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Measuring the potential for bicycling and walking at a metropolitan commuter university

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ABSTRACT

An attitudinal survey was disseminated to faculty, staff, and students at a metropolitan commuter university with the objective to ascertain what travel demand management (TDM) strategies will increase bicycling and walking activity. Using Geographic Information Systems (GIS), the groups were divided spatially into typical walking and bicycling zones from campus. Descriptive analysis was first used to determine attitudinal differences and similarities among the divided groups regarding hypothetical walking and bicycling conditions. It was found that all groups generally favored most bicycling interventions within a bicycling zone versus those who lived outside the zone. Accordingly, most walking facilitators were viewed positively among all groups. A binary logit model was then utilized to understand how distance from campus affected the likelihood that a bicycle or pedestrian mode shift would occur among faculty, students, and staff. Model results indicated that bicycle safety and education may cause faculty to bicycle, whereas higher automobile costs may cause staff to bicycle, and a visible bicycle culture would cause students to bicycle more in a bicycling zone. The probability that staff and students would walk more was linked to increased perceived personal safety. Increased automobile costs and traffic enforcement appeared to be the largest incentive to increase faculty walking activity in a walking zone. The results indicate that a commuter university contains a diverse population, with equally diverse utilitarian non-motorized travel needs. Therefore, effective TDM strategies should reflect this variety by incorporating appropriate bicycling and walking incentives and automobile disincentives that encourage active commuting.

1. Introduction

Universities throughout the world are becoming increasingly concerned with the ill effects of the automobile, while also striving to create a sustainable campus environment (Páez and Whalen, 2010). Increased traffic associated with rising student enrollment has led to various automobile externalities such as congestion, reduced air quality, noise pollution, and high accident rates. Universities, as traffic generators and sources of innovation, are in a perfect position to test new approaches to stemming automobile use (Barata et al., 2011). Implementing sustainable university transportation policies may result in a more attractive university environment and may have strong potential to increase active living for the general population and university constituents.

Policies that reduce the demand for automobile usage on and near colleges have the potential to decrease the demand for parking (Shannon et al., 2006), increase quality of life on campus, with resulting financial benefits (Toor and Havlick, 2004) reduce congestion on and near campus (Delmelle and Delmelle, 2012), aid students in reaching minimum physical activity requirements (Sisson and Tudor-Locke, 2008), foster active travel of nearby residents (Koth, 2006), and facilitate non-motorized commuting habits among young adults (Shannon et al., 2006). To reach these goals, many universities rely on transportation demand management (TDM) tools that address transportation behavior. TDM tools are sustainable transportation planning approaches that consist of strategies focused on discouraging automobile travel and promoting active mode shares such as bicycling, walking, or using mass transit (Balsas, 2003; Miralles-Guasch and Domene, 2010; Tolley, 1996). For example, the University of Florida implemented parking restrictions, parking pricing, transit service, and access improvements, resulting in a significant mode shift (Bond and Steiner, 2006). A recent analysis conducted by Delmelle and Delmelle (2012) highlighted the need to increase student parking fees in

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order to deter commuting by automobiles at a small traditional university. They also found that the possession of a parking permit predicted commuting by automobiles more than distance. Moreover, Shannon et al. (2006) found that policies that would decrease real and perceived travel time, along with increases in the cost of using the automobile, likely would affect university travel behavior. It is clear that successful TDM strategies hold promise in shifting university populations towards active modes of transportation.

To date, there have been few TDM investigations into how to curb automobile use and elevate active transportation modes at small, auto-orientated metropolitan universities. Much of the prior research has been conducted at large, traditional universities (Akar and Clifton, 2009; Molina-Garcia et al., 2010; Sisson and Tudor-Locke, 2008), universities located in suburban areas (Bonham and Koth, 2010; Miralles-Guasch and Domene, 2010), small-town universities (Delmelle and Delmelle, 2012), or colleges in rural areas (Limanond et al., 2010). Arguably, a metropolitan commuter university dominated by single occupant vehicle (SOV) usage and a substantial non-traditional student body requires unique TDM strategies to meet sustainability goals.

Metropolitan commuter universities constitute a substantial physical and economic presence in urban areas and consist of more diverse students, academic programs, and amenities than their traditional university counterparts (Perlman, 1995). The fiscal challenges faced by many metropolitan universities are greater than those faced by traditional universities, in part because of their deep-seated connections to the city and in meeting the social needs of a heterogeneous student body (Johnson, 1995). For instance, commuter universities often provide child-care facilities, extended class offerings, and flexible faculty office hours in an attempt to meet the needs of their diverse student bodies. The student make-up at an urban commuter university typically consists of traditional and non-traditional students of varying ages and ethnic backgrounds who normally reside off-campus (Roe Clark, 2006). Many students in commuter universities have unique college experiences because they need to balance full or part-time jobs, have children, and commute long distances to school (Delmelle and Delmelle, 2012; Perlman, 1995). Furthermore, the travel experience of students at urban commuter universities adds more stress to their college experience in the form of parking, traffic, fixed travel schedules, inclement weather, fares, and the demands of auto maintenance (Jacoby, 1995). Therefore, if metropolitan commuter universities intend to become a beacon of sustainability in their locale, it is imperative that they examine and implement policies specific to their university constituents that have the greatest potential to facilitate active transportation.

The lack of non-motorized travel demand research that focuses on metropolitan commuter universities presents an attractive opportunity to gauge what measures can promote transportation behavioral changes successfully. The present research addresses this need by investigating the attitudes of faculty, staff, and students regarding bicycling and walking at a metropolitan commuter university, the University of Michigan-Flint (UM-Flint). The most popular TDM strategies pertain to encouraging bicycling and walking travel modes (Huang et al., 2012), thus these are the focus of this research. The research strategy was carried out by first disseminating an attitudinal survey and assessing the results via a robust descriptive and inferential statistical assessment. Specifically, the aims of this study were to: (1) design and administer an attitudinal survey to ascertain walking and bicycling preferences of three populations at a metropolitan commuter university, (2) disentangle the relationships between residence-campus distance and walking/bicycling preferences/barriers among faculty, staff, and students using a binary logit model, and (3) provide policy recommendations that commuter universities can use to improve non-motorized travel demand.

