Diffusion of Complete Streets Policies Across US Communities

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Context: Complete Streets policies guide planning in communities by making the transportation system accommodating to all users including vehicle drivers, pedestrians, and bicyclists, as well as those using public transportation. While the number of Complete Streets policies has increased over the past decade, no research has explored the factors attributing to the widespread diffusion of these policies. **Objective:** The purpose of this study was to apply concepts of the Diffusion of Innovation Theory to data related to Complete Streets policies in order to identify potential patterns and correlates. **Methods:** The main outcome of this study was policy adoption. Using the Diffusion of Innovation Theory and results from previous literature, we identified several factors that had the potential to affect the rate of Complete Streets policy diffusion: rural/urban status, state obesity rate, state funding for transportation, state obesity prevention funding, percentage of people who walk or bike to work in the state, presence of a state Complete Streets policy, and the number of bordering communities with Complete Streets policy. We used event history analysis as the main analysis method. **Results:** Data from 49 community-level policies were analyzed, with a "community" defined as a city, a county, or a regional/Metropolitan Planning Organization. Three variables were significant predictors of Complete Streets policy adoption: state obesity rate (odds ratio [OR] = 1.465; confidence interval [CI] = 1.10-1.96) percentage of people who bike or walk to work in the state (OR = 1.726; CI = 1.069-2.79), and presence of a border community with a Complete Streets policy (OR = 3.859; CI = 1.084-13.742). **Conclusion:** Communities with Complete Streets policies varied in geographic and sociodemographic factors. Information about communities that are more likely to adopt a policy can be a tool for advocates and policy makers interested in this topic. Because adoption does not imply implementation, further research is needed to study outcomes of Complete Streets policies.

KEY WORDS: built environment, Complete Streets, diffusion of innovation, policy

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Supporting active transportation infrastructure through policy and environmental improvement is a strategy identified by the Centers for Disease Control and Prevention to improve community health.[1] Despite some evidence on the health benefits of active travel,[2] there is a research gap in identifying which community design or transportation strategies are most crucial in influencing activity patterns.[3] One strategy that has been gaining momentum in communities across the United States is Complete Streets. Complete Streets policies guide planning in states, regions, and communities by making the transportation system accommodating to all users including vehicle drivers, pedestrians, and bicyclists, as well those using public transportation.[4]

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Residents within communities that have adopted Complete Streets policies have noticeable increases in physical activity. Cities in the United States investing in bicycling infrastructure consistently see increases in bicycling rates, as is the case in Portland, Oregon, where Complete Streets work coincided with an increase in bicycling commuters.[5] Complete Streets work in Boulder, Colorado, resulted in walking and biking rates above the national average.[6]

Although support for these policies is currently popular and growing rapidly across the United States, the first Complete Streets policy was adopted more than 40 years ago. In 1971, the state of Oregon adopted a policy that outlined the infrastructure and support for modes of transportation other than automobiles: "footpaths and bicycle trails, including curb cuts or ramps as part of the project, shall be provided wherever a highway, road or street is being constructed, reconstructed or relocated."[4] Between 1971 and 1999, only 7 additional polices were enacted nationwide. This number doubled between 2000 and 2003 and between 2008 and 2010; the number of Complete Streets policies has doubled per annum.[4] Almost half of States in the United States (N = 23) have some form of Complete Streets policy at the community or state level. Suburban communities of fewer than 30 000 people make up the largest percentage of adopters by size and location.[4] There are potentially many factors, including those relevant to federal-, state-, and community-level politics, motivating these policy trends. In 2007, gasoline prices reached an all time high. During the summer of 2008, prices again reached record levels.[7] In addition, there has been increased federal support for the adoption of Complete Streets policies, specifically during the past decade. In 1998, the US Congress passed the Transportation Equity Act for the 21st Century, calling for expansion and improvements in bikeways and walkways.[8] Federal Complete Streets legislation was again on the national government political agenda from 2008 to 2010, with several proposed acts encouraging state- and community-level transportation agencies to plan, fund, and implement improvements to sidewalks and bikeways as part of federal-aided project developments.[9] Such federal-level attention focused on further development of Complete Streets policy likely trickled down to both state- and community-level agenda setting and policy making. However, because of the complex nature of the political process within each level of government, it is important to examine other potential motivating factors.

