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Dose-response association of workplace facilities and policies with commuter bicycling among adults

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A B S T R A C T

Introduction: The objective of this study was to examine the association between workplace facilities and policies with bicycle commuting, and to test interactions by gender, among a convenience sample of adult bicyclists from Austin, TX, and Birmingham, AL.
Methods: Adults aged 18-65 who rode a bicycle in the past year completed an internet-based survey designed to assess potential correlates of bicycling behavior. Participants who reported having ridden a bicycle for transportation in the past year for the purpose of commuting to/from work were categorized as a bicycle commuters. Workplace facilitators assessed included policies that supported biking to work, bicycle lockers, locked rooms/cage, clothes storage, bike racks, and showers. A summary score ordinal variable was derived by adding the total number of reported workplace facilitators per participant. Bivariate and multivariate logistic regression models were conducted to identify the association between each of the workplace facility/policy variables and being a bicycle commuter.
Results: The final analytic sample was of 760 participants employed full- or part-time. All assessed facilitators were significantly directly associated with being categorized as a bicycle commuter in multivariable logistic regression models adjusting for covariates ($p < 0.05$). As compared to no facilitators, 1 facilitator was associated with 2.06 times higher odds of being a bicycle commuter (95% CI:1.63-2.59), 2 facilitators was associated with 2.79 times higher odds of being a bicycle commuter (95% CI:2.00-3.88), 3 facilitators was associated with 4.16 times higher odds of being a bicycle commuter (95% CI:3.80-4.56), and 4 or more facilitators was associated with 7.55 times higher odds of being a bicycle commuter (95% CI:7.36-7.75). No significant interactions between each of the workplace facilitators and gender were observed. Conclusions: Companies that desire to encourage active transportation among their employees should consider how the workplace infrastructure and culture can be changed to support this behavior.

1. Introduction

Individuals who are physically active are healthier across a broad spectrum, as compared to those who are not physically active (Warburton and Bredin, 2017). Despite the known benefits of physical activity, 48% of United States adults do not meet Physical Activity Guidelines for Americans for aerobic activity (Clarke et al., 2017; Departmetn of Heatlh, 2018). Evidence suggests that bicycling is a feasible way for individuals to meet the physical activity guidelines (Chaix et al., 2014; Sahlqvist et al., 2012; Titze et al., 2014). Indeed, compared to both active and inactive non-bicyclists, regular bicyclists are more active, more fit, less likely to develop cardiovascular diseases and cancers,

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and live longer lives (Oja et al., 2011; Andersen et al., 2000).

Bicycling behavior can be divided into two domains – recreation, i.e., riding solely for the purpose of pleasure or exercise, and transportation, i.e., utilitarian riding to get from place to place. When considering bicycling for transportation, estimates from the 2009 United States (US) National Household Travel Survey indicate that individuals who bicycle for transportation engage in approximately 28 min more physical activity per day, as compared to automobile commuters (Mansfield and Gibson, 2016). Bicycling for transportation has itself been associated with significant health benefits, despite a potential increased risk of injury or air pollution exposure when bicycling on roadways (Mueller et al., 2015). Economic and environmental benefits have been associated with transportation bicycling as well, through a reduction in health care costs, fuel expenditure, motor vehicle traffic, and air pollution (Oja et al., 2011; Gotschi, 2011).

Bicycling to work (i.e. bicycle commuting) is a type of active transportation that provides regular physical activity to individuals, in that it can be built into a regular weekday schedule as a means of getting to and from their place of employment. Bicycle commuting in particular has been associated with health benefits such as higher mental wellbeing, as compared to individuals who do not bicycle commute (Mytton et al., 2016). Additionally, bicycle commuting has been found to be associated with reduced sickness absence at work, as compared to individuals who do not bicycle commute (Mytton et al., 2016; Hendriksen et al., 2010). This reduction in workplace absence would produce substantial economic benefit, by limiting lost wages and loss of productivity in the workplace.

