC, Akaike Information Criterion; LTPA, leisure-time physical activity; MSA, metropolitan statistical area; UCP, urban containment policy; UGB, urban growth boundary; VMT, vehicle miles traveled.

The associations between active commuting and strong urban containment policies suggest that strong urban containment policies may support development patterns supportive of multi-modal transportation systems including walking and bicycling.<sup>87</sup> Consistent with the view that weaker policies may potentially exacerbate sprawl, however, was the finding of inverse relationships between enabling legislation and active commuting. A recent panel study examining the effects of urban containment policies on motorized transportation outcomes in 25 large U.S. metropolitan areas found that urban containment policies were related to higher annual VMT/capita from 1982 to 1994.<sup>68</sup> The authors concluded that without complementary strategies such as higher fuel costs and improved transit service, urban containment policies may not successfully promote a shift away from automobile modes. Taken together with the results of other research-

ers,<sup>18,64–69,88</sup> findings from the present study underscore the importance of considering connections between land use and transportation policies across state, regional, and local levels.

### Limitations

Although this time-series study is the first to describe relationships between urban containment policies and physical activity, several limitations warrant mention. First, the ecologic design precludes causal inferences. Unmeasured confounders, including residential preferences, cannot be disregarded when interpreting the observed associations.

Second, bias may have been introduced if cities with smaller (or larger) Behavioral Risk Factor Surveillance System (BRFSS) sample sizes were also more or less likely to have policies. To investigate this possibility, two

sets of sensitivity analyses were conducted: the six cities with the smallest BRFSS sample sizes were deleted from the analysis; then the six cities with the largest BRFSS sample sizes were deleted, and results were compared to the original models. Results were very similar in terms of both the magnitude and significance of the policy coefficients, suggesting that the models are robust. Additionally, the correlation between the BRFSS sample size and policy presence was not significant (Spearman's  $\rho=0.184$  [ $p=0.2375$ ]).

Third, it is possible that the imputation method for the active commuting outcome, which assumed a constant average rate of change, may have influenced the results. A set of simplified general linear models without imputation was run for comparison; these models produced results similar to the original models (Table 4).

Fourth, the self-reported physical activity measures may be subject to bias. Although we controlled for many MSA-level sociodemographic factors, if the geographic samples had demographic differences that affect the validity of the physical activity measures, the bias could be differential. Additionally, because the BRFSS is a telephone survey, persons without telephones, the homeless, and those who did not speak English were excluded. Because the analysis was restricted to large metropolitan areas and data were unweighted, results may not be generalizable beyond the sample.

Fifth, urban containment policies have been defined and measured in different ways.<sup>20,21,35,36,89</sup> This study utilized categorical measures based on extensive previous research<sup>20,21,33,34</sup> but did not include a continuous measure of the population-weighted percentage of policy coverage. Future studies should continue to explore alternative policy measures, including measures of the policy process.

A sixth set of limitations involves assumptions regarding the time lag between adoption and implementation. Because several years may elapse between adoption and implementation, MSAs that adopted policies in the 1990s may not have been followed long enough for changes in the built environment and physical activity to be observed. However, more than 80% of our sample that had adopted policies did so prior to 1990, providing at least 10 years of observation time. The planning literature regarding the expected time lag between policy adoption and implementation is limited, although some researchers have noted that differences in implementation can affect a policy's effectiveness.<sup>18,36,37,42,90</sup> Additional transdisciplinary research, including a policy sciences perspective,<sup>91</sup> could provide further insight into the implementation process.

Despite these limitations, strengths of this study include the time-series analyses, the diverse sample of metropolitan areas, consideration of various policy classifications, and the robustness of the results to different model specifications. The final models ex-

plained between 60% and 78% of the between-MSA variance in physical activity, reinforcing the importance of considering policy and environmental strategies along with individually-oriented approaches to increase physical activity.

## Conclusion

This study contributes to the public discourse surrounding urban containment policies by identifying temporal relationships among urban containment policies, state adoption of growth management legislation, and active living. Results suggested that residents of MSAs with strong urban containment policies averaged significantly more minutes of LTPA/week, reported lower levels of no LTPA, and maintained higher levels of active commuting compared with residents of MSAs without policies during the study period. Future research should examine potential synergies among state, metropolitan, and local policy processes that may strengthen these relationships.

