Does Crowdsourcing Community Input Lead to Equitable Transportation?
The Application of Web-based Tools to Inform Bikeshare System Development

Authors
Daniel Piatkowski, PhD (*corresponding author*)
Assistant Professor
Department of Political Science and Public Affairs
Savannah State University
piatkowskid@savannahstate.edu

Wesley Marshall, PhD, PE
Assistant Professor
Department of Civil Engineering
University of Colorado Denver
wesley.marshall@ucdenver.edu

Nader Afzalan
Lecturer
Urban and Regional Planning Program
San Jose State University
nader.afzalan@colorado.edu

Abstract
Despite the ubiquity of technology and increasing access to smartphones and the Internet, our understanding of the usability of this information for collecting community input and achieving equitable planning outcomes is limited. A primary concern is that online crowdsourcing tools for community engagement may either miss or ignore the needs of low-income and minority populations. This research tests whether using online, crowdsourcing technologies to inform community needs and planning processes will lead to equitable or inequitable outcomes with regard to bikeshare system planning. We examine proposed bikeshare station locations determined via a crowdsourced web-application in four U.S. cities. For each of the cities, we determine the extent to which bikeshare station locations would be spread equitably throughout a community if planners relied solely on community feedback elicited via online, community engagement tools. Findings from this research are relevant to understanding the role of web-based community engagement in ensuring equitable access to bikesharing systems, and also have wider implications for determining the usability and validity of crowdsourced data for transportation planning.

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Introduction

Traditional approaches to community engagement are increasingly being supplemented by technological tools to achieve greater participation and help to identify community needs. Given these advances and the proliferation of "crowdsourcing" tools (i.e., online participatory technologies), the traditional town hall meeting may no longer be the primary means of public engagement. Technological approaches to community engagement have many advantages; they can be accessed at any time, advertised on social media, and can easily accommodate a depth and breadth of comments that would be costly and often infeasible to collect and process through face-to-face interaction. The numerous advantages of web-based tools notwithstanding, their utility is limited by the degree of bias in community feedback they elicit. At issue is whether or not an increasing reliance on web-based tools for public engagement supports equitable or inequitable planning outcomes. This research addresses the question of whether relying on online participatory technologies to inform community needs and planning processes will lead to equitable access to services across diverse populations within a community.

We examine equity considerations of web-based outreach applied to bikeshare system planning in four cities in the United States: Chicago, Illinois; Cincinnati, Ohio; Philadelphia, Pennsylvania; and Portland, Oregon. Each of these cities employed multiple approaches to community engagement as part of their bikeshare system planning, but this research focuses specifically on the ability of a web-based application to inform equitable access to bikeshare for all communities in the case study cities. Each city used an open-source web-application, "OpenPlans" (www.openplans.org) to solicit community feedback on bikeshare station placement. The suggested station locations (based on their popularity) were then joined to socio-demographic data from the US Census to assess station location as a function of travel behavior, income, and race/ethnicity. Findings from this research have implications for determining the usability and validity of online participatory technologies in equitable planning and decision-making. While it is unlikely that a community would rely solely on crowdsourced community engagement strategies, this research provides guidance as to the strengths and weaknesses of web-based engagement strategies with specific implications for bikeshare system development and broader implications for community engagement.

Background

Participatory Planning and Web 2.0

The popularity and ubiquity of the Internet has facilitated new means of communication and eased the process of community outreach. Web 2.0 (i.e., interactive online technologies) and "crowdsourcing" has the ability to produce large amounts of user-generated content (De Longueville, et al., 2008; 2010; Coleman, et al., 2009). Such information has the added benefit of also providing spatial information generated by users (Flanagin & Mezger, 2008; Hall, et al., 2013). However, the utility of user-generated, geo-tagged data for equitable planning remains an unanswered question (Hall, et al., 2013).