Although the benefits of bicycling for transportation, and for bicycle commuting in particular, are clear, only 0.5% of the US population was estimated to bicycle commute in 2017 (United States Census Bureau, 2017). A number of studies have identified factors across multiple levels of the ecological model that influence bicycling for transportation (Nehme et al., 2016; Zlot and Schmid, 2005; Dill, 2009; Fraser and Lock, 2011; Adlakha et al., 2015). City infrastructure, such as bicycle lanes, is associated with bicycling behaviors (Dill, 2009), but when considering bicycle commuting, the workplace environment and policy or regulatory supports may be influential as well. Limited research has been conducted to examine what factors at the institutional and policy level, specifically within the workplace, influence bicycle commuting. Most studies that have examined the influence of the workplace on active travel have not examined walking and bicycling independently (Kaczynski et al., 2010; Petrunoff et al., 2016; Bopp et al., 2013, 2014). The few studies that have examined workplace correlates of bicycling to work specifically have found mixed results, with some finding an association between workplace supports such as bicycle racks, showers, and policies and bicycle commuting (de Geus et al., 2008; Buehler, 2012), whereas others have found no association (Nehme et al., 2017; Bopp et al., 2012; Handy and Xing, 2011).

More research is needed to understand what factors within a workplace may influence an individual's travel to work. The objective of this study was to examine the association between workplace facilities and policies with bicycle commuting, and to test interactions by gender, among a convenience sample of adult bicyclists from Austin, TX, and Birmingham, AL.

2. Methods

2.1. Study sample

An analysis of cross-sectional data from a sample of adults living in Travis County, Texas and Jefferson County, Alabama was conducted in 2018. Data collection procedures for this study have been previously described (Porter et al., 2018a). Briefly, an observational study was conducted to assess multiple level ecological factors (intrapersonal, interpersonal, perceived social environment, perceived built environment, policy, and actual built environment) and their association with frequency of recreation and transportation bicycling behavior. Travis County, Texas and Jefferson County, Alabama were selected as study sites to include a wide range of environmental and social attributes that may be associated with bicycling rates. Austin, located in Travis County, Texas has been defined as one of the best cities for bicycling in the US, while Birmingham, located in Jefferson County, Alabama, is considered to be much less bicycle friendly (Places for Bikes. The bes, 2019). Recruitment was conducted via the Internet, posted advertisements, and word of mouth, from October 2016 to January 2017. Persons were eligible to participate if they lived in the study area, were aged 18–65 years, and reported having ridden a bicycle at least one time in the past year. Individuals who participated were put into a drawing to win a gift card.

Participants responded to an Internet-based questionnaire designed specifically for this study to assess proposed ecological factors of bicycling behavior. Study data were collected and managed using REDCap electronic data capture tools (Harris et al., 2009). The University of Texas Health Science Center at Houston Institutional Review Board deemed this pilot study exempt from review.

2.2. Measures

2.2.1. Bicycle commuting

Bicycle commuting, a dichotomous (yes/no) variable, was the main outcome of interest for the current analysis. Participants were asked if they have ridden a bicycle specifically for transportation in the past year. Those who answered “yes” were then asked what the purposes of their trips were when they rode a bicycle for transportation (Schroeder and Wilbur, 2012). Options included commuting to/from work, commuting to/from school, personal errands, required for my job, drop off/pick up someone, visit a friend or relative, and other. Those who responded that a purpose of their trips was commuting to/from work were categorized as a bicycle commuter. All other participants were categorized as a non-bicycle commuter. This analysis was limited to participants who reported being employed full- or part-time.

2.2.2. Workplace facilities and policies

Six workplace facilities and policies were examined as independent variables, along with one summary variable of total reported workplace facilities and policies for bicycle commuting. As part of the questionnaire, participants who self-reported that they were employed full- or part-time were asked if their workplace had policies that supported bicycling to work. Next, employed participants were asked if any of the following facilities were provided at their workplace for bicycle commuters: bicycle lockers, locked rooms/cage, clothes storage, bike racks, and showers

(Moritz, 1997). For all questions, response options included yes, no, and I don't know. Finally, a summary score ordinal variable was derived by adding the total number of reported policies/facilities per participant. Values of this summary variable ranged from 0 to 6.