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## References

1. Mokdad A, Serdula M, Dietz W, Bowman B, Marks J, Koplan J. The spread of the obesity epidemic in the United States, 1991–1998. *JAMA* 1999;282:1519–22.
2. CDC. Physical activity trends—United States, 1990–1998. *MMWR Morb Mortal Wkly Rep* 2001;50:166–9.
3. McCann B, DeLille B. Mean Streets 2000: a transportation and quality of life campaign report. Washington DC: Surface Transportation Policy Project 2000:1–33.
4. Ernst M, McCann B. Mean Streets 2002: a publication of the surface transportation policy project. [www.transact.org/PDFs/ms2002/MeanStreets2002.pdf](http://www.transact.org/PDFs/ms2002/MeanStreets2002.pdf), 2002.
5. Frank L, Pivo G. Impacts of mixed use and density on utilization of three modes of travel: single occupant vehicle, transit, and walking. *Transportation Research Record* 1994;1466:44–52.
6. Handy S, Clifton K. Local shopping as a strategy for reducing automobile travel. *Transportation* 2001;28:317–46.
7. Ewing R, Cervero R. Travel and the built environment. *Transportation Research Record* 2001;1780:87–114.
8. Giles-Corti B, Donovan R. The relative influence of individual, social and physical environment determinants of physical activity. *Soc Sci Med* 2002;54:1793–812.
9. Boarnet M, Crane R. *Travel by Design: The influence of urban form on travel*. New York: Oxford University Press, 2001.
10. Boarnet M, Sarmiento G. Can land-use policy really affect travel behavior? A study of the link between non-work travel and land-use characteristics. *Urban Stud* 1998;35:1155–69.
11. Atkinson J, Sallis J, Saelens B, et al. The association of neighborhood design and recreational environments with physical activity. *Am J Health Promot* 2005;19:304–9.

