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Promoting Bicycle Commuter Safety

MTI Report 11-08

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REPORT 11-08

PROMOTING BICYCLE COMMUTER SAFETY

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16. Abstract

A basic premise in this report is that cycling should be encouraged because as the number of cyclists increases, the attention of motorists and safety improves; however, an important caveat is that the number of cyclists has to be commensurate with the infrastructure built for cycling to enhance their safety.

We present an overview of the risks associated with cycling to emphasize the need for safety. We focus on the application of frameworks from social psychology to education, one of the 5 Es—engineering, education, enforcement, encouragement, and evaluation. We use the structure of the 5 Es to organize information with particular attention to engineering and education in the literature review. Engineering is essential because the infrastructure is vital to protecting cyclists. Education is emphasized since the central focus of the report is safety.

A series of case studies gives first hand information about bicycle safety. The first three in northern California—covering education in relation to safety in San José; engineering and evaluation in Berkeley; engineering, education, and enforcement in Davis—and the Bicycle Transportation Alliance in the Portland, Oregon area, provide an effective example of the education and encouragement dimensions of the 5 Es. We note the need for future research or evaluation, with particular reference to the use of the social psychological model presented herein. Another critical area for future research is the role of enforcement. What are the most effective ways to get cyclists to follow the rules?

We see the value added of the present report to the extant literature as the following: a clear and concise discussion of safety education, case studies that exemplify the 5 Es and permit the reader to more actively engage in the stories told by the case authors, and the social psychological model to consider when designing the 5 Es. The Health Belief Model's key elements could be applied to the 5 Es in the planning process.

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DEDICATION

Dedicated to Tom Ferrara (3/27/1947-11/13/2010), former co-principal investigator of the project. Tom served as professor and chair of civil engineering at Chico State, where he taught for 36 years.

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EXECUTIVE SUMMARY

A basic premise in this report is that cycling should be encouraged because as the number of cyclists increases, the attention of motorists and safety improves; however, an important caveat is that the number of cyclists has to be commensurate with the infrastructure built for cycling to enhance their safety.

We begin with an overview of the risks associated with cycling to emphasize the need for safety. We focus on the application of frameworks from social psychology to education, one of the 5 Es—engineering, education, enforcement, encouragement, and evaluation. Next we use the structure of the 5 Es to organize information with particular attention to engineering and education in the literature review. Engineering is essential because the infrastructure is vital to protecting cyclists. Education is emphasized since the central focus of the report is safety. We follow the literature review with a series of case studies, the first three in northern California—covering education in relation to safety in San José; engineering and evaluation in Berkeley; engineering, education, and enforcement in Davis—and the Bicycle Transportation Alliance in the Portland, Oregon area, an effective example of the education and encouragement dimensions of the 5 Es. We conclude with a discussion and note the need for future research or evaluation, with particular reference to the use of the social psychological model presented herein.

More nuanced and complete discussions of the following points can be found in the relevant section of the report with their respective citations. The points of interest follow:

1. In 2008 males accounted for 87 percent of bicycling fatalities in the U.S.[1] More cyclists are male, but females may follow the rules more.
2. One-third of fatal accidents involve alcohol.[2]
3. Bicycle accidents that involved a motor vehicle were a very small percentage of all bicycle accidents; however, the vast majority of *fatal* bicycle accidents involved a vehicle. This is why engineers suggest keeping cyclists separate from vehicles.
4. The average age of cyclists killed in crashes in 2008 was 41 years old. This is nine years older than the average age of 32 in 1998. The average age of cyclists *injured* in crashes in 2008 was 31 years old. This is seven years older than the average age of 24 in 1998. Perhaps adults are riding at higher speeds, and with higher speed automobile traffic, than children are. Both of these factors can increase the severity of a crash.[3]
5. Driver behavior was a significant factor in a large fraction of the accidents that involved a motor vehicle operator's failure to yield.
6. A before and after comparison of crashes in Seattle neighborhoods at 119 intersections that had circles added between 1991 and 1994 reported a 94 percent reduction in crashes.[4]
7. Eighty percent of head and brain injuries can be prevented by wearing a helmet.[5]
8. In some instances, helmet use was correlated with drivers offering less space (and thereby increasing the risk of collision) when overtaking cyclists.[6]
9. Helmet laws increase helmet use in children and when combined with educational interventions, legislation seems effective, efficient, and socially acceptable.
10. Multi-dimensional approaches that incorporate education, design, and promotion

provide the most robust and adaptable models for bicycle safety programs.

11. A lack of empirical data on outcomes makes it difficult to identify true best practices[7] regarding safety education programs. However, wearing helmets, maximizing conspicuity, maintaining one's bicycle in good working condition while following the rules of the road seem logical.
12. Few bike safety programs include objective evaluation of their effectiveness over time.
13. Repeated and continually long-term exposure to bike safety education materials is critical to sustained behavior change.
14. Too many cyclists violate the rules of the road, yet enforcement is often lacking.
15. An objective approach to safety involves the analysis of traffic speeds and volumes and collision history at the intersection level in order to determine "Primary Collision Factors" for which new traffic safety control countermeasures can be proposed. The second concept of "subjective safety" holds that people's perception of the relative safety of a transportation facility is an important factor in overall safety. People's perception of the safety of a roadway or bicycle facility plays a critical role in their decision whether or not to bicycle, which in turn can have a direct impact on their objective safety while using that facility.
16. Berkeley bicyclists said that they felt unsafe sharing the road with cars and trucks, and prefer separate bikeways designated for their use. Very experienced cyclists often state a preference for faster routes that may also carry heavy automobile traffic, but surveys cited found that most bicyclists, and especially novice riders, feel more confident in some kind of clearly marked bicycle facility on a street with relatively light traffic.
17. In Berkeley conflict with auto traffic was by far the most often cited difficulty of cycling. Driver aggression, drivers "squeezing past" bicycles when there isn't enough room for them to safely pass and cyclists riding poorly were mentioned as problems in the Berkeley surveys. The report concluded that "the difficulty of a motorist seeing a person on a bicycle seems to be the root of much of the conflict, and is one good reason for establishing visible bikeways where cyclists can be expected."

We see the value added of the present report to the extant literature as the following: a clear and concise discussion of safety education, case studies that exemplify the 5 Es and permit the reader to more actively engage in the stories told by the case authors, and the social psychological model to consider when designing the 5 Es.

I. RISKS ASSOCIATED WITH CYCLING

SECTION AUTHOR: DAVID E. CZERWINSKI, PH.D.

In the U.S., there is an average of one fatality per five million bicycle trips[8]; however, the risk of every trip is not the same. Some behaviors can increase or decrease the safety of bicycling, as can environmental factors, the bicycling infrastructure, and motorist behavior.

While fairly extensive data exists about bicycle accidents, almost no data exists about bicyclists' *exposure* to different risks. Therefore, from existing data it is hard to draw conclusions about the relative risk posed by different behaviors or other factors. For instance, if more fatalities result from behavior A than from behavior B there can be two possible explanations: behavior A is *more dangerous* or behavior A is *more common*.

To give just one example, in 2008 males accounted for 87 percent of bicycling fatalities in the U.S.[9] Most likely, this does not mean that males are tragically worse cyclists than females. Rather, it is likely that males account for much more bicycling activity than females. Without data about the amount of cycling done by males and females, the raw number of fatalities affecting the two groups cannot lead to meaningful conclusions about risk.

In fact, analyses of bicycle accidents without taking into account exposure can lead to potentially erroneous conclusions. Many analyses of bicycle safety data fall into this trap. Still other studies attempt to control for exposure by reporting accidents as a rate per person for a particular population of interest. For example, in a study of head injuries resulting from bicycle accidents Sacks and others[10] report the number of head injuries by age and gender "per Million Population." However, since the amount of bicycling done by different age groups and by different genders can vary drastically, controlling for population size does not properly control for exposure.

Thus, we take care when drawing any conclusions from the analyses that follow. Of course, despite the lack of exposure data, common sense can still be a good guide when analyzing some situations. For instance, the fact that one-third of fatal accidents involve alcohol[11] most likely implicates alcohol as a risk factor. For other situations, until more data is collected about bicyclists' exposure to different risks, it is best to refrain from drawing hasty conclusions.

ACCIDENT DATA

There are two major national sources of data about bicycle accidents in the United States.[12] The National Highway Traffic Safety Administration (NHTSA) collects data in its Fatality Analysis Reporting System (FARS)[13] about all fatal traffic accidents in the United States (not only those involving bicycles). The FARS data is derived from police reports, which are collected by each state and submitted to the NHTSA annually. The data only includes bicycle accidents that involved a motor vehicle. This is a very small percentage of all bicycle accidents; however, it is the vast majority of *fatal* bicycle accidents.

The other set of data comes from the National Electronic Injury Surveillance System (NEISS), compiled by the Consumer Product Safety Commission.[14] The NEISS data is based on emergency room visits. Data is collected from a representative sample of emergency rooms across the country. The data set includes fatal as well as nonfatal injuries and is not limited to traffic collisions. Injuries that are too minor to require an emergency room visit are, of course, not reported.

In addition to the U.S. government, several states and a number of cities have also collected data about bicycle accidents. We highlight some of these as well, but begin with the national level data.

FARS

In 2008, traffic crashes in the U.S. killed 716 cyclists and injured 52,000. Over the period 1998-2008, the number of cyclist killed each year has fluctuated between 600 and 800.[15]

The average age of cyclists killed in crashes in 2008 was 41 years old. This is nine years older than the average age of 32 in 1998. The average age of cyclists *injured* in crashes in 2008 was 31 years old. This is seven years older than the average age of 24 in 1998.[16] Possible reasons for the increase in average age since 1998 could be a larger number of adults bicycling or a smaller number of children bicycling. Also, we note that the average age of cyclists killed in crashes in 2008 was 10 years older than the average age of those injured in 2008. This discrepancy in age between those killed and those injured has persisted over the last 10 years. Perhaps adults are riding at higher speeds, and with higher speed automobile traffic, than children are. Both of these factors can increase the severity of a crash.[17]

Bicycling fatalities are a problem that affects all ages. Half of the cyclists killed were 45 or older.

Table 1. Age Distribution of Cyclists Killed in 2008[18]

Age	Fatalities	Percent
<5	6	1%
5-9	23	3%
10-15	66	9%
16-20	52	7%
21-24	42	6%
25-34	74	10%
35-44	90	13%
45-54	180	25%
55-64	112	16%
65-74	36	5%
75-84	24	3%
85+	7	1%

The vast majority of the cyclists killed in 2008 were male (87 percent). Alcohol was involved (either on the part of the driver or the cyclist) in over one third (37 percent) of the fatal crashes.

Also, according to the NHTSA, "fatalities occurred more frequently in urban areas (69 percent), at non-intersection locations (64 percent), between the hours of 5 p.m. and 9 p.m. (28 percent)."[19]

NEISS

The NEISS makes the data collected since 1991 available to be queried online.[20] For this analysis we obtained records of all ER visits involving bicycles in 2008. The NEISS distinguishes between mountain bikes (NEISS product code 5033) and all other bikes (NEISS product code 5040). For this study, we combined the two. Of the 14,859 bicycle injury records downloaded, only 291 (2 percent) were coded as mountain bikes. Bicycle related injuries reported by the NEISS also include injuries related to bicycle accessories.

Each injury record contains the following information:[21]

- **Date of Treatment**
- **Age** to the nearest year except for those under two years old, for which the age is recorded more precisely.
- **Gender**
- **Diagnosis** can be one of 29 pre-defined diagnoses or "Other." Diagnoses were grouped into broader categories for this analysis.
- **Body Part Affected** can be one of 25 pre-defined body parts or "Not recorded." Body parts were grouped into broader categories for this analysis.
- **Disposition of Case** indicates whether the patient was treated and released, admitted to the hospital or transferred to another hospital, held for observation, left without being seen, died, or "Not recorded."
- **Products Involved** up to two products can be specified—a numeric code.
- **Incident Locale** can be one of home, farm/ranch, street or highway, other public property, mobile home, industrial place, school, place of recreation or sports, or "Not recorded."
- **Race** can be White, Black/African American, Asian, Native American/Alaskan Native, Native Hawaiian/Pacific Islander, Other, or "Not stated."
- **Narrative** up to 142 characters describing the incident.

Each record is also weighted to make the sample representative of the U.S. as a whole.[22] The 14,859 records in the 2008 data set when weighted represent 493,740 bicycling related visits to the ER nationally. All analyses were performed using the weighted values.

Below, we report on the types of injuries that occurred, the demographic characteristics of those injured, and—to the extent possible—the circumstances of the injury.

Table 2 shows the different diagnoses that bicycle injuries resulted in. Scrapes and bruises (contusions/abrasion) are the most common diagnoses. Cuts (laceration) and strains/

sprains are also common. Together these types of relatively minor injuries accounted for nearly 60 percent of all ER visits. Broken bones and dislocations occurred in 21 percent of the cases. Internal organ injuries (mainly head injuries that didn't result in a concussion) and concussions accounted for 9 percent of the visits.

Table 2. Frequency of Diagnoses for Bicycling-Related ER Visits

Diagnosis	Frequency
Contusion/abrasion	27%
Fracture	21%
Laceration	19%
Strain/sprain	13%
Internal organ injury	7%
Concussion	2%
Dislocation	1%
Other/not stated	10%

Table 3 shows the body parts injured by bicyclists. Arms, hands, legs, and feet are the most commonly injured. Injuries to the head are not uncommon—14 percent of the visits were for head injuries and another 14 percent for injuries to the face and mouth.

Table 3. Frequency of Body Parts Injured in Bicycling-Related ER Visits

Body Part	Frequency
Arm & Hand	26%
Leg & Foot	23%
Head	14%
Face & Mouth	14%
Trunk	11%
Shoulder	8%
Other	4%

Relatively few ER visits for bicycling injuries result in hospitalization. 92.6 percent of patients were released after being treated in the ER. 5.5 percent were either admitted or transferred to another hospital. 1.5 percent left without being seen. Less than 1 percent were held for observation (.3 percent), and only .1 percent were dead on arrival or died in the ER.

Table 4 shows the proportion of ER visits for bicycling injuries by age group. Bicyclists aged 10-19 years accounted for the largest group (36 percent) followed by 20-29 year olds. People of all ages visit the ER for bicycling related injuries. Above 50, visits to the ER start to diminish with age.

Table 4. Proportion of ER Visits for Bicycling-Related Injuries by Age Group

Age	Proportion
0-9	8%
10-19	36 %
20-29	20%
30-39	8%
40-49	11%
50-59	9%
60-69	5%
70-79	2%
80-89	1%

The bulk (72 percent) of the ER visits was made by males. Table 5 shows the proportion of ER visits by age group and gender. Visits by females were more common among the 0-19 year age group and less common in the 20-39 year age group. Above 40, the ages of men and women visiting the ER were similar.

Table 5. Proportion of the ER Visits per Bicycling-Related Injuries by Age Group, Stratified by Gender. (Each Column Sums to 100%.)

Age	Male	Female
0-19	42%	48%
20-39	31%	22%
40-59	19%	20%
60+	8%	10%

Different injuries are more common among different age groups. Table 6 shows the frequency of injuries to different body parts by age. Among children ages 0-9, face and mouth injuries are the most common. In fact, face and mouth injuries are more prevalent among this age group than any other age group. Shoulder and trunk injuries, on the other hand, are least frequent among children. Shoulder injuries are most common among bicyclists ages 30-49. Trunk injuries tend to increase with age. Arm and hand injuries are most common among the 10-19-year-old age group.

Table 6. Frequency of Diagnoses for Bicycling-Related ER Visits by Age. (Rows Sum to 100%.)

Age	Arm & Hand	Face & Mouth	Head	Leg & Foot	Shoulder	Trunk	Other
0-9	20	33	21	18	1	3	3
10-19	32	15	13	26	4	7	3
20-29	25	11	14	26	10	10	5
30-39	23	9	10	26	14	14	6
40-49	22	9	11	21	14	17	6
50-59	21	9	13	18	12	21	6
60-69	21	9	14	18	10	22	5
70-79	19	7	21	20	10	19	3
80-89	16	8	25	20	6	25	1

NEISS records provide only a limited amount of information about where bicycling injuries occurred. Table 7 shows the fraction of injuries that occurred at each location.

Table 7. Frequency of Bicycling Related ER Visits by Location. (Less Than 1% of Accidents Occurred on Farms/Ranches, Industrial Places, and Schools.)

Location	Frequency
Not recorded	28%
Home	22%
Street	38%
Other public property	5%
Place of recreation or sports	7%

The narratives in the NEISS data provide a glimpse into the circumstances of an injury, but many relevant details are lacking. Furthermore, because the narratives are free-form text fields there is a high level of variability in how accidents are described.

In the narratives, several aspects of accidents appear to be regularly recorded. If a person fell off their bike, if a motor vehicle was involved, or if the bicyclist went over their handlebars these events are all noted.

Five broad categories of accidents were identified from the narratives. Falls were identified by the words “fall,” “fell” or “falling.” Accidents involving motor vehicles were identified by the words “motor vehicle,” “car,” “truck,” “van,” “motorist,” or “mv” (an abbreviation for motor vehicle used by ER staff). Crashes not involving a motor vehicle were identified by the words “crash” or “wreck.” (A “crash” and a “fall” without the mention of a motor vehicle’s involvement may very well be similar accidents, but we report them separately here.) The words “over handlebar(s)” were used to identify bicyclists who went over their handlebars. The words “alcohol” or “intoxicated” or “ETOH” (an abbreviation for intoxication used by ER staff) were used to identify accidents involving alcohol.

Together, these five categories of accidents accounted for 81 percent of the bicycling accidents in the NEISS data set. A review of a randomly selected sample of narratives representing each type of accident as well as a random sample of those categorized as other, was conducted to confirm the reasonable accuracy of these keywords.

Based on analysis of the narratives, 62 percent of the accidents involved a fall. 15 percent involved a motor vehicle, while 4 percent involved both a fall and a motor vehicle. An additional 6 percent were described as a “wreck” or “crash” without also mentioning a fall or motor vehicle.

Just 2.5 percent of injuries involved alcohol. Of these, 67 percent involved a fall and 21 percent involved a motor vehicle. 2 percent of injuries involved a bicyclist going over their handlebars.