To date, no research has explored the state- and community-level factors that attributed to the widespread diffusion of these policies. Rogers' Diffusion of Innovation Theory (DIT) offers a paradigm in which we can study the diffusion of these policies. There are 4 main elements in Rogers'[10] DIT: an innovation (or policy-something perceived as new), a communication system (a transmission system from one individual, group, or society to another), a social system (provides the domain for the diffusion process), and time (from awareness of innovation through to adoption saturation in the social system). Rogers'[10] theory also suggests factors, both internal and external, that affect these elements, ultimately impacting a community's decision to pursue policy adoption. Such factors might include the following: (1) the characteristics of the innovation (eg, complexity, compatibility with existing social norms and structures, observability of benefits, relative advantage over existing forms, and trialability), (2) the strength and visibility of communication channels, and (3) stability in the structure of the social system. For instance, a policy that is successfully adopted in one community and is compatible with a potential adopter's values is likely to diffuse more rapidly.[10]

The framework of the DIT has been used to study diffusion in a variety of disciplines, at a variety of political levels including global, national, state, and local, and among people. Several correlates of diffusion have been investigated in these research studies and have been found to affect the rate of adoption/support of an innovation (policy). For instance, early scholarship on diffusion focused on regional proximity as a primary determinant of innovation adoption.[11,12] Numerous recent studies have continued to find a regional diffusion effect (Berry and Berry[13], on state tax policy; Daley and Garand,[14] on state environmental policy; and Shipan and Volden,[15] on local antismoking ordinance adoption). Successful peer adoption has also been shown to effect diffusion. Walker[12] wrote, "In all cases . . . the likelihood of a state adopting a new program is higher if other states have already adopted the idea."(p897) Gray[16] also found that the cumulative proportion of adopters of a given policy to be a predictor of the rate of spread, based on logistic regression for 12 laws including civil rights, welfare, and education. The size of the community is yet another factor shown to affect the rate of diffusion. Mohr[17] noted that larger communities have larger organizations and so are the locale of more innovation. On the contrary, some studies have linked adoption of innovation to smaller communities, not larger, perhaps reflecting differences in governmental level, policy issue, or dimension. Shipan and Volden[15] found smaller local governments more likely to adopt smoke-free ordinances.[15] Socioeconomic factors such as education, income, urbanization, and racial and ethnic diversity also have been found to affect diffusion both positively and negatively.[10] Finally, well-developed policy networks have been shown to act as a diffusion prerequisite, fostering the spread of information about innovations and about adoptions by peers.[12] A policy network consists of a group of actors who share an interest in some policy area and who are linked by their direct and indirect contacts with one another.[16,17] Mintrom and Vergari also detailed policy networks as "important resources that successful policy entrepreneurs draw upon when developing and selling their policy ideas"[18,19(p127)] In their view, policy networks facilitate agenda setting, which sanctions diffusion of innovation.[12,18,19]

These identified correlates and how they relate to the rate of diffusion of an innovation, and, in turn, support and adoption of a policy, are useful in studying the process of Complete Streets policy adoption and diffusion throughout the United States. The purpose of this research was to identify the factors that influence the adoption of a Complete Streets policy among US communities.

Methods

Complete Streets policy information was collected from the National Complete Streets Coalition Web site.[4] Eighty-one policies across 23 states were gathered and information aggregated into a data spreadsheet. Forty-nine of these policies were adopted in 2005-2008 and were community level, with a "community" defined as a city, a county, or a regional/Metropolitan Planning Organization. These policies/communities were included in the event history analysis (EHA). There were an insufficient number of states that adopted policies in 2005-2008 ($n = 5$) to conduct a state-level analysis. Location, adoption date, and hypothesized correlated variables were included. The presence and spatial diffusion of Complete Streets policies were also geographically evaluated using ArcGIS 10.0 (ESRI, Redlands, California). Policies were aggregated at 3 time points; those in place in 2000, 2005, and 2008.[20] We collected data from a variety of sources associated with factors affecting the rate of diffusion as outlined in the DIT and previous literature that theoretically influence the rate of adoption of an innovation. Table 1 presents the data variables, host sources, and hypothesized effect on adoption and diffusion rates.

