Evaluation of bicyclist perceptions of current and future infrastructure for the development of a multimodal transportation system

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ABSTRACT

The purpose of this study was to understand safety perceptions and barriers to bicycling through questionnaire, and to identify infrastructure preferences which would increase intermodal transportation rates. Perception of current infrastructure is unsafe, including bike-lane width, adherence to regulations, driver behaviors, and potential for collisions. Factors that would result in initiation or increase of bicycling were more separated lanes and better lighting. The least preferred infrastructure was a 5-foot lane; the most preferred was a painted 8-foot lane with buffer and posts. Regression-modeling showed those who do not travel by bicycle daily were less likely to prefer the current infrastructure compared to all options. When compared to those who use public transit very often, those using transit less frequently were more likely to choose wider or buffered lanes. If the goal is to increase intermodal transportation, actual and perceived barriers should be addressed.

INTRODUCTION

There are numerous environmental, health, and economic benefits of utilizing both active and public transportation, and a combination of the two (intermodal transportation). The Las Vegas Metropolitan Area (LVMA) is a sprawling, western metropolitan area. This auto-centric design and lack of an older 'urban core' have played a significant role in the development of a public transit system. Fulton notes that cities built in such a manner make it difficult to provide efficient public transit options[1]. In addition, LVMA traffic congestion increased by 35% between 2000 and 2010[2]. Thus, intermodal transport options are a key factor in both efficiency and attraction of users to public transit. In contrast to walking, bicycling enables the users to travel longer distances to access public transit, thus increasing the catchment areas of transit lines. Therefore, integrating bicycling options with public transit in LVMA may be the most effective way to increase public transit ridership.

Several studies have found that investment in bicycle infrastructure results in an increase in bicycling rates. In a review of 14 studies, nearly all cities that invested in infrastructure changes saw an increase in rates of cycling[3]. Cities that invested heavily in bicycle infrastructure have higher than average rates of bicycle commuting[4].

Perceived safety is the most important factor in an individual's decision to travel via bicycle[5]. Study results have been mixed about the transportation infrastructure preferences by bicyclists. In a survey of current and potential cyclists, 71-85% of respondents were likely to choose to cycle on off-street paths, 71% on physically separated routes next to major streets, and 48-65% on residential route[6]. A study of Minneapolis cyclists showed that bike lanes on existing streets were preferred over off-street trails[7].

It is important to understand perceptions of bicycling infrastructure concerning safety and barriers at the local level, as many metropolitan areas differ in urban design. The purpose of this study was to understand LVMA residents perception of the current bicycling infrastructure with regard to safety and barriers; and to identify bicycling infrastructure preferences which have the potential to increase the viability of intermodal transportation.

METHODS

A questionnaire was created which aimed to understand residents perceptions of the current bicycling infrastructure and preferences for future infrastructure. Questions included demographic information (age, race, sex, income), travel characteristics (primary mode of transportation, bicycle and public transit use frequency), safety perceptions and factors that might increase bicycle travel based on documented concerns from existing literature, and respondents were asked to choose an infrastructure type that they would be most likely to use to bike for transportation. The survey contained 41 questions which included Likert scale, multiple choice, open-ended, and demographic questions. Trained surveyors distributed the survey forms to LVMA residents in various areas, including major transit lines, to complete the survey. The surveyors approached residents in local businesses of the surrounding areas, at bus stops and while walking or in common spaces in the area, and during travel on the public transport system. An identical online survey was created and administered through Qualtrics (Provo,UT). The online survey was distributed to local biking organizations and non-biking volunteer organizations identified through local social media. In addition, a snowball method of sampling was used, as respondents were asked to share the survey with local friends and relatives. The survey took approximately ten minutes to complete and no compensation was provided.

The analysis of the data was completed using R Statistical Software. To determine the factors that predicted infrastructure choice, a multinomial logistic regression model was fitted

to the response. This model was used because the dependent variable is discrete instead of continuous, allowing modeling of discrete phenomena. We were interested in characterizing the probability that an individual make a discreet decision conditioned to the values of the factors. In this type of analysis it is necessary to define the reference category in which each result will be compared. Thus, the infrastructure choice which most resembled the dominant infrastructure type in LVMA was used as the reference category (non-painted 5 foot bike lane). The model was fitted to the response to determine the factors that predicted infrastructure choice.

