EXPLORATORY ANALYSIS OF HIGH SCHOOL STUDENT TRAVEL SURVEY IN SACRAMENTO

A Project

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Nasha Pailin Wu

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Department of Civil Engineering

Abstract

of

EXPLORATORY ANALYSIS OF HIGH SCHOOL STUDENT TRAVEL SURVEY IN SACRAMENTO

by

Nasha Pailin Wu

Physical activity has many health benefits. Recently many young people do not meet recommended levels of physical activity. Active commuting to school provides an opportunity to increase the daily physical activity levels. However, the rates of walking and bicycling to school have been declining for years. Knowledge of factors that influence the decision to bicycle could be useful information to policy makers and authorities for the development of policies or programs that encourage high school students to bicycle more. Many studies have been conducted to examine factors associated with bicycling to school. However, there are a limited number of studies focused on high school students.

The purpose of this project is to provide a better understanding of what encourages or discourages bicycling among high school students using data from a survey collected in 2010 at Hiram Johnson High School in Sacramento. The analysis indicated that a combination of individual, social environmental, and physical

environmental factors were associated with bicycling to school among high school students. Individuals' attitudes and preferences toward mode choice were found to be important factors that influence the decision to bicycle. Owning a bicycle does not guarantee its use. Of the students who live within bicycling distance (a 2.5-mile radius), 43% own a bicycle but only 4% indicated that they bicycled to and from school. Peers' and parents' attitudes and behaviors also seemed to influence the decision to bicycle. Compared to non-bicyclists, bicyclists were more often to agree that their friends bicycled to school (33.3% for bicyclists vs. 15.6% for non-bicyclists), their parents bicycled frequently (33.3% for bicyclists vs. 10.5% for non-bicyclists), and their parents encouraged them to bicycle (22.2% for bicyclists vs. 17.7% for non-bicyclists). Parents also play an important role by providing resources for different modes of travel.

For the physical environment, less than 30% of all respondents agreed that they felt safe walking or skateboarding to school, and less than 20% of non-bicyclists reported that the felt comfortable bicycling on a busy street with a bicycle lane, all of which suggest that infrastructure can be an important factor on the decision to bicycle. Overall, the results suggest that multiple efforts are need to increase the rates of bicycling among high school students.

_____, Committee Chair

Kevan Shafizadeh, Ph.D., P.E., PTP, PTOE

_____

Date

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Chapter 1

INTRODUCTION

The purpose of this project is to offer a quantitative analysis of a high school student travel survey conducted in Sacramento to seek a way to improve and promote the use of bicycling to school by high school students. The project aims to have a better understanding of the preferred modes of transportation by high school students and to identify potential reasons why students may not bicycle more. It offers an explanation of how students can be encouraged to bicycle or use non-motorized modes of transportation. The project also offers qualitative engineering and policy recommendations to authorities and policy makers of the school where the data were collected to encourage the use of bicycles. This project consists of the analysis and examination of travel survey data collected at Hiram Johnson High School (HJHS) in the City of Sacramento in the spring of 2010. The survey was distributed to students from 9th through 12th grade. Student participation was voluntary.

Physical activity has many health benefits (Oja et al., 2011), but recently many young people do not meet recommended levels of physical activity (Nelson et al., 2008). Chillon et al. (2010) suggested that active commuting, especially bicycling, may provide an opportunity to increase daily physical activity levels. There are numbers of studies that showed a positive relationship between bicycling and health benefits in children and adolescents. Children and adolescents who walk or bicycle to school have significantly higher levels of physical activity than those who travel by other modes (Andersen et al.,

2009; Faulkner et al., 2009). However, the rate of walking and bicycling to school has decreased in recent years, while motorized travel has increased (McMillan, 2007). Policies and programs such as Safe Routes to School were created as an attempt to increase active commuting among youths (McMillan, 2007; Nelsonet al., 2008). Knowledge of factors that influence on decision to bicycle could provide useful information to policy makers and authorities for the development of policies or programs that might effectively encourage high school students to use active travel as their mode of transportation. Many studies have been conducted to examine factors associated with bicycling to school (e.g. Pont et al., 2009; Nelson et al., 2008; Emond and Handy, 2012). However, there is a limited number of previous studies that focused on high school students.

Chapter 2

LITERATURE REVIEW

There are many studies that support a positive relationship between bicycling and health benefits in children and adolescents. Oja et al. (2011) did a systematic review of several bicycling-specific studies to update the evidence on the health benefits of bicycling and concluded that many existing studies provided strong evidence to support health benefits of bicycling in people of all ages. Their study found that "in children and adolescents, there is strong evidence for improved cardiorespiratory endurance and muscular fitness, favorable body composition, improved bone health, and improved cardiovascular and metabolic health biomarkers" (Oja et al., 2011, p. 496).

Other studies also suggest that bicycle commuting offers health benefits in adolescents. Cooper et al. (2006) studied the relationship between travel modes to school and cardiovascular fitness among primary school children. The method grouped children by modes of travel to school, used an accelerometer to record physical activities and used questionnaires to describe travel habits. The study showed that children and adolescents who bicycled to school were nearly five times as likely to be in the top quartile of fitness. They were significantly higher in cardiovascular fitness than the other children and adolescents who walked or traveled by car or bus. Andersen et al. (2009) studied the relationship between the modes of transport to school and different aspects of fitness of students 15 to19 years of age. Physical fitness was estimated through number of field tests. They found that students who bicycled to school had higher aerobic power, muscle

endurance, and flexibility than students who walked or were passive commuters. Cooper et al. (2008) conducted a six-year study to investigate association between the change of transport modes to school and the cardiorespiratory fitness of children who were recruited to participate in 1997 and were studied six years later. The study showed that higher fitness was significantly associated with bicycling to school. Young people who changed from non-bicyclists to bicyclists were more fit than those who remained as non-bicyclists. They concluded that regular bicycle commuting was associated with higher cardiovascular fitness in adolescents.

The value of health benefits versus risk injury has also been a concern. A few years ago, de Hartog et al. (2010) did a study to compare the health benefits gained when shifting from automobile to bicycle in urban commuters and the health risks due to traffic accidents and mortality effect of the increased inhaled air pollution. They concluded that for an individual, the health benefits of bicycling were greater than the risks. For society, the benefits are larger due to the reduction in air pollution emissions and traffic accidents.

Bicycling should be promoted as an important part to improve population health (Cooper et al., 2008; Oja et al., 2011). Public health policies should develop to support the promotion of bicycle friendly environments that enhance bicycling commuting among youths (Chillon et al., 2010). However, many factors, including social environmental and personal factors are likely to influence decision to bicycle (Oja et al., 2011).

Emond and Handy (2012) conducted a study to provide a better understanding of factors that influence bicycling among high school students. Their analysis identified

three important levels of factors that affected student bicyclists as individual, social-environment, and physical-environment. Individual factors include gender, age, driver's license status, attitudes and preferences toward modes of travel are likely to be important factors that influence bicycling behavior. Babey et al. (2009) reported that adolescents who were from lower income families, attending public school, and living in urban areas were more likely to have active commutes. Female students have lower levels of active travel to school, and bicycling rates drop as adolescents are old enough to obtain a driver's license (Emond & Handy, 2012). McDonald (2007), as cited by Babey et al. (2009), found that children and adolescents in households with no vehicles were more likely to walk or bicycle to school. However, Babey et al. (2009) reported that household vehicle access is not significantly related with active commuting.

The social environment factors which include peer-influences, parental-influence, and community influences, have been identified as another important factors for youth travel behavior (Emond & Handy, 2012). High school students are influenced by their parents' encouragement and behavior. Emond and Handy (2012) stated that "parents who encourage bicycling seem to make a positive difference, while parents who readily provide rides apparently deter bicycling" (p. 78). They also cited a previous study done by Tal and Handy in 2008, which indicated the importance of bicycling-oriented families, were consistent with their finding. However, safety from traffic is not a major barrier for active commuter in adolescents (Bungum et al., 2009), as well as parental perception of general neighborhood safety. Babey et al. (2009) reported that parental perceptions of

neighborhood safety were not associated with active commuting to school among adolescents.

Physical environment such as distance between home and school was frequently cites as the most important barrier to active commuting (Babey et al., 2009; Lubans et al., 2011; Nelson et al., 2008). The active commuting rate decreases as the distance increases (McMillan, 2007). If students think that school is too far, they are not likely to bicycle (Emond & Handy, 2012). Nelson et al. (2008) suggested that distance of 2.5 miles is a threshold for active commuting to school. School should be located within 2.5 miles of residential area and physical barriers between students and school, such as a freeway, should be avoided where possible (Emond & Handy, 2012; Nelson et al., 2008).

Chapter 3

DATA COLLECTION AND MEASURES

Background on Hiram Johnson High School

Hiram Johnson High School is a high school in the Sacramento City Unified School District (SCUSD). It was established in 1985 and served as a primarily middle-class community (Sobredo et al., 2008). It is a public school that serves students from 9th through 12th grade. There were 1,899 students enrolled during the 2010-2011 school year, of which 912 were female and 987 were male (CALPADS, 2010). The school's ethnicities are 40.2% Hispanic or Latino, 29.2% Asian, 13.5% African-American, 9.1% White, and 8.0% Other (CDE, 2013). The school is located at the corner of 14th Avenue and 65th Street in Sacramento, California. The school location is shown in Figure 1 below.

