Urban Containment Policies and Physical Activity

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

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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.[1,2] Prior cross-sectional research has examined whether micro-level (neighborhood scale) features of the built environment may promote activity-friendly communities.[3–12] 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,[6,7] encourage efficient use of infrastructure,[7,8] promote social equity,[9,10] preserve farmland,[7,8,11] and set aside land for public greenspace.[13] 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.[14] 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.[13–19]

Nelson et al.[20,21] 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,[22–24] 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

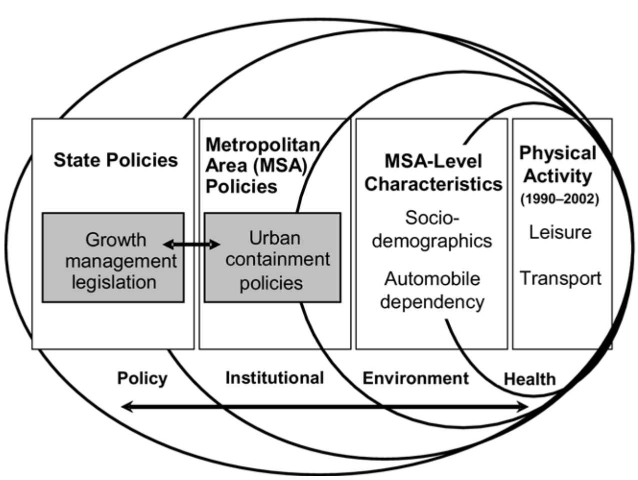

Figure 1. Conceptual model: relationships of urban containment policies to physical activity.

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.[33,34] and subsequent work examining the predominant urban containment frameworks[20] 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[20] 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.[20]

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

Table 1. Measures and data sources

Measure	Data source	Variable(s)/coding	Data quality/comments
DEPENDENT VARIABLES			
MSA-level physical activity			
Percentage walking/bicycling to work (1990–2000)	U.S. Census of Population, Summary File 3,[25,26] 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.[27] 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.[28]	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,[27] 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.[29–32]
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. This variable is available annually from the BRFSS from 1990 to 1992, and then in alternate years for 1994, 1996, 1998, and 2000. Coded as a time-varying continuous variable. No imputation was performed for missing years, as the mixed models can handle arbitrary spacing of measurements.	

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Table 1. *(continued)*

Measure	Data source	Variable(s)/coding	Data quality/comments
INDEPENDENT VARIABLES			.
Main Exposures			
Presence of UCPs in metropolitan areas	Planning literature and prior planning surveys,[13–21,33–37] (A Nelson, unpublished survey, 1999)	**Weak UCP** (Weak-Accommodating and/or Weak-Restrictive[20]) 1=Present 0=Absent (Referent) **Strong UCP** (Strong-Accommodating and/or Strong-Restrictive[20]) 1=Present 0=Absent (Referent) 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).[13–21,33–37] 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[13–17,38–48]	**Enabling Legislation** 1=Present 0=Absent (Referent) **Legislation Mandating Urban Growth Boundaries (UGBs)** 1=Present 0=Absent (Referent) Coded as two time-varying categoric variables.	For the states of Georgia[a] and California[b] 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).
Covariates			
Daily VMT/capita	TTI Urban Mobility Report,[49] 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.[50] Coded as a time-varying variable, deciles, centered at the median value.	Methodology and data quality are summarized in the Annual Urban Mobility Report.[49]
MSA population size	U.S. Census[27]	U.S. Census of Population data for each MSA/PMSA were used to determine population size for each year. 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.

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

Measure	Data source	Variable(s)/coding	Data quality/comments
Net density	NRI[51,52]	Net density was calculated as population (10,000) divided by the amount of built land area,[52] 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),[25,26] 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 Percentage of population with ≥ high school education Median household income	U.S. Census of Population, Summary File 3 (SF-3),[25,26] 1990 and 2000	Estimates were obtained from the census. Values between the decennial census were imputed assuming a constant average rate of change. Coded as separate time-varying variables, deciles, centered at the median value.	

[a]Georgia's program is not considered a true growth-management program according to some scholars,[14,41] 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.[39,40,44]

[b]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.[39,41,46]

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

[a]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).

[b]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[33,34] 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.[53–56] Following the approach of Singer et al.,[54,55] 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 (α=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,[57] 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
≥High school education			
1990	78.6	7	48–88
2000	82.3	7	52–91
Black			
1990	10.2	8	0–45
2000	10.0	9	1–43
Nonwhite			
1990	19.8	9	5–43
2000	25.8	10	9–48
Median household income			
1990	$30,882	$5417	$17,336–$48,115
2000	$44,782	$7124	$26,155–$62,024
≥Aged 65			
1990	16.0	3	10–28
2000	16.8	3	11–28
Population size[a]			
1990	130.2	170.9	13.3–886.3
2000	163.3	185.1	17.2–950.2
Net density[b]			
1990	0.8049	0.1587	0.1134–11.7200
2000	0.8644	0.1614	0.1226–11.9124
Daily vehicle miles traveled per capita			
1990	21.0	3.6	12–29
2000	22.9	5.3	12–40

[a]Population × 10,000.
[b]Net density was calculated as population (10,000) divided by the amount of built land area,[52] 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*[58] 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[a]