Head injuries are arguably the most serious bicycling injuries because they are the most likely to cause a fatality or result in permanent injury. Therefore, we performed further investigation focused solely on those ER visits involving injuries to the head.

Table 8 shows the prevalence of head injuries by age. For instance, among the 0 to 9-year-old age group 21 percent of the ER visits were for head injuries, while the remaining 79 percent were for injuries to other parts of the body. The pattern that emerges from this table is that head injuries are most common among the very young and the very old.

Table 8. Prevalence of Bicycling-Related Head Injuries by Age, Compared to All other Body Parts. (Each Row Can be a Maximum of 100%.)

Age	Head injuries as a percent of all injuries
0-9	21%
10-19	13%
20-29	14%
30-39	10%
40-49	11%
50-59	13%
60-69	14%
70-79	21%
80-89	25%

Table 9 shows the percentage of each type of accident that led to a head injury. Bicycling injuries that involved alcohol were the most likely to lead to head injuries. Cyclists going over the handlebars were the second most likely to suffer head injuries. Over one in five accidents that involved a motor vehicle led to a head injury.

Table 9. Percentage of each Type of Accident that Resulted in a Head Injury. (Each Row Can be a Maximum of 100%.)

Accident Type	Percent that resulted in head injuries
Fall	14%
Of motor vehicle	21%
Alcohol	36%
Over the handlebars	24%
Wreck	15%

FLORIDA

In 2005 the state of Florida conducted a survey of bicyclists and pedestrians.[23] Although the primary purpose of the survey was to identify attitudes about infrastructure, several questions addressed safety and accidents. The survey results are based on 1750 telephone interviews. An interviewee was considered a "bicyclist" if they biked at least once per month.

Among those bicyclists interviewed, there were 76 accidents involving motor vehicles reported. 38 percent of those occurred on a road without a bike lane, 20 percent occurred on a road with a bike lane, 19 percent occurred on the sidewalk,[24] and 7 percent occurred in a crosswalk. Accidents also occurred on multi-use paths, driveways, and parking lots. The survey also found that on average, 43 percent of cycling is done on roads without bike lanes, 22 percent on multi-use paths, 20 percent on sidewalks, and 15 percent in bike lanes. Comparing the fraction of bicycling with the fraction of accidents on each type of facility, there is little evidence that one is any safer than another (with the exception of multi-use paths, which are much less likely to be the site of accidents involving motor vehicles).

A separate study of bicycle lanes found only minor conflicts between cyclists and motorists.[25] During the study, 638 cyclists were videotaped using bicycle lanes. The study was conducted on two streets in southern Florida. Data were collected in the spring of 1999 on weekdays and weekends on clear days.

During the study, 13 conflicts were observed, a rate of 2 per 100 bicycles. The vast majority of conflicts involved cars entering or exiting parking spaces, and the cyclists were able to easily avoid them by changing direction slightly or braking.

A more extensive study of bicycling accidents was conducted in Orlando, Florida.[26] The study analyzed 885 crashes involving motor vehicles in the Orlando area (Orange, Seminole, and Osceola Counties) that occurred in 2003 and 2004.

Key findings include the fact that "of 657 daytime crashes, only 8.4 percent (55) involved sober cyclists who were traveling on the roadway and were confirmed as obeying the rules of the road." And, "of 196 night-time crashes, only 8.2 percent (16) involved sober cyclists who were traveling on the roadway and were confirmed as obeying the rules of the road."[27]

There were 17 fatal crashes. Eight occurred at night and one occurred at dusk. Ten involved cyclists who had been drinking or using drugs. Two involved motorists who had been drinking.

A large percentage of the crashes in the study—64 percent—involved a poor decision by the cyclist such as riding the wrong way on a street, not stopping at a red light, or bicycling while intoxicated. 43 percent of the crashes involved cyclists riding against traffic (whether on the road itself or on an adjacent sidewalk or path). As the authors point out, "traveling against the flow of traffic places cyclists outside the normal scanning pattern of motorists, particularly those making turns from driveways and cross-streets."[28] 28 percent of the crashes involved cyclists riding at dusk or at night without lights or reflective clothing. Approximately 15 percent of the crashes involved cyclists who ignored stop signs, yield signs, or red lights.

Other bicyclist behavior cited in the crashes were poor lane positioning (12 percent), failing to yield when entering the roadway (8 percent), improperly executed left turn (3 percent), a poorly maintained bicycle (9 percent), and intoxication (7.5 percent). In addition, 4 percent of the crashes occurred in parking lots, mostly involving children.

Driver behavior was a significant factor in a large fraction of the accidents. 44 percent of the accidents involved a motor vehicle operator's failure to yield—when passing (8 percent), when entering the roadway from a driveway (20 percent), at an intersection (19 percent), or when turning (5 percent). Driver intoxication contributed to somewhere between 3 percent and 19 percent of the crashes (where the uncertainty is because a number of crashes were hit-and-runs).

MINNESOTA

In 2007 the Minnesota Department of Transportation published a study of bicycle and pedestrian accidents that occurred in the state during the period 1998-2002.[29] As with other studies, data is reported without adjusting for exposure. The authors address the difficulty of collecting exposure data and propose using indirect measures of exposure as a proxy.

Over the period of the study, there were 1.31 bicycle crashes on average on weekdays and 0.72 crashes on average on weekend days. Nearly 70 percent of the crashes occurred on roads with speed limits of 30mph. 80 percent of the bicycle accidents occurred during daylight, while approximately 6 percent occurred at sunrise/sunset, and 14 percent occurred on lit streets at night. 35 percent of the bicycle accidents occurred at signalized intersections, and 24 percent occurred at intersections with stop signs. The number of bicycle accidents was highest during the summer months.[30]

The report also takes a detailed look at the intersections where the most accidents occurred. An intersection near a high school was the site of a number of crashes that involved right-turning vehicles and teenaged cyclists. In another area, near the University of Minnesota on a street with bars and restaurants for students, many cyclists were hit while crossing the road. Also of note is the intersection of Nicollet Avenue South and Franklin Avenue

where a bicycle facility ends and bicyclists continue in mixed traffic. As the authors put it, "the street design creates a bottleneck of too many users using a myriad of modes trying to use the traffic lanes resulting in crashes."[31]

A regression analysis of the bicycle accidents focused on factors in the physical environment near the sites of the accidents. Population density and the number of retail stores were both positively correlated with bicycle accidents. Most likely, such areas are the site of more cycling activity. Higher speed limits were also associated with more crashes, as were the presence of bike lanes (again, likely an indication of more cycling activity).[32]

The authors also cite the need to improve the reporting of bicycle accidents. They propose several ways to decrease the under-reporting of bicycle accidents and to improve the accuracy of reports that are submitted. The location of crashes can be recorded more accurately on police reports. Overlapping and ambiguous questions on the reporting form can be consolidated and clarified to reduce confusion. Time of day should be written in a standard format. Only accidents that involve $1000 in property damage or bodily harm require a police report in Minnesota. Lowering this threshold could lead to more bicycle accidents being reported.[33]

PALO ALTO[34]

The City of Palo Alto, California conducted a study to assess the risk of cycling against traffic. The data in Table 10 comprises the period in Palo Alto from July 1985 through June 1989. Riding against traffic presents a 3.6 times greater risk of an accident than riding with traffic. The risk is most pronounced for those riding on the sidewalk. For example, a motorist turning right at an intersection scans to the left for approaching traffic on the road the motorist is entering. The motorist will often not see or anticipate a fast-moving wrong-way bicyclist approaching from the right. According to the report this is one of the most common types of bicycle-motor vehicle collisions in Palo Alto. The data also indicate that as long as cyclists travel with traffic they are equally safe whether on the roadway or on the sidewalk.[35]

Table 10. Number of Bicycle Accidents in Palo Alto, CA, 1985-1999

	Against Traffic			**With Traffic**			**Risk Ratio**
	Bicyclists Observed	Accidents Reported	Risk (%)	Bicyclists Observed	Accidents Reported	Risk (%)	
All bicyclists	423	33	2.6	2553	56	0.7	3.6
Roadway	108	5	1.5	1897	43	0.8	2
Sidewalk	315	28	3	656	13	0.7	4.5

II. APPLICATION OF SOCIAL PSYCHOLOGY TO BICYCLE SAFETY

SECTION AUTHOR: CAMILLE S. JOHNSON, PH.D.

Successful programs to change public health behaviors often draw upon social psychological theories in their implementation.[36] For example, drawing upon the power of social pressure, campaigns to reduce smoking attempt to make the image of smokers and tobacco companies less positive and reinforce that smoking is deadly. In the same way that social psychological theories have been used to change health behaviors such as smoking and exercise, these theories can be and have been used to address bicycle safety behaviors.

In the application of social psychological theories to the changing of health behaviors, two models have most frequently been employed. Each framework rests upon a series of assumptions regarding the constructs that predict the initiation and maintenance of health behaviors. These frameworks are described below and applications within bicycle safety contexts are discussed. In describing how these frameworks may be used to create effective interventions, references will be made to existing programs that have relied upon the health belief model and the theory of planned behavior. Although most of these existing programs have focused on helmet usage, these interventions could also be used to encourage other bicycle safety behaviors (for example, wearing bright clothing and following traffic laws). Therefore, suggestions are provided regarding how to adapt the health belief model and the theory of planned behavior to changing the other bicycle safety measures.

THE HEALTH BELIEF MODEL

The Health Belief Model posits six key elements that predict whether or not an individual adopts particular health behaviors.[37] These elements are: perceived susceptibility to a particular negative outcome, perceived severity of a negative outcome, perceived benefits of preventative behavior, perceived barriers to the preventative behavior, the cues in the environment that lead to preventative action, and self-efficacy.

Perceived Susceptibility

In the context of bicycle safety, perceived susceptibility is related to riders' assessments of their risks of getting into an accident or to the relative safety of bicycle riding. These assessments could be tied to general beliefs about what is safe or tied to beliefs about specific behaviors. For example, people may believe that riding on sidewalks is a low-risk behavior because it increases the distance between cars and cyclists. If people can be made more aware of the dangers of collisions with pedestrians and the importance of remaining visible to drivers, they may change their assessment of the riskiness of riding on the sidewalks. Factors other than knowledge of risk can also influence perceived susceptibility. For example, in the analysis presented later in this report, we find that riding while intoxicated is associated with bicycle-related injuries. Intoxication may influence perceived susceptibility in two ways. First, people may believe that riding

while intoxicated is safer than driving while intoxicated. Second, intoxication may lead people to perceive that specific behaviors (for example, riding against the direction of traffic) are less dangerous than they actually are. Finally, because perceived susceptibility is related to rider's assessments of the likelihood or probability of an accident occurring, knowing someone or feeling similar to someone who has been in an accident can increase perceived susceptibility and adherence to safety behaviors.[38]

Perceived Severity

Perceived severity is related to the riders' assessments of how severe their injuries would be from any accidents that might occur. Perceived severity and perceived susceptibility might work together to influence health behaviors. For example, individuals might believe that they are susceptible to relatively mild injuries or unlikely to experience a very severe injury—either assumption would lead to fewer safety behaviors. Similarly, one could imagine that the use of safety equipment such as helmets might actually counteract other safety behaviors. Although this relationship has not been empirically demonstrated, correlational data has found that wearing a helmet is associated with a greater chance of injury.[39] One reason for this could be that when riders are wearing helmets they perceive that any injuries they might incur would be minor, and therefore are more likely to engage in risky behaviors.

Perceived Benefits of Preventative Behavior

In the context of bicycle safety, perceived benefits of preventative behavior are tied to rider's assessments of the likelihood that safety-related behaviors will reduce occurrence or extremity of injury. These assessments can be derived from previous experience or general beliefs about the effectiveness of preventative behaviors. For example, people who have previously experienced a bicycle-related injury are more likely to wear a helmet than those who have not. This may be because their personal experience increases their perception that an injury could occur and that wearing a helmet would provide a high level of benefit. Similarly, knowing someone for whom the level of injury was mitigated by wearing a helmet can increase the perception that helmet wearing is an effective safety action. Thus, in order for people to adopt safety behaviors such as wearing a helmet or following cycling rules and regulations, they must believe that such behaviors will provide an adequate benefit.

Perceived Barriers

Perceived barriers are obstacles to enacting health behaviors. Barriers may be material, such as the expense of safety clothing. They may also be physical or social. For example, helmets may be regarded as unfashionable, as uncomfortable, or as creating other appearance problems. In this way, just as seatbelts may be shunned because they wrinkle clothing, social costs can impede the use of helmets and other safety clothing. Thus, obstacles to enacting a behavior may be objective (lacking the resources to acquire a helmet) or subjective (fear of social costs of wearing a helmet).

Cues

Cues are reminders to adhere to safety rules and procedures. These cues may be explicit and directed at cyclists directly by urging them to follow traffic rules, or be directed at drivers. For example, it is typical to see cues such as road signs encouraging drivers to "share the road," and also signs and reminders near bicycle parking areas to wear helmets and follow traffic rules. Cues may also be indirect, such as featuring helmet-wearing bicycle riders in popular press and media. For example, the animated character Dora the Explorer, which is aimed at preschoolers, always wears a helmet when riding a bicycle or scooter. This repeated presentation of a popular character wearing a helmet provides a reminder to children that they should wear a helmet, while also making helmet wearing more socially acceptable.

Self-Efficacy

Self-efficacy refers to individuals' beliefs that they have the resources to enact the behaviors that will increase safety. Efficacy is influenced by prior experience and by the experience of similar others.[40] For example, if riders have friends who have properly adjusted and altered the fit of their helmets, riders may experience higher self-efficacy for adjusting and wearing their own helmet. Thus, if individuals have been successful at one safety behavior, such as remembering to wear a helmet, they may feel confident regarding their ability to wear additional safety clothing as well.

Applications of Health Belief Model

Programs to increase bicycle helmet use have implemented the Health Belief Model to varying degrees and with varying success. A review of the programs reveals that many programs focus largely on removing the obstacles to safety behaviors, such as social pressure and lack of equipment. This focus may be a result of assuming that most people are aware of the dangers associated with riding without a helmet and have decided that the costs associated with helmet wearing are greater than the benefits of helmet wearing. By reducing the obstacles to obtaining appropriate equipment, programs hope to change the cost/benefit analysis and remove excuses for unsafe behaviors. Programs that provide helmets for free have been successful in increasing helmet wearing among school-aged children.[41] Other programs use public information campaigns to address social costs associated with wearing helmets and provide cues to remind riders to be safe,[42] and have been less successful.[43]

While public information campaigns also include information designed to increase risk assessments and perceived susceptibility, this is not generally the main focus of the campaigns and such messages may rely largely on statistical information. The potential severity of the injuries that could be incurred in a bike accident is less frequently addressed. This stands in contrast to other public safety campaigns, such as those discouraging drunk driving, which have included more graphic information (for example, bringing in wrecked cars that have been involved with drunk driving accidents) to highlight the perceived severity of potential injuries. One reason for this might be that a majority of helmet campaigns are focused on children and young adults, and campaigns may be reluctant to use a

vivid fear campaign with that audience. In addition, a campaign highlighting the dangers inherent to bicycle riding might work in contradiction to other public service campaigns encouraging exercise and bicycles as alternative means of transportation. Furthermore, research suggests that merely increasing perceptions of a threat may not increase safety behaviors.[44]

Other methods of influencing safety behavior have relied on increasing the perceived severity of negative outcomes in monetary terms. Rather than highlighting the severity of injuries that could occur, the use of legislation and accompanying punitive measures may be used to increase the perceived severity of not engaging in safety behaviors. Legislation creates an additional class of negative outcomes that could be associated with non-adherence (for instance, monetary fines). In this way, legislation changes behaviors through changing beliefs about the potential severity of outcomes. Notably, the efficacy of legislation may be constrained by the degree to which riders are aware of the laws and regulations (which novice and recreational riders may not be), and by their perceived susceptibility to those negative outcomes. Such legislation is only effective to the degree that riders believe they will be ticketed or fined for breaking those laws. Therefore, enforcement of legislation is an additional factor to be considered.

As noted earlier, most interventions designed to increase helmet usage have focused on children under the age of 18. However, in implementing the Health Belief Model to increase bicycle safety behaviors among adults, it may be important to consider the audience and the specific behavior of focus. For example, it may be useful to distinguish between different kinds of adult riders.[45] One category would include recreational riders, who are infrequent riders. For this group, the relative infrequency of riding may make purchasing a helmet seem onerous and lead individuals to believe that their risk of getting into an accident is fairly low (reduced susceptibility). In addition, they may believe that certain riding behaviors like riding on sidewalks as opposed to in the street or their riding speed may put them at lower risk for severe injury, were an accident to occur (reduced severity). According to the Health Belief Model, campaigns may need to focus on ways to decrease risk behaviors by educating riders about the nature and severity of the risks they are encountering. Another category of riders would include athletic riders, who are individuals who ride frequently and may have a great deal of experience with riding. For these individuals, team norms and competitive regulations may make helmet wearing de rigueur. However, given their experience and goals, individuals from this category may be less likely to engage in other safe bike habits such as following traffic laws. In addition, stereotypes of this group and within this group may create an environment of animosity. For example, within communities where there are frequent interactions and conflicts between cyclists and drivers, drivers can come to view cyclists as annoyances and cyclists can become targets of violence. Similarly, movements such as Critical Mass may increase the environment of conflict. In these complex situations, bicycle safety is not necessarily something to be tackled through individual interventions, but through group and community interventions. These simple examples highlight the need to tailor interventions to different kinds of riders.

THE THEORY OF PLANNED BEHAVIOR

Whereas the Health Behavior Model relies upon five predictors of health behaviors, the Theory of Planned Behavior relies upon three main predictors. These predictors are: attitudes towards the behavior, perceived social pressures for behavior, and perceived behavioral control. These three constructs are thought to contribute to behavioral intentions, which are the most proximal cause of actual behavior.