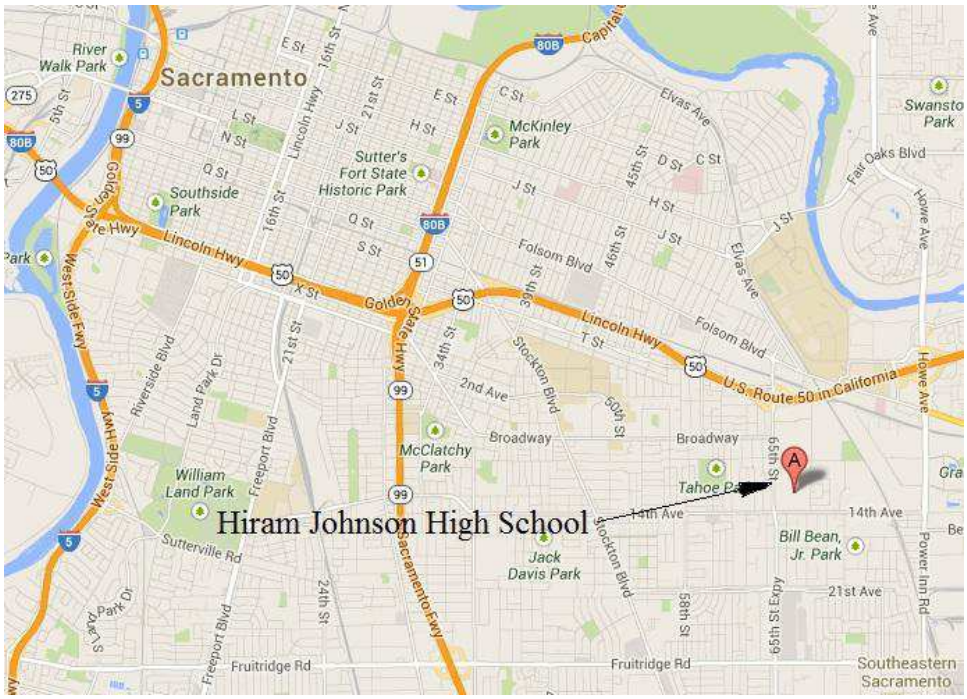

Figure1: Location of Hiram Johnson High School (HJHS)

Source: Google Maps 2013

The section of 14th Avenue, which is in the front of the school, is a two-lane road. At the intersection of 65th Street, the westbound lanes of 14th Avenue are separated into one dedicated left turn lane, one through lane, and one dedicated right turn lane. There are three crosswalks on the section of 14th Avenue in front of the school in addition to the crosswalks at the intersection of 65th Street. 65th Street is a north-south, five-lane arterial that located on the west side of the school perimeter. The section of 65th Street is separated by a two-way left-turn lane (TWLTL). The northbound and southbound directions have two lanes on each side. However, as the southbound lanes get closer to

the intersection of 65th Street and 14th Avenue, the TWLTL changes into a designated left turn pocket for vehicles making a turn onto the eastbound 14th Avenue.

There are three bus stops located near the intersection of 65th Street and 14th Avenue. One is located on northbound 65th Street near the school parking lots, serving bus line 81. Another stop is located on westbound 14th Avenue, at the west side of the intersection, serving bus line 212. The other bus stop is located on the southbound of 65th Street at the south side of the intersection, serving bus lines 81 and 212. The bus stops and crosswalks near the school are shown in Figure 2 below.

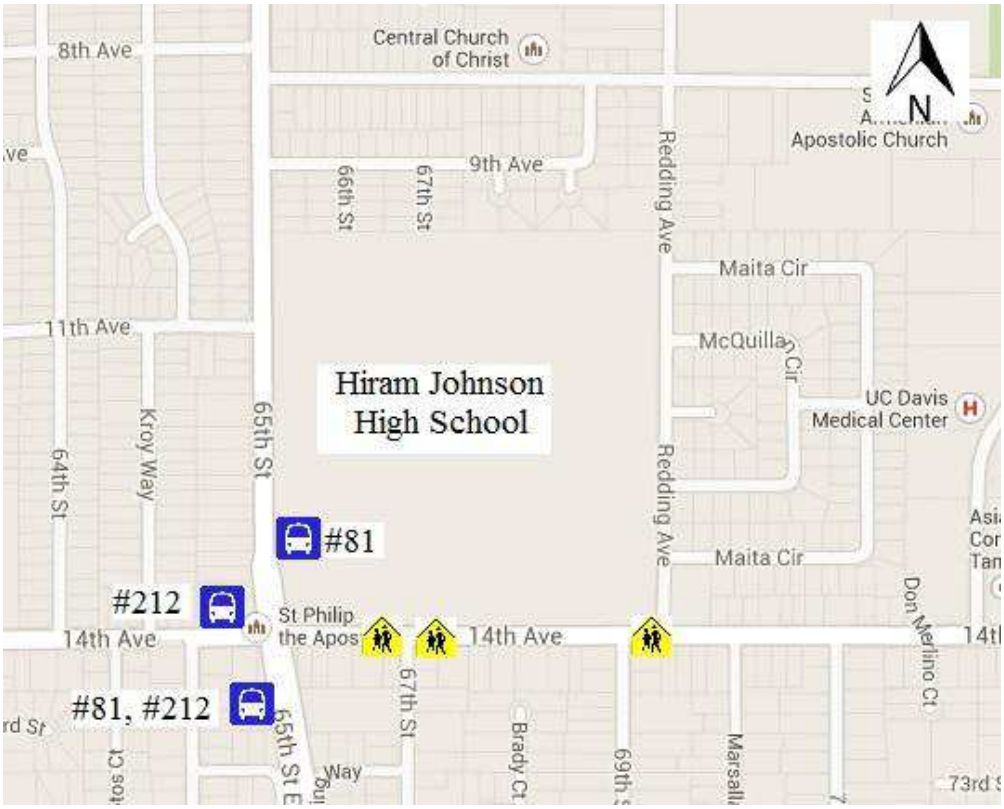

Figure 2: Location of Bus Stops and Crosswalks near HJHS

Designated bicycle lanes on 65th Street were installed at the intersection of Stockton Boulevard and 65th Street, 2.8 miles south of the school, and continue north along the roadway and end at the intersection of 14th Avenue and 65th Street where Hiram Johnson High School is located. There is no designated bicycle lane on the section of 65th Street around the school perimeter. The section of 14th Avenue south of the school perimeter is currently an on-street bicycle route connecting to designated bicycle lanes further east on 14th Avenue. The existing bicycle lanes near Hiram Johnson High School are shown in Figure 3 below.

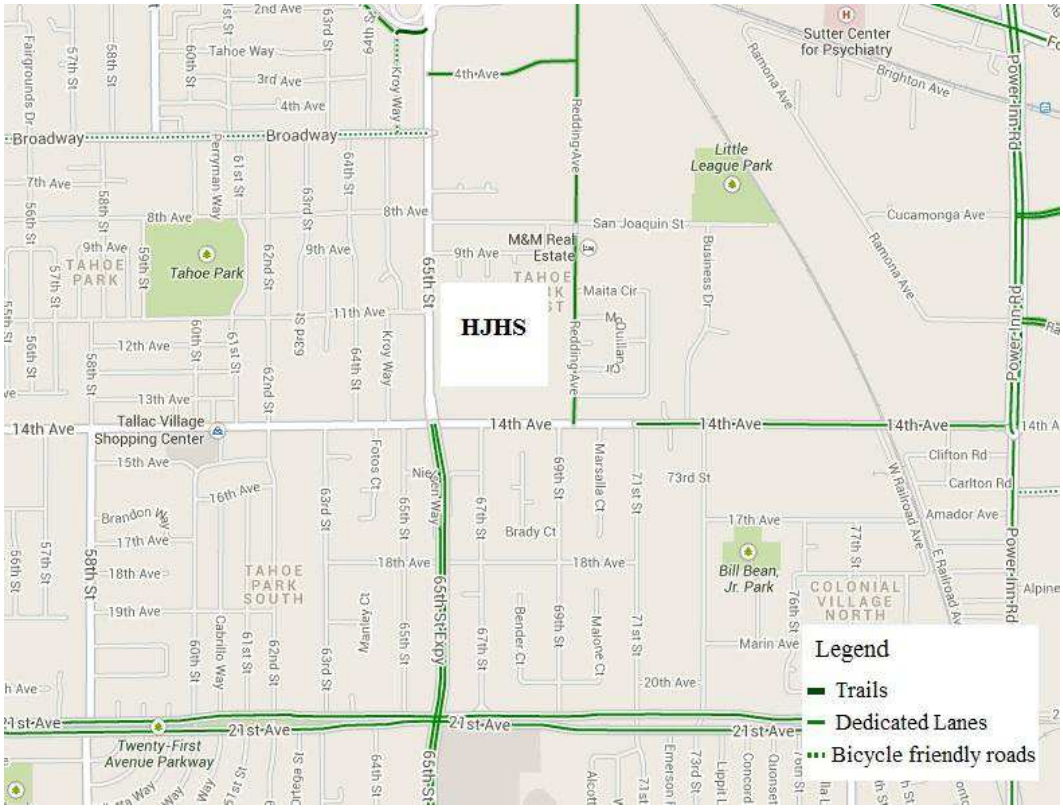

Figure 3: Existing Bicycle Facilities near Hiram Johnson High School

Source: Google Maps 2013

Data Collection and Measures

Surveys were distributed to students in the entire school from 9th through 12th grade during the school's third period between 10:29 a.m. to 11:24 a.m. on Wednesday, May 26, 2010 and Wednesday, June 2, 2010. Teachers of 94 classes were given packets of surveys based on the number of students enrolled in their classes. Surveys were distributed, completed, and collected at the end of the period. The survey was designed to be completed in approximately 10 minutes and was distributed only in English. Student

participation was completely voluntary. Student identification was not collected, and the completion of the entire survey was not required.