The study first outlines the research area, describes the university under investigation, and then details the data collection process in Section 2. Section 3 reviews the empirical research design methodology, and Section 4 provides the results with discussion. Finally, Section 5 summarizes the broader-scale findings and policy implications of the study

2. Data and study area

2.1. Study area

The UM-Flint is situated in the center of the City of Flint, Michigan (Fig. 1). According to the 2010 U.S. Census, the City of Flint contained a population of 102,434. Through its downtown location and strong ties to the city, UM-Flint is considered a strong ally in increasing Flint's economic prosperity. The fall 2011 enrollment at UM-Flint consisted of 8262 total students of which 6959 are undergraduate students and 1303 are graduate students (UMF, 2012). According to the UM-Flint Office of Institutional Analysis, the percent of undergraduate students aged 25 and older was 39% in 2011, signifying a large non-traditional student body. UM-Flint is also one of the fastest growing universities in the state of Michigan (Wiens, 2010). The enrollment growth has placed added pressure on university officials to manage parking, reduce congestion, and become more sustainable. As a result, the "Go Blue, Live Green" strategy has been implemented to increase campus sustainability.

2.2. Survey design

To better understand the potential for bicycling and walking to, from, or on the UM-Flint campus, an attitudinal survey was designed to gauge bicycling and walking barriers and motivators that existed among current faculty, staff, and students. After receiving approval from the Internal Review Board at UM-Flint in August 2011, an online survey using Qualtrax (Qualtrics Labs, Inc.) was disseminated to a random sample of 1139 (15%) undergraduate and graduate students and all faculty (530) and staff (530) at UM-Flint. The participants had 30 days to complete the online survey. A hard-copy version of the survey was also administrated to these groups during two on-campus activities (UM-Flint Welcome Back Event and a Smart Commute Event) during the fall 2011 semester. A total of 110 surveys (95 students, 9 staff, and 6 faculty) were retrieved during these two events. Overall survey response rates obtained were 22% for students, 24% for faculty, and 28% for staff. They are consistent with typical transportation survey response rates found elsewhere (Larson and Poist, 2004).

The survey contained 14 questions within five sections related to general demographic and residence information, attitudes towards bicycling motivators, bicycling barriers, walking motivators, and mass transit. The first section asked questions related to gender, university classification (faculty, staff, student, other), residence address, residential distance from campus (less than one mile, one to five miles, or greater than five miles), and percent of each transportation mode used to travel to campus (car, bicycle, bus, walking, car pool, scooter, other). When a respondent selected two modes with an equal percentage, the analysis accounted for both selections.

Respondents were then asked to rate several bicycling motivators, bicycling barriers, and walking motivators (Table 1). For each set of questions related to these transportation modes, respondents were asked to rank their attitudes on a scale of 1–4, 1 being "very likely" and 4 "very unlikely." A 4-point scale was used in this analysis in order to ascertain more directed responses regarding the hypothetical interventions, and to lessen the chances of ambiguous responses from the participants. Any questions left blank by the respondent were considered missing values and not

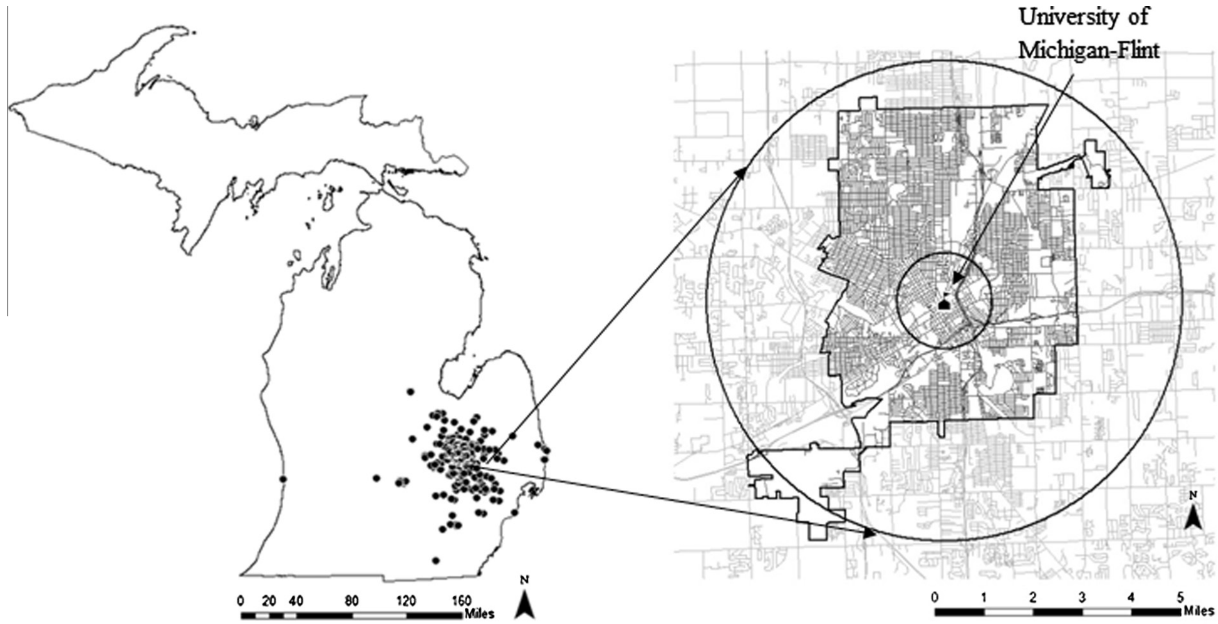

Fig. 1. City of Flint, Michigan, and spatial distribution of faculty, staff, and students from UM-Flint, within five-mile bicycling and one-mile walking zones.