Attitudes Towards Behaviors

Within bicycle safety contexts, attitudes towards the behavior encompass people's attitudes towards safety objects, such as helmets, and people's attitudes towards the use of safety objects, such as the wearing of helmets. Attitudes vary in their valence, their strength, and their relevance. Valence refers to the positivity or negativity of people's attitudes. A positive attitude indicates that people like the object, agree with the opinion, or enjoy the activity. Strength refers to the stability of the attitude over time and how easily the attitude comes to mind. A strong attitude is resilient to persuasive appeals and a person is likely to report the same attitude across different situations and times. Relevance refers to the degree to which the attitude is about something that is important to the person. A highly relevant attitude is associated with an individual's core values or sense of identity. For example, for an avid gardener, attitudes towards organic gardening methods are more relevant than for an individual who does not have a garden. Together, valence, strength, and relevance determine how predictive an attitude is, with greater strength and greater relevance increasing predictive value. Individuals may hold both positive and negative attitudes towards different aspects of helmets (for instance, they may have a positive attitude towards the safety provided by a helmet and a negative attitude towards the appearance of the helmet). The relative strength of these attitudes determines one's overall attitude. That is, a relatively weak positive attitude towards safety and a relatively strong negative attitude towards the appearance of helmets would lead to an overall negative attitude towards helmets.

Attitudes may reflect perceptions of risk and perceptions of the severity of negative outcomes. For example, riders have a less positive attitude towards safety behaviors if they believe they are at low risk for severe outcomes. Therefore, they are unlikely to enact these behaviors. However, these attitudes may be altered through education regarding perceptions of risk and severity. Moreover, research suggests that focusing on attitudes is among the most effective means of changing behavior.[46]

Perceived Social Pressures

Perceived social pressures include social norms and taboos for and against particular actions and opinions. Social norms can arise through formal restrictions, but are more likely to be unwritten rules determining what kinds of behaviors and opinions are appropriate and fit within a particular group identity. Perceived social pressures could include the pressure of peers against wearing helmets[47] because they are "uncool," or the expectation from parents that helmets will always be worn. These pressures can be very powerful. For example, children whose parents wear helmets are more likely to wear helmets when

riding alone.[48] In this component of planned behavior, the *perceived* attitudes of others are the most influential. That is, if few people wear helmets, it may be because everyone *thinks* that everyone else *thinks* that helmets are unnecessary. Indeed, others may actually view helmets positively, but be afraid to express this opinion. For this reason, one might expect that programs that are successful at increasing bicycle safety behaviors may be self-reinforcing—once more people begin to wear helmets, social norms may shift in favor of helmet wearing, which would lead to more helmet wearing.[49] Thus, maintaining safe behaviors may be easier than initiating safe behaviors.

Behavioral Control

Behavioral control is related to whether riders feel that they are able to complete the safety behaviors. Control decreases as individuals perceive obstacles to the safety behaviors (for example, lack of funds to purchase a helmet) or perceive that they cannot enact the behaviors adequately (for instance, lack of ability to remember safety rules). In this way, behavioral control is related to the previously discussed construct of self-efficacy. Furthermore, research suggests that merely increasing perceptions of a threat may increase safety behaviors.[50]

Behavioral Intentions

According to the Theory of Planned Behavior, attitudes, social pressures, and behavioral control contribute to an individual's intentions to enact a behavior. Behavioral intentions are assessed in very specific terms. That is, behavioral intentions relate to specific safety behaviors such as wearing a helmet, stopping at stop signs, or riding with the direction of traffic. If attitudes and pressures are both positive and the level of control is high, then one would expect there to be relatively high intentions and greater enactment of the behavior. Frequently, however, attitudes and social pressures may be contradictory and levels of control may vary. By assessing these three elements, and how they contribute to intentions, programs may be better able to tailor interventions to fit particular populations.

HEALTH BELIEF MODEL VERSUS THE THEORY OF PLANNED BEHAVIOR

In comparisons of the health belief model versus the theory of planned behavior in predicting helmet wearing, the Theory of Planned Behavior has proved to be somewhat more robust and have greater predictive power.[51] This could be because the theory of planned behavior integrates many elements of the health belief model while adding the predictive value of intentions to commit the behavior. Thus, most interventions that have been implemented in the past could be fit into either model.

As noted, the efficacy of programs based upon both the health belief model and the theory of planned behavior often rests upon changing peoples' attitudes about bicycle safety behaviors, attitudes about how easy it would be to implement those behaviors, and so on. However, as with measure of behavioral intentions, reports of attitudes will not necessarily predict behaviors if those attitudes are not measured accurately or appropriately. That is, it may not be appropriate to simply ask people about their attitudes about bicycle safety, but they must be asked about their attitudes toward specific bicycle safety behaviors and

must be educated about specific behaviors. For instance, people may believe that they are acting safely when they ride on the sidewalks, although, as noted in the analysis in this paper, riding on the sidewalks is associated with collisions and injury. Thus, part of the process of increasing bicycle safety behaviors is to teach people what behaviors are unsafe. Most campaigns have focused on helmet and safety gear that would reduce the severity of injuries that might occur, with less focus on following safety laws and rules.

In general, interventions that take a more comprehensive and community-based approach have been more successful. Such programs address multiple components of each model. For example, programs that rely solely upon school-based educational campaigns (including skits, lectures, posters, and take home brochures) that focus on changing perceptions of risk or susceptibility have not been as successful in increasing helmet wearing.[52] However, programs that include public service announcements, coupons, and promotions in retail stores as well as schools have been more successful. These more comprehensive programs influence not only attitudes, but also the obstacles that prevent adherence to safety behaviors. Thus, understanding how attitudes, social norms, perceived barriers, and perceived severity of injury influence behaviors is important for guiding interventions. By knowing what influences the behaviors, interested parties know how to begin changing behavior in focused and effective ways.

III. THE 5 ES: DIMENSIONS OF EFFECTIVE PRACTICES

SECTION AUTHOR: JOHN W. OMWEG

The "5 Es" is a scheme advocated by the Global Road Safety Partnership, the Safe Routes for Schools Program, the League of American Bicyclists, the U.S. Department of Transportation's Federal Highway Administration and many other bicycle and transportation safety organizations. It prescribes five lines of assessment that apply to studies of bicycle safety and to transportation safety generally.[53] A description of the Es follows:

ENGINEERING

This covers the practices that design and improve infrastructure and facilities to promote safe bicycle use; for instance, traffic calming technologies, signal development, intersection design, construction of bike lanes and paths, signage, parking facilities, and so on. Sharing a road with vehicles that travel much faster and are much heavier exposes cyclists to tremendous risks.

Bicycle-friendly cities heavily invest in bike paths and bike lanes. Many have adopted the Complete Streets approach to planning. Bicycle parking and storage facilities are integrated with mass transit to encourage riding to and from the station or transit center.

When an American visits northern Europe and observes the extensive infrastructure that exists for cyclists, one can appreciate how safe and convenient cycling can be. One can often ride on a path or shared sidewalk[54] away from vehicular traffic. Train stations have extensive storage facilities, and trains run often enough to live without owning a car.

A recent review of safety literature by Reynolds and others, argues for the effectiveness of bicycle-tailored facilities (for instance, bike routes, lanes, paths, tracks at roundabouts) in reducing the risk of crashes and injuries compared to facilities that are not primarily intended for cycling (for example, sidewalks and shared roadways). Slope, lighting, and pavement maintenance also appear to contribute to increased cycling safety.[55]

Posted speed limits and the design of a roadway for high-speed transit affect cyclist safety since 80 percent of cyclist injuries involved in collisions at speeds greater than 50 km/hr (33 mph) are severe.[56] In the U.S., streets were generally designed to allow cars to move as quickly as possible. Accordingly, the most dangerous places to walk and cycle are sprawling communities with streets built for driving only.[57] Many roads have no sidewalks or have not been constructed with room for cyclists. When combined with relatively high motorist speeds, this results in greater risks for pedestrians and cyclists since greater speed means less time to react and more energy delivered by the impact.[58] It appears that traffic environments in dense urban areas may actually be safer than suburban streets, due to fewer driving miles per capita and lower speeds, in addition to traffic calming infrastructure design in urban areas.[59]

Moudon and others found that the proximal access for cyclists to trails, business centers, hospitals and clinics, and fast food to be significant environmental factors rather than the traditional correlates of bike lanes, traffic speed and volume, parks, and topography.[60]

Fortunately, recent trends in design implementation for regional or local transportation planning increasingly integrate consideration for cyclists' (and pedestrians') particular needs in roadway construction by taking into account access to popular destinations, local facilities, and transportation terminals; by creating neighborhood plans that make use of bicycle routes and traffic calming measures; and in municipal and zoning planning that acknowledges and incorporates bicycle parking needs.[61]

Infrastructure Facilities for Cyclists

TRAFFIC CALMING MEASURES[62]

Since the reduction of vehicle speed directly relates to the risk for severe injuries for cyclists, methods to limit cyclist exposure to high-speed traffic are a design intervention of considerable promise. Traffic calming measures use vertical and horizontal deflection techniques (for instance, speed bumps, roundabouts, chicanes, and so on) to alter motorist behavior for the benefit of other road users. In the most extreme examples, motorist speed is controlled to match the speed of pedestrian road users.[63] Traffic calming measures can increase numbers of cyclists and pedestrians by making such facilities pleasant and attractive and by enhancing the perception of cycling safety. Traffic calming has also been found to reduce the actual frequency or severity of accidents by achieving their design goal of lowering the speed of motor traffic.[64] In Seattle, Washington, a tendency to use landscaped traffic circles as a traffic calming measure provides an affordable ($3,000-$6,000) intervention in response to high-risk intersections or community requests for traffic calming measures. A before and after comparison of crashes in Seattle neighborhoods at 119 intersections that had circles added between 1991 and 1994 reported a 94 percent reduction in crashes.[65]

BICYCLE LANES AND PATHS

A prevalent form of infrastructure adaptation for multiple transit modalities is to afford each modality a designated space within the transit environment. Traditionally, this means segregating or designating as separate the facilities intended for each class of transit user: sidewalks are for pedestrians and roadways are for cars. Bikes have fallen into a kind of limbo in cultures that focus on cars as priority road users or as delivery mechanisms for pedestrians. Accordingly, many bicycle safety plans seek to designate specific spaces for bicycles to occupy within the built environment.

There are many forms and degrees of segregation between motor vehicles and bicycles. Clearly designated bicycle lanes (Class II bikeways) on roads help to specify the limits and presence of space intended for bicycle use.

Bicycle paths or trails (Class I bikeways) that are separate from surface streets improve the safety and efficacy of bicycle commuting since there is a dramatic reduction in the

stops, signals, intersection cross-traffic, and overtaking vehicles that delay or threaten cyclists. If the most serious injuries for cyclists are the result of high-speed collisions with automobiles, then physically separating the two modes would limit risk exposure for the vulnerable road user.

SHARED LANE PAVEMENT MARKINGS

Class III bikeways without strong cues for cyclists' rightful position in the traffic stream may place them at risk, especially where parked cars present a real danger of dooring (cyclists crash into the opened doors that they didn't have time to avoid), and overtaking traffic leaves little room to maneuver. Instead of designating a separate bicycle lane, pavement markings may be used to signal to motorists and cyclists how to position themselves. In San Francisco, California implementation of such markings on streets provided occasion to study their effects on the incidence of dooring, wrong-way and sidewalk riding, and cyclist exposure to motorist aggression.[66] The study's results were encouraging: the presence of such markings increased the distance of cyclists to parked cars even while being overtaken by passing vehicles; similarly, the distance of cyclists to passing cars increased by over two feet. The bike-and-chevron marking was correlated with a 35 percent reduction in sidewalk riders and an 80 percent reduction in wrong-way riders. While motorist aggression did not seem to be affected, 60 percent of cyclists surveyed as part of the study felt the markings increased their sense of safety.[67] The use of colored bike lanes within a vehicle lane of travel has proven to be highly successful in cities such as Salt Lake City. These methods also promote visibility and reduce collisions.

BICYCLE BOULEVARD

A progressive technique of motor vehicle/bicycle segregation, the bicycle boulevard, is a North American bikeway adaptation of various European traffic calming and "home street" style streetscape treatments. The bicycle boulevard approach designates certain streets primarily for bicycle use and discourages automobile use through means such as the traffic calming measures discussed above. Though data does not directly support the safety benefits of bike boulevards, a strong case can be made for improved safety along such corridors as a result of reduced motorist speed.[68] Studies have found that cyclists would go out of their way to use the boulevard, particularly women, inexperienced cyclists, and those who value cycling on quiet streets.[69] The bicycle boulevard strategy runs counter to historic American motor-centrism, but is already being implemented in a handful of U.S. cities. Some have argued that by "hiding" cycling from regular transit environments, bicycle boulevards may erode the safety benefits of a highly visible cycling population; others counter that boulevards would ultimately increase the numbers of cyclists on the road since they encourage cycling for less experienced and less traffic-tolerant riders.[70]

BIKE BOXES

Placing cyclists in priority positions at intersections may reduce the incidence of right and left-hook collisions. Bike boxes, also known as advanced stop lines, are deployed at signaled intersections and provide clearly demarcated priority positions for cyclists with markings indicating cars to wait behind the box at red lights. Bike boxes also have the

advantage of increasing awareness and visibility of cyclists by providing strong visual cues that alert motorists of the presence of cyclists in a shared transit environment.[71] Though bike boxes are common in Europe, and are being implemented more frequently in the U.S., Australia, and New Zealand, Pucher and others found little research that confirms any safety benefits for cyclists.[72]

Complete Streets

The National Complete Streets Coalition advocates a contemporary domestic approach to safe road design. A "complete street" is one that is designed or re-designed to reclaim transit environments for diverse uses in a shared transit environment, recognizing and respecting pedestrians, bicyclists, as well as motorists, rather than focusing solely on the latter.

The fact that such a program is needed at all indicates that the design of many streets has not traditionally been governed by a philosophy of harmonious co-existence between motorists, bicyclists, and pedestrians. The latter categories of commuter have generally been placed at a disadvantage by street design catering to the motorist. Since transportation infrastructure design has largely assumed motorists to be the primary users of public transportation facilities, steps to refine design priorities to include other transit users like pedestrians and bicyclists are needed not only to ensure that a plurality of transportation modes are serviced, but also to ensure these users are represented appropriately in the planning process.[73]

In the Netherlands, starting in the 1960s, road safety measures emphasized infrastructure (road-building) that already adopted a "complete" approach to road use by encouraging a low-speed, user-rich environment. Programs there in the 1980s focused on educational, enforcement, and media programs to improve road safety.[74]

This approach proved influential. America Bikes, a nonprofit advocacy group for bicycle and pedestrian initiatives, sought to secure federal transportation funding for all road users and this was the founding impetus behind the National Complete Streets Coalition. The coalition brought together bicycle, pedestrian, and other transportation interests (for example, AARP, the American Public Transportation Association, the Institute of Transportation Engineers, and America Walks) to provide research on existing complete streets policies, and to determine which elements successful policies shared.[75] As detailed by the National Complete Streets Coalition, the "ideal" policy for creating complete streets:[76]

- Includes a vision for how and why the community wants to complete its streets.
- Specifies that 'all users' includes pedestrians, bicyclists and transit passengers of all ages and abilities, as well as trucks, buses and automobiles.
- Encourages street connectivity and aims to create a comprehensive, integrated, connected network for all modes.
- Is adoptable by all agencies to cover all roads.

- Applies to both new and retrofit projects, including design, planning, maintenance, and operations, for the entire right of way.
- Makes any exceptions specific and sets a clear procedure that requires high-level approval of exceptions.
- Directs the use of the latest and best design criteria and guidelines while recognizing the need for flexibility in balancing user needs.
- Directs that complete streets solutions will complement the context of the community.
- Establishes performance standards with measurable outcomes.
- Includes specific next steps for implementation of the policy.

The complete streets approach incorporates best practices from across the planning palate. Figure 1 shows how the modifications can transform a roadway that originally favored motorists into a much more friendly and safe shared road environment. The insertion of a landscaped median, the creation and broadening of sidewalks, the addition of lighting, the addition of clearly marked crosswalks and bike lanes, and enhanced curbs provide real and perceived safety benefits for vulnerable road users.

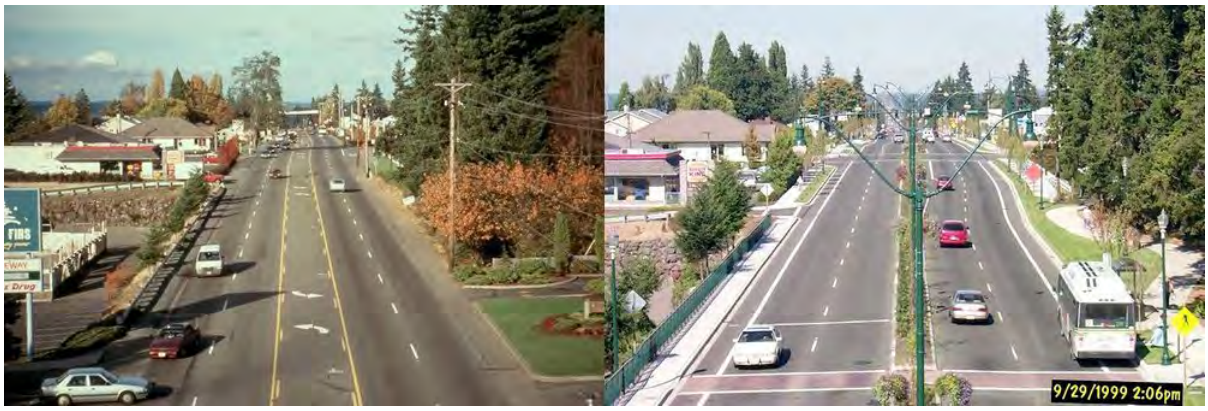

Figure 1. Bridgeport Way in University Place, WA before (left) and after (right) Complete Streets Re-Design (Photo by D. Burden).[77]

The safety benefits of complete streets, though not the subject of any existing research studies, should follow from their traffic calming and speed reducing interventions, from dedicated bicycle facilities, and from the “safety in numbers” effect occurring when more cyclists and pedestrians take to roads that they find convenient, accommodating, and pleasant to use.

Planning Rubric to Evaluate Location, Priority, and Design of Planning Interventions

The following rubric is a general overview of the complex considerations that planners are recommended to take into account when deliberating about improvements to the bicycle network. This list of factors is taken directly from the American Association of State Highway and Transportation Officials' (AASHTO) Guide for the Development of Bicycle Facilities,[78] which provides a widely accepted baseline for bicycle planning in the United States.[79]

Skill Level of Users: Consideration should be given to the skills and preferences of the types of bicyclists who will use the facility. Facilities near schools, parks and residential neighborhoods are likely to attract a higher percentage of basic and child bicyclists than advanced bicyclists.