The survey was two pages long, included 17 questions and 33 agree-disagree statements. The survey was originally designed by University of California Davis (Emond & Handy, 2012). The questions included demographic characteristics (grade, age, gender, driver's license status and parents' education level), mode of travel to and from school on the day of the survey, usual modes of travel to and from school, after school activities, access to car and bicycle, frequency of using bicycle and public transportation and the street on which the students live as well as its nearest cross-street intersection. The agree-disagree statements addressing on individual factors, social-environment factors and physical environment factors associated with travel to school, using 5-point ordinal scale from strongly disagree (1) to strongly agree (5). The individual factors included: mode preferences, bicycling ability, behaviors and attitude toward bicycling. Social-environment factors included: influence on bicycling. Physical-environment factors included: bicycle route and perceived distance.

An assumption was made that the decision about the modes travel to school was made by the students themselves. Therefore, the survey focused primarily on the students. Parental/guardian education level was obtained to determine socio-economic status. The nearest street intersections to the students' home were obtained and plotted on a detailed street level map to determine distance to school from where the students live. The center of the school was placed at the center of a circle. The 2.5 mile radius of the

school was used as a threshold for bicycling for high school students based on a previous study (Nelson et al., 2008). The numbers of students who live within 2.5 miles were manually counted. Students who reported that their usual mode to, from, or both to and from school was bicycle were categorized as bicyclists.

Chapter 4

RESULTS

A total number of 1,775 surveys were distributed. Of that number, 435 students completed the survey, which correspond to a response rate of 24.6%. Of all the respondents, 204 were male and 231 were female. The average age of student respondents was 16.3 years. The majority of both male and female respondents did not have a driver's license. However, 78.4% of the students who did have driver licenses had access to a vehicle. There were 42.1% of all respondents who had access to a bicycle. Additional student demographics are presented in Table 1 below.

Table 1: Students Demographics

	% of all respondents
Grade 9th	27.6
Grade 10th	20.0
Grade 11th	26.2
Grade 12th	26.2
Age 15 years and younger	28.7
Age 16 years	26.0
Age 17 years	26.0
Age 18 years and older	19.3
No driver's license	81.8
Driver learner's permit	9.7
Provisional driver's license	3.7
Regular driver's license	4.8
Access to a vehicle*	78.4
Access to a functioning bicycle	42.1
Parent/Guardian's highest education:	
Some high school	20.9
High school	23.0
Some college	17.5
Associate degree	4.8
Bachelor degree	1.8
Advanced degree	0.7
Other	31.3

*For students with provision or regular license

The most popular usual mode of travel to school and from school was “someone drives me” which accounted for 67.6% and 61.4%, of all respondents, respectively as shown in Figure 4 below. This mode share is far higher than all the other modes combined. Female respondents reported that someone usually drives them to and from school more than male respondents (71.0% and 64.5% for females vs. 63.5% and 57.6% for males). Bicycling was not a popular mode for high school students; less than 2.3% of respondents reported bicycling to travel to and from school both as a usual mode and on the day the survey was conducted. However, some of this pattern may have resulted from habits formed in middle school. There were 60.2% of female respondents and 48.8% of male respondents reported that someone usually drove them to their middle school. Only 12.3% of male respondents and 1.3% of female respondents reported that they usually bicycled to their middle school.

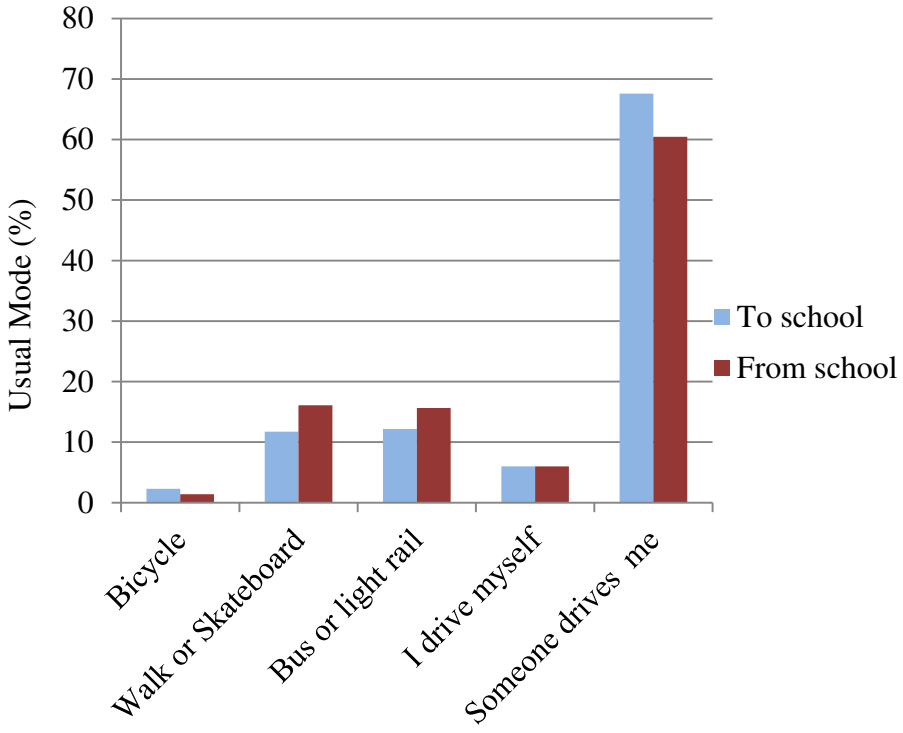

Figure 4: Usual Mode of Travel To and From School

The majority of respondents reported that they never or rarely participated in after-school activities at the high school or in town (61.8% and 73.5%, respectively). Figure 5 below showed that of all the respondents, 84.1% reported that they never or rarely bicycled to places other than school, and 74.9% never took the bus or light rail to places other than school. Only 5.3% of all the respondents reported they rode a bicycle daily; of that number, all of respondents were male and did not have a regular driver's license.

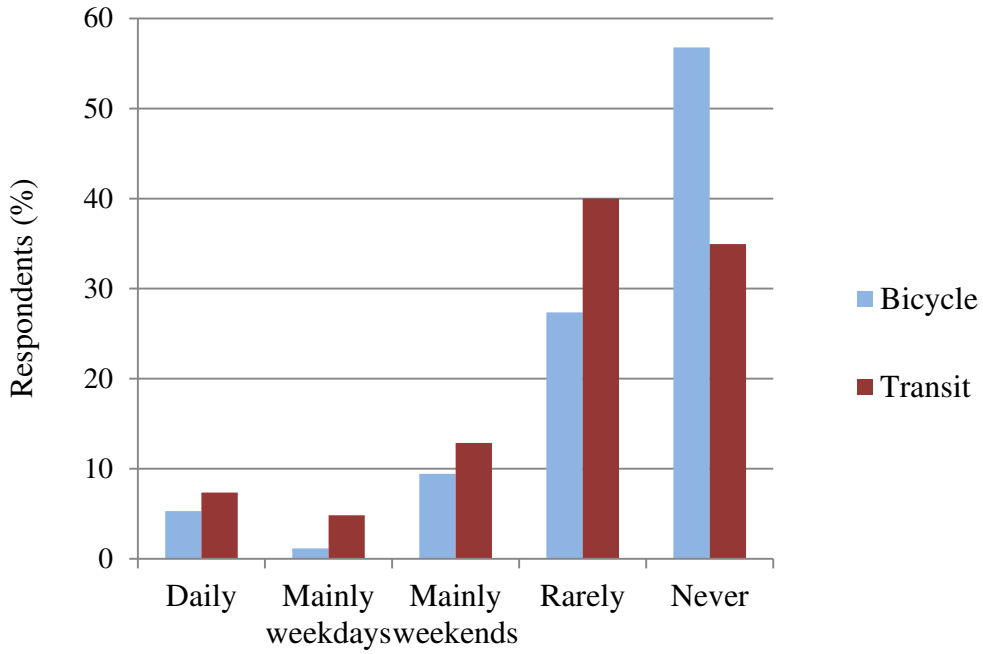

Figure 5: Percentage of Students Using Bicycle and Transit to Places Other Than School

There were 78.9% of the respondents who lived within 2.5 miles and 17.5% who lived further than 2.5 miles from the school. Figure 6 below illustrates the 2.5-mile radius from school and the students' home locations. Even though 2.5 miles is achievable active commuting to school distance (Nelson et al., 2008), of those who lived within 2.5 miles, over 65.0% reported that their usual modes of travel to and from school was "someone drives me" or "I drive myself." About 11.5% reported that they took the bus or light rail,

only about 15.5% reported that they walked, and less than 2.6% reporting that they bicycled.