RESULTS

There were 520 surveys completed, 253 from in-person sampling and 267 from online surveys; 67.8% reported using a personal vehicle as their primary mode of transportation, 26.7% reported using public transit (bus), and 6.0% reported using a bicycle. The mean age of the sample was 37.8 years.

When asked about perception of current bicycle and travel conditions with respect to biking for transportation, the majority agreed or strongly agreed that the speed of vehicles was appropriate for bicyclist safety, yet respondents felt that many of the current conditions are unsafe. The majority of respondents either disagreed or strongly disagreed that the bike lanes are wide enough for bicyclist safety; with adequate signage to remind drivers to be aware of biking zones and courteous to bicyclists; that drivers abide by the current laws and regulations; and that the likelihood of a collision between a vehicle and a bike was low. However, the respondents felt that the likelihood of a collision between a bus and a bike and/or a pedestrian and a bike was low. Table 1 provides additional information about perceptions of the current bicycle and travel conditions in LVMA.

When asked about safety concerns related to biking for transportation, the most commonly reported concern was motorists/distracted drivers (87.3%), followed by conflicts or collisions with vehicles (68.1%), and speed of vehicles (65.2%). When asked about the factors that would initiate or increase the level of biking, the most common factor was separation of bike lanes from vehicle traffic (65.2%), followed by an increase in bike lanes (60.8%), and better lighting around routes (45.6%). Table 1 shows all reported safety concerns and factors associated with initiation or increase of level of biking.

TABLE 1 Safety Concerns Regarding Biking for Transportation and Factors Result in Starting or Increasing Level of Bicycle Travel

Safety concerns about biking for transportation	**%**
Motorists/distracted drivers	87.3
Speed of cars	65.2
Too many cars/trucks	43.9
Conflicts or collision with cars/trucks	68.1
Potential for crime	22.3
Conflicts or collision with pedestrians	17.3
Conflicts or collision with other bicyclists	10.0
Other	12.2
I have no safety concerns	2.9
Factors that would result in starting or increasing level of bicycle travel	**%**
More bike lanes	60.8
Bike lanes separated from traffic	65.2
Secure bicycle parking	37.1
Reduced speed of cars	25.8
Showers and lockers at destination	26.7
Better lighting around routes	45.6
More people cycling	37.5
Lower cost than personal vehicle commuting	12.9
More bike racks on the buses	17.9
The availability of a rental/shared bike	18.7
Incentives from work or school (ie: discounted bus pass/monthly stipends)	33.8
More information about where the bike lanes and paths are located	39.2
More information about where I can access public transit (bus)	13.1
More information about cost of bike and transit commuting	11.2
Other	11.9

The respondents were given a choice of seven different bicycling infrastructure options in picture format and were asked to choose one option, which they would be most likely to use. The most commonly chosen infrastructure was option C (27.6%), a painted 8-foot bicycle lane with a 3-foot buffer and reflective posts on a non-major roadway. The least chosen infrastructure was option A (2.2%), a non-painted 5-foot bicycle lane with no buffer on a non-major roadway. Figure 1 shows a picture and description of all seven bicycling infrastructure options and the frequency in which that option was chosen.

1 (A) Non-painted 5 foot bike lane with no buffer on non-major roadway
2.2%.

1 (B) Non-painted 8 foot bike lane with 3 foot buffer on non-major roadway
26.8%.

1 (C) Painted 8 foot bike lane with 3 foot buffer and reflective posts on non-major roadway.
27.6%.

1 (D) Non-painted 8 foot bike lane with 3 foot buffer and reflective posts on non-major roadway
4.7%.

1 (E) Non-painted 8 foot bike lane with no buffer on major roadway
5.7%.

1 (F) Off-road trail
20.0%.

1 (G) Shared bus and bike lane on major roadway.
12.9%

FIGURE 1 Picture and description of each infrastructure option and frequency chosen as the infrastructure most likely to be utilized.

A multinomial logistic regression model was used to determine factors that predicted infrastructure choice. A linear model was run on the response as a function of the predictors to ensure that there was no issue with multicollinearity; only predictors with Variance Inflation Factors (VIF) <10 were included. Infrastructure A was used as the reference category because it represents the current biking infrastructure in LVMA. Table 2 shows the multinomial regression model for all coefficients.

TABLE 2 Multinomial Logistic Regression Model Results Reflecting Choice of Infrastructure.