Motor Vehicle Parking: The turnover and density of on-street parking can affect cyclist safety (for instance, opening car doors and cars leaving parallel parking spaces). Diagonal and perpendicular parking arrangements are not compatible with bicycle facilities because of restricted sight distance and the related potential for bicycle-motor vehicle conflicts. They should be avoided wherever possible.

Barriers: In some areas, there are physical barriers to bicycle travel caused by topographical features, such as rivers, railroads, freeways or other impediments. In such cases, providing a facility to overcome a barrier can create new opportunities for bicycling.

Crash Reduction: The reduction or prevention of bicycle crashes (for example, bicycle/motor vehicle, bicycle/bicycle, bicycle/pedestrian and single bicycle crashes) is important. Therefore, the potential for reducing crash problems through the improvement of a facility should be assessed. Plans for constructing new bicycle facilities should be reviewed to identify and resolve potential safety issues.

Directness: Particularly for utilitarian bicycle trips, facilities should connect traffic generators and should be located along a direct line of travel that is convenient for users.

Accessibility: In locating a bicycle facility, consideration should be given to the provision for frequent and convenient bicycle access, especially in residential areas. Adequate access for emergency, maintenance and service vehicles should also be considered. Other major traffic generators such as educational facilities, office buildings, shopping areas, parks, and museums should also be considered when evaluating bicycle accessibility.

Aesthetics: Scenery is an important consideration along a facility, particularly for a facility that will serve a primarily recreational purpose. Trees can also provide cooler riding conditions in summer and can provide a windbreak.

Personal Safety/Security: The potential for criminal acts against bicyclists, especially along isolated shared-use paths, and the possibility of theft or vandalism at parking locations, should be considered.

Stops: Bicyclists have a strong, inherent desire to maintain momentum. If bicyclists are required to make frequent stops, they may avoid the route or disregard traffic control devices.

Conflicts: Different types of facilities introduce different types of conflicts. Facilities on the roadway can result in conflicts between bicyclists and motorists. Shared use paths can involve conflicts between bicyclists, horseback riders, skaters, runners and pedestrians on the facility. Conflicts between bicyclists and motorists may also occur at highway and driveway intersections.

Maintenance: Designs that facilitate and simplify maintenance will improve the safety and use of a facility. A local or regional bikeway maintenance program is essential.

Pavement Surface Quality: Bikeways should be free of bumps, holes and other surface irregularities if they are to attract and satisfy the needs of bicyclists. Utility covers and drainage grates should be at grade and, if possible, outside the expected path of travel. Railroad crossings should be improved as necessary to provide for safe bicycle crossings.

Truck and Bus Traffic: Because of their width, high–speed trucks, buses, motor homes, and trailers can cause special problems for bicyclists. Where bus stops are located along a bicycle route, conflicts with bus loading and unloading, and pavement deterioration, such as asphalt pavement shoving, may also be problems.

Traffic Volumes and Speeds: For facilities on roadways, motor vehicle traffic volumes and speeds must be considered along with the roadway width. Commuting bicyclists frequently use arterial streets because they minimize delay and offer continuity for long trips. If adequate width for all vehicles is available on the more heavily traveled streets, it can be more desirable to improve such streets than adjacent streets. When this is not possible, a nearby parallel street may be improved for bicyclists, if stops are minimal and other route conditions are adequate. When such a parallel facility is improved, care must be taken that motor vehicle traffic is not diverted. While inexperienced bicyclists prefer more lightly traveled streets, it should be remembered that preferred routes may change over time as skill levels change.

Bridges: Bridges can serve an important function by providing bicycle access across barriers. However, some bridge features restrict bicycle access and/or create unfavorable conditions for bicyclists. The most common of these are curb-to-curb widths that are narrower than the approach roadways (especially where combined with relatively steep grades), open grated metal decks found on many spans, low railings or parapets, and certain types of expansion joints such as finger-type joints, that can cause steering difficulties.

Intersection Conditions: A high proportion of bicycle crashes occur at intersections. Facilities should be selected so as to minimize the number of crossings, or intersections should be improved to reduce crossing conflicts. At-grade intersections on high-volume (or high-speed) roadways and mid-block crossings should be analyzed with bicyclists' needs in mind to determine the most appropriate crossing design treatments.

Costs/Funding: Facility selection normally will involve a cost analysis of alternatives. Funding availability can limit the alternatives; however, it is very important that a lack of funds not result in a poorly designed or constructed facility. The decision to implement a bikeway plan should be made with a conscious, long-term commitment to a proper level of maintenance. When funding is limited, emphasis should be given to low-cost improvements such as bicycle parking, removal of barriers to bicycle travel, and roadway improvements. Facility selection should seek to maximize user benefits per dollar funded.

State and Local Laws and Ordinances: Bicycle programs must reflect state and local laws and ordinances. Bicycle facilities must not encourage or require bicyclists to operate in a manner that is inconsistent with these laws and ordinances.

A popular system of designating types of bicycle road facilities in the U.S. turns on the articulation of bikeway classes. Part 9 of the California Manual on Uniform Traffic Control Devices for Streets and Highways provides explicit definitions for these common designations:[80]

- Bikeway: A generic term for any road, street, path, or way that in some manner is specifically designated for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.
- Class I Bikeway (Bike Path): Provides a completely separated right-of-way designated for the exclusive use of bicycles and pedestrians with cross flows by motorists minimized.
- Class II Bikeway (Bike Lane): Provides a restricted right-of-way designated for the exclusive or semi-exclusive use of bicycles with through travel by motor vehicles or pedestrians prohibited, but with vehicle parking and cross flows by pedestrians and motorists permitted (for example, a marked lane for one-way bike travel on a street or highway).
- Class III Bikeway (Bike Route): Provide a right-of-way designated by signs or permanent markings and shared with pedestrians or motorists.
- Shared Roadway (No Bikeway Designation): A roadway that permits bicycle use but is not officially designated as a bikeway.

Planning Rubric to Evaluate Rider Stress

The availability of funds for improving eligible roadway facilities often follows from an ability to specify the positive results of the improvements.[81] While powerful analytic planning tools have been developed to predict motorist use of roadway facilities, the development of such tools for bicycle and pedestrian facilities and improvements to such facilities remains underdeveloped.[82]

One way to measure the need and results of such improvements is via bicycle suitability criteria that provide a metric for evaluating the safety and "rider stress" characteristics of transport facilities.[83] A literature review of bicycle suitability criteria in urban roadways grouped them into three basic categories:[84]

- Stress Levels: Criteria intended to allow quantification of the apparent stress experienced by cyclists.
- Table 11 provides a sample rubric for assigning a value to cyclist stress level as a function of traffic volume, speed, and available space (for instance, curb lane width).
- Roadway Condition Index: Criteria inclusive of stress levels and adding other criteria (including pavement, signals, and other location factors) where available.
- Capacity-Based Level of Service: Criteria based on volume analyses.

Table 11. Bicycle Stress Level Values and Components[85]

$$\text{Bicycle Stress Level} = \text{stress level (traffic volume)} + \text{stress level (lane width)} + \text{stress level (vehicle speed)} \quad (1)$$

Stress Level	Interpretation
1 (Very Low)	Street is reasonably safe for all types of bicyclists (except for children under 10).
2 (Low)	Street can accommodate experienced and casual bicyclists, and/or may need altering[a] or have compensating conditions[b] to fit youth bicyclists.
3 (Moderate)	Street can accommodate experienced bicyclists, and/or contains compensating conditions[b] to accommodate casual bicyclists. Not recommended for youth bicyclist.
4 (High)	Street may need altering[a] and/or have compensating conditions[b] to accommodate experienced bicyclists. Not recommended for casual or youth bicyclists.
5 (Very High)	Street may not be suitable for bicycle use.

Curb Lane Traffic Volume (vehicles per hour per lane)	Curb Lane Width (meters)	Curb Lane Vehicle Speed (kph)	Stress Level Component
≤ 50	≥ 4.6	≤ 40	1
150	4.3	50	2
250	4.0	60	3
350	3.7	65	4
≥ 450	≤ 3.3	≥ 75	5

Notes: [a] "Altering" means that street may be widened to include wide curb lane, paved shoulder additions, etc.
[b] "Compensating conditions" can include street with wide curb lanes, paved shoulders, bike lanes, low volume, etc.

EDUCATION

Education refers to safety education used to teach cyclists the rules of the road and other safe practices specific to cycling like helmet use and optimized visibility through the use of bright or iridescent clothing and proper lights (i.e., conspicuity).

Helmet Effectiveness in Injury Prevention

A majority of the 1300 deaths per year resulting from bicycle accidents were due to head injuries.[86] In the U.S., 65-100k of emergency room injuries, 40 percent of all hospital admissions and 62-90 percent of all bicycle crash fatalities involve head injuries.[87]

While Acton, Thomas, and Thompson found that most helmets offer no protection for the face if they do not have a chin protector,[88] data is plentiful confirming the effectiveness of properly fitted and approved-design helmets in reducing the risk of serious head and brain injuries (70-85 percent risk reduction), middle and upper facial injuries (65 percent risk reduction), and reducing the risk of death.[89,90,91] Though more real-world data is needed in situations where randomized controlled trials are neither practical nor ethical, case-controlled studies significantly account or control for factors like age, sex, education, income, and crash severity in helmet use.[92]

Thompson and others, in a case-controlled study of 235 cycling accident head injury patients, showed that helmet use reduced the risk of head injury by 85 percent and reduced the risk of brain injury by 88 percent.[93] Graticer and others found that case-controlled studies show that cyclists without helmets increased their relative risk of head injury by a factor of 6/67 and that the risk of injuries to the upper head was 2-7 times higher for helmetless cyclists.[94] Maimaris and others in their study of an emergency facility's bicycle accident patients found that helmet wearers were less than half as likely to sustain head injury as helmetless cyclists and were just as likely to sustain other injuries.[95]

There are complicating and interesting questions about the effectiveness of helmet use in practical circumstances and how helmet use by cyclists may affect the behavior of other road users. Walker's work suggests that, in some instances, helmet use was correlated with drivers offering less space (and thereby increasing the risk of collision) when overtaking cyclists.[96] If more evidence shows that road user behavior exhibits behavioral risk-compensation factors with regard to perceived helmet use, then qualifications about helmet effectiveness in reducing overall risk to cyclists may be needed when generalizing from research to practice.

INCREASING HELMET USE

In Europe's most cycle friendly and safe cities, helmet use is surprisingly uncommon.[97]

Studies of awareness and attitudes of cyclists found that half of helmetless riders just did not consider wearing one, 16 percent had not got around to it, 20 percent thought them unnecessary, and almost as many did not wear them since they did not ride in traffic.[98] Figure 2, from the *National Survey of Cyclist and Pedestrian Attitudes and Behavior*,

displays cyclists' range of responses as to why they do not always wear a helmet.[99] Finnoff and others, note that although adults and adolescents generally reported believing that helmets provide "great" protection, a majority of both groups only reported believing that cycling without a helmet only confers a slight risk of injury.[100]

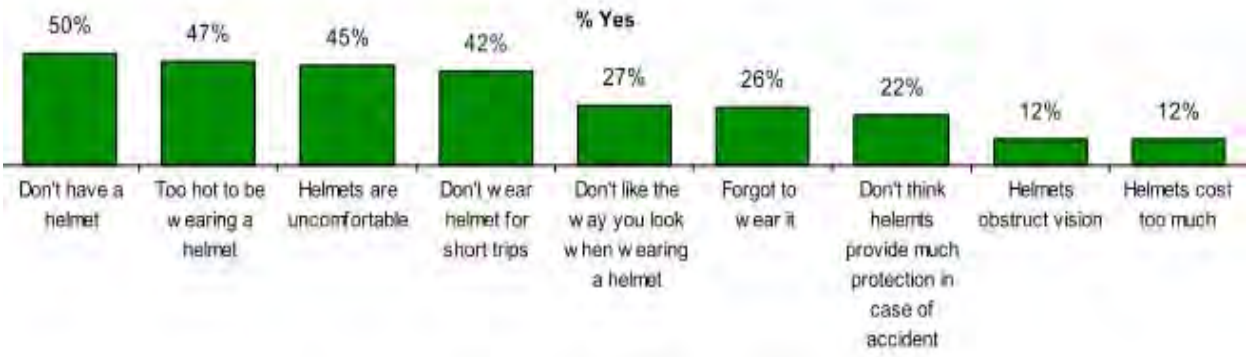

Figure 2. Responses to the Question: "What are the reasons you don't always wear a bicycle helmet? Is it because…?"[101]

Besides design interventions that improve the fit, air circulation, cost, and appearance of the helmets themselves,[102] social context seems to play an important role in increasing use as the effects of helmet use are often distributed though social networks.[103] Helmet use by peers was a significant predictor of helmet use among teens and undergraduates, including children influenced by the helmet use of their parents.[104,105,106] Accordingly, Lajunen and Rasanen suggest that social strategies leveraging social pressure and peer opinion are effective strategies for increasing helmet use.[107]

Multifaceted campaigns seem to be the most effective means to influence youth peer groups to accept helmet use. Indeed, one study effectively and substantially raised helmet use from 27.6 percent to 49.3 percent via a "social marketing" approach that combined peer agents, educational materials, pledge cards to commit to helmet use, free helmets and safety equipment, and a creative campaign identity—"The Grateful Head." The approach sought to overcome the major obstacles to helmet use reported by riders (cost of helmet, comfort issues, and peer disapproval).[108] Graticer et al., confirm that multifaceted social intervention campaigns incorporating educational, legal, and other forms of helmet promotion have proven effective.[109] We may note that while some multifaceted campaigns have been observed to positively influence helmet use, the persistence of their effects is an open question. Thus, the duration of effectiveness of helmet interventions is an open research question.[110]

EFFECTIVENESS OF EDUCATIONAL INTERVENTIONS TO INCREASE HELMET USE

Education is a popular vector for helmet interventions across ages, and is an especially attractive delivery system for children as school-based programs can be delivered reliably to a "captive audience" involved in regular educational activities and programs. School programs can also be targeted at needy groups with greater precision.

Helmet education interventions are common, but careful reports are scarce, and many exhibit methodological limitations that impair rigorous comparative synthesis.[111] A sample of cases strongly suggests that education is most effective when deployed in concert with other supporting interventions.

- An observational study in New York looked at two schools affected by a state law mandating helmet use for children through the age of 14. The Queens group received an educational intervention prior to the legislation while the Brooklyn control group did not. Helmet use in Brooklyn school declined while helmet use nearly tripled in Queens.[112]

- A study carried out by survey in Howard, Montgomery, and Baltimore counties examined self-reported helmet use. In Howard County, education and helmet legislation increased helmet use from 11 percent to 37 percent. In the other two counties, legislation was not enacted, and helmet use after education in Montgomery County remained comparable to helmet use in Baltimore, where interventions were minimal. Howard county successes suggest best practices in helmet interventions that combine education with legislation.[113]

- An effective helmet promotion program in Seattle, under the organization of the Harborview Injury Prevention and Research Center, was able to raise rates of helmet use among children to 40 percent through the concerted use of "classroom education, discount purchase programs, bike rodeos, distribution of printed material through a variety of venues, and intensive promotional efforts by sports leaders, bicycle clubs, and the media to increase children's helmet use." Perhaps owing to the complexity of the intervention, costs could not be accurately assessed.[114]

- A Canadian study concerning a comprehensive education-based program did not yield significant positive impact (comprehensive programs include activities such as classroom teaching, poster design contests, and school-wide events). But a program offering a subsidy proved somewhat effective.[115]

It appears that increasing helmet use is not effectively pursued through education alone. Narrowly executed campaigns (for instance, those delivered only through schools, emergency rooms, or primary physicians) are generally less effective.[116] Similarly, programs providing helmet subsidies and health care distribution did not by themselves significantly impact helmet use. More effective approaches involved broad-based interventions forwarded by coalitions drawing on a variety of marketing and pedagogical approaches.[117] Also, education combined with legislative strategies and enforcement improves helmet use.[118] Since parent participation is a strong predictor of success for interventions aimed at children, and since peer influence is a strong predictor of helmet use, more comprehensive and broader-based approaches that affect behaviors and social contexts outside of school are to be emphasized.[119]

EFFECTIVENESS OF HELMET LEGISLATION TO INCREASE HELMET USE

Helmet laws have clearly designated behavior targets that address proven primary causal influences in serious head injuries, and taking a cue from successful legal safety interventions for the use of seatbelts and child restraint devices in automobiles, policy makers may see legislating and enforcing helmet use as an attractive option.[120] The complexities and costs of effective helmet interventions may also lead to consideration of strategic legislation of mandatory or compulsory helmet laws.[121] Legislation may incur fewer costs compared to educational strategies, but this assertion needs to be supported by financial analysis and better account for the costs of head injury treatments.[122]

Levels of legislation include specifying the applicable age of the rider, the severity of the penalty (ranging from warnings to fines), the specifications of the helmet, and the helmet wearing of bike passengers.[123]

Practically, helmet laws do seem to increase helmet use in children, and when combined with educational interventions, legislation seems effective, efficient, and socially acceptable.[124] A prominent example comes from 1990, when Victoria Australia enacted legislation mandating the use of helmets. In the late 70s, helmet use there was about 5 percent. In the 1980s, a series of initiatives introduced bicycle safety curriculum, discounted helmet distribution, mandates for helmet use at school cycling activities, and campaigns focusing on parental involvement. Enactment of the helmet law in 1990 was followed by observations noting >70 percent helmet use in Victoria bicyclists and a 48 percent reduction in head injuries resulting from bicycle accidents. There was some decline in the numbers of the numbers of child cyclists, but adult cycling seemed to increase in the same period.[125] A study in Howard County found that education and helmet legislation together increased helmet use from 11 percent to 37 percent.[126]

While helmets reduce the risk of head injury and legislation may be effective in raising the frequency of helmet use among a cycling population, some argue that helmet legislation may inhibit people from cycling, thereby offsetting the aggregate health benefits of the helmet.[127]

The effect of helmet legislation on cycling volume is not the only issue that legislative approaches must consider. Other objections to legislative helmet interventions include the possibility of intrusions to individual autonomy; the problem of state paternalism; and concerns that the causal role of automobiles and motorist behavior as risk factors may be ignored.[128, 129] Behavior changes sought through legislation may be effectively promoted through other means.