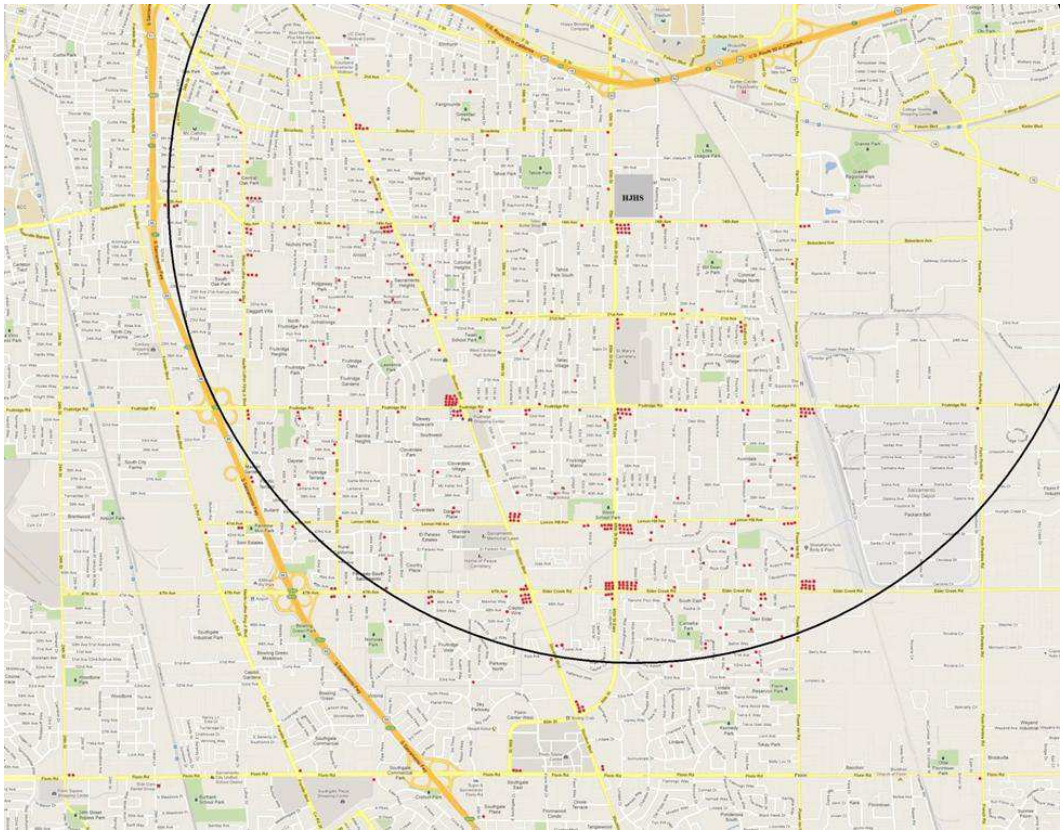

Figure 6: Students' Home Locations and 2.5-Mile Radius

Of the 435 responses, 425 students reported not usually bicycling to or from school, while only 10 respondents, reported usually bicycling to and from school and were categorized in this analysis as bicyclists. There were nine bicyclists reported living within 2.5 miles radius from school and one bicyclist did not report his home location. Of

those who lived further than 2.5 miles, over 96.0% of them reported that their usual modes of travel to and from school was passive commuting which were “I take the bus or light rail,” “I drive myself,” or “someone drives me.” A very small percentage of the respondents reported that they usually walked or skateboarded.

A summary of results from the statements with ordinal agree/disagree responses is shown in Table 2. The results show those bicyclists and non-bicyclists who agreed or strongly agreed with the statements. Because 2.5 mile is the achievable active commuting to school distance, the analysis focused on the respondents who lived within 2.5-miles radius from school when comparing between bicyclists and non-bicyclists.

Table 2: Percent "Agree" or "Strongly Agree" for Non-bicyclist, Bicyclist, and All Respondents*

	Statements	Distance ≤ 2.5 miles		Distance >2.5 miles	All Respondents n = 435
		Non-bicyclist (n = 334)	Bicyclist (n = 9)	Non-bicyclist** (n =76)	
	Individual factors				
1	I like to bicycle	36.2%	66.7%	31.6%	37.5%
2	I am confident in my bicycling ability	56.9%	88.9%	57.9%	58.4%
3	Bicycling is my usual way of getting around town	7.2%	88.9%	6.6%	9.0%
4	I feel comfortable bicycling on a busy street with a bicycle lane	18.9%	44.4%	13.2%	18.4%
5	I hate wearing a bicycle helmet	52.1%	77.8%	39.5%	51.0%
6	I like being driven places	45.8%	55.6%	32.9%	44.6%
7	Driving is the coolest way to get to school	42.8%	33.3%	39.5%	42.1%
8	I need a car to do the things I like to do	62.9%	55.6%	63.2%	62.8%
9	I like taking the bus or light rail	17.1%	11.1%	22.4%	17.9%
10	The bus or light rail is my usual way of getting around town	19.8%	11.1%	23.7%	20.0%
11	I feel safe on the bus or light rail	18.6%	33.3%	17.1%	18.2%
12	Lots of people take the bus or light rail in my neighborhood	37.1%	44.4%	39.5%	37.7%
13	There is a direct bus route from my home to school	38.6%	11.1%	31.6%	37.2%

14	My friends take the bus or light rail to school	37.7%	33.3%	35.5%	36.6%
15	I feel safe walking or skateboarding to school	28.7%	22.2%	26.3%	28.3%
16	I am always rushed to get ready in the morning	30.8%	44.4%	36.8%	32.0%
17	I have lots of stuff to carry to school	20.7%	11.1%	21.1%	20.2%
18	I return from school at the same time every day	30.2%	11.1%	38.2%	31.5%
19	I like being physically active	59.0%	55.6%	56.6%	59.1%
20	Protecting the environment is important to me	52.4%	55.6%	56.6%	53.3%
21	I feel comfortable getting places on my own	41.3%	44.4%	47.4%	42.5%
22	I have a physical condition that makes it hard to bicycle	6.0%	11.1%	6.6%	6.2%
23	The clothes I wear make it hard to ride a bicycle	7.8%	11.1%	9.2%	8.3%
	Social-environment factors				
24	I like to travel to school with friends rather than alone	52.4%	66.7%	53.9%	52.6%
25	My friends bicycle to school	15.6%	33.3%	11.8%	15.4%
26	I am concerned by how my peers will think of me if I choose to bicycle to school	10.5%	0.0%	5.3%	9.7%
27	My parents/guardians allow me to go places by myself	54.5%	55.6%	53.9%	54.3%
28	I can rely on my parents/guardians to drive me places	47.3%	44.4%	39.5%	46.4%

29	One or both of my parents/guardians bicycle frequently	10.5%	33.3%	10.5%	11.0%
30	My parents/guardians encourage me to bicycle	11.7%	22.2%	10.5%	12.0%
31	Lots of people bicycle in my neighborhood	15.6%	33.3%	21.1%	17.0%
32	I worry about my bicycle getting stolen at school	24.0%	77.8%	17.1%	24.6%
	Physical-environment factors				
33	There is a direct bicycle route from my home to school	33.2%	77.8%	22.4%	32.9%
34	There is a safe bicycle route from my home to school	18.3%	44.4%	13.2%	17.9%
35	I live too far away from school to bicycle here	17.7%	11.1%	55.3%	24.1%

* 5-point ordinal scale from strongly disagree (1) to strongly agree (5)
** None of the bicyclists reported living further than 2.5 miles from school

Mode preferences were different between bicyclists and non-bicyclists. Bicyclists were more likely to agree that they liked bicycling (see #1: 66.7% vs. 36.2%) and far more likely to agree that bicycling was their usual way of getting around town (see #3: 88.9% vs. 7.2%). Non-bicyclists were more often to agree that driving was the "coolest" way to get to school (see #7: 33.3% vs. 42.8%), but bicyclists agreed more often that they liked being driven places (see #6: 55.6% vs. 45.8%). However, both groups agreed that they needed a car to do the things they liked to do (see# 8); though non-bicyclists agreed more often with this point (62.9% vs. 55.6%).

Attitudes toward transit were also different between bicyclists and non-bicyclists. Both groups seemed to dislike taking the bus or light rail or using it as their usual way of getting around town; non-bicyclists agreed more often with these two points (see #9 and #10).

Bicycling comfort was much higher among bicyclists. Bicyclists agreed more often that they were confident in their bicycling abilities (see #2: 88.9% for bicyclists vs. 56.9% for non-bicyclists) and felt comfortable bicycling on a busy street with a bicycle lane (see #4: 44.4% for bicyclists vs. 18.9% for non-bicyclists). About half of the respondents agreed that they hated wearing a helmet. Surprisingly, bicyclists agreed more that they dislike helmets (77.8%) more than non-bicyclists did (52.1%). Both bicyclists and non-bicyclists were more likely to agree that they were being physically active and cared about protecting the environment (see #19 and #20).

Mode preferences were also different between non-bicyclists who lived within 2.5 miles from the school and those who lived further away. Non-bicyclists who reported living within 2.5 miles from school agreed more often than non-bicyclists who lived further that they liked being driven places (45.8% vs. 32.9%) and driving was the coolest way to get to school (42.8% vs. 39.5%). In contrast, non-bicyclists who reported living within 2.5 miles from school were less likely to agree that they liked taking bus or light rail and using them as their regular way of getting around town compared to those who lived further away (see #9 and #10).

Social-environmental factors were also varied. Peers seemed to have influences on decision to bicycle. Both groups agreed that they liked to travel to school with friends; bicyclists agreed more often on this point than non-bicyclists (66.7% vs. 52.4%). Bicyclists were more likely to agree that their friends bicycled to school (33.3% vs. 15.6%) and lots of people bicycled in their neighborhoods (33.3% vs. 15.6%). Very few of non-bicyclists agreed that they were concerned by how their friends would think if they bicycled to school (See #26: 10.5%); no bicyclists agreed with this point. Bicyclists were more often to worry about their bicycles being stolen at school compared to non-bicyclists (see #32: 77.8% vs. 24.0%).

