Preventive Medicine 118 (2019) 176–183

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Network influences on the development and implementation of active transportation policies in six U.S. cities

Marissa L. Zwald[a,b,*], Amy A. Eyler[a,b], Debra Haire-Joshu[b], Susan L. Handy[c], Jenine K. Harris[b], Sarah Moreland-Russell[a,b], Ross C. Brownson[a,b,d]

[a] Prevention Research Center in St. Louis, Brown School, Washington University in St. Louis, St. Louis, MO, USA
[b] Brown School, Washington University in St. Louis, St. Louis, MO, USA
[c] Department of Environmental Science and Policy, University of California at Davis, USA
[d] Division of Public Health Sciences and Alvin J. Siteman Cancer Center, Department of Surgery, Washington University School of Medicine, Washington University in St. Louis, St. Louis, MO, USA

ARTICLE INFO

Keywords:
Network analysis
Metropolitan planning organizations
Active transportation
Walking
Bicycling
Physical activity
Collaboration
Policy

ABSTRACT

Many communities have prioritized policy and built environment changes to promote active transportation (AT). However, limited information exists on the partnerships and processes necessary to develop and implement such policy and environmental changes, particularly among organizations in non-health sectors. Within the transportation sector, metropolitan planning organizations (MPOs) are increasingly recognized as organizations that can support AT policies. This study examined inter-organizational relationships among MPOs and their partners working to advance AT policies in six U.S. cities.

In fall 2015, an average of 22 organizations in each city participated in an online survey about partnerships with MPOs and other organizations developing and implementing AT policies. Measures included organizational characteristics and relational attributes including: level of AT policy collaboration, information transmission, resource sharing, and perceived decisional power. Descriptive network analysis and exponential random graph modeling were used to examine organizational attributes and relational predictors associated with inter-organizational collaboration in each network.

MPOs served as collaborative intermediaries, connecting other organizations around AT policies, in half of the cities examined. Organizations in each city were more likely to collaborate around AT policies when partners communicated at least quarterly. In half of the cities, the probability of AT policy collaboration was higher when two agencies exchanged resources and when organizations had perceived decisional authority.

Network analysis helped identify factors likely to improve partnerships around AT policies. Results may contribute to best practices for collaboration among researchers, practitioners, policymakers, and advocates across diverse sectors seeking to promote population-level physical activity.

1. Introduction

Despite the well-established health benefits of regular physical activity (PA), only 48% of adults in the United States (U.S.) meet the national recommendations outlined in the 2008 PA Guidelines for Americans (U.S. Department of Health and Human Services, 2008; Schiller et al., 2012). Concurrently, rates of active transportation (AT), which includes walking and bicycling and represents one way in which individuals can achieve recommended PA levels, have declined over the last several decades (Federal Highway Administration, 2009). Most communities recognize the importance of policy and environmental changes to increase rates of AT, such as sidewalk and trail infrastructure (Marcus et al., 2006; Mozaffarian et al., 2012; Sallis et al., 2012). However, evidence is lacking on the partnerships and processes necessary to achieve policy and environmental changes that promote AT (Sallis et al., 2012; Hoehner et al., 2003a; Schmid et al., 2006).

The development, adoption, and implementation of policy and environmental changes supportive of AT often require collaboration between actors and organizations across various sectors, especially those outside the public health arena (e.g., city planning, transportation, education) (Eyler et al., 2010; Furie and Desai, 2012; Pollard, 2003; Sallis et al., 2006; Sallis et al., 2004). Within the transportation sector, Metropolitan Planning Organizations (MPOs) can serve as an important platform for advancing AT policies. MPOs are the regional entities in

* Corresponding author at: Washington University in St. Louis, Campus Box 1196, St. Louis, MO 63130, USA.
E-mail address: MZwald@wustl.edu (M.L. Zwald).

https://doi.org/10.1016/j.ypmed.2018.10.026
Received 13 April 2018; Received in revised form 22 October 2018; Accepted 26 October 2018
Available online 29 October 2018
0091-7435/

the U.S. federally mandated to facilitate the transportation planning processes and oversee allocation of federal transportation funds in cities with > 50,000 residents (Convergence Partnership, 2009; Handy and McCann, 2010; Deyle and Wiedenman, 2014; Pecket and Lyons, 2012). The role of MPOs is evolving and they are increasingly recognizing that AT is an essential component of a safe and efficient transportation system (Pecket and Lyons, 2012; U.S. Department of Transportation, 1991; Ewing et al., 2010). However, past research has demonstrated considerable variation across metropolitan areas in how federal transportation funding is spent by MPOs. Consequently, the quality of bicycle and pedestrian environments vary widely across the U.S. (Handy and McCann, 2010; Cradock et al., 2009)

Handy and McCann demonstrated an important interplay between backing from local governments, support from advocacy organizations, and sufficient capacity of MPO staff as instrumental in MPOs prioritizing AT projects (Handy and McCann, 2010). These results suggest that the inter-organizational networks in which MPOs are involved could be important to the AT policy process (Handy and McCann, 2010). Research on the role of networks in the policy process and the use of social network analysis as a method to understand policy networks is growing (Roussos and Fawcett, 2000). Social network analysis can be a useful approach to examining relationships between individuals or groups within a network working around specific policy issues, such as AT (Luke and Harris, 2007; Luke and Stamatakis, 2012; Li et al., 2013; Howlett, 2002; Knoke, 2014; Ward et al., 2011). Network approaches are increasingly used in public health to understand intra- and inter-organizational networks, including: research examining the public and private organizations involved in delivering mental health services (Nakao et al., 1986), community health agencies addressing child abuse (Mulroy, 2003), services for the physical and social health of older adults (Bolland and Wilson, 1994), emergency preparedness and response (Kapucu, 2005), tobacco control (Krauss et al., 2004; Luke et al., 2010), cancer support (McKinney et al., 1989), injury prevention and control (Harris et al., 2017), health policy (Provan et al., 2005), and health promotion (Brownson et al., 2010; Meisel et al., 2014; Parra et al., 2011; Harris et al., 2008). Despite this evidence on the role of networks in developing and implementing other health behavior policies, to our knowledge, no studies to date have examined the role of MPOs and key collaborations that exist around AT policies. Therefore, this study aimed to assess inter-organizational collaboration among MPO representatives and their AT partners and to identify predictors of collaboration around AT policies.