Careful consideration should also be given to the enforcement strategies and penalties for helmet-law noncompliance. Some argue that restrictions on exemptions (such as age-related helmet legislation) and harsh penalties for violations do not generally enhance compliance.[130] The relative ease of enforcement monitoring as well as improving the comfort and convenience of helmet-law compliance are factors of relevant yet uncertain importance. What appear most effective in increasing helmet use are diverse social influences rather than simply laws and their enforcement.

In general, legislation is effective in increasing helmet use and that effect does not entirely seem to be dependent on enforcement. As noted above, peer use factors heavily in helmet use, and programs that exploit this fact could be emphasized over enforcement penalties when encouraging compliance. It also seems clear that education campaigns preceding legislative interventions improve the latter's effectiveness.[131]

EFFECTIVENESS OF SUBSIDY PROGRAMS TO INCREASE HELMET USE

Helmet use can be partly influenced by controlling the availability of helmets and convenience of acquiring them. Mixed results from subsidy programs are seen: a Seattle helmet campaign studied by Rivera suggested that subsidies were very effective, but a Canadian study showed no difference in helmet use between neighborhoods that were or were not offered a subsidy.[132] A promotion that offered discounted helmets sold over 100,000 units, but no data exists to confirm if that program was successful in changing behavior or accidents rates.[133]

EFFECTIVENESS OF INTERVENTIONS THROUGH A PHYSICIAN'S OFFICE TO INCREASE HELMET USE

Despite a ready access to patients in need and a potent context for clinical authorities to suggest helmet-related health promotion, physician-based interventions by themselves did not appear effective in increasing helmet use among ambulatory or emergency room bicycle patients, at least not compared to those who received no such counseling.[134]

EFFECTIVENESS OF COMMUNITY PROGRAMS TO INCREASE HELMET USE

As noted above, multidimensional campaigns combining publicity, education, and distribution solutions enjoy success. Many are based on campaigns developed by the National SAFE KIDS Campaign or the Harborview Injury Prevention and Research Center in Seattle, Washington. In Seattle, helmet campaigns combined resources from health, bicycle, and helmet industry organizations. In 1992, helmet use increased from 1 percent to 40 percent among children. These results were achieved through comprehensive and intensive community-wide efforts that included stories in print and electronic media, public service announcements, press conferences, posters, brochures, stickers, health fairs, bike rodeos, school and youth programs, and distribution of discount coupons.[135]

Conspicuity Gear: Lights, Reflectors, Clothing

One strategy for reducing the risk of collision for cyclists is to increase their conspicuity. This typically includes using reflectors and lights on bikes as well as bright or reflective clothing for cyclists.

A study issued to enrolled participants in the 2006 Wattyl Lake Taupo Cycle Challenge tracked self-reported crashes in the previous year. Respondents were mostly adult males who biked about 130 km per week. About half reported sustaining injuries that disrupted usual activities for 24 hours, and a third of these resulted in a visit to a health

care professional. Riders that reported always wearing fluorescent colors experienced a substantial reduction (77 percent) in the number of days missed from work due to injuries.[136]

Kwan and Mapston's review of interventions for increasing cyclist visibility examined over 40 cases assessing driver's responses to various visibility aids. Fluorescent colors in the daytime and lamps and flashing lights at night increase visibility and detection, but studies were not available to support increased safety as a result of such measures.[137]

Other Safety Gear

In addition to helmets and conspicuity gear, other kits may enhance cyclist safety. Portable sets of tools and maintenance gear may be of assistance to address mechanical difficulties related to safety. Clothing and shoes may provide protection from the elements, moving parts, and abrasions due to falls. A bell is a cheap and effective means of alerting pedestrians or other cyclists to the presence of a rider. Eye protection such as sunglasses can help protect cyclist eyes from airborne particles, flying debris, and sun glare.

When seeking to modify the behavior of a population, legislation and accompanying enforcement are often considered to be primary causes in preventing certain behaviors by deterring non-compliance through the threat and enforcement of penalties. But enforcement is not the sole reason for obeying the law, and the causal effect of deterrence is notoriously difficult to demonstrate. We might note that most bicycle helmet laws in the U.S. are not rigorously enforced and have only modest penalties, and thus do not provide a strong deterrent for noncompliance.[138] Thorough consideration should be given to other motives for obeying the law (for instance, obligations of citizenship, moral expectations, peer pressure, convenience, or personal health) to develop a better picture of how population behavior is influenced by legislation and enforcement.

For people opposed to government regulation of personal behavior, the costs to liberty from legislating behavior outweigh the benefits afforded by the legislative safety intervention. Also, legislating cyclist responsibilities and behavior (like helmet use) may conceal the importance of other, highly relevant risk factors, such as motorist behavior.[139] Legislative change, by itself, is not the most effective path to promoting bicycle safety.[140] National or state level legislation may very well be ignorant of the relevant local conditions that affect the application or effectiveness of the law.[141] Multi-dimensional approaches that work outside explicit law-enforcement domains, and that incorporate education, design, and promotion provide the most robust and adaptable models for bicycle safety programs.[142]

"Vehicular cycling" treats bikes as non-motorized vehicles and advocates training cyclists to ride as equal users of the roads. John Forester derides the change in U.S. bicycle policy in 1944 that classified bicycles as "devices" rather than "vehicles," a change that heralded the rise of a motor-centric culture that did everything it could to get cyclists out of the way of cars.[143] Rather than keeping cars and bikes categorically and physically separate, Forester recommends more consistency in our treatment of these differing transportation modes, indicating that "the best way to reduce bicycle accidents is to educate cyclists as drivers of vehicles and that people who ride regularly to school and work will learn to cycle correctly and safely."[144]

In cities viewed as conducive to cycling, instruction is provided on safety through special classes, bike rodeos, and other events. Interventions to enhance public awareness and behavior like Portland's "See and Be Seen" and "Light the Bike" programs combat the problems of limited visibility of cyclists.

Enforcement of helmet laws seems most effective when levied in concert with community education campaigns.[145] Multifaceted approaches often exploit indirect or alternative inroads to influencing behavior; for instance, helmet use in youth is strongly predicted by peer and parental helmet use, so educational, viral, and "social marketing" interventions that make use of peer-influence, rather than being directly administered to the target population, can be expected to indirectly influence wider transit population behavior.[146]

In many cases, legislation is most effective in concert with educational interventions.[147]

Graticer, Kellermann, and Christoffel found that educational interventions and health-care distribution of educational materials did not significantly impact helmet use if deployed in the absence of other reinforcing safety programs (for example, helmet use legislation and helmet subsidies).[148] A sample of the educational interventions, reviewed by Graticer and others, shows that effectiveness varies considerably over different contexts:

- A Canadian study concerning an educational program (including classroom teaching, poster design contests, and school-wide activities) did not have a significant positive impact. The study did find, however, that offering a subsidy for helmet acquisition proved somewhat effective, suggesting that education combined with subsidy programs can have positive impact.[149]
- Another study found that "Bike Smart" software intended for young children was more effective in producing positive results in computer-based testing and observations of helmet use than a control group that was only exposed to an educational video.[150]
- Other helmet use interventions included information delivered by physicians. However, despite direct access to patients via authoritative clinical professionals, physician-based interventions did not appear effective in increasing helmet use among ambulatory or emergency room bicycle patients—at least not compared to those who received no such counseling.[151]

EDUCATION COMPLEMENTED BY LEGISLATION

We combine legislation with education since education programs teach what is legally required and such programs are complemented by legislation.

Jacobsen's "safety in numbers" effect, where the risk to cyclists decreases as the volume of cyclists increases, may lead us to consider the indirect effects of legislation in promoting bicycle safety. Laws and policies that make driving less convenient or more expensive that, as a result, discourage the use of motor vehicles (for instance, parking restrictions, gas taxes, traffic calming measures, toll roads, environmental regulations, increased traffic

enforcement and penalties) might be expected to increase the mode share of cyclists on the road. Such motor-restrictive measures are already being recommended or implemented in many European nations.[152,153]

Laws that directly promote bicycle and road safety might be broken into three categories: distributed responsibility laws, motorist responsibility laws, and cyclist responsibility laws.

Distributed responsibility laws are policies applied equally to most network users. Such laws often detail basic traffic laws, require the bicycle safety content and standards in issuing drivers' licenses, or determine regional zoning, planning procedures, and speed limits. Since speed is a critical feature in the severity of bicycle accidents, the posting and enforcement of lower or higher speed limits may significantly affect the risk to cyclists.

Motorist responsibility laws aim to compel motorists to respect non-motorized users of roadways.[154] In 2007, Oregon lawmakers passed a bill that created enhanced penalties (in the form of civil fines) for motorists who are involved in accidents with "vulnerable users of a public way."[155] Legislation protecting vulnerable roadway users (for example, pedestrians, bicyclists, and skateboarders) was subsequently adopted by state legislatures in Illinois, Vermont, Iowa, Michigan, and Pennsylvania.[156] Legislatures in the U.S. have also moved to acknowledge the vulnerability of cyclists by passing state laws that mandate motorists to observe "safe passing" guidelines when passing cyclists. As of 2008, Arizona, Arkansas, Florida, Illinois, Maine, Minnesota, Oklahoma, Tennessee, Utah, West Virginia, and Wisconsin have adopted specific "three-foot passing" laws. North Carolina and Virginia specify two feet of passing space.[157] Penalties vary from state to state, ranging from points on the motorist's license, to fines, to criminal misdemeanors.

Bicyclist responsibility laws mandate cyclist behavior in some fashion. California and New Hampshire both mandate the use of lights or reflective clothing at night to increase rider visibility.[158]

Helmet Legislation

An area of controversy in bicyclist responsibility laws involves the effectiveness of helmet legislation. Bicycle helmets are understood as an effective means of preventing serious head injuries and so, helmet laws requiring some or all cyclists to wear them are attractive interventions for policy makers looking to improve bicycle safety; helmet laws have clearly designated behavior targets that have a primary causal influence on injuries and may be a paradigm case of "evidence-informed policy."[159] Different approaches to helmet legislation vary with respect to: which riders the law applies to, the severity of the penalty for not wearing a helmet, and legal design specifications of an acceptable helmet.[160] Since 1994, helmet use has been mandated through Australia, New Zealand, and many states in the U.S.[161] In 1990, Victoria, Australia enacted legislation mandating the use of helmets for riders of all ages. Head injuries from bicycle accidents dropped 48 percent after introduction of the law, and the average severity of head injuries also declined, as did the volume of cyclists.[162,163]

Helmet laws can increase helmet use in children, especially when combined with educational interventions. For example, Howard County, Maryland legislation and educational activities increased helmet use significantly compared to other Maryland counties where only educational activities took place.[164] Graticer, Kellermann, and Christoffel as part of their review of helmet legislation, assert that helmet laws may be as effective as child restraint device laws for motorists when employed in conjunction with other reinforcing strategies.[165]

Studies indicated that a strong predictor of helmet use among youth is whether parents and peers use helmets.[166]

Head injury is a common and often fatal type of injury, and 22-47 percent of injured cyclists sustain a head injury.[167] In addition, one-third of cyclist emergency room visits, two-thirds of hospital admissions, and three-quarters of deaths involve head injuries.[168] Despite evidence suggesting that 80 percent of head and brain injuries can be prevented by wearing a helmet.[169]

In the case of helmet use, education by itself is not always an effective means of increasing helmet use. More effective were broad-based interventions forwarded by coalitions drawing on a variety of marketing and pedagogical approaches.[170]

The education section covers safety education in general, but with specific reference to San José, California.

ENFORCEMENT

Legislative bodies craft the laws and ordinances that govern traffic behavior and specify the penalties for their violation, as well as the role of law enforcement in monitoring adherence to traffic laws and issuing penalties for infractions.

Besides increasing the visibility of patrolling police officers and limiting automobile access to some areas, some localities that promote cycling have lowered fines for bicycle violations, encouraging patrolling officers to write more tickets, and hopefully to gather compliance without discouraging cycling.

The case study on Davis also deals with some of the challenges regarding enforcement.

ENCOURAGEMENT

Jacobsen (2003) uses data from California, Denmark, the UK, the Netherlands, and a European Commission report to study the relationship between the numbers of bicyclists and pedestrians and the number of injuries among them. He concludes that collisions between motorists and bicyclists or pedestrians diminish where more people bike or walk. He found that where there are more than fifty bicyclists per hour, there is an abrupt decrease in the number of conflicts with motorists. He posits from this that drivers, not cyclists or pedestrians, are the cause, writing that “the most plausible explanation for the improving safety of people walking and bicycling as their numbers increase is behavior modification by motorists when they expect or experience people walking and bicycling.”[171] Others

have taken Jacobsen to task, writing that the cause of fewer conflicts may be something other than the number of cyclists, such as infrastructure or culture and that it is tricky to separate cause from effect from secondary effect.

Fischer and others visited five European countries selected for their innovative practices, and note that the shift in transit awareness contributed by increased levels of cycling and walking makes a difference to transportation safety, especially at conflict points.[172] Thus, policies that serve to increase the numbers of pedestrians and cyclists may be an effective means to achieving greater safety for cyclists.[173]

With about 800 million bikes in the world, bicycles globally outnumber cars 2 to 1, and three times more bikes are produced each year than automobiles. [174,175] Pedestrians and cyclists together account for 14 percent of U.S. traffic fatalities, while accounting for less than 5 percent of the total mode share.[176] In the U.S., the number of bicycle trips has doubled in the last 20 years,[177] and over 67 million cyclists ride 15 billion hours annually; 27 million U.S. cyclists ride once per week.[178] Proximity of destination appears to play a significant role in determining the population of cyclists since most bicycle trips are 3 miles or less.[179]

Factors influencing the recent rise of cycling in the U.S. include recreational practices (especially trail riding), cyclist advocacy groups, concerns regarding the environmental impact and energy use of transportation modes, economic benefits of cycling, as well as personal health benefits.[180] Cycling in the top European cycling nations (Netherlands, Denmark, Germany, and Switzerland) exhibit many times the rates in the United States. Table 12 displays data compiled by Pucher and others that compares U.S. cycling rates to top prominent cycling countries in Europe,[181] noting that only around 1 percent of the trips in the U.S. are by bicycle, whereas people in the Netherlands use bicycles for 27 percent of their trips.[182]

The marked differences between cycling rates in the U.S. and European countries are matched by pronounced differences in the distance travelled by cyclists, and, as shown below in Table 12, in the cycling share of short trips less than 2.5 kilometers (1.6 kms=1 mile so 2.5 kms=1.5625 miles). Despite rapid growth in U.S. cycling volume over the last few decades, it is evident that the bicycle is still not generally treated as a primary mode of transportation. In the United States, cyclists tend to be younger (46 percent of cyclists are under 16 years old,)[183] male, and are generally recreational users. By contrast, in Northern Europe, cycling is prevalent among older individuals, cyclists are just as likely to be women, and cycling is used for all trip purposes.[184]

Table 12. Bicycle Share, Biking Distance, Eligible Trips, and Purpose for Bike Trips in the Netherlands, Denmark, Germany, and the United States.[185]

	Bicycle trip share (%)	Per capita distance biked per day	Trips less than 2.5 km	Bike share for trips less than 2.5 km	Bike trip to work or school	Bike trip for recreation
Netherlands	27%	2.5 km	44%	37%	32%	27%
Denmark	18%	1.6 km	37%	27%	38%	24%
Germany	9%	.9 km	41%	14%	22%	27%
United States	1%	.1 km	27%	2%	11%	~75%

If, as Jacobsen argues, drivers can be expected to modify their behavior in the presence of conspicuous bicyclists and pedestrians, and if roads become safer if motorists perceive themselves to be sharing the road with more cyclists,[186] then increasing the awareness in motorists becomes, at least partially, a function of successfully encouraging greater numbers of cyclists on the roads. More cyclists on the road provide frequent reminders that the transportation environment is shared between varied user modalities. Increasing the numbers of cyclists partly depends on a potential cyclist's perception about the safety of the cycling environment.[187] The 5 Es provides a conceptual framework for the literature review.

Advocacy groups and organizing of popular events are used to promote cycling as social phenomena that brings networks of individuals together, building on commonalities of interest or lifestyle. Encouragement includes promotional practices that provide incentives for participation (for instance, free or reduced-price helmets, stipends for non-motor commuting) and that do not depend on legislative mandate. Encouraging bicycle safety best practices also addresses the attitudes of transit populations towards users of various transport modalities.

When civic leaders cycle themselves, empathy for cyclists and promotion of commuter cycling is enhanced. Bicycle associations and alliances organize community celebrations to promote safe cycling.

People are encouraged to ride for health promotion as well.

EVALUATION

The ongoing process of collecting information, documenting trends, and assessing programmatic outcomes is essential. Evaluation includes research methods that produce and collect data, as well as the methods that are used to interpret and evaluate data.

BRIEF CASE STUDIES OF BICYCLE FRIENDLY CITIES

The 5 Es provide an excellent framework to understand why some cities are bicycle friendly. A sampling of case studies of the most bicycle friendly U.S. cities follows. Brief descriptions of San Francisco, CA; Stanford University, CA; and Palo Alto, CA are included because they are all in northern California close to the Mineta Transportation Institute that sponsored this research. Portland is included because the Bicycle Transportation Alliance, an advocacy group, agreed to write a case study. Davis, CA is also included.

San Francisco, CA (Gold Level Community)

Being a large and densely populated city, San Francisco is a leading example of a highly urban environment accommodating a robust cycling system. There are 63 miles of bicycle lanes and paths in the city.[188] Notable scenic and commuter paths starting to the north and extending over the Golden Gate Bridge, and soon over the Bay Bridge, as well as Bay Area Rapid Transit integrated bicycle facilities all provide a varied and growing cycling

infrastructure.[189] In a city of tight streets that is known for its hilly terrain, community bicycle maps and information have advised bikers of the best routes.