12. Aytur S, Rodriguez D, Evenson K, Catellier D, Rosamond W. Promoting active community environments through land use and transportation planning. *Am J Health Promot* 2007;21(Suppl 4):397–407.
13. Nelson A. Growth management. In: Hoch CH, Dalton LC, So FS, The practice of local government planning. 3rd ed. Chicago: American Planning Association, 1999:375–400.
14. Nelson A. Comparing states with and without growth management: analysis based on indicators with policy implications. *Land Use Policy* 1999;16:121–7.
15. Porter D. Managing growth in America's communities. Growth Management Institute, Washington DC: Island Press, 1997.
16. Knaap G, Nelson A. The regulated landscape: lessons on state land use planning from Oregon. Cambridge MA: Lincoln Institute of Land Policy, 1992.
17. Nelson A, Duncan J. Growth management principles and practices. Chicago: Planners Press, American Planning Association, 1995.
18. Dawkins C. Regional development theory: conceptual foundations, classic works, and recent developments. *Journal of Planning Literature* 2003;18:131–73.
19. Daniels T. When city and country collide: managing growth in the metropolitan fringe. Washington DC: Island Press, 1999.
20. Nelson A, Dawkins C. Urban containment in the United States: history, models, and techniques for regional and metropolitan growth management. Planning Advisory Service Report #520. Chicago: American Planning Association, 2004:109–24.
21. Nelson A, Sanchez T, Dawkins C. Urban containment and society. Hampshire UK: Ashgate, 2007.
22. Stokols D. Establishing and maintaining healthy environments: toward a social ecology of health promotion. *Am Psychol* 1992;47:6–22.
23. Stokols D. Translating social ecological theory into guidelines for community health promotion. *Am J Health Promot* 1996;10:282–98.
24. Sallis J, Owen N. Ecological models. In: Glanz K, Lewis FM, Rimer BK, Health behavior and health education. Theory, research, and practice. 2nd ed. San Francisco CA: Jossey-Bass, 1997:403–24.
25. U.S. Bureau of the Census. Census of population, Summary File 3. Washington DC: Department of Commerce, 1990.
26. U.S. Bureau of the Census. Census of population, Summary File 3. Washington DC: Department of Commerce, 2000.
27. U.S. Bureau of the Census. Statistical abstract of the U.S., 117th edition. About metropolitan and micropolitan statistical areas. Washington DC: Office of Management and Budget, Department of Commerce, Economics and Statistics Administration, 1997.
28. Remington P, Smith M, Williamson D, Anda R, Gentry E, Hogelin G. Design, characteristics, and usefulness of state-based behavioral risk factor surveillance: 1981–1987. *Public Health Rep* 1988;103:366–75.
29. Shea S, Stein A, Lantigua R, Basch C. Reliability of the behavioral risk factor survey in a triethnic population. *Am J Epidemiol* 1991;133:489–500.
30. Stein A, Lederman R, Shea S. The Behavioral Risk Factor Surveillance System questionnaire: its reliability in a statewide sample. *Am J Public Health* 1993;83:1768–72.
31. Stein A, Courval J, Lederman R, Shea S. Reproducibility of responses to telephone interviews: demographic predictors of discordance in risk factor status. *Am J Epidemiol* 1995;141:1097–106.
32. Evenson K, McGinn A. Test–retest reliability of adult surveillance measures for physical activity and inactivity. *Am J Prev Med* 2005;28:470–8.
33. Nelson A, Dawkins C, Sanchez T. Urban containment and residential segregation: A preliminary investigation. *Urban Stud* 2004;41:423–39.
34. Nelson A, Sanchez T, Dawkins C. The effect of urban containment and mandatory housing elements on racial segregation in U.S. Metropolitan Areas, 1990–2000. *J Urban Affairs* 2004;26:339–50.
35. Pendall R. Local land use regulation and the chain of exclusion. *J Am Plann Assoc* 2000;66:125–42.
36. Pendall R, Fulton W. Holding the line: urban containment policies in the United States. Washington DC: Brookings Institution Center on Urban and Metropolitan Policy, 2002. [www.brookings.edu/dybdocroot/es/urban/publications/pendallfultoncontainment.pdf](http://www.brookings.edu/dybdocroot/es/urban/publications/pendallfultoncontainment.pdf).
37. Burby R, Nelson A, Parker D, Handmer J. Urban containment policy and exposure to natural hazards: Is there a connection? *J Env Plann Manag* 2001;44:475–90.
38. Burby R, May P. Making governments plan: state experiments in managing land use. Baltimore MD: Johns Hopkins University Press, 1997.
39. Carruthers J. The impacts of state growth management programmes: a comparative analysis. *Urban Stud* 2002;39:1959–82.
40. Zovanyi G. Growth management for a sustainable future: ecological sustainability as the new growth management focus for the 21st century. Westport CT: Praeger, 1998.
41. Weitz J. Sprawl busting: state programs to guide growth. Chicago: Planners Press, American Planning Association, 1999.
42. Wassmer R. Fiscalisation of land use, urban growth boundaries, and non-central retail sprawl in the Western United States. *Urban Stud* 2002;39:1307–27.
43. Wassmer R. The influence of local urban containment policies and state growth management on the size of United States urban areas. *J Reg Sci* 2006;46:25–65.
44. Gale D. Eight state-sponsored growth management programs: a comparative analysis. *J Am Plann Assoc* 1992;58:425–39.
45. Berke P, Godschalk D, Kaiser E, Rodriguez D. Urban land use planning. 5th ed. Urbana-Champaign IL: University of Illinois Press, 2006.
46. Fulton W. Guide to California planning. Point Arena CA: Solano Press, 1999.
47. Maryland Department of Planning. Smart growth priority funding areas act of 1997. Maryland: The Department, 2005.
48. King County Department of Developmental and Environmental Services. History and background of the comprehensive plan. Washington: The King County Department, 2004.
49. Schrank D, Lomax T. Urban mobility study. College Station TX: Texas Transportation Institute, 2003. [mobility.tamu.edu/ums/](http://mobility.tamu.edu/ums/).
50. Aytur S. Relationships of land use and transportation policies to physical activity and obesity [dissertation]. Chapel Hill (NC): University of North Carolina, 2006.
51. Natural Resources Conservation Service. National resources inventory: a statistical survey of land use and natural resource conditions and trends on U.S. non-federal lands. Department of Agriculture, Natural Resources Conservation Service, 2004.
52. Natural Resources Conservation Service. National resources inventory, 1997. Summary report. Appendix 3: Glossary of Selected Terms. [www.nrcs.usda.gov/technical/NRI/1997/summaryreport/glossary.html](http://www.nrcs.usda.gov/technical/NRI/1997/summaryreport/glossary.html).
53. Guo G, Hongxin Z. Multilevel modeling for binary data. *Annu Review Sociol* 2000;26:441–62.
54. Singer J. Using SAS PROC MIXED to fit multilevel models, hierarchical models, and individual growth models. *J Educ Behav Stat* 1998;24:323–55.
55. Singer J, Willett J. Applied longitudinal data analysis: modeling change and event occurrence. New York NY: Oxford University Press, 2003.
56. Bryk A, Raudenbush S. Application of hierarchical linear models to assessing change. *Psychol Bull* 1987;101:147–58.
57. CDC. Behavioral risk factor surveillance system: trends data. Atlanta GA: CDC, 2005.
58. U.S. DHHS. Healthy People 2010, 2nd edition. [www.healthypeople.gov/publications/](http://www.healthypeople.gov/publications/).
59. Saelens B, Sallis J, Frank L. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Ann Behav Med* 2003;25:80–91.
60. Schmid T, Frank L, Engelke P, Killingsworth R. How land use and transportation systems impact public health: a literature review of the relationship between physical activity and built form. Atlanta GA: Active Community Environments (ACE) Working Paper #1, CDC, 2003.
61. Frank L, Andresen M, Schmid T. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med* 2004;27:87–96.
62. Ewing R, Schmid T, Killingsworth R, et al. Relationship between urban sprawl and physical activity, obesity, and morbidity. *Am J Health Promot* 2003;18:47–57.
63. McCann B, Ewing R. Measuring the health effects of sprawl: a national analysis of physical activity, obesity, and chronic disease. Washington DC: Smart Growth America and Surface Transportation Policy Project, 2003.
64. Badoe D, Miller E. Transportation-land use interaction: empirical findings in North America, and their implications for modeling. *Transportation Research Part D* 2000;5:235–63.
65. Handy S. Critical assessment of the literature on the relationships among transportation, land use, and physical activity. Washington DC: Transportation Research Board and Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use, 2005.
66. Crane R. The influence of urban form on travel: an interpretative review. *J Plann Educ Res* 2000;15:3–23.
67. Ewing R, Cervero R. Travel and the built environment. *Transportation Research Record* 2001;1780:87–114.