The power of online participatory technologies rests in their ability to provide both qualitative and quantitative spatially-relevant local information (Barton, et al., 2005). Such high-quality information, provided by a variety of individuals from diverse backgrounds, provides a degree of information impossible using traditionally mapping and engagement processes due to it usability (Seeger, 2008). However, existing literature identifies multiple constraints and concerns regarding user-generated content. Specifically, it may not be applicable to all socio-economic problems (Fischer, 2000) and relies on bottom-up approaches to generating information and therefore lacks the quality-control possible from top-down processes; Volunteered Geographic Information (VGI) is unfiltered, and can be unorganized, inaccurate, and inapplicable (Metzger & Flanagin, 2003; Goodchild & Li, 2012; Flanagin & Metzger 2008; Rieh & Danielsen, 2008). The quality of the data is unclear (Giordano, Liersch, Vurro, & Hirsch, 2010; Hall et al., 2013; Scheuer et.al., 2013). The credibility of user-generated data is typically unknown (Bishr & Kuhn, 2007; Seeger, 2008; Flanagin & Metzger, 2008). Utilizing such data also raises issues of privacy, security (Barton et al., 2005), and inequitable access to the Internet (Seeger, 2008). At its best, user-generated geospatial content offers a simple means for local organization and governments to share spatial information, gather community feedback, and identify possible tensions or conflicts (Seeger, 2008). But, if Web 2.0 technologies are applied in place of existing methods for community engagement, are equitable planning outcomes possible?

Bicycle Sharing Systems and Equity

Bicycle sharing (i.e., “bikeshare”) systems have gained prominence in both the US and Europe in recent years (Buck, 2013). Bikeshare systems provide stations in which individuals can rent a bicycle for a short period of time and return it to another station (García-Palomares, Gutiérrez, & Latorre, 2012). Increasingly, bikeshare is seen as a complementary system to existing bus and light rail networks; one that may address the “last mile” issue transit planners face (i.e., individuals can exit transit and use a bikeshare bike to get them to their destination). Cities are interested in bikesharing for its potential to reduce greenhouse gas emissions, enhance active modes of transportation, and decrease car dependency (Contardo, Morency, & Rousseau, 2012; Shaheen et al., 2010). Traditionally, equity concerns regarding bikeshare systems relate to the fact that users tend generally to be wealthy and white (Buck, 2013); in contrast, this research centers on equity regarding station location decisions.

As bikeshare systems have become more popular, the equitable distribution of station locations within a metro area has become increasingly relevant to system planners and designers. Station location decisions can be the deciding factor in the success of bikeshare systems (Lin & Yang, 2011; García-Palomares, Gutiérrez, & Latorre, 2012). Location decisions are frequently determined based on numerous factors, such as proximity to one another (Midgley, 2011); existing transit facilities and services (Martens, 2007; Burden & Barth, 2009; García-Palomares et al., 2012); leisure attractions (i.e., concert halls and theatres, retail shopping), population density (NYC Department of City planning, 2009); pick up locations and travel destinations (Lin & Yang, 2011; Contardo et al., 2012); total bicycle fleet, travelling bicycle fleet, the needed investment; and the users’ demand and desires and the relative operational costs (Martinez, Caetano, Eiró, & Cruz, 2012). There are multiple examples of bikeshare station design decisions utilizing a top-down, quantitative approach to system design. Lin and Yang apply statistical and modeling approaches to identify optimal station locations, (Lin & Yang, 2011); Landis (1996) estimates latent travel demand according to various generators of bicycle trips, including parks, schools and shopping malls (Landis, 1996); Shu, et. al. (2010) suggest a linear model to examine such factors as the rate of bicycle utilization, and the capacity of the stations.

Existing approaches have been criticized as reductive, suggesting instead more holistic approaches that integrate social, demographic, environmental, land-use, and transportation information (Wilons, 2001). Generally, a more flexible and collaborative approach to transportation decision making has been advocated (Meyer and Miller, 2001; Harvey, 1985). The drawback to collaborative processes and the inclusion of multiple viewpoints and data sources is that they are costly and time-consuming. As such, there is a great deal of interest in the potential of online participatory technologies to facilitate more inclusive and holistic planning (Evans-Cowley & Hollander, 2010).