2.2.3. Sociodemographic characteristics

The following sociodemographic characteristics were included in this analysis as covariates: age in years, gender (male, female, neither/both/other), race/ethnicity (White, Black, Hispanic/Latino, other), education (less than high school/high school diploma or equivalent, some college/associates degree, 4-year college degree, graduate degree), household income (less than $30,000, $30,000 to less than $75,000, $75,000 and above), number of licensed motor vehicles available for use (0–4 or more), married or living with partner (yes, no), and having children under age 18 living at the participant's home at least 3 days per week (yes, no).

2.3. Statistical analysis

For the purposes of this analysis, the workplace facilities and policies summary score values 4, 5, and 6 were combined into a "4 or more" category due to small sample size. Mean and standard deviation were utilized to describe the study population for continuous variables, while count and percentage were utilized for categorical variables. Logistic regression models were used to assess the association between each of the workplace facility/policy variables (three categories: yes, no [referent], I don't now), as well as the summary score variable (0 [referent], 1, 2, 3, 4+), and being a bicycle commuter (yes vs. no [referent]). Six independent bivariate logistic regression models were first conducted to assess the unadjusted association between each of the workplace variables and being a bicycle commuter. Second, six independent multivariable logistic regression models were conducted to identify the association between each of the workplace facility/policy variables and being a bicycle commuter, while adjusting for sociodemographic characteristics. Finally, a multivariable logistic regression model was conducted to identify the association between the summary score variable for "total workplace facilitators" and being a bicycle commuter, while adjusting for sociodemographic characteristics. A post-hoc test for linear trend was then conducted.

Interactions were tested between gender and each of the workplace facilitator/policy and summary score variables. Significant interactions were defined as a p-value <0.15 with the Wald test (Hosmer et al., 2013). If a significant interaction was identified, the estimates in the adjusted models were reported as a linear combination by each level of the gender. Clustering by study site was accounted for in all models. Collinearity of all variables was assessed via the variance inflation factor (VIF). A VIF for any variable greater than 10 indicated collinearity (Kutner et al., 2004). Sensitivity analyses were conducted. First, associations were explored stratified rather than clustered by study site. Second, "frequent" bicycle commuters were examined, defined as individuals who reported that a purpose of their trips was commuting to/from work as well as reported bicycling for transportation 4 or more times a month. Each multivariable logistic regression model was run with the outcome of frequent bicycle commuters (yes, no [referent], I don't know). All analyses were conducted using STATA 15.1 (STATA Corporation, College Station, TX, USA).

3. Results

A total of 998 participants completed the questionnaire. After excluding those participants who were not employed full- or part-time (n = 145, 14.5%), those with missing data (n = 75, 8.8%), unrealistic ages (n = 11, 1.3%), and those who reported gender as neither/both/other (exclusion due to small sample size; n = 7, 0.9%) the final analytic sample was of 760 participants. Descriptive characteristics of the sample are reported in Table 1. In this sample of bicyclists, 45% of participants reported bicycling to work in the past year. As compared to participants who did not bicycle to work, participants who bicycled to work were slightly younger (mean age 37 vs. 39), more likely to be male, less likely to be Black, more likely to be Hispanic/Latino, lower income, less likely to have multiple motor vehicles, and less likely to have children living at home. In this sample, 71% of bicycle commuters were from Travis County, whereas 66% of non-bicycle commuters were from Jefferson County. Access to workplace facilities/policies varied by type, from 7% for bike lockers to 50% for bike racks. Thirty-one percent of participants reported no workplace supports, whereas 16% of participants reported 4 or more supports; these distributions differed based on bicycle commuter status.

All six workplace facilitator variables were significantly directly associated with being a bicycle commuter in the bivariate logistic regression models, as compared to non-bicycle commuters (Table 2). In the fully adjusted multivariable logistic regression models (adjusting for age, gender, race, education, income, number of motor vehicles, relationship status, and children in household), having bike lockers was associated with a significant 4.93 times higher odds of being a bicycle commuter (95% CI 4.40, 5.52), having locked rooms or cages was associated with a significant 2.04 times higher odds of being a bicycle commuter (95% CI 1.35, 3.09), having clothes storage was associated with a significant 1.94 times higher odds of being a bicycle commuter (95% CI 1.40, 2.72), having bike racks was associated with a significant 3.05 times higher odds of being a bicycle commuter (95% CI 2.58, 3.61), having showers was associated with a significant 2.04 times higher odds of being a bicycle commuter (95% CI 1.90, 2.18), and having workplace policies for bicycling to work was associated with a significant 3.13 times higher odds of being a bicycle commuter (95% CI 2.40, 4.09). As compared to bicyclists who reported "no", individuals who reported "I don't know" to having bike lockers, clothes storage, bike racks, and showers had significantly lower odds of being a bicycle commuter (results not reported).