2. Methods

2.1. Sampling

Purposive sampling was used to identify metropolitan areas to participate in the study. Characteristics of the metropolitan area each MPO represented were considered in selection, including population size, population density, socioeconomic characteristics of residents, and AT prevalence of residents. Organizational characteristics of the MPO, such as number of operating years, structure (i.e., independent or hosted by another governmental organization), and board size, were also considered. Two metropolitan cities from three states were selected to account for state-level differences. More specifically, differences in collaboration between an MPO and the state department of transportation were considered. Metropolitan areas included in this investigation were Sacramento and San Diego, California; Kansas City and St. Louis, Missouri; and Knoxville and Memphis, Tennessee. Characteristics of the six metropolitan areas and MPOs selected for the study are presented in Table 1.

Once metropolitan areas were selected, the sample of participants from each site, or AT policy network, was identified. For this investigation, a policy network was defined as actors from both inside and outside an MPO that were highly involved in the AT policy process. The policy process was defined as the actions and interactions of diverse individuals and organizations working together around a specific policy issue, like AT (Adams and Kriesi, 2007; Moreland-Russell and Carothers, 2015).

For this study, targeted participants were MPO staff most involved with AT policies within their organizations and representatives from their partnering organizations. Drawing upon prior network analysis research, a modified reputational snowball sampling method was used to identify AT policy network members (Farquharson, 2005; Doreian and Woodard, 1992). First, executive directors from each MPO were asked to identify all MPO staff and representatives from partnering agencies that were involved in AT policies. Additional names of potential AT policy network members were generated using web resources, including long-range transportation plans, bicycle and pedestrian plans, and transportation improvement program documents of MPOs. Second, a representative from an AT advocacy organization within each AT policy network (i.e., a bicycle and pedestrian coordinator for the organization or a representative with a similar position title) reviewed the list and asked to supply names for additional partners. A full roster of partners was compiled for each AT policy network and all representatives listed were invited to participate.

Guided by the Policy Network Theory and network questions used in past studies (Brownson et al., 2010; Meisel et al., 2014; Harris et al., 2008; Parra et al., 2011; Harris et al., 2012; Luke et al., 2013), an online survey was developed and tailored for AT policy network to reflect the final roster of MPO staff and representatives from partnering organizations. In fall 2015, each network member was emailed to complete the web-based survey. Up to two email reminders were sent to network members who did not respond to the original invitation. Individuals who did not respond to email correspondence received up to two telephone call reminders. Respondents were offered a $20 gift card incentive upon completion of the survey within 21–28 days. The study was approved by the Washington University Institutional Review Board.

2.2. Measures

2.2.1. Organizational characteristics

Participants reported their organization type, experience working in current position, and organizational involvement in AT policies. Participants represented nine organization types including: (1) advocacy or nonprofit organizations, (2) local government organizations, (3) local transit agencies, (4) MPOs, (5) planning or engineering firms, (6) public health agencies, (7) state-level departments or commissions of transportation, (8) academic institutions, and (9) other agency types. Descriptions of each organization type are presented in Table 2. Participants were asked the number of years the organizational representative had been working in their current position (< 1 year, 1–5 years, 6–10 years, 11–15 years, or ≥16 years). Organizational involvement in AT policies represented the engagement in the development, adoption, or implementation in the following policies: Safe Routes to School policy (yes, no, or don't know), Complete Streets policy (yes, no, or don't know), or Transit-Oriented Development policy (yes, no, or don't know) (Centers for Disease Control and Prevention, 2017).

2.2.2. Network characteristics

Guided by the Policy Network Theory, participants were presented a full roster of compiled partners from their specific AT policy network and asked about information transmission, resource exchange, decisional authority, and collaboration (Knoke, 2014). For information transmission, participants were provided the full partner roster and asked to indicate “how often you have had direct contact (e.g., meetings, phone calls, emails, or letters) with the individuals below during the past year?” Response options were no contact, yearly, quarterly, monthly, weekly, and daily. For resource exchange, participants were

Table 1
Characteristics of selected study sites, 2015.

	Sacramento, California	San Diego, California	Kansas City, Missouri	St. Louis, Missouri	Knoxville, Tennessee	Memphis, Tennessee
Metropolitan area characteristics						
Population size[a]	2,274,557	3,095,271	1,895,535	2,571,253	542,827	1,077,697
Population density (per sq. mile)[a]	367.5	726.6	874.7	560.7	821.2	711.8
Median household income[b]	49,753	64,058	45,275	34,582	45,151	36,912
% poverty[b,c]	21.9	15.6	19.1	27.4	17.3	26.9
% walk[b,d]	3.1	3.1	2.2	4.3	1.4	1.8
% public transit[b,e]	4.0	4.0	3.3	9.8	0.6	2.3
MPO characteristics						
MPO designation year[a]	1967	1972	1974	1973	1978	1977
MPO structure[a]	Council of government[f]	Council of government[f]	Council of government[f]	Council of government[f]	Independent organization[g]	Independent organization[g]
MPO board size[a]	33	33	38	24	19	29

[a] Federal Highway Administration (2014). Metropolitan Planning Organization Database.
[b] U.S. Census Bureau (2014). American Community Survey Data.
[c] % poverty defined by American Community Survey represents percentage of all people whose income in the past 12 months was below the federal poverty level.
[d] % walk defined by American Community Survey represents percentage of workers who reported walking to work.
[e] % public transit defined by American Community Survey represents percentage of workers who reported commuting to work by public transportation.
[f] Represents a Metropolitan Planning Organization within a council of government. A council of government is a multi-service entity with state- and locally-defined boundaries that deliver a variety of federal, state, and local programs, while also carrying out its function as a planning organization to its member local governments.
[g] Represents an independent Metropolitan Planning Organization not hosted by another organization.

presented the full partner roster and asked: "Have you shared (e.g., money, personnel, goods, or services) with the individuals below to support AT during the past year?" Response options were yes or no. For decisional authority, participants were presented the full partner roster and asked: "Do the individuals below hold authority to make decisions that impact AT policies in the metropolitan area where you work?" Response options were yes or no. For collaboration, participants were asked to indicate from the full partner roster the "level of collaboration with the individuals below that reflects your work together on AT during the past year." Response options were unlinked (do not work together), contact (share information only), cooperation (work together as an informal group to achieve common goals), collaboration (work together as a formal team to achieve common goals), and partnership (work together as a formal team across multiple projects to achieve common goals) (Slonim et al., 2007).