	Infrastructure choice											
	B		**C**		**D**		**E**		**F**		**G**	
	B	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
Bike daily [a]	-1.0	0.8	-2.5*	0.8	-2.2*	1.01	-1.0	0.911	-2.7*	0.857	-1.9*	0.9
Age	0.03	0.03	-0.01	0.3	-0.01	0.04	0.04	0.036	0.02	0.033	0.04	0.04
Gender [b]	-0.9	0.7	-0.5	0.7	-0.4	0.8	-0.3	0.774	-0.3	0.668	-0.9	0.7
$30-49,999 [c]	0.4	1.3	0.6	1.2	0.6	1.4	0.9	1.415	0.69	1.233	1.0	1.3
$50-69,999 [c]	0.6	1.1	-0.6	1.1	-1.3	1.5	0.2	1.281	-0.8	1.095	0.7	1.1
$70-89,999 [c]	12.8*	0.5	11.1*	0.6	11.5*	0.9	12.9*	0.759	10.8*	0.685	14.0*	0.5
$90-150,000 [c]	1.4	1.3	-0.3	1.4	0.5	1.6	14.	1.465	1.2	1.341	1.6	1.4
Greater than $150,000 [c]	0.7	1.4	-0.9	1.5	-0.2	1.8	0.9	1.524	-0.7	1.476	1.1	1.5
Public transit-often [d]	16.3*	0.9	1.2	1.4	2.2	1.6	-0.3*	0.000	1.9	1.431	1.2	2.0
Public transit-rarely [d]	16.3*	0.7	-0.5	1.1	1.4	1.4	16.0*	0.809	0.5	1.175	2.8	1.5
Public transit-very rarely [d]	18.2*	0.9	0.9	1.4	-11.7*	0.00	16.9*	0.977	1.7	1.459	3.8*	1.8
Public transit-never [d]	18.1*	0.8	0.5	1.2	2.0	1.5	17.0*	0.809	1.3	1.260	3.8*	1.6
Number vehicles in household	-0.4	0.3	-0.3	0.3	-0.4	0.4	-0.7	0.397	-0.4	0.317	-0.4	0.3

n=489,*p-value≤0.05, SE = standard error

a.reference category: no bike trips daily b.reference category:females

c.reference category: less than $30,000 d.reference category:public transit-very often

CONCLUSIONS

It is essential to understand perceptions of bicycling infrastructure concerning safety and barriers at the local level to effectively plan for future development. Given the results in this study, it is apparent that LVMA residents perceive many barriers to bicycling related to safety and infrastructure type. If the goal is to increase intermodal transportation by integrating bicycling with public transit, actual and perceived barriers need to be adequately addressed.

The most interesting finding was that the infrastructure type, which was chosen the least by the respondents, resembles the current bicycling infrastructure in LVMA. Only 2.2% of respondents chose the non-painted 5-foot bicycle lane with no buffer on a non-major

roadway and 5.7% chose the non-painted 8-foot lane with no buffer on a major roadway. In order to increase intermodal transportation, the infrastructure needs to be one, which residents are likely to use. This information will be useful in determining the future infrastructure type to invest in, as well as understanding how best to retrofit existing lanes, when appropriate.

There were many safety concerns; it appeared that many of the perceived barriers were about joint bicycle-vehicle travel and driver behavior. This issue can be addressed by raising awareness of specific courteous behaviors surrounding joint travel and the importance of being aware of bicyclists and abiding by all regulations put in place to ensure safety, such as giving the bicyclist a minimum of 3 feet of space while passing. Research shows that persuasive or emotional campaigns are more effective at behavior change than educational campaigns[8]. A safety campaign, such as the United Kingdom's Automobile Association's (AA) "Think Bikes" campaign and Fort Collins, CO "Coexist" campaign are two examples, which humanize cyclists and remind drivers and bicyclists to be aware and courteous of one another. Implementation of such a campaign in LVMA is a necessary first step in addressing many of the safety concerns, as perceived safety is one of the most important factors in decisions surrounding travel choice[5].

It was hypothesized that residents might find the speed of vehicles to be unsafe, given that the majority of roadways throughout LVMA have a posted speed limit of 35 or 45 miles per hour. One survey question revealed that about 69% of respondents agreed that vehicle speed was appropriate for bicyclist's safety, while 65% reported speed of vehicles as a barrier to bicycling in a different question. European cities have more active transport than many American cities, with 25 to 40% of trips consisting of non-motorized travel. European studies have shown that traffic calming significantly increases bicycle travel, bicyclist safety, and reduces the number of crashes. Further, the average speed limit in many residential areas of Europe is about 19 miles per hour with the overall speed limit being 31 miles per hour[9]. This, coupled with many of the auto-restrictive policies, make driving inconvenient, thus encouraging active and intermodal transport. Given the overwhelming evidence that speed reduction increases bicyclist safety, traffic calming measures on LVMA roads, which contain bicycle infrastructure should be investigated.