68. Rodriguez D, Targa P, Aytur S. Transportation implications of urban containment policies: a study of the largest 25 U.S. metropolitan areas. *Urban Stud* 2006;43:1879–97.
69. Dill J, Carr T. Bicycle commuting facilities in major U.S. cities: If you build them, commuters will use them. *Transportation Research Record* 2003;1828:116–23.
70. Cervero R. Built environments and mode choice: towards a normative framework. *Transportation Research Part D* 2002;7:265–84.
71. Cervero R, Kockelman K. Travel demand and the 3Ds: density, diversity and design. *Transportation Research Part D* 1997;2:199–219.
72. Kitamura R, Laidet L, Mokhtarian P. A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area. *Transportation* 1997;24:125–58.
73. Frank L, Engelke P, Schmid T. *Healthy community design: the impact of the built environment on physical activity*. Washington DC: Island Press, 2003.
74. Greenwald M, Boarnet M. The built environment as determinant of walking behavior: analyzing nonwork pedestrian travel in Portland, Oregon. *Transportation Research Record* 2001;1780:33–42.
75. Cervero R. Rail-oriented office development in California: how successful? *Transportation Quarterly* 1994;48:33–44.
76. Rodriguez D, Joo J. The relationship between non-motorized mode choice and the local physical environment. *Transportation Research Part D* 2004;9:151–73.
77. Ewing R, Deanna M, Li SC. Land use impacts on trip generation rates. *Transportation Research Record* 1996;1519:1–6.
78. Pendall R. Do land-use controls cause sprawl? *Environ Plann B Plann Des* 1999;26:555–71.
79. Peiser R. Density and urban sprawl. *Land Econ* 1989;65:193.
80. Downs A. Some realities about sprawl and urban decline. *Housing Policy Debate* 1999;10:955–74.
81. Downs A. Growth management: Satan or savior? Regulatory barriers to affordable housing. *J Am Plann Assoc* 1992;58:419–29.
82. Jud G, Winkler D. The dynamics of metropolitan housing prices. *Journal of Real Estate Research* 2002;23:29–39.
83. Dawkins C, Nelson A. Urban containment policies and housing prices: an international comparison with implications for future research. *Land Use Policy* 2002;19:1–12.
84. Fischel WA. Growth management reconsidered: good for the town, bad for the nation? A comment. *J Am Plann Assoc* 1991;57:341–4.
85. Richardson H, Gordon P. Market planning: oxymoron or common sense? *J Am Plann Assoc* 1993;59:347–52.
86. Brueckner J. Urban sprawl: diagnosis and remedies. *Int Reg Sci Rev* 2000;23:160–71.
87. Song Y. Smart growth and urban development pattern: a comparative analysis. *Int Reg Sci Rev* 2005;28:239–65.
88. Vandegrift D, Yoked T. Obesity rates, income rates, and suburban sprawl: an analysis of U.S. states. *Health Place* 2004;10:221–9.
89. Galster G, Hanson R, Ratcliffe M. Wrestling sprawl to the ground: defining and measuring an elusive concept. *Housing Policy Debate* 2001;12:681–717.
90. Talen E. Do plans get implemented? A review of evaluation in planning. *J Planning Literature* 1996;103:248–59.
91. Ascher W. Resolving the hidden differences among perspectives on sustainable development. *Policy Sci* 1999;32:351–77.