Table 1
Overview of bicycling motivators, bicycling barriers, and walking motivators included in the survey.

Bicycling motivators
Better and safer on-road bicycle routes
Better lighting conditions on and near campus
More attractive destinations in Flint, i.e., parks, shopping
Campus Bicycle Share Program
Seeing more bicyclists
Bicycle repair or air station on campus
Traffic enforcement
More bicycle racks
A campus bicycle map
Increase in fuel costs
Classes that teach bike safety and commuting tips
Increase in parking costs
Increase in parking fees
Bicycling barriers
Adverse weather conditions
Travel distance
Bicycle theft
General threat of crime
Lack of bicycle lanes or trails
Do not own a bicycle
Lack of interest in bicycling
Walking motivators
Better lighting conditions
Greater presence of UM-Flint or City of Flint police officers
More attractive destinations in Flint, i.e., parks, shopping
Safer street intersections
More emergency phones on campus
Increased traffic enforcement
Increase in fuel costs
Increase in parking costs

included in the analysis. All survey data were entered into Microsoft Excel version 2010 and SPSS (IBM, Inc.) version 20 for further data analysis.

3. Methods

3.1. Exploratory and spatial analysis

The network travel distance from each survey respondent's residence to campus was determined using Environmental Systems Research Institute (ESRI) ArcInfo version 10.0 Geographic Information System (GIS) software. Using this distance, survey respondents were partitioned into two bicycling and walking areas surrounding campus. One- and five-mile radii were chosen to represent feasible walking and bicycling distances, respectively, from the residential trip origin (Cervero and Duncan, 2003; Tolley, 1996). The distance categories used in this research are based on previous studies that have integrated distance as a measure of accessibility and a predictor of travel behavior (Bopp et al., 2011; Delmelle and Delmelle, 2012; Molina-Garcia et al., 2010; Parkin et al., 2008; Shannon et al., 2006). In addition, the categorization of the groups by distance to campus was used to reveal how geography and university classification affected attitudes towards bicycling and walking. Similarly, a survey conducted by Páez (2013) found that geography and personal characteristics explained underlying self-reported behavioral processes. It should be noted, however, that other factors have shown strong potential to influence alternative transportation behavior. For instance, variables such as density, connectivity, land-use mix, weather, and socio-demographics have been shown to affect bicycling and walking (Ahmed et al., 2013; Saelens et al., 2003).

The mode share for each university group was obtained by summarizing the dominant (>50%) transportation choice for each university group and then dividing by the total population. The major mode choice was then assessed relative to bicycling and walking zones to highlight broadly groups that have the most potential to shift transportation modes from the automobile. For each survey question related to bicycling and walking, the responses were dichotomized into "yes" (very likely, likely) when the proposed condition would influence their travel decision, or "no" (unlikely and very unlikely) when the proposed condition would not. The "yes" survey responses were divided by the total number of responses and multiplied by 100 to yield the percentage of respondents who agreed with the proposed condition. The percent of the sample that favored each proposed condition was evaluated for faculty, staff, and students collectively and separately. This output revealed how each condition was received by the campus community, indicating the general preferences needed to increase bicycling and walking. These conditions were then ranked based on the proportion of the population that favored

Table 2
University group respondent profiles.

	Total%	Faculty%	Staff%	Students%
Male	38.7, (n = 200)	52.4, (n = 54)	31.1, (n = 46)	37.9, (n = 97)
Female	61.3, (n = 317)	47.6, (n = 49)	68.9, (n = 102)	62.1, (n = 159)
Less than 1 mile (walking zone)	10.2, (n = 52)	2.4, (n = 12)	2.5, (n = 13)	5.3, (n = 27)
Greater than 1 mile (non-walking zone)	89.8, (n = 458)	17.8, (n = 91)	26.9, (n = 137)	45.1, (n = 230)
Less than 5 miles (bicycling zone)	27.6, (n = 141)	6.3, (n = 32)	7.6, (n = 39)	13.7, (n = 70)
Greater than 5 miles (non-bicycling zone)	72.4, (n = 369)	13.9, (n = 71)	21.8, (n = 111)	36.7, (n = 187)

Table 3
Mode share proportions for faculty, staff, and students per walking and bicycling zones (%).

Mode choice	Group	All zones, 0–88.6 miles	Walking zone, <1 mile	Non-walking zone, >1 mile	Bicycling zone, <5 miles	Non-bicycling zone, >5 miles
Walk	Faculty	7.6	61.5	0.0	23.5	0.0
	Staff	1.4	7.7	0.7	5.3	0.0
	Students	11.4	82.1	3.0	36.1	2.1
	All groups	7.8	59.3	1.7	25.0	1.1
Bicycle	Faculty	6.7	23.1	4.3	17.6	1.4
	Staff	1.4	7.7	0.7	5.3	0.0
	Students	2.3	7.1	1.7	6.9	0.5
	All groups	2.9	11.1	1.9	9.0	0.5
SOV	Faculty	76.2	15.4	84.8	52.9	87.3
	Staff	88.5	84.6	88.9	86.8	89.1
	Students	71.9	10.7	79.1	38.9	84.3
	All groups	77.5	29.6	83.1	54.9	86.3
Car Pool	Faculty	8.6	0.0	9.8	2.9	11.3
	Staff	8.8	0.0	9.6	2.6	10.9
	Students	12.2	0.0	13.6	12.5	12.0
	All groups	10.5	0.0	11.7	7.6	11.6
Bus	Faculty	1.0	0.0	1.1	2.9	0.0
	Staff	0.0	0.0	0.0	0.0	0.0
	Students	2.3	0.0	2.6	5.6	1.0
	All groups	1.4	0.0	1.5	3.5	0.5

the proposed conditions in each zone. Once the trends were established, the levels of agreement among the three groups in each zone, and for each condition, were assessed by finding the difference between the groups' high and low percentages. This step was conducted to determine group consensus or dissention among faculty, staff, and students regarding the proposed bicycling and walking conditions.