	Model 1. State legislation	SE	*p* value	Model 2. MSA containment policy	SE	*p* value	Model 3. State legislation and MSA policy	SE	*p* value
Intercept (percentage walking/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
State growth-management legislation (ref=none)									
Enabling	−0.10	0.02	<0.0001				−0.09	0.02	0.0002
Mandate growth boundary (UGB)	0.65	0.49	0.1890				0.59	0.49	0.2275
Metropolitan containment policy (UCP) (ref=none)									
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
MSA-level SES factors									
Percentage ≥ High school[b]	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[b]	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[b]	0.39	0.07	<0.0001	0.40	0.07	<0.0001	0.40	0.07	<0.0001
Percentage of between-MSA variance explained	60			60			60		
Model fit: AIC	−1490.9			−1485.5			−1496.7		

[a]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).
[b]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.[7,59–63] Additionally, relationships between travel behavior and urban form[64–68] with respect to mode choice,[69–71] street networks,[72–74] and accessibility to activity centers[71,75–77] 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,[35,78,79] shifting sprawl to areas with weaker land-use controls. Critics also argue that urban containment policies decrease housing affordability,[80–83] disrupt land markets,[84,85] and may be economically inefficient relative to pricing and taxing incentives.[86]

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[a]

	Model 1. State legislation	SE	*p* value	Model 2. MSA containment policy	SE	*p* value	Model 3. State legislation and MSA policy	SE	*p* value
Intercept (Proportion no LTPA in 1990)	25.35	1.07	<0.0001	25.86	1.07	<0.0001	25.74	1.06	<0.0001
Year	0.94	0.25	0.0002	0.95	0.25	0.0002	0.98	0.25	0.0001
Year Sq	−0.07	0.02	<0.0001	−0.07	0.02	<0.0001	−0.08	0.02	<0.0001
State growth-management legislation (ref=none)									
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
Metropolitan containment policy (UCP) (ref=none)									
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
MSA-level SES factors									
Percentage ≥ high school[b]	−0.65	0.15	0.0001	−0.64	0.15	<0.0001	−0.55	0.15	0.0004
Median household income[b]	−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
Percentage of between-MSA variance explained	75			77			78		
Model fit: AIC	2842.7			2842.7			2837.2		

[a]Models include random intercepts as well as a random slope for *YEAR*, utilizing an unstructured covariance matrix.
[b]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.

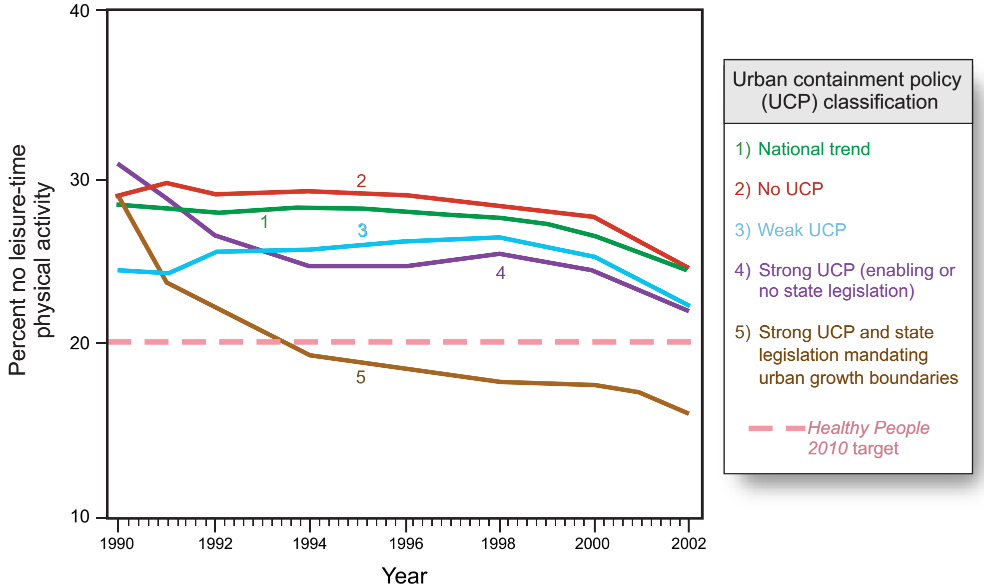

Figure 2. Percentage of no leisure-time physical activity, 1990–2002, by type of urban containment policy in large U.S. metropolitan areas.
Note: To facilitate comparison with *Healthy People 2010* population-wide targets, trends are not adjusted for sociodemographics.

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

	Model 1. State legislation	SE	p value	Model 2. MSA containment policy	SE	p value	Model 3. State legislation and MSA policy	SE	p value
Intercept (Mean minutes LTPA per week in 1990)	178.20	11.19	<0.0001	177.90	11.20	<0.0001	175.86	10.72	<0.0001
Year	0.92	1.24	0.4551	0.79	1.24	0.5239	0.7625	1.20	0.5265
State growth-management legislation (ref=none)									
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
Metropolitan containment policy (UCP) (referent=none)									
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
MSA-level SES factors									
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[a]	2.49	1.49	0.1008	2.64	1.49	0.0827	1.42	1.44	0.3309
Median household income[a]	−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[a]	−4.50	2.15	0.0373	−3.99	2.18	0.0686	−4.21	2.11	0.0475
Population size[a]	1.45	1.48	0.3300	0.68	1.47	0.6466	1.06	1.38	0.4423
Percentage of between-MSA variance explained	61			61			69		
AIC	3255.3			3258.7			3252.7		

[a]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.[87] 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.[68] 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 researchers,[18,64–69,88] 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.[20,21,35,36,89] This study utilized categoric measures based on extensive previous research[20,21,33,34] 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.[18,36,37,42,90] Additional transdisciplinary research, including a policy sciences perspective,[91] 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 explained 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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