2.3. Data management

Data management was conducted in Pajek (version 5.02) and R (version 3.3.3). To conduct analyses at the organizational level, participants' responses for organizations with more than one respondent were combined. For the binary network measures of decisional authority and resource exchange, the "yes" response was used to represent the organization if it was selected by at least one respondent from an organization. For the network measures of information transmission and collaboration, participants' responses for organizations with more than one respondent were averaged.

Consistent with previous research, the information transmission and collaboration network scales were dichotomized (Luke et al., 2010; Brownson et al., 2010; Harris et al., 2008; Moreland-Russell and Carothers, 2015; Luke et al., 2013). For information transmission, organizations were considered linked if they had direct contact with one another at the level of quarterly or more. For collaboration, organizations were considered unlinked if they did not work together or shared information only. Organizations were considered linked if they worked together as an informal group to achieve common goals, worked together as a formal team to achieve common goals, or worked together as a formal team across multiple projects to achieve common goals. For both the information transmission and collaboration networks, the ties were symmetrized. The higher reported value between two organizations (or the presence of a tie) was used, as the organization reporting the higher value may be more aware of information transmission or

Table 2
Description of each organization type represented in the active transportation policy networks.

Organization type	Description
Advocacy or nonprofit organizations	Local nonprofit or voluntary organizations, coalitions, or partnerships that support increased AT or improved air quality
Local government organizations	Local government organizations or departments; if specified, the departments within this organization type included air quality, engineering, law enforcement, parks and recreation, planning, and public works
Local transit organizations	Regional or local transit agencies that plan and operate public transportation services; may include local transit districts, commissions, or authorities
Metropolitan planning organizations	Regional policy agency serving urbanized areas and responsible for carrying out the metropolitan transportation planning requirements of federal highway and transit legislation; may include metropolitan planning organizations, transportation planning organizations, or councils of government
Planning or engineering firms	Private planning or engineering organizations or firms
Public health agencies	Local or state level health departments, or local health care organization
State-level departments or commissions of transportation	State level departments of transportation or commission tasked with transportation planning and project funding decisions in their states
Academic institutions	Local universities; if specified, the departments within this organization type included administration, public health, kinesiology, transportation, or engineering
Other agencies	Other local, state, or federal organizations not represented in the organization types above

collaboration occurring between the organizations than the organization reporting the lower value.

2.4. Data analyses

Descriptive analyses were conducted in R to summarize organizational characteristics. Betweenness centrality was calculated to descriptively examine characteristics of specific organizations within each policy network. The betweenness centrality measure was selected to further explore how often an actor in a network acts as a bridge between other organizations that are not directly connected. Larger nodes represented more central intermediaries in the network.

Exponential random graph modeling (ERGM) was used to identify predictors of AT policy collaboration based on organizational attributes; relational attributes (e.g., information transmission, resource exchange, decisional authority); and structural patterns of the network. ERGM is a new analytic method used to build and test social network hypotheses (Harris, 2014). Similar to logistic regression models, ERGM can serve as a powerful tool to predict the probability of a link between any two network organizations while accounting for the assumption that ties in a network are not independent (Harris, 2014). Three stages of model building were performed in R:

Model 1. A null-baseline model without any predictors (Goodreau, 2011). Null models predict the probability of a tie in the network, which is essentially the network density.
Model 2. A model based on node attributes, including the number of years the organizational representative worked in their current position and organizational involvement in a Safe Routes to School policy, Complete Streets policy, and Transit-Oriented Development policy. Similar to logistic regression, this model tested whether the likelihood of a collaboration tie increased or decreased between two network members with increased years of experience and involvement in the abovementioned AT policies.
Model 3. A model based on node attributes, relational attributes, and network structural patterns. The relationship terms added to this model were information transmission, resource exchange, and decisional authority. The geometrically weighted degree (GWDegree) term was added to the model to account for the likelihood of organizations with higher degrees to be linked to other organizations in the network (Harris, 2014).

Model fit was compared across all models using the Akaike information criterion (AIC).

3. Results

An average of 25 individuals at 22 organizations in each AT policy network participated in the online survey, with a total of 149 respondents, representing an organizational response rate of 78.4% for Sacramento, 78.9% for San Diego, 76.9% for Kansas City, 77.8% for St. Louis, 68.3% for Knoxville, and 80.0% for Memphis.

Table 3 describes organizational characteristics of the overall sample and stratified by AT policy network. The majority of organizations represented in the sample were advocacy or nonprofit (31.5%) and local government (31.5%). Most organizational representatives were in their current position for 1–5 years (46.3%). The majority of organizations across the entire sample engaged in Complete Streets policies (87.9%), followed by Safe Routes to School policies (77.7%), and Transit-Oriented development policies (60.1%).

Network size varied across AT policy network, where the Sacramento network consisted of 37 organizations, San Diego had 19, Kansas City had 39, St. Louis had 18, Knoxville had 41, and Memphis had 20. Fig. 1 depicts the structure of collaboration for each policy network. The color of each node represents the type of organization, the tie between each node denotes the presence of collaboration between two organizations, and the size of each node represents the betweenness centrality score (or the extent to which an organization lies between two organizations that would not otherwise be connected). Differences in the types of organizations that were important in connecting other organizations within the network were observed among the six policy networks. As denoted by the large green nodes for San Diego, St. Louis, and Knoxville, MPOs in the corresponding AT policy network had the highest betweenness centrality scores. A private planning firm in Sacramento, a health care organization in Kansas City, and a local AT advocacy organization in Memphis had the highest betweenness centrality scores in their respective networks.

ERG models were constructed to predict AT policy collaboration relationships for each region based on a variety of attributes of the organizations, relational attributes, and structural network characteristics. The final model (Model 3) for each metropolitan area is depicted in Table 4. When controlling for all other variables, the association between years of experience at the organization and collaboration were mixed. For the majority of metropolitan areas, years of experience was positively associated with collaboration; however, most of these associations were not significant. No consistent significant relationships emerged for involvement in Complete Streets policies, Safe Routes to School policies, and Transit Oriented Development policies and collaboration. For all metropolitan areas, the likelihood that two organizations collaborated on AT policy was significantly higher when the two organizations were exchanging information when controlling for all other variables ($p < 0.05$). Additionally, the coefficients across the information transmission networks had consistent values, indicating that the likelihood of an information transmission tie between two organizations across all of the metropolitan areas was similar. For Sacramento, San Diego, and Knoxville, when controlling for all other variables, the probability of AT policy collaboration was significantly higher when resources were exchanged between two agencies ($p < 0.05$). For Sacramento, Kansas City, and Knoxville, AT policy collaboration was significantly more likely to occur when organizations were perceived as having decisional authority around AT policies ($p < 0.05$).