3.2. Model development

To examine further the probability for faculty, staff, and students to utilize the bicycle or engage in pedestrian activity, a univariate logistic regression model was used in this study. Logistic regression is well suited to study the relationship between a categorical outcome variable and one or many categorical or continuous predictor variables obtained from survey choices (Peng et al., 2002). In all cases, the explanatory variable was a dichotomized measure where 1 represented faculty, staff, or students within bicycling or walking zone, and 0 represented these groups residing beyond the aforementioned zones (reference group). The dependent variables in all models were the dichotomized survey responses (1 = yes, the proposed barrier or motivator would cause a behavior change, or 0 = no it would not). The odds ratios of increasing bicycling among faculty, staff, and students living less than five miles from the university compared to those living five or more miles from the university were calculated (Table 4). In addition, the odds ratios were calculated of decreasing bicycling among faculty, staff, and students living less than five miles from the university compared to those living five or more miles from the university (Table 5). Finally, the odds ratios of increasing walking under certain conditions among faculty, staff, and students living less than one mile from the university compared to those living one or more miles from the university were calculated (Table 6). All regression results were considered significant at $p < .05$.

4. Results and discussion

4.1. University group characteristics

Table 2 displays the gender distribution of the sample and the distribution of the respondents with respect to bicycling and

Table 4
Group comparisons within the bicycling zone (<5 miles).

Conditions to increase bicycling	Faculty[a]		Staff[b]		Students[c]	
	OR	S.E.	OR	S.E.	OR	S.E.
Safer routes	5.609***	.507	4.379***	.425	2.807***	.320
Lighting	10.000***	.521	3.382**	.413	2.221*	.320
Seeing more bicyclists	4.800***	.482	4.010***	.409	3.581***	.319
Repair/air station	5.630***	.491	4.782***	.422	2.269**	.298
Attractive Flint destination	3.962**	.470	1.183	.430	3.125***	.326
More bicycle racks	3.98**	.478	3.557**	.422	3.336***	.304
Traffic enforcement	6.429***	.497	3.134**	.410	1.864*	.294
Bicycle share	1.635	.472	2.057	.403	1.880*	.294
Bicycle maps	3.036*	.506	3.095**	.427	2.559**	.299
Inc. fuel costs	4.176**	.503	5.786***	.435	1.613	.299
Bicycle classes	9.868***	.645	3.643**	.465	2.128*	.308
Inc. parking costs	3.857*	.569	5.776***	.545	1.262	.326
Inc. parking fees	3.992*	.569	5.227**	.530	1.471	.331

* Significant 0.05 level.
** Significant at the .010 level.
*** Significant at the .001 level.
[a] Reference group = faculty residence > 5 miles from UM-Flint.
[b] Reference group = staff residence > 5 miles from UM-Flint.
[c] Reference group = student residence > 5 miles from UM-Flint.

Table 5
Group comparisons within the bicycling zone (<5 miles).

Conditions to decrease bicycling	Faculty[a]		Staff[b]		Students[c]	
	OR	S.E.	OR	S.E.	OR	S.E.
Adverse weather	2.348	.607	2.833	.787	1.365	.395
Bicycle theft	2.549	.533	2.288	.504	3.214**	.436
General crime	2.571	.515	1.028	.414	1.563	.355
Lack of bicycle lanes	2.783	.533	2.500*	.461	1.421	.309
No bicycle	2.989*	.521	1.219	.428	2.200*	.334
Distance	0.113***	.532	0.513	.464	0.393**	.318
Lack of interest	1.148	.478	0.673	.452	0.810	.300

* Significant 0.05 level.
** Significant at the .010 level.
*** Significant at the .001 level.
[a] Reference group = faculty residence > 5 miles from UM-Flint.
[b] Reference group = staff residence > 5 miles from UM-Flint.
[c] Reference group = student residence > 5 miles from UM-Flint.

Table 6
Group comparisons within walking zone (<1 mile).

Conditions to increase walking	Faculty[a]		Staff[b]		Students[c]	
	OR	S.E.	OR	S.E.	OR	S.E.
Police presence	7.609	1.073	5.443	1.066	3.238	.755
Lighting	1.889	.713	4.976	1.063	3.254	.754
Safer street intersections	4.186	.812	2.083	.692	2.002	.564
Attractive Flint destination	8.000	1.072	1.550	.614	1.892	.565
Traffic enforcement	6.171*	.813	4.350	.803	2.426	.516
Emergency phones	3.333	.713	1.396	.633	1.379	.463
Inc. fuel costs	5.743**	.673	2.471	.664	0.908	.417
Inc. parking costs	4.286*	.711	3.048	.689	1.344	.418

***Significant at the .001 level.
* Significant 0.05 level.
** Significant at the .010 level.
[a] Reference group = faculty residence > 1 miles from UM-Flint.
[b] Reference group = staff residence > 1 miles from UM-Flint.
[c] Reference group = student residence > 1 miles from UM-Flint.

walking zones. The majority of student and staff respondents were female, whereas the majority of faculty respondents were male. The student gender composition in this study was representative of the university gender composition; 62.1% of the student survey respondents were female compared to 62.0% at UM-Flint as a whole in 2011 (Skarsten, 2010). Of the sample, approximately 90% resided outside of the walkable zone, and 72% resided outside of the bicycling zone. The remaining 10% and 28% lived within a walkable and bicycling zone, respectively; these respondents represented those that may utilize active transportation modes such as walking or bicycling for their campus commute.