Event history analysis

The standard approach for assessing policy diffusion is through a pooled time-series, discrete, and nonrepeating EHA.[21-23] The EHA is preferred over traditional multiple regression models because EHA is one type of model that can analyze data that varies over time.[24] Central to the EHA is the concept of the "risk set," which, in a policy diffusion study, is the set of communities in the sample that have a chance of experiencing the event of policy adoption at a particular time.[25]

The exploratory EHA design and model used in this study are based on those used by the authors Berry and Berry[25] in 1990 to study state lottery adoptions as policy innovations. The pooled design is recommended to allow the dependent variable to be affected by independent variables with the right time property.[25] The assumption of a nonrepeating EHA model is that the event is single and does not repeat,[26] such as the initial adoption of a policy. The assumption of a discrete EHA model is that the time of event occurrence is measured in discrete, nonexact units,[26] such as years. A pooled design involves creating a separate observation for each community for each year; therefore, this study's data set uses "community-years" as the unit of analysis.[25] Data for the time period of 2005-2008 were included in the analysis. Prior to 2005, data for many of the predictor variables were not available.

In this study, the outcome variable was policy adoption. Each community was considered "at risk" of adoption until a policy was adopted.[21] Therefore, the a*doption* variable for each community was coded as "0" in the years before the policy was adopted and "1" in the year of adoption. The community was removed from the data set in the years after adoption. The final data set contained 139 community-years, with all 49 communities analyzed in 2005, 44 communities analyzed in 2006, 30 communities analyzed in 2007, and 16 communities analyzed in 2008.

Binary logistic regression in IBM SPSS Statistics 19 was used to analyze the data. There were 6 predictor variables entered into the model (see Table 1). The variables representing the *presence of bordering communities with Complete Streets policy*, *state obesity prevention funding*, *presence of state-level Department of Transportation Complete Streets policy*, and *rural/urban status* were identified as categorical predictors in the analysis. The variables were all time variant, except for *rural/urban status* and *presence of bordering communities with Complete Streets policy*. For *rural/urban status*, the group with the largest population (counties in metro areas of 1 million populations or more) was selected as the reference category because policies are hypothesized to diffuse across communities with larger populations.[17] The 3 remaining categories of *rural/urban status* that had data were entered into the model as dichotomous variables. Probabilities, coefficients, standard errors, and odds ratios (ORs) and their confidence intervals (CIs) were calculated for the predictor variables. The Nagelkerke R^2 value was calculated for the model.

Results

The Figure provides a geospatial representation of the adoption and diffusion of Complete Streets policies

TABLE 1 ● Variables Used to Describe Adoption and Diffusion of Complete Streets Policies

Data Variable	Hypothesized Association to Adoption/Diffusion	Data Source
Rural/urban status	Higher urbanity increase likelihood for adoption	United States Department of Agriculture[a]
State obesity prevention funding	Presence of funding increases likelihood for adoption	Centers for Disease Control and Prevention[b]
State obesity rate	Higher obesity rates increase likelihood for adoption	Division of Nutrition, Physical Activity, and Obesity, Centers for Disease Control and Prevention[b]
Percentage of people who bike or walk to work in the state	Higher percentages increase likelihood for adoption	American FactFinder
Presence of state-level Department of Transportation Complete Streets policy	Presence increases likelihood for adoption	National Coalition of Complete Streets database
Presence of geographically bordering communities with Complete Streets policies	Presence increases likelihood for adoption	National Coalition of Complete Streets database

[a]Available at: http://www.ers.usda.gov/Briefing/Rurality/UrbanInf/.
[b]Available at: http://www.cdc.gov/nccdphp/dnpao/index.html.
[c]Adult Obesity Facts. Available at: http://www.cdc.gov/obesity/data/adult.html.

occurring across the United States between 2000 and 2008. Areas appearing to have the most proximate spatial diffusion include the following: (1) the Pacific Coast, with policies diffusing across California and the King-Pierce County area of Washington; (2) the Four Corners region (Utah, Colorado, New Mexico, and Arizona); (3) the Midwest (especially between 2005 and 2008); and (4) the Mid-Atlantic and Southeast. There are also several local policies stretching along Interstate 85 and 95, from Atlanta, Georgia, to Greenville, South Carolina, to Charlotte, North Carolina, and Arlington, Virginia, to New York City.

Table 2 shows the summary statistics for the 6 predictor variables, including the 3 dichotomous variables, and the community-years included in the EHA model.