These facilities and services support cycling as an increasingly popular mode of transportation in San Francisco. Cycling increased 108 percent from 1990 to 2000.[190] In 2000, San Francisco had the highest percentage of bike commuters among large cities (population>500,000) in the United States.[191] Since 2000, bicycle commuting has risen another 37 percent.[192] Approximately 40,000 residents are commuting to work regularly by bicycle, and 35,000 cyclists rode into the city on Bike to Work day. This large share of bicycle commuters reflects an abnormal statistic in the U.S.: 60 percent of bicycle trips in San Francisco are not for recreational purposes, but are utilitarian in nature.[193]

However, most bike facilities projects here have been on pause since 2006, pending the completion of a procedural review resulting from a suit brought against the city for failing to observe the appropriate environmental impact review process.[194] It is hoped that the final hurdles against implementing the bike plan will be decided in late summer 2010.[195]

Stanford University, CA (Gold Level Community)

A progressive and expansive Bay Area campus, Stanford University has a thriving bicycle population. Biking makes up a major share of student commuting, with many students living on campus and relying on cycling for daily transport to classes. Stanford also offers progressive programs to reduce private automobile commuting, promoting ride-shares, public transportation, and cycling. The university goes as far as to offer a stipend (about $300 annually) to those who commit to reducing car commuting.[196] The university also provides educational and promotional events, like the Dormitory Road Show program, which travels to student residences to provide advice, bike lights, and helmets.[197] Enforcing bicycle compliance to traffic laws is a challenge and the university has recently gathered positive feedback from its implementation of a “Bicycle Safety Diversion” that provides an opportunity to participate in safety education in lieu of paying fines for bicycle infractions.[198]

Palo Alto, CA (Gold Level Community)

Palo Alto, California has committed to a vision of a sustainable future in part by addressing bike safety and supporting a growing cycling population. The historical movement there goes back to the 1967 decision to plan 43 km of residential streets as “bicycle route” streets. Upon implementation, results were not encouraging: bicyclists preferred other routes rather than the new bicycle route streets, which did not satisfactorily connect to activity centers, and for reasons still not understood, bicycle-automobile accidents increased by 24 percent during the trial.[199] But just a year later, the implementation of bicycle lanes and their regular, safe use by cyclists proved successful and an important approach in future bicycle development.[200]

In 1972, a plan to bring bicycle lanes to arterial and collector roads with significant accident histories was approved. Surveys taking place in the following year indicated a 13 percent increase in cyclists and 18 percent decrease in accident rates on roads with bicycle lanes.[201] The bicycle lane experiment indicated that “a reserved area for most cyclists on

streets with considerable motor vehicle traffic achieves the physical separation between motor vehicle traffic and bicycle traffic needed and demanded by most of the bicycle public to improve cycling safety."[202] While rigorous analysis was not undertaken, there was recognition that implementation of bike lanes improves safety, reduces collisions, and reassures cyclists.[203]

In the late 1970s, bicycle paths on designated sidewalks of certain roads where bicycle lanes could not be established were officially trialed. Use of the sidewalks by cyclists was initially deemed compulsory, but later field observations and an analysis of accident data indicated that this particular concept presented an undesirable high-risk situation, increasing the accident rate 2.7 times. [204]

More recent efforts include three centrally-located "bicycle boulevard" projects that converted residential streets for cycling use by removing stop signs, adding stops for side traffic, and introducing barriers to thwart through traffic.[205] These Bike Boulevards, as part of the Urban Bicycle Route System (UBRS), provide service to three local schools.

A city partnership with the Palo Alto Unified School District and the Palo Alto Council of PTAs provides a program of periodic training for traffic, pedestrian and bicycle safety for kindergarten through sixth grade students.[206] About 45 percent of total enrolled middle schools students, and more than 33 percent of students in two high schools, bike to school.[207, 208]

Davis, CA and Portland, OR are also bicycle friendly cities, but they are discussed within the case studies that follow.

IV. BICYCLE SAFETY – EDUCATION

SECTION AUTHOR: JOHN M. BRAZIL

INTRODUCTION

Non-bicyclists perceive bicycling to be unsafe and note this as one of the top reasons for not riding.[209] In support of this subjective perception, objective traffic collision analysis shows bicyclists are over-represented in traffic collisions: though just less than 1 percent of trips are made by bike in the United States, 2 percent of roadway fatalities are bicyclists.[210]

Bike Safety Education is also needed to dispel common misperceptions about which bicycling behaviors are safe and legal. For example, surveys show that many believe bicycling against the direction of roadway traffic is both safe and legal. In fact, this behavior is generally neither safe nor legal in the United States.[211]

Bike safety can and should be advanced through the four Es of Engineering, Enforcement, Encouragement and Evaluation. But to successfully increase safe bicycling, effective Education tools—the fifth E—are also needed.

For drivers of motor vehicles, the need for safety education is addressed through a formal licensing requirement: to legally drive a car, one must complete training and pass a standardized safety test. For bicycling, however, no such requirements exist. To address this need, a variety of bike safety education programs and media campaigns have arisen over the years. This section surveys and evaluates these bike safety tools.

This section begins with an overview of the evolution of bike safety education, continues with a discussion of key components of effective bike safety education, and concludes with a survey of various bike safety education materials and programs.

A few important points serve as a background to this discussion. First, this section provides a sampling, not a complete compilation, of bike safety education programs. The review includes a variety of types and sizes of bike safety programs, including some of the largest and most admired. But it would not be possible to review all of the dozens, if not hundreds, of individual programs and variations. Second, a lack of empirical data on outcomes makes it difficult to identify true best practices.[212] Very few bike safety programs include an objective assessment of their effectiveness over time. Therefore, in this section, “best practices” generally takes on a subjective meaning referring to established, well-known, popular, or well-regarded programs. Finally, by their nature, education efforts fare better with repeated exposure. The more times individuals receive training and exposure to bike safety, the greater likelihood the desired behaviors will be sustained. Therefore institutionalizing regular and frequent bike safety education, such as school-based training, will be more successful than one-time bike safety events.[213]

THE EVOLUTION OF CYCLING – CREATING DEMAND FOR BIKE SAFETY EDUCATION

With technology advances in the late nineteenth century, bicycles evolved from a novelty to a popular mode of transportation. During this time, bicycles developed from "high wheelers" (also known as ordinary bikes or penny farthings)—with a large front wheel and the bicyclist sitting high above the ground—to "safety bicycles" that allowed bicyclists to stop and touch the ground without dismounting. These advances, along with the cushion provided by recently introduced pneumatic tires, caused a rapid increase in cycling. By 1898, the League of American Wheelmen had more than 100,000 members.[214] Bicycling at that time required sharing the road with trolleys and horse-drawn carriages. Thus the need for bike safety education was born.

The proliferation of automobiles in the first half of the twentieth century magnified this need for bike safety education. In 1910, the Boy Scouts of America began offering a Cycling Merit Badge that included safety information; however, very few other bike safety education programs existed. It wasn't until the 1970s that bike safety education programs began to gain momentum. In the United States, John Forester's *Effective Cycling*, first published in 1977, is considered by many to be the first comprehensive, published bike safety program. Though the latest edition (sixth 1993) runs nearly 600 pages in length, *Effective Cycling* principles are often summarized by the phrase "Cyclists fare best when they act and are treated as drivers of vehicles." *Effective Cycling* is often described as *vehicular cycling* because it starts with the notion that bicyclists should generally follow the same rules as, and ride on the same roads with, motorists.

Over the last thirty years, most U.S. bike safety programs have been largely based on vehicular cycling principles. In contrast, European bike safety programs often emphasize separation of bicyclist from motor vehicle traffic via dedicated bikeways such as cycle tracks. In recent years, some U.S. bike safety professionals are taking a closer look at the European model. However, debate continues over which method is more effective. This section focuses primarily on Bike Safety Education in the United States.

KEY COMPONENTS OF BIKE SAFETY EDUCATION

Generally, Bike Safety Education curricula must address at least three core topics: (1) Bike and Equipment; (2) Applicable Laws; and (3) Key Bicycling Skills. While not the focus of this section, the need for education materials in languages other than English should be addressed.[215] Cultural differences must be taken into account and may require changes to content or tone of materials.

Bike & Equipment

Many state vehicle codes require a bicycle to have brakes and be of a size that allows riders to stop and place one foot on the ground. These codes also generally require that bikes used at night have proper lights and reflectors, and that minors use helmets. Each of these requirements is a bare minimum and can be supplemented with optional, supplemental safety equipment.

A properly functioning bicycle is a prerequisite for safe bicycling. A bike that cannot effectively be pedaled, turned, or stopped is not a safe bike; therefore, any effective bike safety education must describe how to check that the essential bike features are working effectively. Many bike safety education programs emphasize the importance of inspecting the bike before each ride. Essential features that should be inspected include brakes, steering, drive train, seat and wheels. If any of these five elements fail to function properly, the rider's safety will be significantly impaired. If problems are found, the bike should be repaired before using. For those not interested in performing their own bike repairs, local bike shops provide repair services.

BRAKES

To test brakes, while standing next to the bike, pull each brake lever until a fair amount of resistance is felt. If the brake lever touches the handlebar, the brakes may be too loose and should be adjusted. While holding the brake lever, push the bike forward. With the rear brake engaged, pushing the bike forward should cause the rear wheel to skid. With the front brake engaged, the rear wheel will lift up when the bike is pushed forward. If this test fails, the brakes may not function properly and should be adjusted before riding.

Next, without pulling the brake lever, lift each wheel off the ground and spin it to make sure the brakes are not rubbing against the wheel. If they rub, brake adjustment or wheel realignment may be required.

STEERING

While standing next to the bike, turn the handlebars each direction to make sure steering is unobstructed and firmly fixed to the bike frame.

DRIVETRAIN

The drive train includes the pedals, chain, crank arms and shifters. While standing next to the bike, lift the rear wheel and rotate the pedals to confirm the drive train is working. When riding the bicycle, try shifting through each gear to confirm they all work properly.

SEAT

While standing next to the bike, grab the seat and try to move it up, down, and to the side. The saddle should not move and should maintain a stable position relative to the bike frame. While pedaling and seated, check that with each foot in the lowest pedal position, there is a slight bend in your knee. While personal preference allows for minor variations, a bicyclist should not need to fully extend his or her leg or lock her knee to reach the lowest pedal position. Nor should he or she have excessive knee bend at the lowest pedal position.

WHEELS

Bike wheels include the tire, tube, axle, spokes, and rim. Bike tubes must be properly inflated. Follow the recommended tire pressure, which is often listed on the side of the tire. If no pressure is listed, inflate the tire so that, when sitting with full body weight on the bike, the tire deforms or flattens only a small amount, perhaps a few millimeters. If the tire flattens too much under the bicyclist's body weight, then it is under-inflated. Under-inflation is a common problem and can result in flat tires.

Check that wheels are properly affixed to the bike frame. Wheels are generally attached via either a bolt or a quick-release lever. Bolts should be tight and levers closed.

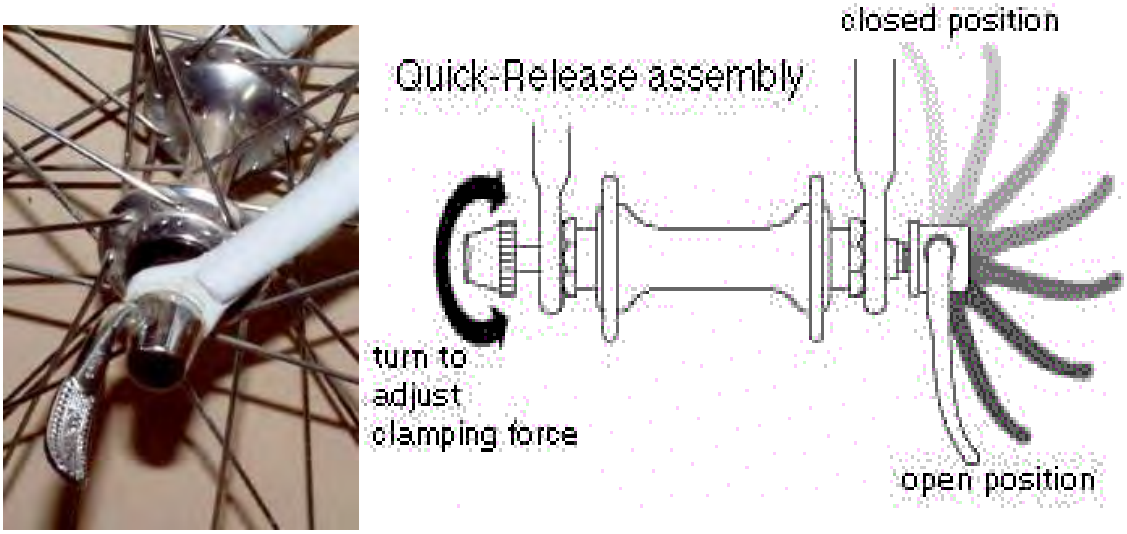

Figure 3. Wheel Attachment: Quick Release Assembly

In addition to these five key bicycle features, general bicycle fit can affect bike safety. A bicycle frame that is too large may prevent a person from placing his or her foot on the ground when coming to a stop. So when bike safety education materials discuss the bicycle itself, they should include a description of how to check for appropriate bike fit.

HELMET

In California, generally, minors under the age of 18 years must wear a properly fitting and fastened helmet whenever riding a bicycle.[216] Bicycle safety education should describe this requirement, as well as discuss how to select and properly use a helmet. Common errors with bike helmets include straps that are unbuckled or too loose and helmets sitting too far back on the head failing to protect the forehead. Generally, helmets should be adjusted to fit snugly and level on the head.

Helmets should only be purchased new. This avoids the risk of a used helmet that may have non-visible damage or defects. Helmets must also be certified by the Consumer Product Safety Commission as complying with federal safety requirements. Usually, labeling inside the helmet indicates compliance with these safety requirements. Compliance with additional optional standards such as Snell or ANSI is not legally required, but may

provide a higher degree of protection. Additional information on helmet safety is available from organizations such as the Bicycle Helmet Safety Institute, which serves as a useful clearinghouse for helmet safety information.[217]

Safety educators should consider underlying assumptions and themes conveyed when providing helmet information and fittings. Messages that bicycling is a dangerous and risky behavior may deter some individuals from ever getting on a bike. Instead, educators may want to convey that effective on-bike skills and attention to other roadway users can prevent most collisions and injuries from occurring. This is a more empowering message.[218] Helmets should serve as a safety tool of last resort—a seatbelt for your brain.

Figure 4. Proper Helmet Fitting (California Department of Health Services)

LIGHTS & REFLECTORS

State laws also generally require that bicycles used at night must include proper lights and reflectors. As a common example, the California Vehicle Code requires bikes used

at night to have a white front light visible from the front from 300 feet, a red rear reflector visible from the rear from 500 feet; a white or yellow reflector on each pedal, shoe or foot visible from the front and rear from 200 feet; white or yellow reflectors on both sides of the front of the bike (usually on the front wheel); and white or red reflectors on both sides of the rear of the bike (usually on the rear wheel).[219] It's important to remind bicyclists that, just as with motor vehicles, front lights must be white and rear reflectors or lights must be red. This allows roadway users to identify whether a bike or motorist is traveling towards or away from them.

Educational materials should address two common mistakes with installing bike lights and reflectors: lights that are either improperly aligned or obstructed by other bike equipment. Bike lights and reflectors must be installed so that their light is directed back toward other roadway users. Lights or reflectors that direct light too far up, down, or to the side will not be effective or visible. Lights and reflectors must also be installed and tested to make sure that other parts of the bike do not obstruct the light or reflection. For example, racks, baskets, bags, and other gear must not obstruct lights or reflectors. Lights and reflectors should be tested at night in a safe place by having a person shine a strong flashlight toward the bicycle while it's ridden toward, away from, and parallel to him.

OPTIONAL SAFETY EQUIPMENT

Effective bike safety education should include a discussion of optional safety equipment such as a repair kit, additional lights or reflectors, reflective clothing, gloves, fenders, glasses, shoes, a bell, and rain gear.

A bicycle repair kit is not required to ride a bike. But it can come in handy. While mechanical failures occur infrequently, flat tires are not uncommon. Many bike safety education materials provide instruction on fixing a flat tire and encourage bicyclists to carry a flat tire kit. The kit should include a mini-pump, a patch kit, tire levers, and a spare tube.

Supplemental lights can be helpful in serving two purposes: (1) to improve the cyclist's visibility of the road and those on it; and (2) to make the cyclist more visible to other roadway users. Generally, supplemental bike lights are either bike-mounted or helmet-mounted. Bike-mounted lights may be more stable and reduce weight on the cyclist. Helmet-mounted lights allow cyclists to direct the beam where they choose without affecting steering. While reflectors do not help light a cyclist's path, they do increase a motorist's visibility of cyclists by reflecting vehicle headlights back to the driver. Supplemental lights or reflectors on ankles, shoes, or pedals provide a distinct pattern of light movement. This may improve other roadway users' ability to identify the type of object (bicycle) as well as its direction.

Clothing and gloves also serve at least two purposes: (1) to protect the cyclist from inclement weather (cold, rain, and snow); and (2) to protect cyclists from abrasions in case of a fall or crash. Fenders help keep cyclist dry in the rain and may prevent dry-weather road grit from being projected off wheels into the cyclist's clothes, eyes, or face. Glasses also protect cyclists' eyes by reducing glare and wind. Bike bells provide non-confrontational notice that a bicyclist is approaching, which can be particularly helpful on facilities such as multi-use trails where pedestrians may be present. Finally, some bicyclists prefer to use

bike-specific shoes that attach to the pedals via a clip. While these optional devices do not provide any significant safety benefit, they are sometimes used by cyclists for perceived performance benefits. Each of these optional items may increase the safety, comfort, or convenience of bicycling.

Laws: Riding in Traffic

A thorough understanding of laws that apply to bicycling is essential to any bike safety curriculum. Generally, state laws govern bicycling on public roads and sidewalks. From state to state, laws are usually similar with some minor variations. For example, some states require three feet of clear space when a motorist passes a bicyclist, while others require only a “safe” distance.

State laws generally treat bicyclists the same as motor vehicles. This notion—summarized by the phrase “same rights, same responsibilities”—forms the core of many bike safety education programs. Like motorists, bicyclists must heed all stop signs and traffic signals, ride on the right side of the road, signal before turning, and yield to straight traffic when turning or changing lanes. These and other key traffic laws comprise a critical component of effective bike safety education.