4.2. Transportation modes among the survey respondents

Table 3 summarizes the distribution of mode share choices for each university group separately and cumulatively in each of the four zones. The dominant mode choice for the sample was single occupant vehicle (SOV) (77.5%), followed by car pool (10.5%), walking (7.8%) bicycling (2.9%), and mass transit (1.4%). Over the full range of commute trip distances, the predominant mode of transportation for faculty (76.2%), staff (88.5%), and students (71.9%), was an SOV. Staff utilized the SOV most often, regardless of distance from campus. A significant proportion of faculty (52.9%) and students (38.9%) drove alone to campus while residing in a bicycling zone. These mode choice proportions exceed those found at a traditional university (Akar and Clifton, 2009). Eighty-two percent of students walked to campus within the walkable zone and 17% of faculty utilized the bicycle when living within biking distance from campus. Furthermore, students utilized alternative transportation modes more so than the other groups. This result aligns with previous research that indicates students are more inclined to use these modes most often (Akar and Clifton, 2009).

4.3. Bicycling motivators

There was a generally low level of agreement between the groups; in other words, the faculty, staff, and students viewed the proposed interventions differently. From visual inspection of Fig. 2a, students were most receptive to bicycling motivators beyond the bicycling zone. The percent of students who stated they would increase bicycling was greater than that for either faculty or staff for each proposed intervention. At least 50% of students favored a mode shift to bicycling if safer routes, better lighting, and attractive Flint destinations were present. Less than 50% of faculty and staff viewed these bicycling interventions positively. Predictably, all groups that reside beyond five miles were generally not receptive to any of the hypothetical bicycling facilitators.

All groups that lived within five miles (Fig. 2b) said they would increase their bicycling compared to those living beyond this distance (Fig. 2a) for all of the proposed interventions. This outcome is revealed by the elevated level of agreement among the groups for most of the interventions. Specifically, there was a difference of less than 5% between the groups for five of the proposed interventions (safer routes, repair/air stations, bicycle classes, increased parking costs, and increased parking fees), meaning that most groups agreed that these factors would promote their bicycling. Having more attractive Flint destinations was the exception, exhibiting a difference of 41.4% in level of agreement between students

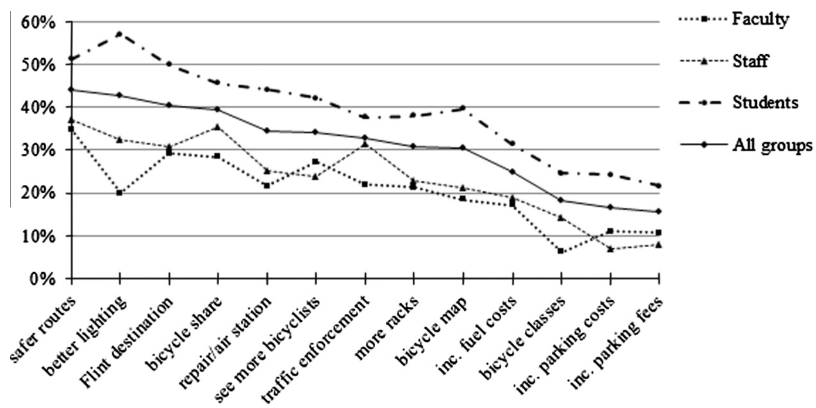

Fig. 2a. Conditions to increase bicycling ⩾ five-mile zone.

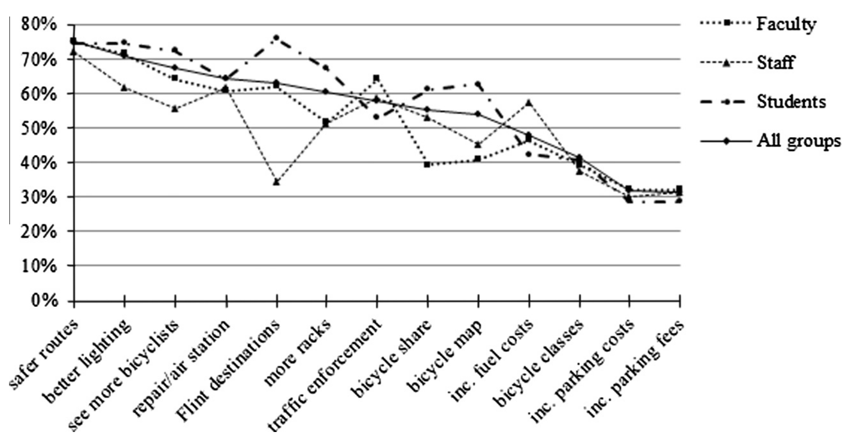

Fig. 2b. Conditions to increase bicycling < five-mile zone.

and staff. Staff were unaffected by the presence of downtown destinations. This response may be a result of their current reliance on the automobile, fixed employment schedules, or lack of bicycle access.

A change in the ranking of interventions between the two zones was observed (Figs. 2a and 2b). Most notably, seeing more bicyclists ranked sixth among all bicycling interventions for those living outside the bicycling zone (Fig. 2a). It ranked as the third most favorable intervention for those in the bicycling zone (Fig. 2b). Therefore, observing other bicyclists is a prominent factor in changing travel behaviors for all groups. Similarly, in prior research, observed bicycling increased real and perceived feelings of safety, thus contributing to increased bicycling (Horton, 2007; Jacobsen, 2003). Policies for increasing the number of bicyclists in the community are proposed in the conclusion.

The model results summarized in Table 4 indicate that differing interventions may cause a mode shift to occur among the three groups. Faculty who lived within a bicycling area were more apt to use a bicycle when safety and education were maximized. Specifically, the proposed interventions that contained the greatest probability of increased bicycling among faculty included improved lighting (OR = 10.000), bicycle classes (OR = 9.868), and traffic enforcement (OR = 6.429). The outcomes indicate the importance of education for faculty and suggest that programming, dissemination of bicycle-related literature, and bicycle safety classes may induce a bicycling mode choice.