Table 3 shows the results of the logistic regression. This model explains approximately 18% of the variance in the event of adopting a Complete Streets policy (The Nagelkerke $R^2 = 0.176$). Three variables were significant predictors of Complete Streets policy adoption. First, as the obesity rate of a state increases, so do the odds of a community in the state adopting a Complete Streets policy (OR = 1.47; CI = 1.10-1.96). Second, as the percentage of people who bike or walk to work in a state increases, so do the odds of a community in the state adopting a Complete Streets policy (OR = 1.73; CI = 1.07-2.79). Finally, the presence of a border community with a Complete Streets policy was a significant predictor (OR = 3.86; CI = 1.08-13.74) of Complete Streets policy adoption.

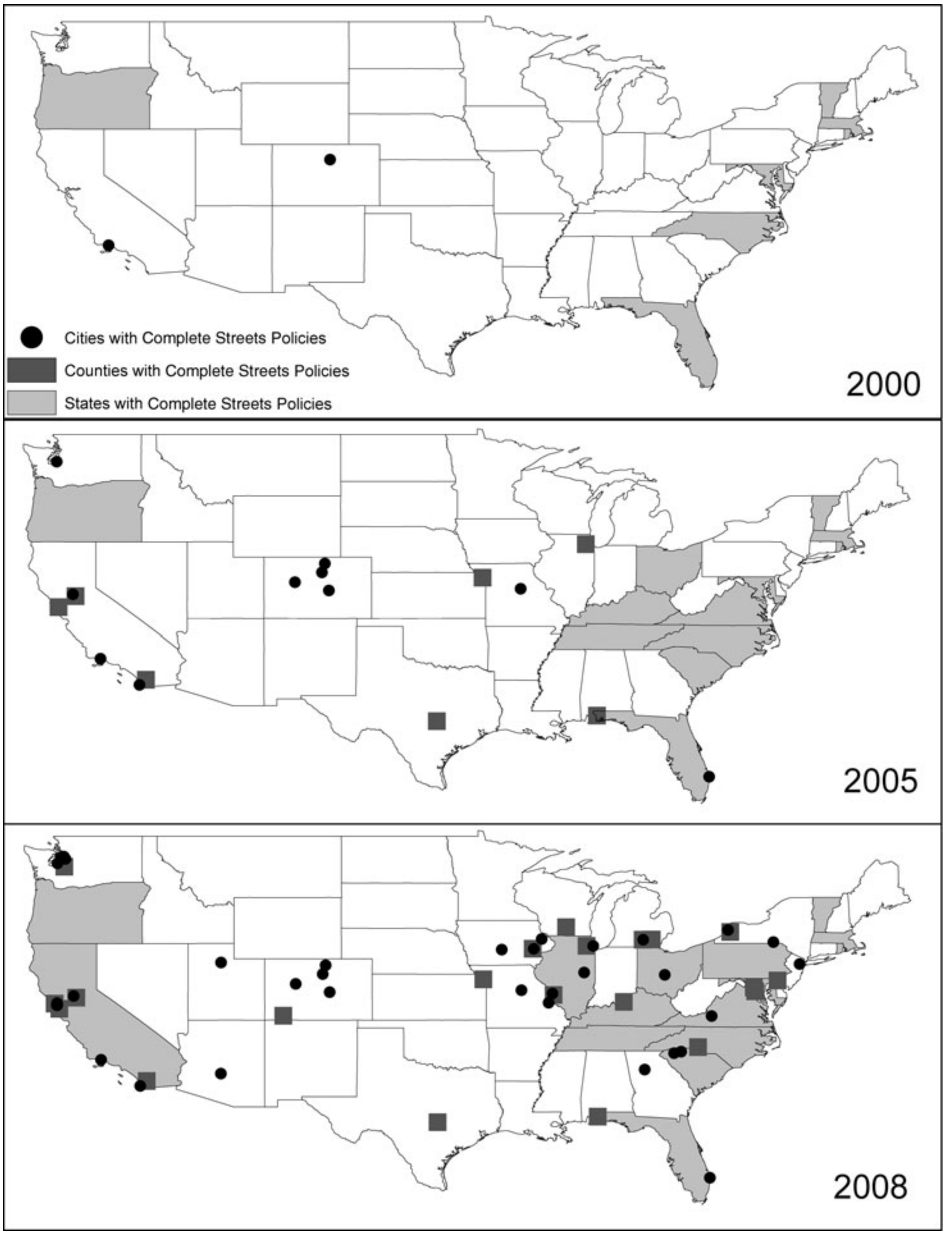
The rural/urban status, presence of Department of Transportation state policy, and state obesity prevention funding were not found to be significant predictors of Complete Streets policy adoption at the $P < .05$ level. State obesity prevention funding was found to have a nonsignificant relationship ($P = .062$) with the outcome variable in the opposite direction of what was hypothesized (ie, funding would be associated with policy adoption).