Cities may implement local ordinances so long as they don’t contradict state laws. The local treatment of sidewalk bicycling is one important area where cities may differ. Most states do not prohibit sidewalk bicycling, thereby allowing cities to regulate this activity. Some cities do not regulate (and thus allow) sidewalk bicycling; others prohibit it in specific areas (such as downtown business districts); and others prohibit it entirely. While sidewalk bicycling may be allowed, sidewalk bicycling *against* the direction of adjacent wrong-way traffic—“wrong-way sidewalk bicycling”—is a high-risk behavior that should be discouraged.[220]

Skills: Riding in Traffic

In addition to learning laws that apply to bicycling, bike riders must also practice key skills to enable safe bicycling. Different programs emphasize a variety of skills. For example, the League of American Bicyclists curriculum focuses on emergency maneuvers to suddenly turn, stop, or avoid obstacles.[221] While most of these skills can be helpful, three essential skills must be included in any bike safety education program: riding a straight line, arm signaling, and looking back over your shoulder for traffic.

Riding a straight line ensures that bicyclists avoid conflicts with other traffic and communicates to others the bicyclist’s intended direction. Because bicycles do not have turn signals, bicyclists must use *arm signals* to communicate their intention to turn. In most states, a horizontally extended left arm signifies a left turn and either a left arm bent 90 degrees upward at the elbow or a right arm extended horizontally signifies a right turn. *Looking back over one’s shoulder* is critical to safely starting, merging, turning, and stopping among motorists, pedestrians, and other bicyclists.

A competent bicyclist must be able to combine these three skills when bicycling in traffic. Consider a bicyclist wanting to turn left at an intersection. First one would look back over one's shoulder to make sure no one's immediately behind or next to her. Next one would use an arm signal to communicate one's intention to change lanes and turn. Finally, one must ride a straight line and avoid swerving into other traffic. Successful bicycle safety education materials must include these three skills to insure bicyclists can navigate safely.

BIKE SAFETY EDUCATION RESOURCES

In the following discussion, bike safety education programs and tools are categorized as either Formal or Informal. Formal programs generally require active registration and participation in training. Informal safety training generally involves passive exposure to media or special events.

Formal Bike Safety Education

MANDATORY PROGRAMS

Though most bike safety education programs are optional, a few mandatory programs exist. One example is Juvenile Traffic Diversion Classes. Analogous to traffic schools for ticketed car drivers, diversion programs allow bicyclist who receive tickets for moving violations to take a bike safety class in lieu of paying the violation fee. Bike diversion programs require collaboration between police departments, traffic courts, and program sponsors (such as city departments of public works or transportation). The Traffic Safe Communities Network has piloted a successful bike diversion program in Santa Clara County, California. City police departments agree to ticket identified dangerous bicycling behaviors among bicyclists under age 18. The ticket includes information on free bike skills classes that may be taken in lieu of paying the ticket. Since its inception, fourteen cities and 1,145 children have participated.[222]

Employer-based bicycle fleets often require bike safety training as a condition of access to bicycles. While the training and safety of employees driving motor vehicles can be assumed based on possession of a valid driver's license, no such licensing requirement exists for bicyclists. Employer-based safety training for bicycle fleets addresses this need. For example, the City of San José, California operates a bicycle fleet for employees. Employees must complete a two-hour training to gain access to the bicycles. The training includes a one-hour classroom discussion of the rules of the road[223] and a one-hour on-bike session covering basic bicycling skills. Courses are based on the League of American Bicyclists (LAB) Bike Education curriculum. Instructors are trained and certified through LAB's League Cycling Instructors program.

VOLUNTARY PROGRAMS

LAB has developed one of the most well-known, national bike safety curricula, known as Smart Cycling.[224] The program offers an instructor certification program as well as course materials for adults and children. The series includes both classroom and on-bike segments. Course offerings include Traffic Skills 101 & 201, Commuting, Motorist

Education, and Kids I & II. Most bike safety education programs are based at least in part on LAB materials.

LAB also offers Bicycling 123, a curriculum directed towards bicycle retailers. Bicycling 123 provides materials and training for bike store employees to provide safety training for its bike shop customers.

Whether based on LAB or other curricula, voluntary programs are generally offered by non-profit, public sector, and for-profit organizations.

Figure 5. A Bike Rodeo

NON-PROFIT

Local member-based bicycle advocacy organizations have become the largest venue for providing voluntary bike safety education. Nearly every large U.S. city or metropolitan area is served by such an organization. These groups vary from small bike clubs with fewer than 100 members to large bicycle coalitions with thousands of members. One of the largest, for example, is San Francisco Bicycle Coalition (SFBC). SFBC serves more than 10,000 members and offers programs that include Urban Cycling Workshops, a web-based Bike Law 101, and an Employer's Bike Commuting Guide.[225]

Non-profits that are not member based offer another example of bike safety education resources. For example, Safe Moves, an award-winning traffic safety education non-profit, has offered bike safety education programs since 1983. It utilizes bike rodeos and other

interactive trainings. One client city attributed a 25 percent decrease in bicycle-related deaths over five years, in part, to Safe Moves programs.[226] Safe Moves reaches up to 100,000 school age students per year.[227]

PUBLIC SECTOR

Several local and regional governments offer transportation programs that provide resources, incentives and encouragement for travel by bicycling, walking, and public transportation. These programs often include a bike safety component. At the local level, Portland, Oregon's SmartTrips program offers bike safety equipment as well as a Portland Bicycle Guide that includes rules of the road.[228] In California, Alameda County's TravelChoice program offers similar bike safety resources.[229]

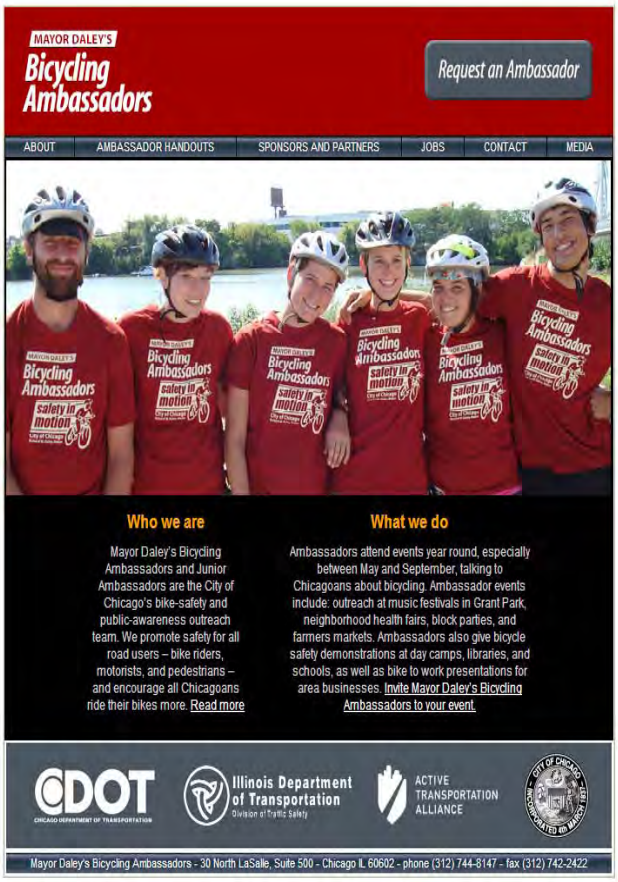

Figure 6. Mayor Daley's Bicycle Ambassadors, City of Chicago

In Chicago, former mayor Richard Daley's Bicycle Ambassadors program conducts community outreach at public fairs, festivals, block parties, farmers' markets, day camps, schools, and businesses.[230] During 2009, program staff of seven ambassadors and 19 junior ambassadors attended 347 events, reached 48,050 people. These activities included fitting 2,218 helmets, directly educating 6,435 people at 22 Share the Road safety events, and conducting 50 Lakefront Trail events that provided trail safety to 7,690 people.[231]

Voluntary bike safety education also exists in the form of school-based programs. Because state educational standards generally do not require bike safety training, these programs are offered optionally at the encouragement of local or regional advocates, parents, and school administrators. In 2000, Marin County, California developed one of the first and most successful school-based bike safety programs, now known as Safe Routes to School (SR2S). In 2005, the program reached 18,740 students at 45 schools. Currently, the countywide program operates in nearly all elementary schools, and most middle and high schools.

Bike safety is only one of multiple program focuses in Marin County's SR2S program. Other goals include reducing drive-alone trips and increasing exercise. The program contains four elements: Education and Encouragement; Crossing Guards; Planning (engineering and enforcement); and Safe Pathways (construction of facilities). The Education and Encouragement component provides a SR2S curriculum with lesson plans; SR2S School Teams and Tasks Forces; school-based Contests and Events; and Program Evaluations. These program evaluations quantified significant reductions in motor vehicle traffic, increases in walking and biking to school, and improved perceptions of bicycling safety. For example, 9 percent of parent survey respondents indicated the program was effective in making their child confident about biking safely. And 9 percent indicated the greatest program value was teaching safe biking and walking skills. However, no objective analysis appears on changes in bicycling collision or injury rates.[232] This lack of safety outcomes analysis and emphasis on motorized trip reductions is not uncommon among school-based bike safety programs.[233]

The National Center for Safe Routes to School offers engineering, enforcement, encouragement, and education resources. Their Safe Routes Coaching Action Network incorporates webinars that provide instruction for parents and educators seeking to encourage bicycling to and from school.[234]

In San José, California, the City of San José's School Safety program provides in-school safety training. The program is staffed by one full-time employee in the Department of Transportation. This staff person is a certified League Cycling Instructor and conducts bike rodeos, helmet fittings, and other safety presentations. During 2009, the School Safety program provided 81 presentations, distributed and properly fit 1,600 helmets, and reached more than 20,400 students.[235] In 2010, the City of San José reached the greatest portion of school age children (1 in 8) among the largest 50 U.S. cities.[236]

Employer-based programs offer another type of voluntary public sector bike safety education. The largest and most well-regarded program is the International Police Mountain Bike Association (IMPBA). This program is offered only to law enforcement officers seeking bike training for patrolling purposes. It includes IPMBA's training manual "Complete Guide to Public Safety Cycling" as well as a 32-hour "Police Cyclist" course, which includes 20 hours of on-bike training and covers eleven subjects including: Bike Handling and Vehicular Cycling; Bike Fit; Group Riding; Hazard Recognition & Common Crashes, and Obstacle Clearing and Riding Techniques. More than 3,000 public safety officers have completed this training. IPMBA also includes training for Emergency Medical Service providers and additional advanced training courses.

The City of Winterthur, Switzerland provides a novel approach to bike safety education: it constructed a “traffic garden”—a reduced-scale closed course that includes traffic signals, roundabouts, bike lanes, sidewalks, and other traffic situations. Children may practice safe bicycling skills in this real-life environment. Winterthur also supports a “children’s traffic club,” a safety education program found in various European communities that offers safety material and learning activities to parents and children.[237]

Figure 7. Traffic Garden in Winterthur, Switzerland

FOR-PROFIT

Despite a lack of mandates and funding for bike safety education, a few for-profit organizations have developed a niche market providing bike safety education materials and services. Seidler & Associates offers video public service announcements that address cycling rules, sharing the road with motorists, and proper helmet usage.[238] Bicycle Solutions offers bike safety education trainings and materials including a unique one-on-one training designed for adults learning to ride for the first time.[239]

Informal Bike Safety Education

MEDIA CAMPAIGNS

Bike safety training is generally more effective through human intervention in the form of a qualified trainer or instructor. However, because bike safety training is neither mandated nor legally required, dedicated funds for instructors rarely exist. In the absence of staff funding, the vast majority of bike safety education takes the form of media campaigns including brochures, posters, flyers, bus banners, and billboards.

Perhaps the most ubiquitous informal bike safety education media campaign is the "Share the Road" movement. While no single organization leads the effort, communities and organizations across the country have adopted the "Share the Road" slogan in bike safety education materials. The Federal Motor Carrier Safety Administration (an agency of the U.S. Department of Transportation) provides brochures, graphics, public service announcements and research supporting the campaign.[240] Some state governments offer Share the Road themed motor vehicle license plates.[241] And many cities post Share the Road street signs.[242]

W11-1 / W16-1
Share the Road with Bicyclists assembly

Figure 8. Share the Road Signs

Several cities have developed media campaigns to improve bicycling safety. These often use variations on the "Share the Road" theme that encourages bicyclists and motorists to share space on roadways. The City of San José's award-winning Street Smarts campaign provides an example that has been adopted by more than 25 other agencies. The Street Smarts campaign "brings education into the equation by building awareness, offering safety tips, and reminding all of us to take responsibility for our actions on the road."[243] The

program provides a branded, multi-lingual toolkit including templates for print flyers, public service announcements, web and email campaigns, bus banners, and neighborhood lawn signs, among other resources. For bike safety, Street Smarts emphasizes the use of helmets and lights, following the rules of the road, and proper lane positioning and signaling. While the campaign has won several awards, like most bike safety programs, little analysis exists on the actual benefit of the campaign.

Figure 9. The City of San José Street Smarts Program Home Page

BIKE TO WORK DAY, WEEK, AND MONTH

In 1956, LAB launched a Bike to Work day event. Since then, Bike to Work events have proliferated at the local, regional, statewide, and national level.[244] While these events focus primarily on encouragement, they often include bike safety education elements described above. These education components generally take the form of bike safety education classes offered by local governments or bike advocacy non-profit organizations, as well as print and web materials described below.

Figure 10. Bike to Work Day Web Resources, 511 (San Francisco Bay Area)

BIKE/WALK TO SCHOOL DAY

According to the International Walk to School Day website:

> In 1997, the Partnership for a Walkable America sponsored the first National Walk Our Children to School Day in Chicago, modeled after the United Kingdom's lead... By the year 2002, children, parents, teachers and community leaders in all 50 states joined nearly 3 million walkers around the world to celebrate the second annual International Walk to School Day.[245]

While often referred to as "Walk to School Day" or "iWalk," this international movement now emphasizes bicycling as well. Since 2005, it has been operated by the National Center for Safe Routes to School. The campaign provides promotional materials, a media toolkit, and safety education materials. Rather than create new materials, the bike safety education resources offer links to existing programs in other communities.[246]

Figure 11. iWalk Website

WEB TOOLS

One solution to the lack of resources for hiring and training bike safety instructors is web-based learning tools. Computer technology allows use of animation to simulate real-life bicycling scenarios. It also provides a consistent, controlled learning experience by eliminating the variability in human teaching styles and skills. One example is eHealth's "Bike Smart" program developed in 2005. The Bike Smart program uses video, animations, and still images to provide bike safety training to kindergarten through third grade children. The program includes components of safety rules (for instance, proper hand signals, helmet fitting) and hazard discrimination (on-street, on-sidewalk, at-intersections). The program was evaluated with 243 children and found to be effective for on-street and on-sidewalk safety training, but not necessarily for at-intersection safety. The study noted the need for: (1) more analysis on whether skills are retained over time; and (2) analysis with a larger, more diverse sample of students.[247]

CONCLUSION

A variety of bicycle safety education resources exist. Most take the form of training curricula or media campaign resources. Very little quantitative outcomes analysis exists to determine which tools are most effective in changing behaviors. Experiences to date suggest repeated and continually long-term exposure to bike safety education materials is critical to sustained behavior change.

V. REFLECTIONS ON THE BICYCLE CULTURE OF DAVIS BY A BICYCLE POLICE OFFICER

SECTION AUTHOR: PETER FAETH

INTRODUCTION TO DAVIS, CA (PLATINUM LEVEL COMMUNITY)

In the 1960s, two Davis residents, inspired by cycling culture in the Netherlands, formed a bike advocacy group, leading to a grassroots movement that eventually resulted in 1966 elections promoting pro-cycling citizens to seats at the city council level. [248] Despite such early gains, by the late 1990s and early 2000s, the share of cyclists in the transit environment had decreased and motor vehicle use was increasing. Political momentum for the pro-cycling culture had dwindled, and there were no clear solutions to increase the number of cyclists on the roads. [249] Faced with erosion of the bicycle culture, changes were made to reinvigorate the cycling community. Today, Davis is now hailed as one of the very best cities in the U.S. for cycling.

This small city of 65,000 people has over 100 miles of bike lanes and bike paths. In fact, there are more bikes in Davis than cars.[250] Fourteen to seventeen percent of commuters do so via bicycle—almost 35 times national average.[251,252] The city has also eliminated public school buses, which has pressed a greater number of families to send their children to school *via* walking or biking. [253]

Davis has long been an innovator in bicycle infrastructure well in advance of national, state, or local planning guidelines. CALTRANS loosely based much of their own guidelines on the work already done in Davis, and in turn, CALTRANS guidelines have helped to inform national transportation planning guidelines.[254]

Davis was the first city in the U.S. to have bike lanes.[255] The city also trialed bicycle lanes that were separated from motor traffic by curb-like barriers (similar to Danish bicycle lanes), but later concluded that the separated lanes were dangerous: restricting movement in critical situations, collecting dangerous debris, and complicating vehicular-code right turns.[256] Today, Davis has over 100 miles of bike lanes and paths, with bike lanes over 95 percent of all arterial and collector roads. Bike detectors, signal heads, and bicycle-only roundabouts have been implemented as part of the great project of developing new techniques to accommodate a biking population.[257] The city, in conjunction with the local University of California, provides plentiful bicycle parking throughout the city.[258] In the last decade, over $14 million has been spent on bicycle projects, including $7.4 million on a bicycle under-crossing that bypasses a country road, six interstate highway lanes, and two railroad tracks.[259] A recent project, the Fifth Street Road Diet, is designed to enhance the titular arterial for cycling and walking by reducing car lanes, adding bike lanes, improving pedestrian crossings, and promoting connectivity with neighborhoods near the downtown area.[260]

Bicycle-related traffic enforcement has proceeded by lowering fines, encouraging patrolling officers to write more tickets, and increasing disincentives (via more frequent citations)

for cyclists to adhere to the rules of the road.[261] Officers also give away blinking lights to cyclists.[262]

In addition to a Bicycle Advisory Commission, the City of Davis has its own bicycle coordinator and bicycle advisory committee. The University of California at Davis also maintains its own coordinator and Bicycle Programs Committee.[263] Full-time League of American Bicyclists instructors run Smart Cycling courses.[264]

The University of California at Davis has partnered with the city in numerous ways to promote cycling. For example, university policies discourage freshman from owning automobiles by engineering a dearth of parking permits for students.[265] The university places strict restrictions on car traffic, including "lockdowns" on automobile use at the university to ensure cyclist right-of-way during classes.[266]

Community education and encouragement programs feature a "Cyclebration" in the month of May, which includes auctions, bike tours, commute days and other activities promoting cycling culture.[267] Community bike maps are available.[268] Davis is home to the U.S. cycling Hall of Fame and the California Bicycle Museum.[269] In 2009 and 2010, Davis hosted a Start Stage for the Tour of California.[270]

REFLECTIONS[271]

Davis is an interesting place. It is at the crossroads of many different backgrounds, cultures, nationalities, educational levels, and transportation needs. It has a mix of long-time residents and college students, Americans and internationals, law-abiders and criminals, trains, buses, cars, and lots of bikes. All of these factors blend together to create a unique bicycling experience.