There is a dearth of literature examining crowdsourced information as an efficient and effective tool for bikeshare station planning, but multiple concerns regarding equity and social media have been raised. Information technology may serve to further empower the already powerful and exacerbate the vulnerability of the less powerful (e.g. Choudrie, Weerakkody, & Jones, 2005; Dawes, 2008; Graham, 2002). Similarly, the use of social media in participatory planning may lead to unequal citizen participation (Afzalan & Muller, 2014). There is a well-documented digital divide in access and ability to engage online (Afzalan, 2014; Cranshaw, Hong, & Sadeh, 1977; Design, Planning, & Streich, 2011; Frias-Martinez, Soto, Hohwald, & Frias-Martinez, 2012; Lee & Kim, 2014; Soukup, 2006; Sui & Goodchild, 2011). This research offers a novel opportunity to specify the digital divide as evidenced in a crowd-sources approach to bikeshare system planning.

Research Overview

This research asks the question: can an equitable distribution of bikeshare stations be achieved through quantitative crowdsourced data? To answer this question we examine data collected via an open-source web-application, "OpenPlans" in four US Cities. This data is combined with socio-demographic data from the US Census in a geographic information system (GIS) and examined statistically to identify significant correlations between station-area location and socio-demographics. The following section describes the data sources and methods.

Data

1. <u>Crowdsourced online participatory data</u>: The OpenPlans app has been designed for use as an outreach and engagement tool that has been applied to bicycle parking, bikesharing, bike network improvements, neighborhood asset-mapping, street safety, and urban tree canopies (openplans.org). The web-application allows users to identify locations where they would like to see new bikeshare station. Other users could then "support" this location (this is akin to an individual clicking "like" on a Facebook post), as well as input new locations. Examples of the web interface are provided in Figure 1. Our analysis uses data collected through the OpenPlans web-application in Philadelphia, Pennsylvania; Chicago, Illinois; Cincinnati, Ohio; and Portland, Oregon as part of their planning efforts for bikesharing systems. This data – station location and level of support for the station location – was then geocoded and input into a GIS. Note: each city limited the area that individuals were allowed to suggest bikeshare stations through the web-application (for example, see Alta Planning and Design, 2012). To control for this, we limited the statistical analysis to only block groups that included at least one suggested station location. Figure 2 illustrates station locations within each city (missing block groups on

city maps indicate that no stations were suggested). Station locations generally clustered around central business districts (CBDs) in each of the cities – as indicated by the circled region of each city map.