3.1. Model fit

To determine the best fitting model for each metropolitan area, AIC scores between the models within each metropolitan area were compared. For all metropolitan areas, the final model had the best AIC fit.

4. Discussion

The current study sought to assess collaboration among MPO representatives and their partners involved in AT policies and to identify predictors of AT policy collaboration. Based on descriptive network analysis, MPOs were vital in connecting other organizations around AT policies within their respective policy network for half of the cities in this investigation, including San Diego, St. Louis, and Knoxville. However, MPOs did not serve as collaborative intermediaries in Sacramento, Kansas City, or Memphis. This inconsistent pattern of MPOs as a liaison for AT policy collaboration may be due to the variation in how MPOs prioritize broader public health issues into their organizational roles and requirements. One major federal requirement of MPOs is to facilitate the development of a long-range transportation plan for their metropolitan area, which formulates transportation investments for a 20-year period (Deyle and Wiedenman, 2014; Pecket and Lyons, 2012; Singleton and Clifton, 2014). Past research has demonstrated variation in how MPOs integrate more general public health issues into these long-range transportation plans (Singleton and Clifton, 2014; Lee and Sener, 2016). For example, in a 2014 content analysis of long-range transportations of selected MPOs, Singleton and Clifton reported that public health was inconsistently considered (Singleton and Clifton, 2014). The investigators also reported that fewer than half of

Table 3
Organizational characteristics of each active transportation policy network.

Characteristics	Sacramento (n = 34)	San Diego (n = 18)	Kansas City (n = 33)	St. Louis (n = 16)	Knoxville (n = 31)	Memphis (n = 17)	Full sample (N = 149)
	n (%)						
Type of organization							
Advocacy/nonprofit	8 (23.5)	9 (50.0)	8 (24.2)	5 (31.3)	9 (29.0)	9 (47.1)	47 (31.5)
Local government	9 (26.4)	3 (16.8)	13 (39.5)	5 (31.3)	14 (45.1)	3 (17.6)	47 (31.5)
Local transit agency	6 (17.6)	1 (5.6)	1 (3.0)	1 (6.3)	0 (0.0)	2 (11.8)	11 (7.4)
Metropolitan planning organization	1 (2.9)	3 (16.7)	2 (6.1)	3 (18.8)	1 (3.2)	1 (5.9)	11 (7.4)
Planning/engineering firm	4 (11.8)	0 (0.0)	1 (3.0)	0 (0.0)	0 (0.0)	1 (5.9)	6 (4.0)
Public health	1 (2.9)	0 (0.0)	4 (12.1)	0 (0.0)	2 (6.5)	1 (5.9)	8 (5.4)
State-level transportation	4 (11.8)	1 (5.6)	2 (6.1)	1 (6.3)	1 (3.2)	0 (0.0)	9 (6.0)
University	1 (2.9)	0 (0.0)	0 (0.0)	1 (6.3)	3 (9.7)	1 (5.9)	6 (4.0)
Other	0 (0.0)	1 (5.6)	2 (6.1)	0 (0.0)	1 (3.2)	0 (0.0)	4 (2.7)
Time in organization (years)							
< 1	1 (2.9)	0 (0.0)	0 (0.0)	4 (25.0)	3 (9.7)	5 (29.4)	13 (8.7)
1–5	13 (38.2)	11 (61.1)	13 (39.4)	5 (31.3)	19 (61.3)	8 (47.1)	69 (46.3)
6–10	11 (32.4)	3 (16.7)	8 (24.2)	2 (12.5)	4 (12.9)	1 (5.9)	29 (19.5)
11–15	6 (17.6)	0 (0.0)	4 (12.1)	5 (31.3)	1 (3.2)	1 (5.9)	17 (11.4)
≥16	3 (8.8)	4 (22.2)	8 (24.2)	0 (0.0)	4 (12.9)	2 (11.8)	21 (14.1)
AT policy involvement (yes)							
Complete Streets	29 (85.3)	17 (94.4)	31 (93.9)	15 (93.8)	25 (80.6)	14 (82.4)	131 (87.9)
Safe Routes to School	28 (82.4)	16 (88.9)	26 (81.3)	12 (75.0)	22 (71.0)	11 (64.7)	115 (77.7)
Transit-oriented development	18 (52.9)	16 (88.9)	22 (68.8)	10 (62.5)	13 (41.9)	10 (58.8)	89 (60.1)

the reviewed plans included policies to increase PA through mentions of AT modes (Singleton and Clifton, 2014). In addition to long-range transportation plans, there may be variation in how MPOs integrate public health issues into their broader transportation planning activities. In a 2012 case study analysis of select MPOs, Lyons and colleagues identified the following best practices for MPOs to prioritize public health concerns: form partnerships with local and state organizations with public health-related missions; build capacity for data collection of the health benefits of transportation plans and projects (e.g., health impact assessments); strengthen support from MPO boards and community members for the incorporation of health into MPO planning and activities; and take an incremental approach towards prioritizing public health into transportation planning (Lyons et al., 2012). Given the variation in MPOs roles as a collaborative intermediary observed in this study, and the variation in how MPOs prioritize broader public health concerns into their transportation planning activities described in past studies (Singleton and Clifton, 2014; Lee and Sener, 2016), researchers should continue to investigate who MPOs are collaborating with and how they are prioritizing AT and other health issues.

Based on inferential network analysis, regular contact was a significant predictor of collaboration for all of the AT policy networks assessed. These results align with a previous social network analysis conducted for a PA network in Brazil, where frequency of contact was positively associated with organizational collaboration (Brownson et al., 2010). Given this finding, there may be opportunities to forge a transdisciplinary paradigm through existing and future communication channels that promote AT (King et al., 2002). This may include increasing the number and range of professional meetings that intentionally convene experts from diverse sectors that support AT, which could encourage cross-pollination and build consensus around the prioritization of AT policies. Another opportunity to improve communication channels around AT may be utilizing websites, online discussion forums, social media, text messaging, and other virtual mediums where professionals can identify and connect with other professionals across varied sectors to collaborate around AT. It may also be important to promote and develop regular avenues for cross-sector conversations outside of professional meetings and other mediums (e.g., bicycle and pedestrian advisory committees, coalitions, or boards) to ensure frequent communication among AT stakeholders (King et al., 2002; Burbidge, 2010; Hoehner et al., 2003b; Cohen et al., 2014; Corbun, 2004).