In addition, both groups of respondents were likely to agree that their parents or guardians allowed them to go places by themselves (see #27: 54.5% for non-bicyclists vs. 55.6% for bicyclists). Non-bicyclists agreed more often that they could rely on their parents/guardians to drive them to places compared to bicyclists (see #28: 47.3% for non-bicyclists vs. 44.4% for bicyclists). However, parental influences were different between the groups. Both groups seemed to disagree that their parents or guardians bicycled frequently or encouraged them to bicycle, though bicyclists agreed more often with these two points (see #29 and #30).

The survey results show that the students' perceptions of the physical-environment factors also vary. As far as bicycle routes from home to school were concerned, bicyclists agreed far more often than non-bicyclists that there was a safe (see #34: 44.4% for bicyclists vs. 18.3% for non-bicyclists) and direct (see #33: 77.8% for bicyclists vs.

33.2% for non-bicyclists). Both groups that lived within than 2.5 miles from school were more likely to disagree that home was too far away from school to bicycle, though bicyclists were less often to agree with this point (11.1% for bicyclists vs. 17.7% for non-bicyclists). In contrast, those non-bicyclists who lived further than 2.5 miles from school were far more often to agree with this point than others (55.3%).

Chapter 5

DISCUSSION AND CONCLUSIONS

A combination of social-environment, individual, and physical-environment factors are associated with the decision to bicycle to school in high school students. Social environment have an influence on whether students bicycle. Peers' behaviors seem to influence students to bicycle. Bicyclists agreed more often that lots of people bicycled in their neighborhoods and their friends bicycled. Parents' attitudes seem to be an important factor on students' decision to bicycle. Students are influenced by their parents' encouragement and behavior, which is consistent with findings from Emond and Handy (2012).

Even though the percentages of respondents who "agree" and "strongly agree" that their parents bicycled frequently and encouraged them to bicycle were low (less than 12%), bicyclists agreed more often on these two points than non-bicyclists did. Parents also play a role by providing modes of travel to and from school for students such as providing access to a vehicle and giving them a ride. All of those respondents who had a driver's license and had access to a vehicle reported that their usual mode to and from school was either "I drive myself" or "someone drives me," but none of them reported "I bicycled."

Of those respondents who lived within bicycling distance and did not have a driver's license or only had a driver's learner permit, 60% of them reported that someone usually gave them a ride to and from school. If parents eliminate these alternative modes,

many of the students might consider bicycling to school which is consist with a previous study that suggests active commuting may increase when young people have fewer resources for alternate modes of transport to or from school (Babey et al., 2009).

More than half of the respondents in this study reported that their parents allowed them to go to places by themselves, but only a little over 40% agreed that they were comfortable getting places on their own and less than 20% agreed that they felt safe on the bus or light rail. These results suggest that students' perception of their personal safety could also be a deterrent to bicycling, at least in this particular area, where the school located.

In addition, the results indicate a potential need for infrastructure improvements to address safety concerns. Less than 30% of the respondents agreed that they felt safe walking or skateboarding to school. Less than 20% of non-bicyclists agreed that they felt comfortable bicycling on a busy street with a bicycle lane, while only 50% of the bicyclists did. The survey design did not allow the students to explain what their specific safety concerns were, and an additional survey designed to address these problems should be administered to identify these issues further.

For the physical environment factors, of those respondents who lived within 2.5 miles from school, less than 20% agreed that they lived too far, yet almost all of them did not bicycle to school. Those individuals who usually bicycled to school were less likely to agree that they lived too far to bicycle. These results could indicate that perceived distance plays a role in students' decision to bicycle; if students think that they live too

far to bicycle to school then they are not likely to bicycle, which is consistent with earlier work (Emond & Handy, 2012). Respondents, who lived within 2.5 miles from school, were likely to disagree that they lived too far and agreed that they were confident in their bicycling abilities; however, few of them chose to bicycle to school.

About 43% of respondents who lived within 2.5 miles and disagreed that they lived too far from school reported that they had access to a bicycle. More than half of them reported that usually someone gave them a ride or they drove themself to and from school. For those individuals who did not receive a ride or drove themselves to school, about 11% reported that bus or light rail was their usual mode of travel both to and from school. About 17% of the respondents in this group reported that they walked both ways, and 4% reported that they bicycled both ways. Few respondents in this group reported that they usually received a ride in the morning and had to use different modes to get home; their mode choice to get home was either walking or taking bus or light rail. These results could reflect that the individual attitudes and willingness to bicycle may be a more powerful influence on the decision to bicycle than perceived distance or bicycle ownership, which is consistent with previous research by Foster & Charlie (2012) which concluded owning a bicycle does not guarantee its use. Usual mode choices to and from school of respondents who lived within 2.5 miles, disagree that they lived too far and had access to a bicycle, are shown in Table 3 below.

Table 3: Mode of Travel To and From School of Respondents Who Lived Too Far and Had Access to a Bicycle

	Usual Mode From School					
Usual Mode to School	I bicycle	I walk	I take the bus or light rail	I drive myself	Someone drives me	Total
I bicycle	5	0	0	0	0	5
I walk	0	21	0	0	1	22
I skateboard	0	0	0	0	1	1
I take the bus or light rail	0	0	13	0	2	15
I drive myself	0	0	0	6	0	6
Someone drive me	0	8	7	0	58	73
Total	5	29	20	6	62	122

For the individual factors, the results seem to be mixed. According to the results in Table 2, the respondents' opinions and their needs seem to be conflict. Bicyclists agreed more often than non-bicyclists that they liked to bicycle (66.7% vs. 36.2%). They also agreed more often that they liked being driven places (55.6% vs. 45.8%). Few bicyclists (33.3%) agreed that driving was the "coolest" way to get to school, but many of them (55.6%) reported that they needed a car to do things they like to do. Few respondents agreed that they liked taking the bus or light rail, or used it as their usual way of getting around town. These conflicting results may reflect that individuals' preferences and attitudes are more important than other individual factors. It appears that if students make up their minds that they need a car, regardless of whether or not they like bicycling or think that driving a car is "cool," they still may not bicycle.

Similar results were observed when non-bicyclists were surveyed. Non-bicyclists who lived within 2.5 miles from school seemed to agree that they lived close enough to bicycle and were more likely to agree that there was a safe direct bicycle route from home to school than those who lived further. Non-bicyclists who lived within 2.5 miles from school agreed more often that driving is the "coolest" way to get to school and that they like being driven places. These conflicting statements also support the conclusion that individuals' perceptions and preferences are likely to play a role on decision to bicycle.

Gender also appears to be a factor. Females were far less likely to bicycle than males. In fact, in this study, none of the bicyclists were female. Even though the sample size in this study was small, this result is consistent with previous studies with larger sample sizes (Babey et al., 2009; Emond & Handy, 2012).

Limitations

There are some limitations to this study. First, the sample size of bicyclists was small. Of all the completed survey distributed, the response rate was low. Of those valid responses, only 10 students were categorized as bicyclists, and they all were males without a driver's license. Second, the 2.5-mile radius from school was drawn based on a straight-line distance from the center of the school. A student's home location was approximated based on the intersection nearest to their homes. A student whose home was located in the 2.5-mile radius circle was categorized as one who lives within 2.5

miles from school, but the actual route travelled by students was not collected and so the actual distance travelled was unknown. As a result, the distance between school and home likely underestimated the actual distance travelled, for example, students who lived within a 2.5-mile radius from school could travel a greater distance because of potential obstacles such as one-way traffic. In addition, many students provided inaccurate information about the two street intersections nearest to their homes. For example, some respondents provided two streets that paralleled each other instead of intersected. As a result, their home locations could not be determined.

Chapter 6

RECOMMENDATIONS

To encourage bicycle commuting among high school students at Hiram Johnson High School, a combination of efforts is likely needed, which is consistent with previous findings. Infrastructure improvements that create safe routes to high schools are likely to be a necessary step to increase bicycling among students (Emond & Handy, 2012). Bicycling-friendly environments could increase bicycling rates (Hunt & Abraham, 2007). Even though Moudon et al. (2005) argued that increasing in bicycle infrastructure does not have a significant effect on bicycling rates and that the decision to bicycle is largely based on personal factors, they agreed that improving the environment for bicycling may help promoting the frequency of bicycling trips and the number of bicyclists. Several countermeasures are available to improve the infrastructure along Hiram Johnson High School to accommodate bicycling to the school.

A road diet treatment should be implemented on the section of 65th Street around the school perimeter and extended north along the roadway to the intersection of 65th Street and 4th Avenue. A road diet involves converting a four-lane roadway (two lanes in each direction) to a three-lane roadway with one in each direction plus a center two-way left turning lane (FHWA, 2013a). The reduction of lanes allows the roadway to be reallocated for other uses such as bike lanes, pedestrian crossing islands. By reducing number of lanes, the speeds of the motorists in the through lanes are limited by the speed of the lead vehicle in their own lane, resulting in a reduction in vehicle speeds which

enhances bicyclists comfort. The document also suggested that if the prospective roadway has few signals and left turns with an average daily traffic (ADT) of less than 18,000 vehicles per day, a road diet could be implemented.

The section of 65th Street around the school perimeter currently has two lanes in each direction plus a center turn lane with no existing bicycle lanes on either side of the street. The width of each lane is twelve feet. There are three signalized intersections and few unsignalized intersections on the roadway section. Its ADT counts range from 13,000 to 17,000 vehicles per day (City of Sacramento, 2012). Based on this information, 65th Street met the criteria and should be a good candidate for a road diet treatment. A road diet provides space to install bicycle lanes with buffer lines separating the bicycle lane from the vehicle travel lane on both sides of the street. An eight-foot bicycle lane with a four-foot buffer would connect to the city's existing bicycle routes and facilities at 4th Avenue. The illustration of the recommended buffered bicycle lane locations is shown in Figure 7. The illustration of the cross section of existing roadway and the cross section of the roadway after road diet treatment are shown in Figure 8 and 9 below.