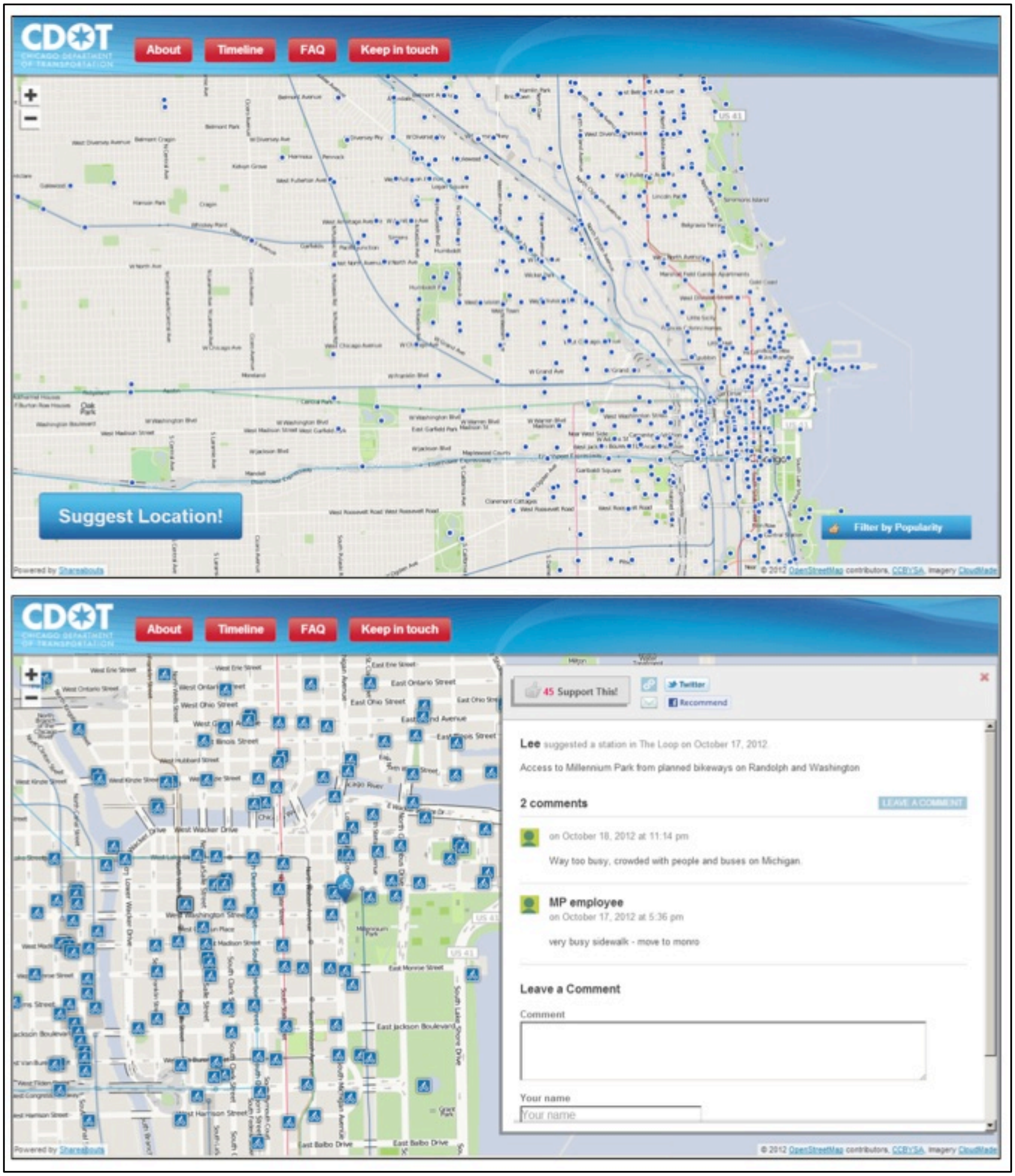

Figure 1: User Interface for the OpenApps bikeshare web-application (Chicago, Illinois)