When examining the multinomial model, those who reported biking daily were less likely to choose infrastructure options which offered more protection from vehicles than the option similar to current infrastructure. It is likely that exposure to the current infrastructure has resulted in increased perceptions of safety when compared to those who do not bike daily. It is possible that increased exposure to the current infrastructure for those who do not bike daily would result in increased perceptions of safety without requiring a large number of infrastructure changes. However, to make a significant increase in the rate of intermodal transit users, it is essential to target those individuals who do not bike daily. Creating infrastructure options, which are perceived as safe, are a critical component to achieving that increase.

The residents with an annual income of $70,000-89,999 were significantly less likely to choose infrastructure A than all other infrastructure types. Given that infrastructure A is similar to the current infrastructure in LVMA, this is likely indicative that this population does not prefer the current infrastructure. In addition, this was the smallest subcategory (n=43) and only two individuals reported biking as their primary mode of transportation; exposure to the current infrastructure would likely increase their perceptions of safety. Even so, it is critical that those who do not currently travel by bicycle perceive it as a viable option in order to increase rates of intermodal transit.

When those who use public transportation very often were compared to those who use it less frequently or never, the latter choose infrastructure B over A. Infrastructure B offers more protection from vehicles by providing a 3-foot painted buffer. Those who take public transit very often likely observe bicyclists using the current infrastructure and thus, perceive it as a safer option than those who may not observe use. Initially it was hypothesized that infrastructure E would be perceived less safer zone and less likely to be chosen by the residents. However, those who reported taking public transit either rarely, very rarely, or never were more likely to choose either infrastructure E or G over A. Infrastructure E offers a wider bicycle lane (8-feet versus 5-feet) and G offers a shared bike/bus lane, both are on a major arterial street. Again, those who are exposed to the public transit system have likely experienced the use of the current infrastructure and may have a different perception than those who have not.

Given the sprawling urban design of LVMA, intermodal transportation, which incorporates bicycle travel is likely to create the most efficient transportation option. To effectively increase intermodal transportation rates, resident's perceptions of safety and infrastructure preferences need to be considered. The results from this study revealed that survey respondents have many safety concerns with the current bicycling infrastructure and provides ideas for future infrastructure investments and related policy in LVMA.

REFERENCES

1. Fulton, W., R. Pendall, M. Nguyen, and A. Harrison. *Who sprawls the most?: How growth patterns differ across the U.S.* Center on Urban & Metropolitan Policy, The Brookings Institution, 2001.
2. Schrank, D., T. Lomax, and B. Eisele. *The 2011 urban mobility report. texas transportation institute.* The Texas A&M University System: Texas Transportation Institute, College Station, TX, 2012.
3. Pucher, J., J. Dill, and S. Handy. Infrastructure, programs, and policies to increase bicycling: An international review. *Preventive Medicine,* Vol. 50, 2010 pp. s106-s125.
4. Dill, J., and T. Carr. Bicycle commuting and facilities in major U.S. cities: If you build hem, commuters will use them - another look. CD-ROM. Presented at Transportation Research Board Annual Meeting, Washington D.C., 2003
5. Tilahun, N., D. Levinson, and K. Krizek. Trails, lanes, or traffic: Valuing bicycle facilites with an adaptive stated preference survey. *Transportation Research Part A: Policy and Practice,* Vol. 41, 2007 pp. 287-301.
6. Winters, M., and K. Teschke. Route preferences amoung adults in the near market for bicycling: Findings of the cycling in cities study. *American Journal of Health Promotion,* Vol.25, No. 1, 2010, pp. 41-47.
7. Krizek, K. Two approaches to valuing some of the bicycle facilities' presumed benefits: Propose a session for the 2007 national planning conference in the city of brotherly love. *Journal of the American Planning Association,* Vol. 72, No. 3, 2006, pp. 309-320.
8. Delaney, A., B. Lough, M. Whelan, and M. Cameron. *A review of mass media campaigns in road safety, No 220,* Monash University Accident Research Center, Victoria, Australia, 2004.
9. Pucher, J. Making Walking and Cycling Safer: Lessons from Europe. *Transportation Quarterly,* Vol. 54, No. 3, 2000, pp. 25-50.