The association between number of workplace facilitators and bicycle commuting is depicted in Fig. 1. As compared to no facilitators, having 1 facilitator was associated with 2.06 times higher odds of being a bicycle commuter (95% CI 1.63, 2.59), having 2 facilitators was associated with 2.79 times higher odds of being a bicycle commuter (95% CI 2.00, 3.88), having 3 facilitators was associated with 4.16 times higher odds of being a bicycle commuter (95% CI 3.80, 4.56), and having 4 or more facilitators was associated with 7.55 times higher odds of being a bicycle commuter (95% CI 7.36, 7.75). Testing for linear trend indicated a significant direct linear association between number of facilitators and odds of being a bicycle commuter ($p < 0.001$). Examination of the VIF indicated that collinearity could be discarded as a concern for all models. No significant interactions between each of the workplace facilitators and gender were observed. Sensitivity analyses

Table 1
Descriptive characteristics of adult bicyclists residing in Travis County, Texas and Jefferson County, Alabama, October 2016–January 2017.

Variable	Full Sample n = 760	Bicycle commuter n = 342	Non-bicycle commuter n = 418
Age [mean (SD)]	38.1 (10.6)	36.6 (10.1)	39.3 (10.9)
Gender [n (%)]			
Male	430 (56.6)	223 (65.2)	207 (49.5)
Female	330 (43.4)	119 (34.8)	211 (50.5)
Race [n (%)]			
White	649 (85.4)	295 (86.3)	354 (84.7)
Black	32 (4.2)	4 (1.2)	28 (6.7)
Hispanic	37 (4.9)	24 (7.0)	13 (3.1)
Other	42 (5.5)	19 (5.6)	23 (5.5)
Education [n (%)]			
Less than high school/high school graduate or equivalent	26 (3.4)	8 (2.3)	18 (4.3)
Some college/associates degree	116 (15.3)	55 (16.1)	61 (14.6)
4-year college degree	350 (46.1)	159 (46.5)	191 (45.7)
Graduate degree	268 (35.3)	120 (35.1)	148 (35.4)
Household Income [n (%)]			
Less than $30,000	100 (13.2)	64 (18.7)	36 (8.6)
$30,000 to less than $75,000	261 (34.3)	134 (39.2)	127 (30.4)
$75,000 or more	399 (52.5)	144 (42.1)	255 (61.0)
Number of licensed motor vehicles available for use [n (%)]			
0	33 (4.3)	28 (8.2)	5 (1.2)
1	243 (32.0)	137 (40.1)	106 (25.4)
2	339 (44.6)	128 (37.4)	211 (50.5)
3	99 (13.0)	33 (9.7)	66 (15.8)
4 or more	46 (6.1)	16 (4.7)	30 (7.2)
Married or living with partner [n (%)]			
No	265 (34.9)	133 (38.9)	132 (31.6)
Yes	495 (65.1)	209 (61.1)	286 (68.4)
Children under the age of 18 living at home at least 3 days per week [n (%)]			
No	547 (72.0)	263 (76.9)	284 (67.9)
Yes	213 (28.0)	79 (23.1)	134 (32.0)
Site [n (%)]			
Jefferson	372 (49.0)	98 (28.7)	274 (65.6)
Travis	388 (51.0)	244 (71.3)	144 (34.4)
Workplace facilitators for bicycling to work			
Bike Lockers [n (%)]			
Yes	56 (7.4)	44 (12.9)	12 (2.9)
No	668 (87.9)	291 (85.1)	377 (90.2)
I don't know	36 (4.7)	7 (2.1)	29 (6.9)
Locked Rooms/Cage [n (%)]			
Yes	103 (13.6)	61 (17.8)	42 (10.1)
No	616 (81.0)	266 (77.8)	350 (83.7)
I don't know	41 (5.4)	15 (4.4)	26 (6.2)
Clothes Storage [n (%)]			
Yes	208 (27.4)	115 (33.6)	93 (22.3)
No	514 (67.6)	214 (62.6)	300 (71.8)
I don't know	38 (5.0)	13 (3.8)	25 (6.0)
Bike Racks [n (%)]			
Yes	381 (50.1)	228 (66.7)	153 (36.6)
No	353 (46.5)	110 (32.2)	243 (58.1)
I don't know	26 (3.4)	4 (1.2)	22 (5.3)
Showers [n (%)]			
Yes	270 (35.5)	143 (41.8)	127 (30.4)
No	463 (60.9)	189 (55.3)	274 (65.6)
I don't know	27 (3.6)	10 (2.9)	17 (4.1)
Bike Policy [n (%)]			
Yes	279 (36.7)	178 (52.1)	101 (24.2)
No	360 (47.4)	123 (36.0)	237 (56.7)
I don't know	123 (15.9)	41 (12.0)	80 (19.1)
Workplace Facilitators [n (%)]			
0	233 (30.7)	57 (16.7)	176 (42.1)
1	164 (21.6)	72 (21.1)	92 (22.0)
2	138 (18.2)	70 (20.5)	68 (16.3)
3	102 (13.4)	60 (17.5)	42 (10.1)
4 or more	123 (16.2)	83 (24.3)	40 (9.6)