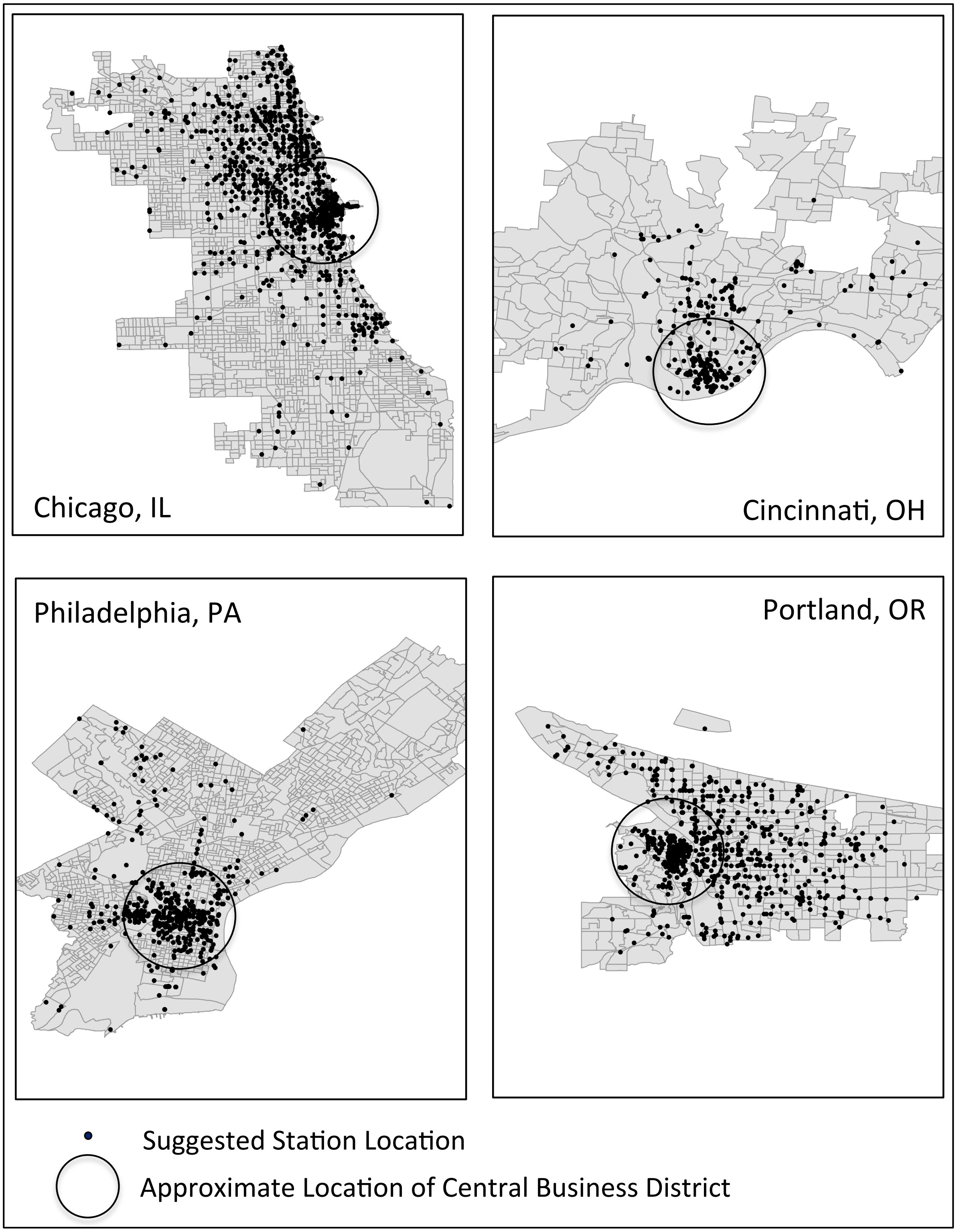

Figure 2: Suggested Station Locations for Case Study Cities

2. Socio-demographic Data: To identify the extent to which bikeshare station locations collected via the web-app are equitably distributed in each city, we gathered socio-demographic data from the 2010 US Census. Data was collected at the block group level (the smallest geographical unit of data published by the US Census Bureau (www.census.gov)) to provide as fine-grained an analysis as possible. Descriptive statistics are presented in Table 1.

3. Combined Data: Once census data and crowdsourced data were inputted into the GIS, it was joined to block group layers for each of the three cities. Bikeshare station locations and number of supports (a measure of popularity of each location among OpenPlans users) were aggregated to the block group level, joined to existing Census socio-demographic data, and extracted for analysis.

Research Method – Hierarchical Linear Regression

The statistical analysis tested the correlations between proposed bikeshare station locations and travel behavior and socio-demographic variables, while controlling for the influence of each city (respectively). The census block group served as the level analysis in the hierarchical (i.e., nested) linear regression model. The number of times that each station is supported in each block group is summed to form the dependent variable in the statistical analysis. Theoretically speaking, we reasoned that the specific station location (e.g., which corner of an intersection) is less important than the general location (e.g., which city block), thus number of stations and number of supports were summed to create the aggregate bikeshare station measure. A hierarchical linear regression model was employed to identify significant relationships between socio-demographic variables and the location of bikeshare stations, while controlling for the nested nature of the data. That is, we examined proposed station locations within four different cities. Thus, the first stage of the model controls for the city, and stage two identifies significant variables within each city. The hierarchical linear regression model is of the form:

Dependent Variable:

- Number of bikeshare stations (and supports) at the Census Block Group Level

Independent Variables:

- Median Household Income
- Travel Mode to Work
- Percent of the Population Black or African American
- Percent of the Population Hispanic or Latino
- Level of Education
- Travel Time to Work

The hierarchical structure of the model can be described as:

1) Step 1: Station location predictors as a function of the City
2) Step 2: Station location predictors controlling for across-city differences

Results – Hierarchical Linear Regression

The regression model reveals significant relationships between a variety of socio-demographic variables, including: travel mode to work, percent of population black, and median household income. Model results are presented in Table 1 and summarized below:

- Travel Mode to Work: Increased rates of driving are significantly ($p<0.05$) correlated with reduced proposed station locations, while the opposite is true of block groups associated with increased rates of walking and bicycling ($p<0.01$). This relationship likely also reflects a correlation between increased walking and cycling, mixed of land uses, accessibility, and density (see: Ewing and Cervero, 2010 for a comprehensive review of the pertinent literature linking travel and the built environment).