Staff within the bicycling zone were dramatically influenced by transportation expenditures. In particular, staff who lived fewer than five miles away from campus were almost six times more likely to bicycle if fuel (OR = 5.768) or parking associated costs (direct parking costs OR = 5.776, parking fees OR = 5.227) increased, compared to staff who lived beyond five miles from campus. This result indicates that staff members are sensitive to parking-cost surges, resulting in an increased probability to utilize bicycling. This result echoes a study by Bonham and Koth (2010), where staff suggested that parking discounts should be provided for those persons bicycling to campus at least some days of the week.

The highest odds of increasing bicycling among students in the bicycling zone were due to seeing more bicyclists (OR = 3.581), having a greater number of bicycle racks on campus (OR = 3.336), and more attractive Flint destinations (OR = 3.125). Previous research supports these results. For example, Bonham and Koth (2010) discovered that students were concerned about bicycle theft and preferred secure bicycle storage on campus. Their work also postulated that bicycle racks help support a bicycle culture by portraying contextual evidence of bicycle friendliness. The positive relationship between student bicycling and attractive Flint destinations also signifies the importance of contextual bicycle facilitators in promoting a mode shift and a bicycle culture. In other words, increasing the number of viable trip destinations may increase social opportunities, create a sense of community, increase safety, and induce student bicycling. This result is supported by Páez and Whalen (2010), who found that students would bicycle more if they lived in a vibrant community. The positive influence on student bicycling from seeing other bicyclists represents a latent demand for social activities that revolve around bicycling. Moreover, prior research has posited that witnessing

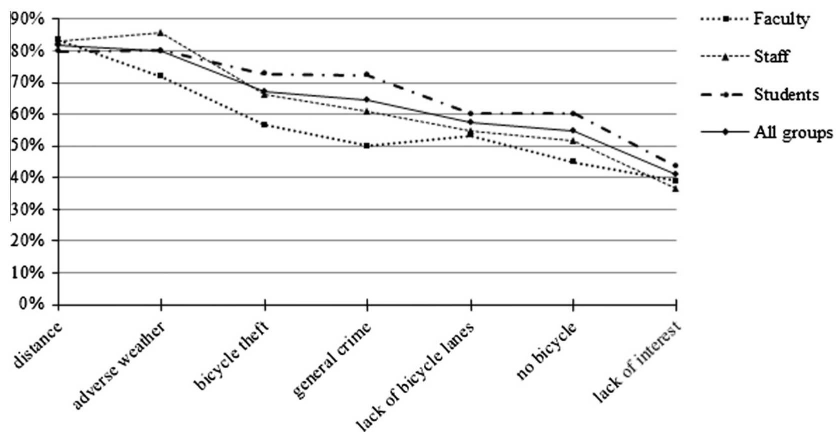

Fig. 3a. Conditions to decrease bicycling ⩾ five-mile zone.

bicycling activity may reduce social stigmas associated with bicycling (Aldred, 2013), increase a sense of belongingness from becoming part of a bicycling citizenry (Aldred, 2010; Steinbach et al., 2011), provide an opportunity to partake in the positive aspects of bicycling (Daley and Rissel, 2011), validate bicycling as a viable utilitarian transport mode (Gaterslebena and Haddad, 2010), and perpetuate feelings of independence (Furness, 2010). Furthermore, Páez and Whalen (2010) found that students would increase their walking/bicycling activity if they did not have to do it alone.

4.4. Bicycling inhibitors

In the non-bicycling zone, a large proportion of the university sample indicated that at least six bicycling inhibitors would decrease their willingness to bicycle (Fig. 3a). Faculty appeared less deterred by the hypothetical bicycling inhibitors than all other groups (Fig. 3a). Moreover, students generally indicated that each bicycling barrier would cause a decrease in bicycling. The greatest level of agreement (3.4% difference) between all of the groups occurred among those residing outside the bicycling zone. This finding seems plausible, as distance is a strong deterrent to non-motorized transportation modes such as bicycling (Carse et al., 2013; Handy et al., 2010). Groups were least in agreement concerning general crime; they exhibited a difference of 22.3%, with students being most deterred from bicycling by this potential barrier.

The three most highly ranked bicycling barriers for all groups in the bicycling zone were adverse weather, bicycle theft, and general crime (Fig. 3b). Adverse weather and crime are known barriers to bicycling. For instance, Ferrell et al. (2008) discovered that neighborhood crime levels altered active travel-mode choice for home-based trips, and Brandenburg et al. (2007) found that weather affected utilitarian and recreational bicyclists. Bicycle theft was also found to be an important barrier to bicycling and is corroborated by previous studies from Mokhtarian and Salomon (2001), Nkurunziza et al. (2012), Shannon et al. (2006), and Koth (2006).

Table 5 displays the probabilities that the hypothetical bicycling barriers would decrease bicycling. Distance appears to be the greatest inhibitor to bicycling among all groups within the bicycling zone. This is evidenced by the reduced odds-ratios (<1) for faculty (OR = 0.113), staff (OR = 0.513), and students (OR = 0.393). In addition, not owning a bicycle had a negative influence on the probability of faculty bicycling near campus, indicating a latent need for better bicycle access (OR = 2.989). Faculty and staff appeared to be dissuaded from bicycling when bicycle lanes were absent; faculty were also deterred when they feared crime. Bicycle theft (OR = 3.214) and not owning a bicycle (OR = 2.200) were associated with decreased probability of student bicycling within the bicycling zone (Table 5). When a criminal element is perceived, these two groups are deterred from bicycling within this zone. As a result, increased law enforcement and safe bicycle facility implementation are two logical tactics to promote bicycling. Consistent with previous findings by Shannon et al. (2006), providing secure bicycle parking to decrease bicycle theft may increase student bicycling. Therefore, providing bicycles to students via a university rental or bicycle-share program may promote more bicycling. This recommendation is supported by Chatterjee et al. (2013) who