Associations between resource sharing and decisional authority with AT policy collaboration were mixed in the current study. Resource sharing was significantly associated with AT policy collaboration for half of the AT policy networks (Sacramento, San Diego, and Knoxville). Policy changes often require investments not only in relationships that can span a number of years to develop, but also resources. In a 2010 review of the evidence on the use of partnerships to advance the performance of public health systems, Mays and Scutchfield reported that the array of varied actors in a network is associated with the amount and type of organizational resources that are shared (Mays and Scutchfield, 2010). The three networks in which resource sharing was a significant predictor of AT policy collaboration had representation from varied organization types and sizes. In another 2010 review of the evidence, Woulfe and colleagues described the importance of resources, including money, skills, and expertise, to population health improvement. The investigators suggest that while resources alone do not ensure effective cross-sector partnerships, sufficient and sustainable resources are vital to supporting the partnerships' goals and objectives (Woulfe et al., 2010). For organizations within AT policy networks with limited fiscal resources, consideration should be given to what other human and built capital resources can be shared to support AT policies in a given metropolitan area. This could include in-kind resources, data, information technology, web sources, staff and volunteers, and health, planning, and legal expertise (Gustat et al., 2013; Litt et al., 2013a; Litt et al., 2013b).

Collaboration was more likely to occur when organizations were perceived as having decisional authority around AT policies in Sacramento, Kansas City, and Knoxville. In a recent study, Litt et al. (2015) examined organizational and network level factors associated with perceived network effectiveness in supporting environmental improvements and policies among 53 active living collaboratives in the U.S. Although not a measure for decisional power, and while their investigation did not assess dyadic relationships, their study findings revealed a significant relationship between organizations in leadership positions and perceived effectiveness of the network (Litt et al., 2015). If not currently involved, this may suggest that local and regional leaders who possess decisional authority should be invited to engage in AT policy networks to improve collaborations and position networks for success (Litt et al., 2013a; Litt et al., 2013b).

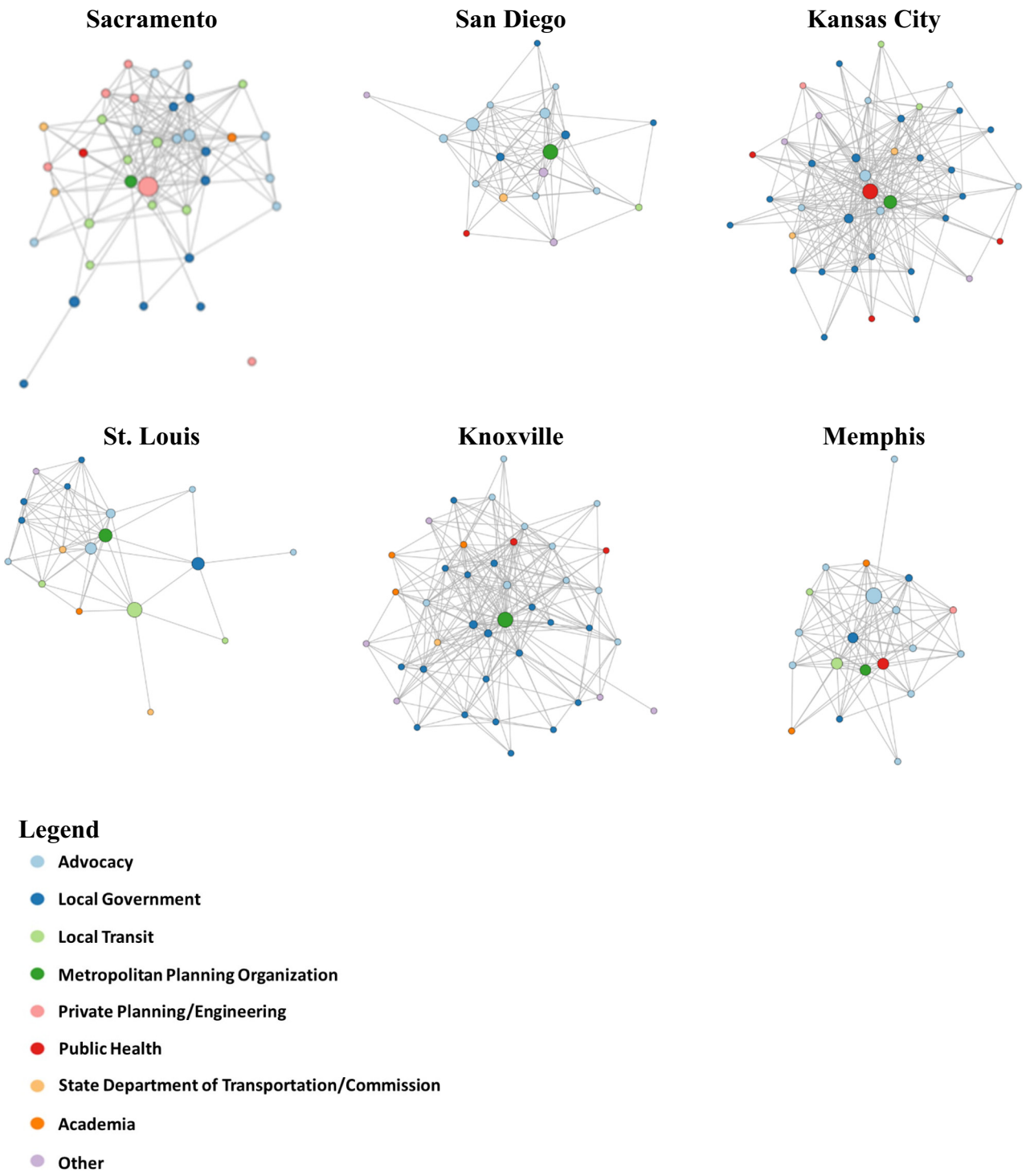

Fig. 1. Active transportation policy collaboration networks.
Notes: The color of each node represents the type of organization.
The size of each node represents the betweenness centrality score (or the extent to which an organization lies between two organizations that would not otherwise be connected).
The tie between each node denotes the presence of collaboration between two organizations.
Collaboration was defined as organizations either worked together as an informal group to achieve common goals, worked together as a formal team to achieve common goals, or worked together as a formal team across multiple projects to achieve common goals.