- Race and Ethnicity: The percent of the population that described themselves as "Black or African American" on the US Census, and the percent of the population that described themselves as "Hispanic or Latino" were both significant in the statistical model ($p<0.05$). Both variables were positively correlated with reduced number of suggested stations (i.e., increasing non-white populations are associated with a decrease in suggested bikeshare stations).

- Employment and Income: Neither employment rate nor median household income were significantly correlated with station location in the regression model.

Table 1: Statistical Analysis – Hierarchical Regression (n = 1061)

	Mean (SD)	Step 1 (R^2 = .11)	Step 2 (R^2 = .22)
		Standardized β	Standardized β
Chicago (Constant)[1]	0.48 (0.49)	-	-
Portland[1]	0.24 (0.42)	0.009	-0.048
Philadelphia[1]	0.19 (0.39)	-0.334***	-0.427***
Cincinnati[1]	0.08 (0.26)	-0.021	-0.027
Median Household Income ($)	52,037 (27,832)		-0.043
Employment Rate (%)	52.7 (15.3)		0.053
Black or African American (%)	21.1 (29.8)		-0.133***
Hispanic or Latino (%)	13.3 (19.8)		-0.115***
Journey-to-work: Car (%)	54.3 (20.6)		-0.082**
Journey-to-work: Transit (%)	24.3 (15.7)		0.021
Journey-to-work: Bike and walk (%)	14.5 (15.6)		0.203***

- **Dependent Variable = Number of station suggestions (and corresponding number of station "supports") per Census Block Group. Note: The dependent variable was positively skewed (skewness = 3.771; kurtosis = 19.224), as such a logarithmic transformation was applied (skewness = .239; kurtosis = -0.620). As such, the dependent variable should be interpreted cautiously.**
- **[1] = Dummy Variable (+)**
- *** = p < .1; ** = p < .05; *** = p < .001**

Results – Web-based outreach and implications for bikeshare planning

To understand the utility of web-based applications for bikesharing, it is useful to consider bikeshare system planning and maturation as a process that begins with locating stations in areas with existing bicycling and increased densities to spur ridership (Toole Design, 2012). As the system matures and ridership increases, planners can place new stations in lower-income or minority neighborhoods to enhance equitable access. Descriptive maps (Figure 2) and statistical results (Table 1) indicate that currently, web-based outreach can be beneficial for early stages of bikeshare system planning, but are unable to provide directions for equitable system development. Statistical results illustrate that quantitative information garnered from web-based community outreach can lead to inequity bikeshare station distribution along race/ethnicity lines. Alternately, station location decisions are significantly positively associated with increased bicycle and pedestrian journey-to-work mode shares. These relationships indicate that crowdsourced community input may not address equity concerns in its current form, but still holds value for planners since it provides opportunities for them to hear from those that may not participate in traditional public meetings.

Conclusion

This research finds that online participatory technologies may be sensitive to biases along socio-demographic lines. Given the increasing access to technology, the ability to reach a large number of people, and the quality of data possible from crowdsourced, web-based technologies, these tools are extremely attractive. However, the data collected from social media tools can be highly selective, despite its richness. Such tools are generally anonymous, and in the case of this research, it is impossible to identify even basic socio-demographic characteristics of users. This analysis cannot identity users of the web-app, but input from prospective bikeshare users in low-income and minority communities could prove extremely valuable for equitable system planning. The value of crowdsourced planning and equity will likely depend on two issues, (i) access and technological literacy, and (ii) tailored public awareness campaigns. The data collective via the web-based application contains extensive qualitative information that may be useful for site planning, but garnering input from key stakeholders in underserved areas will be a significant challenge for web-based community engagement.

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