examining the association between facilities and policies stratified by study site resulted in similar findings, although the strength of some associations were attenuated and no longer significant, likely due to smaller sample sizes (Supplemental Table 1). The dose response association between number of facilitators and bicycling to work was evident in both study sites. Similarly, sensitivity analyses examining the

Table 2
Bivariate and multivariable logistic regression models of the association between workplace facilities/policies and bicycle commuting, adult bicyclists (n = 760) residing in Travis County, Texas and Jefferson County, Alabama, October 2016–January 2017.

Workplace Variable	Bivariate OR (95% CI)	Multivariable[a] OR (95%CI)
Bike Lockers	4.75 (3.26, 6.93)***	4.93 (4.40, 5.52)***
Locked Rooms/Cage	1.91 (1.55, 2.35)***	2.04 (1.35, 3.09)***
Clothes Storage	1.77 (1.35, 2.33)**	1.94 (1.40, 2.72)***
Bike Racks	3.29 (2.63, 4.12)***	3.05 (2.58, 3.61)***
Bike Policy	3.40 (2.94, 3.92)***	3.13 (2.40, 4.09)***
Showers	1.63 (1.52, 1.75)***	2.04 (1.90, 2.18)***

*p < 0.05, **p < 0.01, ***p < 0.001.
[a] Adjusted for age, race, education, income, number of motor vehicles, relationship status, children in household, and gender.