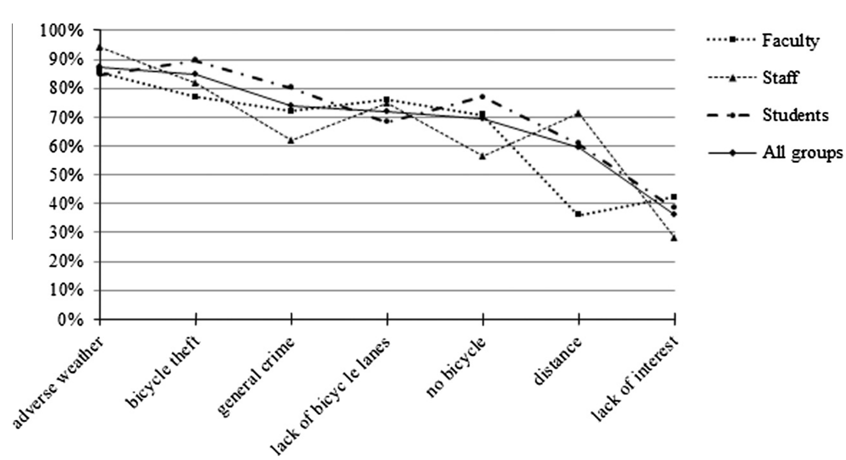

Fig. 3b. Conditions to decrease bicycling in < five-mile zone.

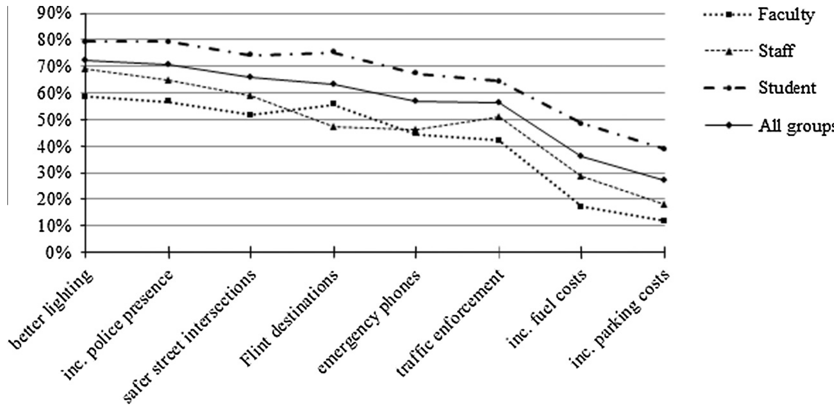

Fig. 4a. Conditions to increase walking in ⩾ one-mile.

discovered that increased bicycle availability spurred more bicycling for those contemplating using this mode.

4.5. Walking motivators

The influence of several proposed walking motivators for those who lived in the non-walking zone is presented in Fig. 4a. It was found that more than 50% of the university population responded favorably to six of the eight proposed walking interventions in this zone. Students displayed the greatest willingness to walk to campus when each of the hypothetical walking conditions was met. In the non-walking zone, the level of agreement among faculty, staff, and students ranged from a difference of 20.8% regarding improved lighting to a 31.3% difference for increased fuel costs.

The inclination to walk was greater among all groups for all interventions within a walking distance of campus compared to groups outside the walking zone (Figs. 4a and 4b). Over 70% of all groups within this zone favored six of the eight proposed interventions (Fig. 4b). The highest agreement among groups (0.3%) occurred in response to increased police presence, demonstrating a strong need among all groups for planning or policies set on increasing personal safety on and near campus. The largest disparity in attitudes towards the proposed walking facilitators occurred in regards to attractive Flint destinations (32.6%), with staff being least receptive to this facilitator. In this zone, an increase in police presence and better lighting were the most popular incentives for all groups when considering walking. Despite a large proportion of staff driving in this zone (84.6%), it appears that policies geared towards increasing personal safety may induce more walking for all groups in this zone.

Attractive Flint destinations (OR = 8.000) and increased police presence (OR = 7.609) increased the odds of a faculty mode shift to walking; these were not statistically significant. Traffic enforcement (OR = 6.171), greater fuel costs (OR = 5.743), and elevated parking costs (OR = 4.286) increased the odds of a faculty mode shift to walking (see Table 6). This result follows Meyer's (1999) supposition that economic disincentives may be the most influential factor to discourage SOV usage. A parking cost increase, therefore, may be an effective university TDM tool. Although lacking statistical significance, the interventions with the highest probability to incentivize walking for staff and students included a greater police presence (staff OR = 5.443; student OR = 3.238), better lighting (staff OR = 4.976; student OR = 3.254), and traffic enforcement (staff OR = 4.350; student OR = 2.426). The odds-ratios evidenced here once again reflect a shared perception among staff and students that an increase in personal safety measures may produce the greatest probability for a mode shift to occur.

5. Conclusion

This study was prompted by the limited research on TDM measures at metropolitan universities dominated by auto-commuting. It was also conducted to address the limited research involving attitudes regarding non-motorized transportation among faculty, staff, and students. This research provides some insights for commuter universities seeking to reach their sustainability goals. An important finding is that TDM incentives could potentially increase utilitarian bicycling and walking at a metropolitan commuter university.