Discussion

These analyses highlight both methodological and conceptual findings. This is the first study to apply the DIT framework to policies related to the built environment. These findings highlight factors that contributed toward the rapid diffusion of Complete Streets policies within communities across the United States between 2005 and 2008. According to our results, Complete Streets policies were more likely to be adopted in communities where the state obesity rate was higher, where the percentage of people who bike or walk to work in the state was greater, and where there was a bordering community with a Complete Streets policy in place.

The increase in state obesity rate during the study period was a significant predictor. The obesity epidemic, particularly in children, has motivated the implementation of national and state prevention efforts.[27] Coalitions and networks for improving health through active living have been developed[28] and may have advocated for Complete Street policies as awareness of increasing obesity rates became known. Similarly, we hypothesized that receiving state obesity prevention funding from the Centers for Disease Control and Prevention would increase the odds of a Complete Streets policy adoption, but this variable was not a significant

FIGURE ● Geospatial Representation of the Adoption and Diffusion of Complete Streets Policies Across the United States: 2000-2008



predictor. Perhaps, the states with funding focused more expressly on strategies related to nutrition rather than those specific to the built environment or increasing physical activity.

The likelihood of adoption of a Complete Streets policy was related to the percentage of people within a state who report active commuting. This finding is intuitive in the sense that with more active commuters in a community, the support base and advocacy for such policies are also greater. Assessments of communities that have the highest percentage of active commuters also have large numbers of bicycle lanes, sidewalks, and other facilitators of walkability/bikability. Eleven of the 13 US cities where at least 6.5% of the commuting population walks or cycles has a Complete Streets policy as of 2008 (city- or state level). The 2 missing cities (Minneapolis and New Orleans) have instituted policies since 2008.[29]

The odds of adopting a Complete Streets policy was related to bordering a community with a Complete Streets policy. These findings correspond to constructs of the DIT and highlight the importance of geographic proximity, successful peer adoption, and the compatibility of the policy innovation with the community's

TABLE 2 ● Summary Statistics of Predictor and Outcome Variables in the Event History Analysis Model

Variable	Description	Levels/Range	Mean	SD
Adoption (outcome variable)	Dummy variable if the community had adopted a Complete Streets policy	1 in the year that a community adopted a Complete Streets policy; 0 in the years prior to adoption and observation was removed from years after adoption[15]	0.35	0.48
State DOT Complete Streets policy	Dummy variable if the community's state DOT had adopted a Complete Streets policy	1 if the state DOT had a Complete Streets policy in effect that year and = 0 if it did not	0.12	0.33
State obesity prevention funding	Dummy variable if the community had received funding for obesity prevention from the CDC	1 if the community received funding for obesity prevention that year and = 0 if it did not	0.83	0.38
Rural/urban status	Categorical variable, included in model as 3 dummy variables, for the community's USDA rural or urban status category	0 if counties in metro areas of 1 million population or more (reference group); 1 if counties in metro areas of 250 000 to 1 million population; 1 if counties in metro areas of fewer than 250 000 population; and 1 if urban population of 2 500-19 999 adjacent to a metro area	. . . . . . 0.24 0.16 0.03	. . . . . . 0.43 0.37 0.18
State obesity rate	Continuous variable (%) for the obesity rate in the community's state	Range = 17.80-30.70	25.21	2.64
Percentage of people who bike or walk to work in the state	Continuous variable (%) for the percentage of people in the community's state who bike or walk to work	Range = 1.67-6.81	3.62	1.44
Border community with Complete Streets policy	Dummy variable for if a border community had a Complete Streets policy in effect	1 if a border community (ies) has (have) adopted a Complete Streets policy and 0 if no border community (ies) has (have) adopted a Complete Streets policy	0.45	0.50

Abbreviations: CDC, Center for Disease Control and Prevention; DOT, Department of Transportation; USDA, US Department of Agriculture.

needs, social norms, values, and beliefs (ie, high obesity rate and percentage of people walking or biking) in increasing the likelihood of adoption and diffusion of policies across communities. Our geospatial analysis findings also points to regional diffusion in several areas across the United States. Regional diffusion effect has been found in studies on state tax policies,[13] state environmental policy,[14] and on local smoke-free ordinance adoption.[15] These findings suggest the need for further research examining these more proximal diffusion effects.