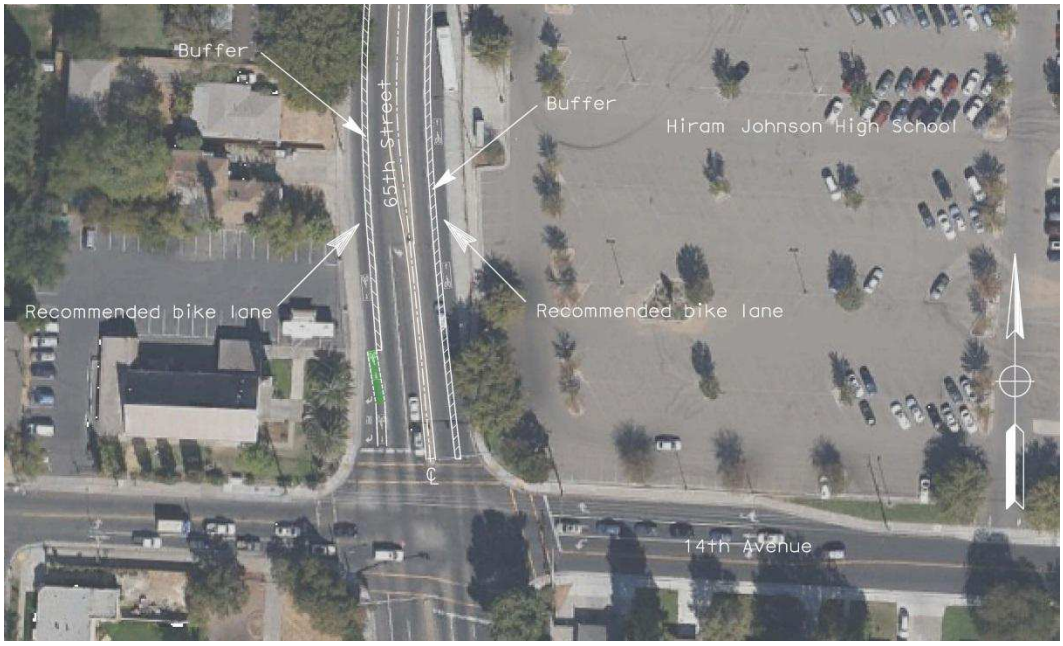

Figure 7: Location of Recommended Bicycle Lanes and Road Diet

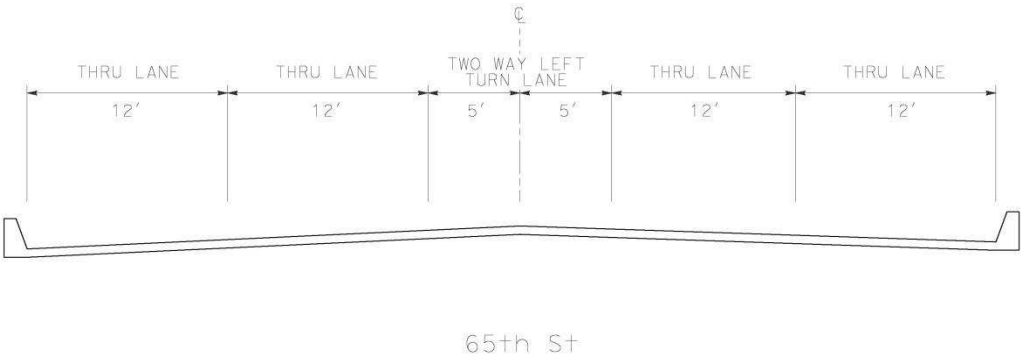

Figure 8: Cross Section of Existing 65th Street

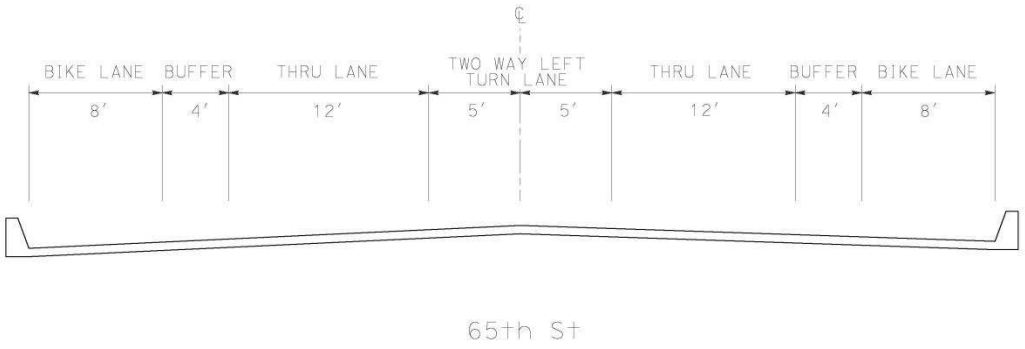

Figure 9: Cross Section of 65th Street after Road Diet Treatment

Bicycle lanes designate exclusive space for bicyclists, make behavior and movement between bicyclists and motorists more predictable and also promote bicyclist comfort and confidence on busy streets (NACTO, 2013a). Buffered bicycle lanes provide greater distance between bicyclists and motorists and provide space for one bicyclist to pass another bicyclist without encroaching into the adjacent travel lane (NACTO, 2013b). The cost of restriping and installing bicycle lanes with buffer is approximately $5,000 to $10,000 per mile, depending on the condition of the pavement and the need to remove and repaint the lines (BIKESAFE, 2013a). The proposing project starts at the intersection of 14th Avenue and 65th Street and ends at 4th Avenue; the total length is approximately 0.6 miles. The costs to implement this project should range from $3,000 to $6,000.

Southbound 65th Street near the intersection of 65th Street and 14th Avenue is an area that can have a potential conflict between bicyclists and motor vehicles. The conflict occurs when a motorist merges in to the right turn lane to make a turn crossing the through movement of a bicyclist in the bicycle lane. Green colored pavement within a

bicycle lane can be used at this conflict location. Green colored pavement within a bicycle lane increases the visibility of the facility and reduces confusion between bicyclists and drivers (NACTO, 2013c). The city of Portland, Oregon did a study to investigate the effectiveness of colored pavement markings in reducing bicyclist-motorist conflicts at designated crossing areas and found positive results. Significantly, more motorists yielded to bicyclists and slowed or stopped before entering the merging areas. The percentage of motorists yielded to bicyclists increased 27% and the percentage of motorists slowed or stopped for bicyclists increased 23% after the installation of the colored pavement. The majority of bicyclists (76%) and motorists (49%) felt the painted area enhanced safety (City of Portland, 1999). A buffered bicycle lane with green colored pavement is shown in Figure 10 below.

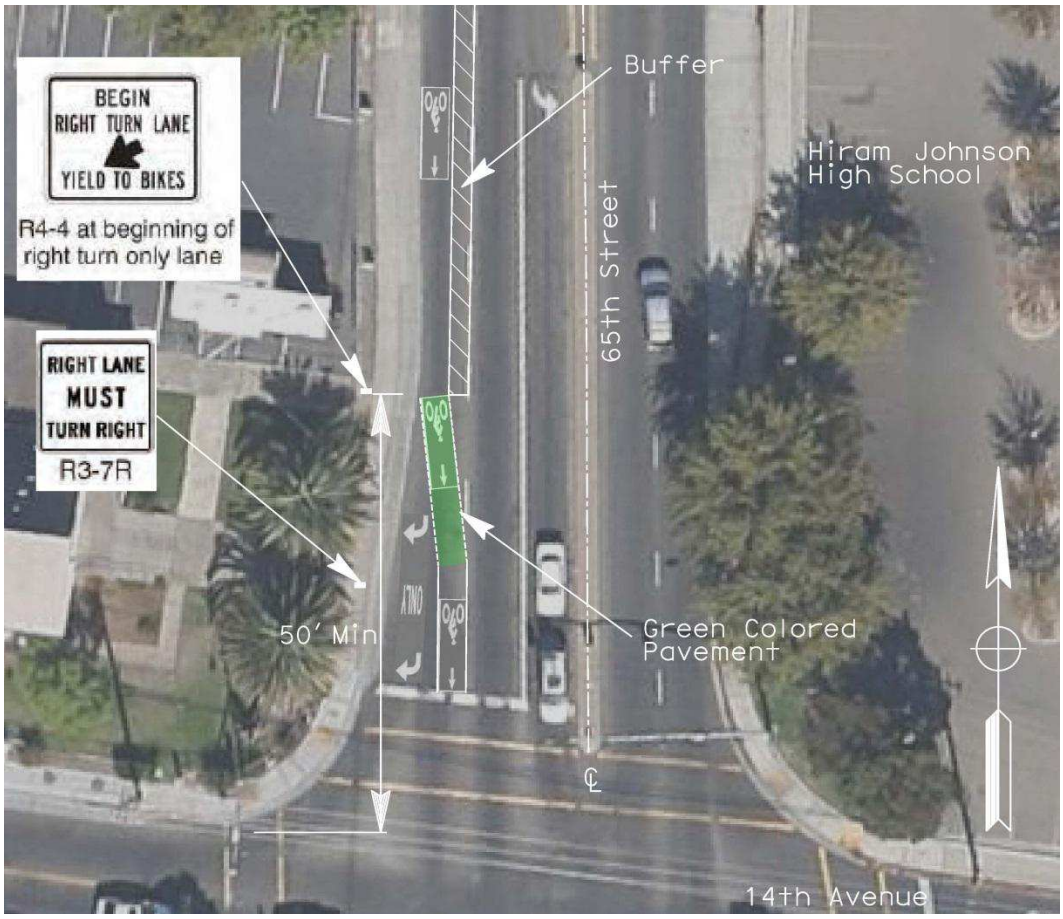

Figure 10: Buffered Bike Lane with Green Colored Pavement

The green colored pavement, however, is currently not adopted by the 2012 California MUTCD. During the past 10 years, many state and local governmental agencies, including: the City of San Francisco, CA, the city of Long Beach, CA, and the City of Portland, OR have received approvals from the Federal Highway Administration (FHWA) to experiment with using green colored pavement as a traffic control device to designate locations where bicyclists and motorists might have potentially conflicting

crossing or weaving movements. The FHWA evaluated the experimental data and considered that the green colored pavement has positive effects on bicyclists and motorists with low risk of safety or operational concerns. Bicyclists were positioning themselves more accurately as they traveled across intersections and through conflict areas. Bicyclists felt safer when the green colored pavement was presented and could position themselves more accurately while traveling across intersections and through conflict areas. Green colored pavement increased awareness in motorists that bicyclists may be present and were likely to be positioned within the designated way (FHWA, 2013b). The interim approval from FHWA is required prior to implementing any green colored pavement marking.