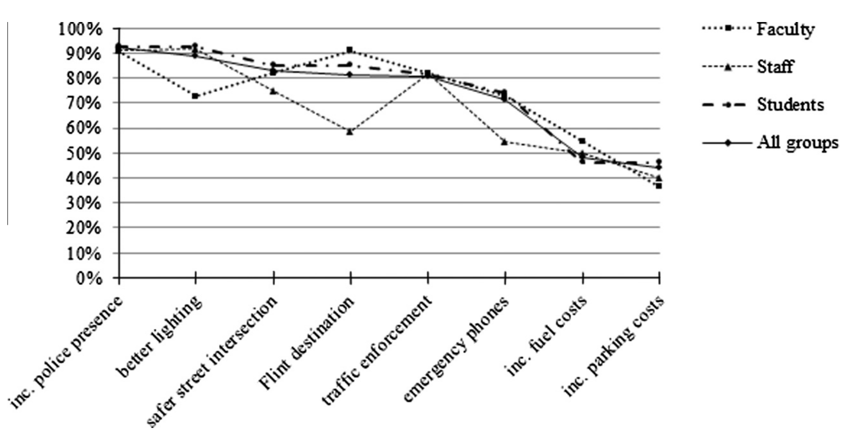

Fig. 4b. Conditions to increase walking in < one-mile zone.

The analysis indicates that faculty, staff, and students would bicycle more if safer bicycle routes, better lighting, and visible bicyclists were present. Universal bicycling deterrents included inclement weather, reduced bicycle security, crime, fear about personal safety, and lack of bicycle lanes. Faculty reported an increased preference for walking and biking if there were more attractive Flint destinations. Staff, however, did not have such an increased preference when attractive Flint destinations were proposed. One interpretation for the lack of such preference is that staff members utilized an SOV most frequently, indicating that they may prefer to visit destinations closer to their place of residence. Staff appeared willing to bicycle if automobile costs increased. Educational classes on bike safety, commuting tips, and street lighting were incentives for faculty to bike. Top incentives for students to bicycle included seeing bicyclists around them, attractive Flint destinations, and secure bicycle racks. The results suggested that bicycle and walking mode shifts were realistic outcomes for all university groups, especially if unique incentives were provided to each group.

The use of distance as a predictor of travel behaviors in this study has certain drawbacks. For example, Whalen et al. (2013) noted that disparate travel behaviors can be found within similar distances from the trip origin. Curtis and Scheurer (2010) echoed this finding and suggested that other accessibility factors such as travel time, cost of transport, travel reliability, frequency of travel opportunities, or any combination of these were a better substitute for distance. Distance, however, has been widely used as one of several possible predictors of travel behavior in prior research. For example, distance categories were used to determine the willingness to bicycle to work in a study conducted by Heinen et al. (2010), and recent research by Páez (2013) suggested that traveler's attitudes are partly based on their geography. In addition, a study by Bonham and Koth (2010) found that university participants would bicycle more if they lived close to campus. Delmelle and Delmelle (2012) revealed that the probability of using active transportation to campus decreased with distance. Therefore, distance is an appropriate predictor in this study as it focuses on a commuter university. A commuter university has a larger variation of commute distances, i.e., geographies (see Fig. 1), compared to a traditional or rural college where most of the population resides in close proximity to campus. Future research may require the use of other travel predictors, some of which have been previously noted in this research.

The results presented in this research have important policy implications. For example, the implementation of policies to reduce the fear of crime, such as increased lighting and police patrol presence, is a necessary first step in promoting walking and bicycling. Afterwards, university policies designed to un-subsidize parking costs may especially promote bicycling among staff, and make other forms of transportation more attractive for all groups. A recommended parking management strategy that charges the full cost of parking to all university users was highlighted by research conducted by Tolley (1996) and Barata et al. (2011). Due to the significant time constraints faced by non-traditional students, facilitating access to bicycles through the implementation of a bicycle-lending system on campus may lead to a bicycle mode shift. In addition, events to promote the attractiveness of Flint destinations, such as organized bicycle rides, bicycle competitions, and bicycle skills safety classes, may further encourage bicycling, especially among students and faculty. Such events, in combination with the installation of safer bicycle routes, bicycle racks, or bicycle repair stations, may help deter the social stigmas related to bicycling and help support a bicycling culture.

Another relevant outcome from this research is the potential for developing a bicycle culture in Flint. A bicycle culture is defined as a mainstream culture supporting bicycle use, and includes social activities, contextual factors, and policy-information (Bonham and Koth, 2010; Furness, 2010). The reason for the development potential of such a culture in the City of Flint is that many of the survey respondents would not bicycle unless more bicyclists were observed in the community. This desire to see more bicyclists can be construed as an indicator of demand for a bicycling culture. To meet this demand, top bicycling motivators that will increase accessibility and mobility need to be incorporated to promote a bicycling culture, in addition to those discovered in this study. Complementary bicycling motivators that have proven successful include car-free zones, bicycle racks on public transit systems, bicycle boulevards, off-street bike paths, bicycle traffic signals, smooth pavement, showers at work places, and organized critical mass rides (Furness, 2007; Pucher et al., 2010; Stinson and Bhat, 2003; Tolley, 1996). Furthermore, coordinated parking policy development among government and private industry entities was seen as one tactic to encourage bicycling on campus (Bonham and Koth, 2010). Future research should investigate the effectiveness of the above-proposed facilitators to promote walking and bicycling longitudinally. Similar to the work by Krizek et al. (2009), an experimental and control group can be compared. For example, the TDM policies suggested in this study and those by Balsas (2003), such as intelligent transportation systems (ITS) on buses or bicycle dismount zones, can be implemented at UM-Flint and then tested longitudinally to determine if the intervention(s) spurred an increase in bicycling or walking when compared to a control site such as Kettering University-located 1.5 miles away from UM-Flint.

Our results underscore the utility in understanding the complex attitudes and preferences for bicycling and walking at a small metropolitan commuter university seeking to become the center of sustainable practice in the community. This research has provided evidence that can be used to develop a comprehensive TDM package in developing a bicycle and walking culture at an automobile-centric metropolitan commuter university comprised of a unique population.

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