4.1. Limitations

There are a few limitations worth noting, several of which are related to the sampling strategies used. For most organizations in each network, the survey was completed by one or a few individuals within an organization, which assumes that his or her responses accurately represented the entire organization. Since the sampling strategy relied on the MPO within each network to identify partners and then an AT advocacy organization from each network to verify the partner list, it is also possible that findings were biased in favor of these two

Table 4
Final exponential random graph results predicting the probability of a collaborative tie[a] between two organizations working on active transportation policy for all networks.

Parameters	Sacramento (n = 37)s	San Diego (n = 19)	Kansas City (n = 39)	St. Louis (n = 18)	Knoxville (n = 41)	Memphis (n = 20)
	b (SE)					
Edges	−3.33 (0.51)*	−3.8 (1.04)*	−3.26 (0.41)*	−1.22 (1.15)	−4.10 (0.49)*	−3.09 (0.95)*
Node attributes						
Experience (in years)						
< 1	Ref.	–	–	Ref.	Ref.	Ref.
1–5	0.69 (0.49)	Ref.	Ref.	−0.18 (0.84)	−0.14 (0.38)	0.35 (0.52)
6–10	0.98 (0.43)*	1.26 (0.75)	0.12 (0.39)	1.83 (1.21)	0.64 (0.49)	1.33 (1.28)
11+	0.15 (0.37)	−0.16 (0.63)	0.30 (0.25)	−1.16 (0.82)	0.27 (0.42)	2.18 (0.84)*
Complete Streets involvement	−0.61 (0.38)	−0.24 (0.71)	0.53 (0.37)	−1.77 (1.02)	0.05 (0.37)	0.09 (0.89)
Safe Routes to School involvement	−0.49 (0.39)	0.48 (1.35)	−0.13 (0.31)	0.93 (0.70)	0.34 (0.31)	−0.57 (0.83)
Transit-oriented development involvement	1.15 (0.39)*	0.39 (1.21)	−0.18 (0.26)	0.20 (0.75)	0.01 (0.27)	−0.07 (0.52)
Link attributes						
Information transmission[b]	3.56 (0.34)*	4.67 (0.77)*	4.40 (0.33)*	4.91 (1.03)*	4.76 (0.33)*	4.30 (0.80)*
Resource exchange	1.96 (0.48)*	3.39 (1.10)*	1.20 (0.65)	–	3.11 (0.78)*	1.52 (0.89)
Decisional authority	1.72 (0.39)*	0.59 (0.70)	1.08 (0.32)*	1.04 (1.00)	2.01 (0.39)*	1.13 (0.89)
Structural predictor						
GWDegree	−1.56 (0.83)	−0.31 (3.47)	−3.94 (0.95)*	−2.64 (1.58)	0.10 (2.04)	−2.55 (1.48)
Model fit						
AIC	335.3	107.7	394.0	78.1	325.2	129.3

[a] Collaboration considered present if organizations either worked together as an informal group to achieve common goals, worked together as a formal team to achieve common goals, or worked together as a formal team across multiple projects to achieve common goals.
[b] Information transmission was considered present if organizations had direct contact with one another at the level of quarterly or more.
* p-Value < 0.05.

organization types. Although this is a common approach for network delineation, there may be partners that were excluded that may have been identified if another sampling method was used (Marsden, 1990). However, given the aim of the study to explore the role of MPOs and their collaborations, MPOs represented an appropriate starting point for network sampling.

The network measure used for collaboration was selected because of use in previously published studies (Brownson et al., 2010; Harris et al., 2008; Parra et al., 2011). The collaboration question asked participants to select the level of interaction they felt best represented their relationship with a specific partner; the measure may not have captured the number of collaborative interactions around AT policies or around which type of AT policy they collaborated. Methods used in past studies were replicated to symmetrize data to the highest level of collaboration, which may have increased the number of network ties, but would have done so for all six AT policy networks (Harris et al., 2008; Parra et al., 2011; Schoen et al., 2014).

The cross-sectional design of the study does not allow causality to be inferred. Data were also self-reported and thus potentially influenced by inaccuracies and recall bias. Additionally, the selected sample included only networks within six metropolitan areas with a population of 50,000 or more residents. The findings are not be generalizable to AT policy networks in other cities, particularly rural areas. Data collected represented one point in time from one or a few members within an organization. Because the AT policy process is inherently longitudinal, where current policy collaborations and outcomes may or may not reflect previous policy collaborations, findings from this study offer opportunities for future analyses to examine longitudinal changes in AT policy networks and relationships. Finally, future studies may seek information on additional network characteristics, such as personal friendships or barriers to collaboration, and examine how these characteristics might influence policy collaboration.

5. Conclusions

Creating and improving environments and policies supportive of AT extends beyond the purview of any one organization, sector, or level of government. While collaborating with organizations across diverse sectors can help establish healthy and equitable transportation policies and systems in the U.S. and in other countries, a “one size fits all” for AT policy collaboration may not be appropriate. Our results indicated that MPOs served as an intermediary organization for half of the studies in the investigation. Our findings also suggested that organizations were more likely to collaborate around AT policies if they were regularly communicating with other organizations for all six of the cities in our study. Sharing resources and having decisional authority were also associated with increased collaboration around AT policies, but were only significantly associated for three of the six cities in our study. Despite mixed findings for the inter-organizational collaboration predictors, communicating frequently, pooling resources, and fostering decisional authority may help organizations working to support AT policies across diverse sectors achieve aligned public health and transportation goals. Thus, these partnerships and policy changes may result in increased PA and long-term population health.

Conflict of interest

None.

Acknowledgments

This study was funded by a pre-doctoral fellowship from the American Heart Association (15PRE25690044). The authors would like to acknowledge Mary Adams, Linda Dix, and Cheryl Valko at the Prevention Research Center in St. Louis for their logistic support, as well as Leslie Meehan at the Tennessee Department of Health for her support during formative work for this investigation.

References

Adams, S., Kriesi, H., 2007. The network approach. In: Sabatier, P. (Ed.), Theories of the Policy Process. Westview Press, Boulder, CO.
Bolland, J.M., Wilson, V., 1994. Three faces of integrative coordination: a model of interorganizational relations in community-basd health and human services. Health Serv. Res. 29 (3), 341–366.