Traffic calming can enhance safety and comfort for bicyclists and pedestrians by encourage people to drive at slower speeds. Traffic calming devices such as crossing signs, speed signs, school zone pavement markings, and high-visibility crosswalks help improve road safety by reminding drivers to treat the area with special care and attention. Traffic calming effects such as fewer and less severe crashes are clearly measurable (BIKESAFE, 2013b). Bicycle use is encouraged by traffic calming. The reducing in vehicle speeds associated with the devices can reduce both the severity and incidence of motor vehicle-bicycle crashes and can also make bicyclists feel more comfortable in traffic (Clarke and Dornfeld, 1994).

The 2012 *California Manual on Uniform Traffic Control Devices* (CAMUTCD) stated in Section 7C.02 that warning signs should be installed for all marked school crosswalks at

non-intersection locations; additionally, adequate visibility of students by approaching motorists and of approaching motorists by students should be provided (California MUTCD, 2012). There are three marked crosswalks on the section of 14th Avenue around the school perimeter. In-street crosswalk signs, such as R1-6 or R1-6b, as shown in Figure 11 below, should be installed at each crosswalk. These signs should be placed in advance of the crosswalk to make motorists aware of their responsibility before they enter the crosswalk. The fluorescent yellow-green background signs, installed in the middle of the road and low to the surface, will enhance visibility of the crosswalk, will increase drivers' awareness and remind drivers that state law requires them to yield for pedestrians within a crosswalk. The sign will also make the travel lane seem narrower, which will encourage motorists to drive more carefully past the crosswalk. The cost of signs generally ranges from $50 to $150 per sign plus installation costs (PEDSAFE, 2013a). The section of 14th Avenue around the school is currently designated as an on-street bicycle route but does not have adequate room to install a bicycle lane. Motor vehicle parking should be restricted during the school arrival and dismissal times. According to Hiram Johnson High School 2012-2013 bell schedule, the school's first period starts at 7:18 a.m. and the last period ends at 4:08 p.m. on regular days (Hiram W. Johnson High School, 2013). On-street parking should be prohibited from 6 a.m. to 8 a.m. and from 4 p.m. to 6 p.m. on school days to provide greater sight distance and space for bicyclists to ride, which will result in enhanced safety and comfort for bicyclists

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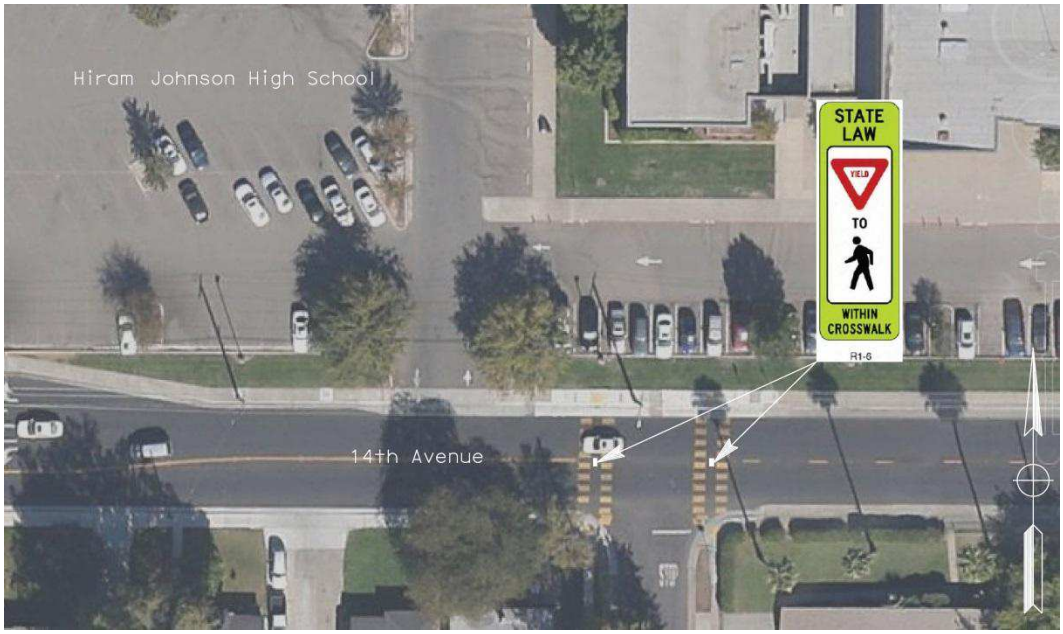

Figure 11: Traffic Calming Signage

Sidewalks and waiting areas at the intersection of 65th Street and 14th Avenue should be extended to make tighter corner to enhance safety and provide more spaces for bicyclists and pedestrians while waiting for traffic signal. A wide curb radius allows motorists to make high speed turns and increases the crossing distance for pedestrians (PEDSAFE, 2013b). Motorists who drive at higher speeds are less likely to have time to check for pedestrians (Clarke and Dornfeld, 1994). Reconstructing the corner radius produces a tighter turn and results in decreasing in turning speeds, shortening the crossing distance for pedestrians and bicyclists and improving the ability of pedestrians and motorists to see each other. Costs of reconstructing a tighter curb radius range from

$2,000 to $20,000 per corner, depending on site conditions (PEDSAFE, 2013c). The illustration of curb extension is show in Figure 12 below.

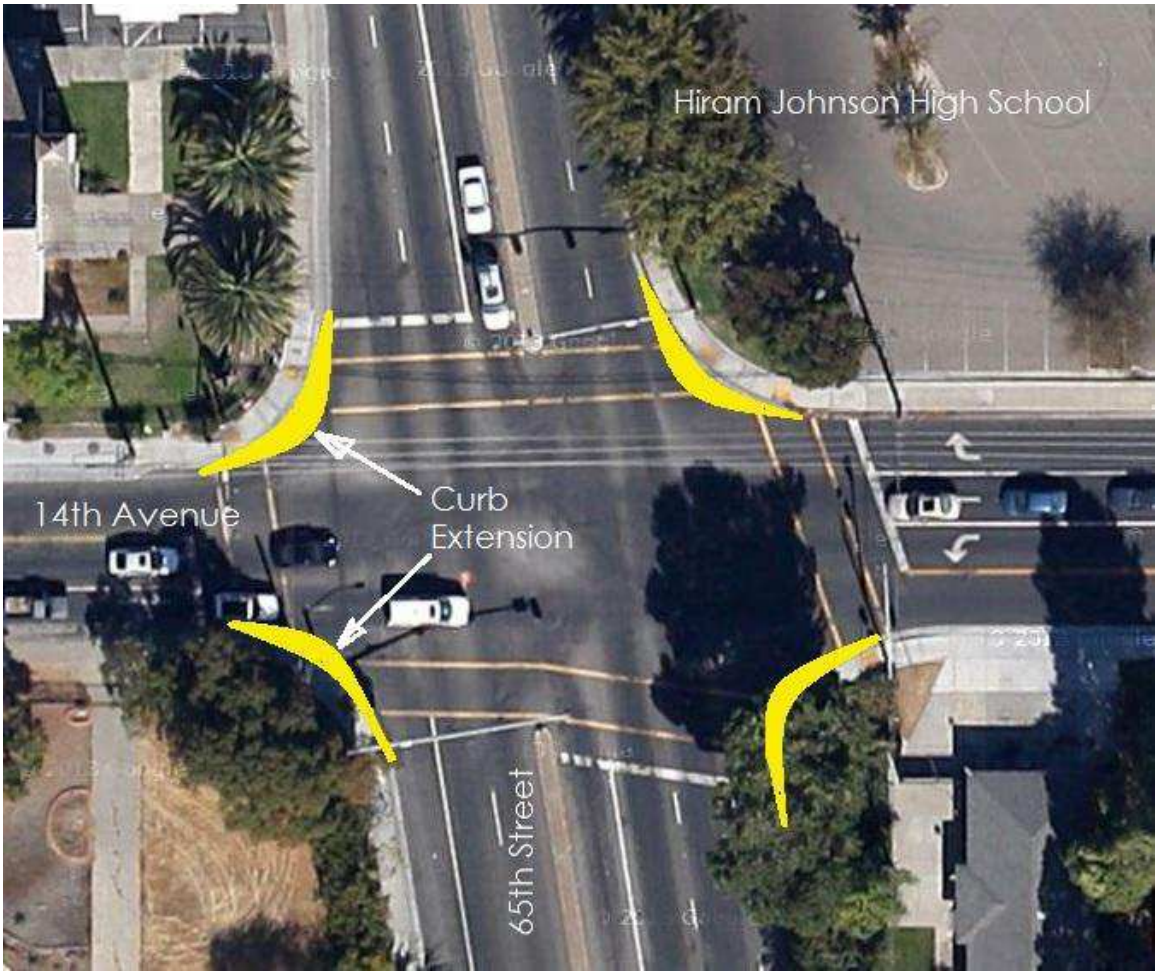

Figure 12: Curb Extension

In conjunction with infrastructure improvements, policies and programs that support bicycling among high school students should be established by the school. Training programs targeted to increase students' bicycling abilities might help promote

bicycling rates because bicyclists who have good riding skills tend to like bicycling more (Emond & Handy, 2012). In addition, attitude is an influential factor on choice to commute by bicycle (Heinen et al., 2011). People need a reason for bicycling and making the reasons to bicycle more apparent is part of promoting bicycling (PBIC, 2013). Educational programs to promote acknowledgement on benefits of bicycling might help students to develop good attitudes toward bicycling.