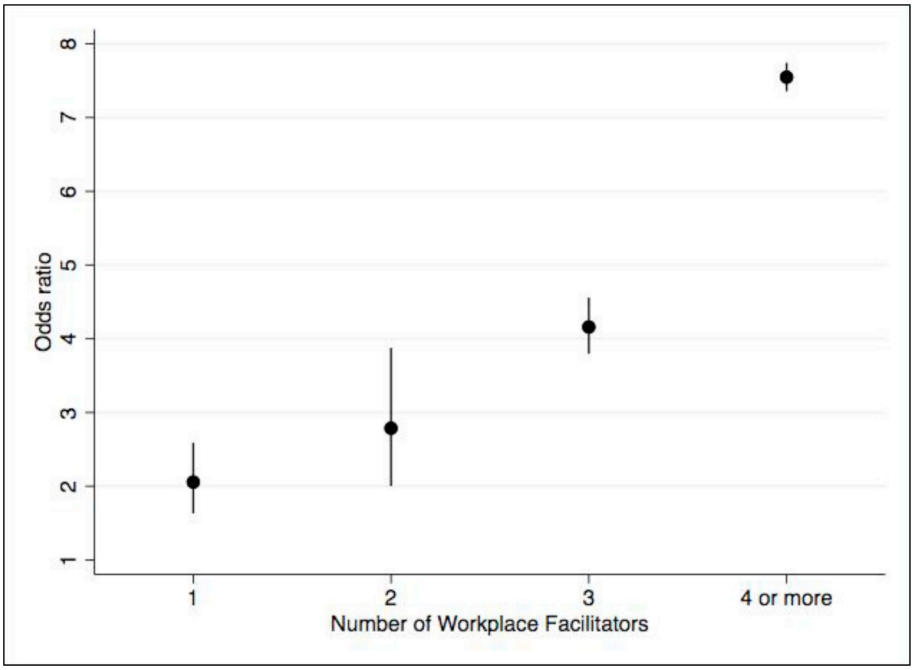

Fig. 1. Multivariable logistic regression models of the association between number of workplace facilities/policies and bicycle commuting, adult bicyclists (n = 760) residing in Travis County, Texas and Jefferson County, Alabama, October 2016–January 2017
Note: Adjusted for age, race, education, income, number of motor vehicles, relationship status, children in household, and gender. p-trend <0.001.

outcome of frequent bicycle commuting as compared to all other bicyclists in the sample resulted in similar findings for all models with the strengths of the associations slightly attenuated, but continued evidence of the dose response association between facilitators and frequent bicycle commuting (Supplemental Table 2).

4. Discussion

This study assessed the influence of workplace bicycle facilities and policies on bicycling to work in a convenience sample of adult bicyclists residing in Travis County, Texas, and Jefferson County, Alabama. Results indicate that all facilitators explored were significantly associated with bicycling to work, including bicycle lockers, locked rooms/cages, clothes storage, bicycle racks, showers, and policies. Further, this study identified a dose response relationship between the number of workplace facilitators and odds of bicycling to work, such that as the number of facilitators increased, the odds of bicycling to work increased. These findings were not modified by gender. When frequent bicycle commuting was examined, results were comparable, with all workplace facilitators significantly associated with bicycle commuting among those individuals who rode a bicycle for transportation 4 or more times a month. The dose response relationship was also evident when examined by study site.

Individuals who reported they did not know if a particular facility or policies were available at their workplace had lower odds of bicycling to work, as compared to individuals who reported “no” to the presence that facility or policy. These individuals may or may not work in places that do have supportive bicycling facilities or policies, but perhaps due to lack of interest they are unaware. These

individuals can be conceptualized using the Transtheoretical Model of Health Behavior Change, a behavioral theory that posits that individuals move through six stages during behavior change - precontemplation, contemplation, preparation, action, maintenance, and termination (Prochaska and Velicer, 1997). In the precontemplation stage, individuals have not yet conceived of or have no interest in the behavior (Prochaska and Velicer, 1997). It can be difficult to influence an individual in precontemplation to change their behavior if they have no interest or if there are seemingly insurmountable barriers. In the context of bicycling to work, for example, the presence of absence of workplace facilitators may be irrelevant to individuals that don't like to bicycle, or have physical or family barriers that they are unable to overcome. However, for those in the contemplation stage, where they intend to change in the next 6 months (Prochaska and Velicer, 1997), awareness of facilitators may increase and, further, the availability of facilitators may be a meaningful motivator for changing from contemplation to preparation, action, and eventually maintenance.

Previous findings on this topic have been variable; the results reported here support some of the previous work and refute others. From an international perspective, research reports from Flanders, Belgium, showed that the presence of facilities for bicyclists at the workplace, such as showers, shelters, and safe bicycle parking, were significantly associated with bicycling to work (de Geus et al., 2008). Looking at work in the United States, one study conducted in Washington, DC, found that presence of bicycle parking, showers, and lockers was significantly associated with commuting to work by bicycle (Buehler, 2012). Handy and Xing (2011), in contrast, found that bicycle facilities such as racks and showers close to work were not significantly associated with bicycle commuting in six small US cities located in California and Colorado. Another study in Manhattan, Kansas also found no significant associations between bicycle parking or policies and bicycling to work at least one time per week (Bopp et al., 2012).