Brownson, R.C., Parra, D.C., Dauti, M., et al., 2010. Assembling the puzzle for promoting physical activity in Brazil: a social network analysis. J. Phys. 7 (Suppl. 2), 242–252.
Burbidge, S.K., 2010. Merging long range transportation planning with public health: a case study from Utah's Wasatch Front. Prev. Med. 50, S6–S8.
Centers for Disease Control and Prevention, 2017. The community guide: physical activity and built environment approaches. https://www.thecommunityguide.org/findings/physical-activity-built-environment-approaches, Accessed date: 9 April 2018.
Cohen, J.M., Boniface, S., Watkins, S., 2014. Health implications of transport planning, development and operations. J. Transp. Health 1 (1), 63–72.
Convergence Partnership, 2009. Healthy, Equitable transportation policy: recommendations and research. http://www.convergencepartnership.org/atf/cf/%7B245a9b44-6ded-4abd-a392-ae583809e350%7D/TRANSPORTATIONRX.PDF, Accessed date: 14 April 2015.
Corbun, J., 2004. Confronting the challenges in reconnecting urban planning and public health. Am. J. Public Health 94 (4), 541–546.
Cradock, A.L., Troped, P.J., Fields, B., et al., 2009. Factors associated with federal transportation funding for local pedestrian and bicycle programming and facilities. J. Public Health Policy 30, S38–S72.
Deyle, R., Wiedenman, R., 2014. Collaborative planning by metropolitan planning organizations: a test of causal theory. J. Plan. Educ. Res. 34 (3).
Doreian, P., Woodard, K.L., 1992. Fixed list versus snowball selection of social networks. Soc. Sci. Res. 21, 216–233.
Ewing, R., Handy, S.L., McCann, B., 2010. Effect of Infrastructure Investments on Bicycling and Walking in Two Metropolitan Areas. https://trid.trb.org/view/909508.
Eyler, A., Brownson, R., Schmid, T., Pratt, M., 2010. Understanding policies and physical activity: frontiers of knowledge to improve population health. J. Phys. Act. Health 7 (Suppl. 1), S9–12.
Farquharson, K., 2005. A different kind of snowball: identifying key policymakers. Int. J. Soc. Res. Methodol. 8, 345–353.
Federal Highway Administration, 2009. Summary of travel trends: 2009 National Household Travel Survey. http://nhts.ornl.gov/2009/pub/stt.pdf.
Federal Highway Administration, 2014. https://www.planning.dot.gov/mpo.asp.
Furie, G.L., Desai, M.M., 2012. Active transportation and cardiovascular disease risk factors in U.S. adults. Am. J. Prev. Med. 43 (6), 621–628.
Goodreau, S.M., 2011. Advances in exponential random graph (p*) models applied to a large social network. Soc. Networks 72 (2), 181–204.
Gustat, J., Healy, I., Litt, J., et al., 2013. Lessons in promoting active living: the collaborative perspective. J. Public Health Manag. Pract. 19 (3 Suppl 1), S58–S64.
Handy, S., McCann, B., 2010. The regional response to federal funding for bicycle and pedestrian projects. J. Am. Plan. Assoc. 77 (1), 23–38.
Harris, J.K., 2014. An Introduction to Exponential Random Graph Modeling. Sage Publications, Incorporated, Thousand Oaks, CA.
Harris, J.K., Luke, D.A., Burke, R.C., Mueller, N.B., 2008. Seeing the forest and the trees: using network analysis to develop an organizational blueprint of state tobacco control systems. Soc. Sci. Med. 67 (11), 1669–1678.
Harris, J.K., Carothers, B.J., Wald, L.M., et al., 2012. Interpersonal influence among public health leaders in the United States Department of Health and Human Services. J. Public Health Res. 1, 67–74.
Harris, J., Jonson-Reid, M., Carothers, B., Fowler, P., 2017. The structure of policy networks for injury and violence prevention in 15 US cities. Public Health Rep. 132 (3).
Hoehner, C.M., Brennan, L.K., Brownson, R.C., Handy, S.L., Killingsworth, R., 2003a. Opportunities for integrating public health and community environments. Am. J. Health Promot. 18 (1), 14–20.
Hoehner, C.M., Brennan, L.K., Brownson, R.C., Handy, S.L., Killingsworth, R., 2003b. Opportunities for integrating public health and urban planning approaches to promote active community environments. Am. J. Health Promot. 18 (1), 14–21.
Howlett, M., 2002. Do networks matter? Linking policy network structure to policy outcomes: evidence from four Canadian policy sectors, 1990–2000. Can. J. Polit. Sci. 35 (2), 235–267.
Kapucu, N., 2005. Interoganizational coordination in dynamic context: networks in emergency response management. Connect 26 (2), 33–48.
King, A.C., Stokols, D., Talen, E., Brassington, G.S., Killingsworth, R., 2002. Theoretical approaches to the promotion of physical activity: forging a transdisciplinary paradigm. Am. J. Prev. Med. 23 (02), 15–25.
Knoke, D., 2014. Policy networks. In: Scottt, J., Carrington, P.J. (Eds.), The SAGE Handboook of Social Network Analysis. Sage Publications Inc., Thousand Oaks, CA.
Krauss, M., Mueller, N., Luke, D., 2004. Interorganizational relationships within state tobacco control networks: a social network analysis. 1 (4), 1–25.
Lee, R., Sener, I., 2016. Transportation planning and quality of life: where do they intersect? Transp. Policy 48, 146–155.
Li, J.S., Barnett, T.A., Goodman, E., Wasserman, R.C., Kemper, A.R., 2013. Approaches to the prevention and management of childhood obesity: the role of social networks and the use of social media and related electronic technologies: a scientific statement from the American Heart Association. Circulation 127 (2), 260–267.
Litt, J., Reed, H., Zieff, S.G., et al., 2013a. Advancing environmental and policy change through active living collaboratives: compositional and stakeholder engagement correlates of group effectiveness. J. Public Health Manag. Pract. 19 (3 Suppl 1), S49–S57.
Litt, J.S., Reed, H.L., Tabak, R.G., et al., 2013b. Active living collaboratives in the United States: understanding characteristics, activities, and achievement of environmental and policy change. Prev. Chronic Dis. 10 (2), E19.