One surprising finding was the fact that the urban/rural status was not a significant predictor of diffusion of Complete Streets policies. Prior diffusion research has been inconclusive in relating size of community to rate of diffusion,[17] possibly reflecting differences in

TABLE 3 ● Event History Analysis Logistic Regression Results[a]

Predictor	*B* (SE)	*P*	OR	CI
State obesity rate	0.382 (0.148)	.010[b]	1.465	1.096-1.957
Percentage of people who bike or walk to work in the state	0.546 (0.245)	.026[b]	1.726	1.069-2.787
State DOT Complete Streets policy	0.382 (0.782)	.625	1.466	0.317-6.789
State obesity prevention funding	− 1.524 (0.818)	.062	0.218	0.044-1.082
Rural/urban status	. . .	.124		
Counties in metro areas of 250 000 to 1 million population	0.175 (0.666)	.793	1.191	0.323-4.391
Counties in metro areas of fewer than 250 000 population	1.471 (0.849)	.083	4.353	0.824-23.008
Urban population of 2 500-19 999 adjacent to a metro area	3.603 (1.882)	.056	36.718	0.918-1468.396
Border community with Complete Streets policy	1.350 (0.648)	.037[b]	3.859	1.084-13.742

Abbreviations: CI, confidence interval; DOT, Department of Transportation; OR, odds ratio; SE, standard error.
[a]Model included constant* not shown here due to space considerations.
[b]$P < .05$.

governmental level, policy issue, or dimension. However, we hypothesized that urbanity would increase the rate of diffusion, especially since motor vehicle accidents resulting in pedestrian fatalities are more likely to occur in urban settings.[30] It is therefore advantageous that lives and costs saved for urban, more populous areas to be covered by Complete Streets policies. The null finding therefore may be due to the use of the US Department of Agriculture categorical variable for urbanity and/or reflect that previous research showing that the diffusion is not always affected by size of populace but more influenced by key innovative policy makers.

Limitations

This study uses an exploratory EHA model on adoption of a complex policy issue and several limitations warrant mention. We used only those policies that were found in the National Coalition for Complete Streets Database and were limited to policies enacted through 2008. Future research should include analysis with the most current list of policies. Also, this was the first study to assess policies using factors of the DIT framework and using the EHA methodology. Researchers should work to refine and strengthen these analysis methods by including unmeasured confounders, such as sociodemographic factors, and factors controlling for temporal dependence. While one of the major strengths of this study is the use of many variables hypothesized to be related to adoption of Complete Streets policies, data at a more local level (vs state level) would add to the precision of the analysis. Finally, this, like other policy diffusion studies, is observational and cannot imply causation. Despite these limitations, this study adds to the scant body of literature on diffusion as it related to policy and environmental change.

Conclusion

Complete Streets policy adoption is a potential strategy in building healthy and safe community environments that support active living. Knowledge of specific factors related to the growth and expansion of Complete Streets policies is important for communicating with advocates and policy makers about this topic. For instance, policy makers might be more likely to set their policy agendas in support of Complete Streets policy on the basis of factors known to influence adoption. In addition, according to other research using the DIT in studying the diffusion of policies, it is important to develop strong networks. At the national level, the National Complete Streets Coalition provides resources and opportunities for communities to learn from other communities. This information may facilitate development of strong local policy networks that include stakeholders committed to working toward policy adoption[31] and help these networks mobilize to more effectively promote community policies. In addition, policy adoption can be the impetus for long-term behavior outcome changes. Knowing how policies such as Complete Streets are being diffused can help set up evaluation strategies so that correlations can be measured. By tracking policy adoption and changes, we can look at and compare trends of state obesity rates and other physical activity indicators such as active commuting prevalence.

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