The way the bicycling behavior was operationalized may in part explain these differences - Bopp and colleagues (Bopp et al., 2012) and Handy and Xing (2011) both examined bicycle commuting in a typical week. Bicycle commuting as frequently as one time a week or more may not be as influenced by accessible workplaces as compared to any reported bicycle commuting activity. In an attempt to explore more frequent bicycle commuting in the current study, a sensitivity analysis was conducted to assess the association between workplace facilitators and what was defined as “frequent” bicycle commuting, defined as reported bicycling to work and bicycling for transportation 4 or more times in the past month. This is an imperfect approximation of weekly bicycle commuting to work, however, as there was no way to identify the purpose or destination for transportation bicycling frequency in this study. Despite this limitation, the results of this sensitivity analysis were very similar to what was identified in the more basic bicycle commuter analysis, in that workplace facilities are significantly associated with frequent bicycle commuting. Nonetheless, further exploration to determine how much workplace facilities influence the frequency of the behavior over and above other environmental and sociodemographic factors.

Another explanation of the differing findings from similar studies may be in the built environments of the cities where these studies were conducted. Washington, DC is a large metropolitan area with a dense urban core, whereas the cities explored by Bopp and colleagues (Bopp et al., 2012) and Handy and Xing (2011) are smaller university towns with other factors influencing bicycle commuting, such as parking costs (Handy and Xing, 2011). The counties in our studies are not necessarily comparable to either Washington, DC or Manhattan, Kansas, but do have diverse urbanicity that may contribute to the differing findings. Indeed, it is known that environmental context is important for urban-based physical activity behaviors such as transport-based and recreational walking (Salvo et al., 2014, 2017; Feuillet et al., 2015). Therefore, when considering how environments and policy influence physical activity behaviors, it is essential to also understand the context of communities in which the behaviors take place.

Nehme and colleagues (Nehme et al., 2017) examined the association between the introduction of new worksite showers and physical activity behaviors, including bicycling to work. Due to small sample size, they were unable to identify if the introduction of showers was associated with changes in bicycle commuting, but they found no effect with more general employee physical activity (Nehme et al., 2017). A simulation study out of Edmonton, Canada found that bicyclists considered showers for cyclists at destinations to be attractive, but determined that secure bicycle parking was much more important (Hunt and Abraham, 2007). The current study did find a significant association between presence of showers and bicycle commuting, but out of all the facilitators examined, showers was the least strongly associated with commuting by bicycle. Similar to the results of Hunt and Abraham (Feuillet et al., 2015), parking facilities, such as bicycle lockers and bicycle racks, were the facilities most strongly associated with bicycle commuting, along with policies. However, barriers to bicycling for travel to work or during the workday have been previously explored in populations, and lack of facilities such as showers have been identified as important in encouraging individuals to bicycle to work or during the workday (Tin et al., 2010; Webster and Cunningham, 2013), as is a lack bike racks or other method of secure bicycle storage (Webster and Cunningham, 2013).

Somewhat surprisingly, these associations were not modified by gender. Previous studies have shown substantial differences by gender in bicycling prevalence (Porter et al., 2018b), in which factors influence physical activity behaviors (Valson and Kutty, 2018), and what workplace supports are associated with active commuting (Kaczynski et al., 2010), which led to an expectation of differences in the present analysis. However, evidence from this study suggests that, among this sample of bicyclists, workplace supports for bicycling are important for both men and women to participate in bicycle commuting. More research is needed to understand if these findings apply across population groups and in differing contexts.

Overall, it is evident that, in this non-representative sample, workplace facilities and policies that support employees to bicycle to work are important for bicycle commuters. Further, the findings indicate that there is not necessarily one particular workplace intervention that is the most important for bicycle commuting – the more bicycle commuting facilitators present, the more likely it will be that an employee bicycles to work. The cost of implementing many of these facilitators would be negligible, particularly the development and implementation of supportive policy and the installation of bicycle racks. Therefore, companies that desire to increase active transportation, and specifically bicycle commuting, among their employees should consider how their infrastructure and workplace culture can be changed to support this behavior. Employees who are supported to engage in active transportation such as bicycling may improve physical and mental health outcomes, and in turn reduce health care costs and absenteeism for employers (Mueller et al., 2015; Gotschi, 2011; Mytton et al., 2016; Hendriksen et al., 2010).