Litt, J., Varda, D., Reed, H., et al., 2015. How to identify success among networks that promote active living. Am. J. Public Health 105 (11), 2298–2305.
Luke, D.A., Harris, J.K., 2007. Network analysis in public health: history, methods, and applications. Annu. Rev. Public Health 28, 69–93.
Luke, D.A., Stamatakis, K.A., 2012. Systems science methods in public health: dynamics, networks, and agents. Annu. Rev. Public Health 33 (25), 357–376.
Luke, D.A., Harris, J.K., Shelton, S., Allen, P., Carothers, B.J., Mueller, N.B., 2010. Systems analysis of collaboration in 5 national tobacco control networks. Am. J. Public Health 100 (7), 1290–1297.
Luke, D.A., Wald, L.M., Carothers, B.J., Bach, L.E., Harris, J.K., 2013. Network influences on dissemination of evidence-based guidelines in state tobacco control programs. Health Educ. Behav. 40, 33S–42S.
Lyons, W., Pecket, H., Morse, L., Khurana, M., Nash, L., 2012. Metropolitan Area Transportation Planning for Healthy Communities. (Cambridge, MA) Government report: https://www.planning.dot.gov/documents/Volpe_FHWA_MPOHealth_12122012.pdf.
Marcus, B.H., Williams, D.M., Dubbert, P.M., et al., 2006. Physical activity intervention studies: what we know and what we need to know: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism. Circulation 114 (24), 2739–2752.
Marsden, P., 1990. Network data and measurement. Annu. Rev. Sociol. 16, 435–463.
Mays, G.P., Scutchfield, F.D., 2010. Improving public health system performance through multiorganizational partnerships. Prev. Chronic Dis. 7 (6), A116.
McKinney, M.M., Morrissey, J.P., Kaluzny, A.D., 1989. Interorganizational exchanges as performance markers in a community cancer network. Health Serv. Res. 28 (4), 459–478.
Meisel, J.D., Sarmiento, O.L., Montes, F., et al., 2014. Network analysis of Bogotá's Ciclovía Recreativa, a self-organized multisectorial community program to promote physical activity in a middle-income country. Am. J. Health Promot. 28 (5), e127–e136.
Moreland-Russell, S., Carothers, B., 2015. An examination of two policy networks involved in advancing smokefree policy initiatives. Int. J. Environ. Res. Public Health 12 (9), 11117–11131.
Mozaffarian, D., Afshin, A., Benowitz, N.L., et al., 2012. Population approaches to improve diet, physical activity, and smoking habits: a scientific statement from the American Heart Association. Circulation 126 (12), 1514–1563.
Mulroy, E.A., 2003. Building a neighborhood network: interorganizational collaboration to prevent child abuse and neglect. Soc. Work 42 (3), 255–265.
Nakao, K., Milazzo-Sayre, L.J., Rosenstein, M.J., Manderscheid, R.W., 1986. Referral patterns to and from inpatient psychiatric services: a social network approach. Am. J. Public Health 76 (7), 755–760.
Parra, D.C., Dauti, M., Harris, J.K., et al., 2011. How does network structure affect partnerships for promoting physical activity? Evidence from Brazil and Colombia. Soc. Sci. Med. 73 (9), 1365–1370.
Pecket, H., Lyons, W., 2012. Evolving role of metropolitan planning organizations in transportation planning for megaregions. J. Transp. Res. Board 2307 (1).
Pollard, T., 2003. Policy prescriptions for healthier communities. Am. J. Health Promot. 18 (1), 109–113.
Provan, K.G., Harvey, J., Dezapien, J.G., 2005. Network structure and attitudes toward collaboration in a community partnership for diabetes control on the US-Mexican border. J. Health Organ. Manag. 19 (6), 504–518.
Roussos, S., Fawcett, S., 2000. A review of collaborative partnerships as a strategy for improving community health. Annu. Rev. Public Health 21, 369–402.
Sallis, J.F., Frank, L.D., Saelens, B.E., Kraft, M.K., 2004. Active transportation and physical activity: opportunities for collaboration on transportation and public health research. Transp. Res. A Policy Pract. 38 (4), 249–268.
Sallis, J.F., Cervero, R.B., Ascher, W., Henderson, K.A., Kraft, M.K., Kerr, J., 2006. An ecological approach to creating active living communities. Annu. Rev. Public Health 27 (1), 297–322.
Sallis, J.F., Floyd, M.F., Rodríguez, D.A., Saelens, B.E., 2012. Role of built environments in physical activity, obesity, and cardiovascular disease. Circulation 125 (5), 729–737.
Schiller, J.S., Lucas, J.W., Ward, B.W., Peregoy, J.A., 2012. Summary health statistics for U.S. adults: National Health Interview Survey, 2010. Vital Health Stat. 10 (252), 1–207. http://www.ncbi.nlm.nih.gov/pubmed/22834228.
Schmid, T., Pratt, M., Witmer, L., 2006. A framework for physical activity policy research. J. Phys. Act. Health 3 (1), S20–S29.
Schoen, M.W., Moreland-Russell, S., Prewitt, K., Carothers, B.J., 2014. Social network analysis of public health programs to measure partnership. Soc. Sci. Med. 123C, 90–95.
Singleton, P.A., Clifton, K.J., 2014. Incorporating public health in US long-range metropolitan transportation planning: a review of guidance statements and performance measures. In: Conf Proc from 94th Annu Meet theTransportation Res Board.
Slonim, A., Callaghan, C., Daily, L., Leonard, B., Wheeler, F., et al., 2007. Recommendations for integration of chronic disease programs: are your programs linked? Prev. Chronic Dis. 4 (A34).
U.S. Census Bureau, 2014. https://factfinder.census.gov/.
U.S. Department of Health and Human Services, 2008. Physical Activity Guidelines for Americans. (Washington, DC).
U.S. Department of Transportation, 1991. Intermodal Surface Transportation Efficiency Act of 1991. http://ntl.bts.gov/DOCS/istea.html, Accessed date: 20 April 2015.
Ward, M.D., Stovel, K., Sacks, A., 2011. Network analysis and political science. Annu. Rev. Polit. Sci. 14 (1), 245–264.
Woulfe, J., Oliver, T.R., Zahner, S.J., Siemering, K.Q., 2010. Multisector partnerships in population health improvement. Prev. Chronic Dis. 7 (6), A119.