According to the results of this study, less than half of the respondents had an access to a bicycle. If students have access to a bicycle, they might want to bicycle more. A bicycle loan program, currently operating at Portland Community College, is an example of program that could enable students to gain more access to bicycles by allowing students to borrow or rent bicycles for a period of time at little cost, which could result in increasing in bicycling rates (Portland Community College, 2013). Studies on associations between increasing the accessibility to bicycle and an improvement in the bicycling rate in high school students are not available at the current time. However, Fuller et al. (2013) did research to examine the association between residential exposure to BIXI (Bicycle-taXI) - a public bicycle share program that implemented in Montreal, Quebec in 2009, which increases accessibility to bicycling and the likelihood of cycling. Their study concluded that the implementation of a public bicycle share program can increase the rate of bicycling among people who live in the areas where bicycles are made available. Therefore, it should be expected that if students' accessibility to bicycle increases, bicycling rates may increase.

Future Research

Combinations of factors are found to be associated with the decision to bicycle to school in high school students. However, the real reasons why high school students do not bicycle to school remain unclear. To encourage high school students to bicycle to school, further research to expand the understanding of the factors that influence their decisions is needed. Further research should examine on gender differences on mode choices as well as individual's perception on distance and attitude toward bicycling to school. In addition, perceptions of safety from real or perceived safety concerns, which are the predictors of physical activity among young people, especially females (Nelson et al., 2008), as well as safety from crashes should be observed further if any of these factors have an influence on bicycling to school by high school students. Additional research on bicycling infrastructure and its effects on high school students' decision to bicycle to school are also needed.

APPENDIX A.

Sacramento State Survey on Student Travel to Hiram Johnson High School

(Originally developed by Emond & Handy, 2012)

Sacramento State Survey on Student Travel to Hiram Johnson High School

Researchers at Sacramento State University are collecting data about how high school students travel to and from school. The survey should take less than 10 minutes to complete. Your participation is completely voluntary and you are not required to finish the survey, but the results of this survey may be used to help address transportation issues faced by students like you. There are questions on both sides. Your responses will be completely confidential; no one will know which survey is yours. There is no direct benefit or compensation for participating. If you have any questions, please contact Sacramento State Professor Kevan Shafizadeh at (916) 278-5348) or shafizadeh@csus.edu. Your school will receive a copy of the survey results, but you may also request a personal copy to be sent to you.

Thank you for your time and help!

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1. What grade are you in? □ 9th □ 10th □ 11th □ 12th
2. What is your birth date? Month: _____ Year: _____
3. What is your gender? □ Male □ Female
4. What is the nearest street intersection to your home? (For example: 5th Avenue and Green Street)
   _____ and _____
5. How did you get to school *today*? (check one)
   - □ I bicycled
   - □ I walked
   - □ I skateboarded
   - □ I took the bus or light rail
   - □ I drove myself
   - □ Someone drove me
   - □ Other: _____
6. How do you *usually* get to school? (check one)
   - □ I bicycle
   - □ I walk
   - □ I skateboard
   - □ I take the bus or light rail
   - □ I drive myself
   - □ Someone drives me
   - □ Other: _____
7. How do you plan to get home from school *today*? (check one)
   - □ I will bicycle
   - □ I will walk
   - □ I will skateboard
   - □ I will take the bus or light rail
   - □ I will drive myself
   - □ Someone will drive me
   - □ Other: _____
8. How do you *usually* get home? (check one)
   - □ I bicycle
   - □ I walk
   - □ I skateboard
   - □ I take the bus or light rail
   - □ I drive myself
   - □ Someone drives me
   - □ Other: _____
9. What is the most recent driver license/permit you have obtained?
   - □ I do not have a driver license or learner's permit - **skip to Question 10**
   - □ Driver learner's permit- **skip to Question 10**
   - □ Provisional license
   - □ Regular driver's license

   a. When did you get your license? Month: _____Year: _____
   b. Do you have regular access to a car? □ No □Yes
   c. Do you pay for your own gasoline? □ No □ Yes
10. How many days a week do you currently participate in after-school activities at high school?
    □ 5 □4 □3 □2 □1 □rarely/never
11. How many days a week do you currently participate in after-school activities elsewhere in town?
    □ 5 □4 □3 □2 □1 □rarely/never
12. Do you currently own or have regular access to a functioning bicycle? □No □ Yes
13. How often do you ride your bicycle to places other than school? (check one)
    □ Daily □ Mainly weekdays □ Mainly weekends □ Rarely □Never

OVER ➡

14. How often do you take the bus or light rail to places other than school? (check one)
□ Daily □ Mainly weekdays □ Mainly weekends □ Rarely □Never

15. How did you *usually* get to middle school? (check one)
□ I bicycled □ I took the bus or light rail
□ I walked □ I drove myself
□ I skateboarded □ Someone drove me □ Other: _____

16. Please tell us whether you agree or disagree with the following statements on a scale from "strongly disagree" to "strongly agree."

	Strongly Disagree		Neutral		Strongly Agree
a. I am always rushed to get ready in the morning.	□1	□ 2	□3	□4	□5
b. I like being physically active.	□1	□ 2	□3	□4	□5
c. I have lots of stuff to carry to school.	□1	□ 2	□3	□4	□5
d. I return from school at the same time every day.	□1	□ 2	□3	□4	□5
e. Protecting the environment is important to me.	□1	□ 2	□3	□4	□5
f. My parents/guardians allow me to go places by myself.	□1	□ 2	□3	□4	□5
g. I like being driven places.	□1	□ 2	□3	□4	□5
h. I can rely on my parents/guardians to drive me places.	□1	□ 2	□3	□4	□5
i. I need a car to do the things I like to do.	□1	□ 2	□3	□4	□5
j. Driving is the coolest way to get to school.	□1	□ 2	□3	□4	□5
k. I like to travel to school with friends rather than alone.	□1	□ 2	□3	□4	□5
l. I feel comfortable getting places on my own.	□1	□ 2	□3	□4	□5
m. I feel safe walking or skateboarding to school:	□1	□ 2	□3	□4	□5
n. I like taking the bus or light rail.	□1	□ 2	□3	□4	□5
o. The bus or light rail is my usual way of getting around town.	□1	□ 2	□3	□4	□5
p. I feel safe on the bus or light rail.	□1	□ 2	□3	□4	□5
q. Lots of people take the bus or light rail in my neighborhood.	□1	□ 2	□3	□4	□5
r. There is a direct bus route from my home to school.	□1	□ 2	□3	□4	□5
s. My friends take the bus or light rail to school.	□1	□ 2	□3	□4	□5
t. There is a direct bicycle route from my home to school.	□1	□ 2	□3	□4	□5
u. I am confident in my bicycling ability.	□1	□ 2	□3	□4	□5
v. I have a physical condition that makes it hard to bicycle.	□1	□ 2	□3	□4	□5
w. Bicycling is my usual way of getting around town.	□1	□ 2	□3	□4	□5
x. The clothes I wear make it hard to ride a bicycle.	□1	□ 2	□3	□4	□5
y. Lots of people bicycle in my neighborhood.	□1	□ 2	□3	□4	□5
z. I worry about my bicycle getting stolen at school.	□1	□ 2	□3	□4	□5
aa. I like to bicycle.	□1	□ 2	□3	□4	□5
bb. One or both of my parents/guardians bicycle frequently.	□1	□ 2	□3	□4	□5
cc. There is a safe bicycle route from my home to school.	□1	□ 2	□3	□4	□5
dd. I feel comfortable bicycling on a busy street with a bicycle lane.	□1	□ 2	□3	□4	□5
ee. My friends bicycle to school.	□1	□ 2	□3	□4	□5
ff. I hate wearing a bicycle helmet.	□1	□ 2	□3	□4	□5
gg. My parents/guardians encourage me to bicycle.	□1	□ 2	□3	□4	□5
hh. I live too far away from school to bicycle here.	□1	□ 2	□3	□4	□5
ii. I am concerned by how my peers will think of me if I choose to bicycle to school.	□1	□ 2	□3	□4	□5

12. What is the highest level of completed education for each parent/guardian (check one)?

a. Parent/Guardian 1: □ Some High School □ Some College □ Bachelor Degree □ Other
□ High School □ Associate Degree □ Advanced Degree

b. Parent/Guardian 2: □ Some High School □ Some College □ Bachelor Degree □ Other
□ High School □ Associate Degree □ Advanced Degree

THANK YOU FOR YOUR PARTICIPATION!

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