4.1. Strengths and limitations

This study addresses a gap in the literature for understanding how the presence of workplace facilities and policies are associated with bicycle commuting behavior among employees. This work stands apart from previous research on bicycle commuting to work (de Geus et al., 2008; Buehler, 2012; Nehme et al., 2017; Bopp et al., 2012), in that the individual facilities were examined independently, as well as via a summary variable, and further, that these results were examined for an interaction by gender. In addition, this study examined bicycling as an independent activity, rather than considering "active commuting", i.e. bicycling and walking together. This information provides an increased level of detail for helping to understand what facilitators may be of particular value to individuals who are interested in commuting by bicycle.

This study also has limitations. Due to the cross-sectional nature of these data, reverse causality is possible, such that individuals who are interested in bicycling to work may have chosen workplaces that support that behavior. Further, facilitators may have been introduced into the workplace to support bicycle commuters already performing the behavior. In this case, however, one could argue that though one or more bicycle commuters were the catalyst for environmental or policy change, the addition of facilitators that support bicycling to work may in turn influence other employees to take up the behavior as well. Longitudinal studies are warranted to elucidate these potential causal mechanisms. Distance between home and workplace is a potential moderator of this association as well, in that commuting by bicycle may not be a feasible option for individuals that live too far from their workplace location. Hence, the effectiveness of workplace policies to promote bicycling may depend on the proportion of employees that reside close to the given workplace location. Although in this study participants were asked to report their home and work addresses, there was a high amount of missing data for these variables, precluding us from calculating home-to-work distances and including this variable in the analysis. In addition, employer name or industry sector was not assessed. Future research should examine how distance, as well as other barriers such as family responsibilities, home and work neighborhood environments, employment industry sector, and social norms may modify these associations.

The variables under study were assessed via self-report, which may introduce error due to misreporting and response bias. Previous research on this topic have also utilized self-report to examine the association between the workplace environment and bicycling to work (de Geus et al., 2008; Buehler, 2012; Bopp et al., 2012; Handy and Xing, 2011), indicating a need for research on the association between objectively measured workplace environments and bicycling to work. The use of a convenience sample introduces selection bias that prevents these data from being generalizable to a larger population and may violate some of the assumptions of hypothesis testing. In particular, this sample was majority white, highly educated, high income, and from a limited age range. Comparing to 2017 estimates from the US Census to the study sample from Jefferson County, Alabama, the population were 52.1% white (88.2% in study sample), had a median household income of $49,321 (54.5% had income above $75,000 in study sample), and 20.6% had a bachelor's degree (43.6% in study sample) (United States Census Bureau, 2013–2017). Data from the 2017 US Census estimates were more comparable to the study population for Travis County, Texas – the population were 74.9% white (79.3% in study sample), had a median household income of $72,884 (45% had a household income above $75,00 in study sample), and 31.6% had a bachelor's degree (45.7% in study sample) (United States Census Bureau, 2013–2017). However, it is difficult to gauge how comparable these results are to the population of bicyclists, or of transportation and recreation bicyclists as population representative data are not available. In the US, transportation bicyclists are less likely to be high school educated as compared to non-bicyclists (Porter et al., 2018b), indicating a need-based motivation for bicycling for transportation that may not be true of the present sample. Moving forward, more and better research is warranted examining the effect of workplace facilitators among low-income commuter bicyclists, who remain understudied.

4.2. Conclusions

In this sample of bicyclists, workplace facilities and policies were shown to be strongly associated with bicycle commuting, and further the number of facilitators was associated with bicycle commuting in a dose-response fashion. Although other factors certainly influence an individual's decision to be a bicycle commuter, such as sociodemographic factors and the perceived and actual built environment in their neighborhood and along the commute route (Porter et al., 2018a, 2018b; Wahlgren and Schantz, 2012), the workplace environment clearly is an important consideration. Workplaces that wish to prioritize active transportation by bicycle should consider providing facilities for safe bicycle storage, as well as accommodations employees to prepare for the workday. In addition, developing and implementing policies that outline this support for active transportation are warranted.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2019.100603.

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