Rumor has it that there are over 20k cyclists riding in Davis at any given time during the school year. This number includes young children on trendy retro wooden bikes without pedals, students on cruisers, future professional cyclists on high-end road and mountain bikes, and daily commuters. It is estimated that Davis residents own over 130,000 bikes. They have to share the road with each other in addition to vehicles and pedestrians. Some of these cyclists ride every day; some of them have not ridden for a long time. Riders must constantly negotiate through a complex but safe network of bike-accessible paths, lanes, and comparatively friendly street riding conditions. Over the decades, the city has put a significant amount of time, money, effort, and thought into the development of its bicycle infrastructure. This has resulted in efficient, sustainable, and enjoyable bike paths and lanes that can be used by all types of riders. Davis has been honored with *Platinum Bike City* status for its ideal biking concepts and commitment to cycling.

I have lived, visited, attended college, and worked in Davis for over 20 years. I have observed the bicycle culture through the eyes of a student, average worker, and as a peace officer. I have ridden and explored the bike paths, greenbelts, and city center both casually and professionally. These are some of my observations and beliefs about why people ride bikes and drive cars like they do in Davis. Most of these observations are fairly recent because I am now a full time bicycle officer. I have also included a short description

of some of the programs and activities that are currently offered in the city or that have been tried in the past along with my assessment of their success or failure.

The most obvious observation you see when you initially enter the city is the intimate and ever present image of the bicycle. An old-fashioned “Penny Farthing” big wheel bicycle is the official symbol of the city. We are now the proud hosts of the Bicycle Hall of Fame and a nicely stocked bicycle museum. There are clearly marked bike lanes on many of the primary vehicle thoroughfares that intersect every neighborhood. When the streets do not have clearly delineated bike lanes, they are often wide enough for shared vehicle usage lined by adequate sidewalks. Bike paths are also evident everywhere you look. The city currently has over 100 miles of bike paths available. Many of these paths spider web through residential neighborhoods while some link the city core to the outlying apartment complexes at the outskirts of the city limits. Additionally, the city limits are confined with approximately 10 square miles of urban residential development and defined clearly by major roads and agricultural fields. And of course with our bike-friendly reputation, most visitors come to town expecting to be overrun by cyclists. One important attribute of long-time and recent Davisites’ mindset is that they are notorious for communicating their opinions about laws and codes that they feel should be rigidly enforced, created on the spot, or ignored.

There is a certain breed of cyclists who admit to me that they know the laws, but choose not to follow them. They claim that they don’t feel like stopping at the stop signs because it is too much work or that the cars are the ones who need to be on the lookout because bikes have the right of way. They want to listen to music, so they use headphones, and insist that the law is another case of micromanagement. Cyclists basically say that they are very good riders and safety conscious; therefore, they can do as they please on the streets as long as they think it is safe to do so. This blatant disregard of existing bike laws is what puts most cyclists at risk.

Infrastructure improvements also play an important part in Davis’s bicycle mentality and have come about due to decades of thoughtful and careful planning. The bike lanes are concentrated in the heavily trafficked corridors while the paths shorten travel time from one part of the city to another and pass through many residential zones. Bike lanes often line some of our busiest streets. While riding around, I have noticed that most cyclists stay within the painted lines or ride on the sidewalks. In the rare event a cyclist rides into the primary vehicle lane, it appears to be due to obstacle avoidance, overtaking slower traffic, or initiating a turn. This behavior is expected and predictable given the amount and quality of lanes and paths that are available.

Figure 12. Bike Lane Marking on Sycamore Lane, Davis, CA

Ironically, the most frequently encountered obstacles and hazards to cyclists are approved and encouraged by the city. Unlike most cities that have receptacles for weekly green waste disposal, Davis utilizes a completely different system. Residents pile their green waste, trimmings, clippings, and branches on the side of the road. This green waste is loosely piled into square piles not to exceed 5 feet. The piles are also not supposed to block bike lanes. Most residents are respectful of this requirement; however, the piles often protrude into the paths of cyclists riding on arterial streets. This potential hazard becomes even more dangerous to cyclists riding at night, regardless of the quality of light they are using. The waste is dark colored, camouflaged, and blends into its background. The city is diligent about picking up the waste on time, but I have responded to and witnessed quite a few cyclists in accidents against the green waste piles.

One of the best examples of bike lane design is our downtown's section of 3rd Street, which runs east to west and intersects about six 4-way stops en route from a residential part of town towards the UCD campus. Because this corridor offers the shortest distance to campus for cyclists, there are thousands of cyclists riding it every day. The street has one lane in each direction with a solid white line indicating the bike lane. Each bike lane is also marked at the beginning of each city block with a painted lane marking on the pavement. Marked bike lanes offer a clear section of roadway that cyclists are encouraged to ride. Of course, the California Vehicle Code does not limit cyclists to using the bike lanes; it is just the obvious and safest place to ride. Additionally, each vehicle parking place along the route is clearly marked and is monitored by our Parking Enforcement Unit to ensure that there is plenty of clearance for the cyclist. Downtown Davis is a bustling commercial center with stores, shops, and restaurants lining the street. Any type of traffic is encouraged by the city in order to increase accessibility for potential customers. The result is that motor vehicles are constantly pulling into and out of the parallel parking places. These drivers, even when aware of cyclists, occasionally cut them off as they ride past in the path. The four way stops do limit the motor vehicle speeds and ideally, the speed at which our cyclists travel as well. There are very few vehicle vs. cyclist accidents in this part of the city.

The 3rd Street corridor is also the most heavily patrolled and most frequently cited street for cyclists. An interesting phenomenon happens along this street at approximately 10 minutes before and after each hour during the daytime—hundreds of students rush to and from class on their bicycles. A large number of them copycat the cyclist in front of or near them. If the bike in front of them stops at a stop sign, the following cyclists generally do the same. If the lead cyclist runs the stop sign, those following will often follow them through the intersection. Another common scenario occurs when a bike attempts to follow a car through a stop sign. In this case, the car is stopped while the bike is approaching the stop sign. The car begins to enter the intersection while the bike follows it through. The safety issue occurs when the car decides to initiate a turn that ultimately turns into the cyclist. This happens regardless of traffic density, or time of day, and sometimes results in a string of cyclists running stop signs while a motor vehicle waits at the intersection.

This area is of high interest to the city and the police department. The vehicle drivers complain about the cyclists, the cyclists complain about the drivers, and pedestrians complain about both. As a bike cop, I am in constant contact with the public. Cyclists, motorists, or pedestrians have no problem waving me down or yelling out the window informing me that a perceived violation just occurred. Usually followed by a “Did you just see that?” with an expectation to cite each of the thousands of violations that occur near me. Along 3rd Street, cars are definitely not at fault for the majority of accidents and near accidents that happen daily. I have observed that most motorists are hypersensitive to driving properly while downtown. They know there are a lot of bikes, they know there are a lot of pedestrians, and they know there are a lot of peace officers, so they stop at the stop signs. Motorists rarely speed and generally don’t pull into the bike lanes unnecessarily. Moving violations such as speeding and running stop signs is fairly uncommon downtown for motor vehicles during the times of heavy traffic. The majority of the vehicles cited involve cell phone and seatbelt violations. However, because of the heavy motorist traffic, there are plenty of opportunities to educate the motorist for more severe violations and to educate them on the safest way to drive in unison with bikes and pedestrians. These violations do seem to increase as the amount of foot and bike traffic decreases and the roadways clear up.

Cyclists, on the other hand, are by far the worst offenders with respect to minor violations. Whether due to lack of knowledge or lack of caring, bikes constantly run stop signs. On any given day, I can sit at any of the stop signs, in a full police uniform and on my black and white police bike, in plain view, and observe countless violations. Some cyclists slow down at stop signs, some just pedal through intersections, some have no hands on their handlebars, and most have headphones with music playing in both ears. After hundreds of stops for these violations, I have heard quite a variety of reasons, excuses, and personal opinions on bike laws and safety.

Cyclists in Davis are cavalier about a couple of things. As they ride through town, they pay no attention to the traffic devices that are prevalent. They pedal past stop signs barely slowing down. Sometimes there are cars at the other 3 way stops, sometimes there are cars that have already entered the intersection after waiting their turn, but many cyclists just proceed through the intersection at their leisure. More times than not, the cyclist will look at the motorist and offer a dirty look or some choice comment on their driving skills. In

return, the motorist yells out the window about the cyclist getting out of the road. Who is at fault? Most times the cyclist is at fault.

This kind of behavior does not always happen, but you can sit at any city intersection during peak hours and witness this exchange. One cause of this conflict is that cyclists often do not know how the vehicle code applies to them. Whether it's a stop sign, stop light, bike light, headphones, riding on the sidewalk, riding the wrong way, or any of the other bike specific violations, they are unsure of their expectations. Do they have the same rules as cars or are they considered pedestrians? Maybe they are their own category? The answer to these questions is not complicated, but it is also not clear.

I once had someone tell me that a cyclist should think of himself as a slow motorcycle driver. This is true in many cases while riding on the roadway, for instance, stay to the far right of the road and ride with the flow of traffic. While this may be true, the issue of cycling is an ever changing position that switches between all three of the aforementioned groups. While on the road, cyclists must abide by the rules of the road, with a few minor additions and adjustments made for bike-specific issues. These same rules apply while riding in a designated bike lane. While on the sidewalks or paths, cyclists must act like a pedestrian. They need to use crosswalks, not ride at an unsafe speed, and avoid true pedestrians. Cyclists must adapt to these changes as quickly as they ride through the different locations.

The explanation they are given during stops is fairly straightforward. When on roads, ride like you would drive a car. When on a sidewalk, ride like you would walk. And in both cases, be aware of the relatively few bike-specific codes that are most frequently violated. This usually appeases the cyclist and the individual issue is resolved.

Most cyclists are adamant that they do not have to follow the rules of the road. They refer to their regular riding habits that they practiced in the city or country that they come from. Some educate me about other states' codes and tell me that they think it should be the same here. For example, Idaho allows cyclists to treat stop signs as yield signs. Many say that they looked, didn't see any other traffic, and just kept going (this is also a common response during my vehicle vs. cyclist post-accident crash interviews). There are also countless online forums discussing bike laws and opinions concerning cycling with safety and common sense.

Another issue that comes up is right of way while at an intersection. Motorists are forced to stop at each intersection from all four directions because of the legal stop signs that are posted. Motorists will generally assume that cyclists either have the right of way or that they will take the right of way. This results in one of two things happening. The first and less dangerous is that both parties will sit at the intersection until one of them decides to take the initiative and proceed. The second and more dangerous is that both will assume the right of way and enter the intersection together. In this scenario, the cyclist generally rides on leaving the motorist in an uncomfortable position in the middle of the intersection further disrupting traffic. Basic education for both the cyclist and the motorist would help eliminate the confusion. Bikes are vehicles too and must follow the same rules of the road!

Bike paths are also an important part of Davis's infrastructure. They provide non-motor vehicle access to most parts of the city. This encourages cycling by offering a safe route to almost any destination. All levels of schools are connected to the surrounding neighborhoods and public parks. There are multiple under and over crossings connecting the city center to the outlying residential neighborhoods that increase commercial bike traffic. Greenbelts frequently line the paths. The city spends a significant amount of time and money to maintain and create these greenbelts in order to make them aesthetically pleasing to the cyclist. These paths offer a fairly safe and efficient route of transportation. The only traffic issues that occur on the paths are when they meet a vehicle roadway, such as an intersection or crosswalk. By bypassing potential conflicts, paths easily offer the safest route to a destination.

Figure 13. Bike Crossing Button. Davis, CA

Many stop light controlled intersections offer both pedestrian and bicycle crossing buttons. There are bicycle buttons usually placed in a location that they can be pressed by the cyclist while stopped on the furthest right side of the road, even without dismounting their bike. Some of these intersections also have bicycle specific stoplights that help separate motor and bicycle traffic. These lights are strategically placed at high traffic intersections. These lights offer a well-timed light sequence allowing bicycles to cross while motor vehicles must remain stationary. The lights are located where both elementary, junior high, and college-age students cross many times a day.

Figure 14. Bike Signal Located at Russell Blvd and Sycamore Ln. Davis, CA

In general, stop lights appear to be more respected than stop signs. Cyclists frequently run stop lights, but they tend to slow down and look in both directions prior to proceeding through the intersection. In contrast, it is not uncommon for a cyclist to continue pedaling through a stop sign controlled intersection without slowing and without regard to the other traffic. This difference may be due to the common belief that light controlled intersections have more traffic than sign controlled intersections. Another contributing factor may be the dynamic nature of a light, going from green to yellow to red, and that a cyclist is more inclined to wait for the light to let them cross, thus taking the decision and timing out of their hands. Either way, lights are more effective. Unfortunately the cost of lights and the public perception are prohibitive for most cities.

Another bicycle-specific measure that the city has concerns downtown. Due to the large amounts of pedestrians and cyclists that frequent the commercial core, cycling on sidewalks is prohibited. To make this clear to people not familiar with the code, each corner ramp at each intersection is painted with the code. Confusing the code is the fact that all of the bike racks and parking places are located on the sidewalks, usually just outside the cyclists destination. The rack placement would not be an issue if cyclists rode in the street until they arrived next to the desired rack and place of business. Because of the rack location and despite the painted warning, there are frequent clashes between cyclists and pedestrians that are usually mediated with a simple verbal warning or reminder.

Davis has an uncommon mentality concerning the positive aspects of cycling. Residents love to be known as the bike capital of the country, they love housing the Hall of Fame, they love having bike paths, lanes, and events geared towards cycling. With this attitude come the willingness to embrace the bike and the willingness to enhance the cycling experience. One of the greatest things you see when you come to the city is the large number of school-age children riding bikes. College students ride because it is often cheaper and more convenient. Younger kids ride for quite a few different reasons ranging from health, convenience, and enjoyment. Based on these factors, the city, parents, and local organizations have taken steps to make cycling the first option in transportation.

School buses are not even an option. They just don't exist in town. They don't go to the high school, junior highs, or any of the elementary schools. Of course there are a few buses for special events such sporting matches and field trips, but they aren't used for the daily transportation of students. This program has been effective for the almost two decades it has existed and has alleviated the strain on school resources and finances. Many parents still drive their kids to school, but the school bike lots are full every day. Even at the high school where many of students drive cars because of the increased travel distance, the bike lot is full. County and UC Davis buses still run extensive regular bus routes in and out of the city.

Another benefit of not having daily school buses is that it has contributed to an increase in cycling to school. Most of the elementary schools are easily accessible by bike lanes and paths. The children must only travel a short distance to school each day. Junior high students have a little further to go, but the schools are located at opposite ends of the city and are still accessible through the extensive path network. Even the high school is centrally located with multiple paths and lanes offering a safe and direct route to school. The natural layout of the city limits helps achieves the goal of making all the benefits of city life accessible by bicycle.

Since so many children ride bicycles on a daily basis for transportation and recreational uses, safety is paramount. Annual bicycle rodeos are successfully run on a consistent basis at each of the elementary schools. The rodeo program takes approximately 1 hour for each session and includes riding skills, situational awareness exercises, and a classroom presentation. Handouts, stickers, and other attention getting materials are handed out to the students during the presentation. Feedback on this program has been overwhelmingly positive with constant requests from school administration for more training dates. The police department has acquired training material such as particle board hand-held cars and vans to aid in more realistic skills training. Multiple cones and chalk are also used liberally to help the children stay on track and to provide them with a quality experience. There are between four to six peace officers assisting along with other city employees, bike advocacy representatives, and local bike shop employees.

The police department also participates in the "Street Smarts" program, which is run through the city. Typically one uniformed peace officer will give safety tips to over 200 day campers each session. Topics include the importance of wearing a helmet, stop signs, and riding on the right side of the road, followed by a presentation including a question and answer session. This program runs for 9 weeks every summer and the feedback from the families and staff involved has also been very positive.

Both of these program coordinators continually request more police presence and participation. Unfortunately, we are limited by time and resources, similar to many sister agencies throughout the state. We have begun using non-sworn employees and Motor Unit officers to augment our numbers and meet the demand for this community service. This type of asset use encompasses and emphasizes our police department's philosophy of community policing and outreach.

During these safety programs, normal bike traffic stops, and general public contacts, the issue of wearing helmets often comes up. Our county requires juveniles who receive bike helmet tickets to attend court with a parent in order to get the ticket signed off and cleared. The intent of this process is to alert and inform both the child and the parent of the importance of wearing a helmet. Because so many children ride during the school week, there are many opportunities to educate them on the spot. We emphasize the proper wearing, sizing, and buckling of the helmet. The response often depends on the age and attitude of the child. Some claim that it messes up their hair, that they didn't feel like putting on the buckle, it doesn't look cool, or that their parents don't care if they wear them. After contacting the parent, I often find that this last claim is false. A primary factor in the enforcement of helmet wearing is the financial aspect of the violation. Although the fine is relatively small, the fine and the time involved always catch the parent's attention.

Adults who don't wear helmets don't do so for many of the same reasons as the children. Although they aren't required by law to wear helmets in most cities, the majority of adult cyclists are aware of the benefits of doing so. In a city with as many cyclists as we have, the amount of helmets worn during casual cycling is still impressive.

Cyclists who don't wear helmets claim that they can't afford them or that they left them in their homes. Over the years the police department has coordinated with a couple of local organizations that donate an almost endless number of child, youth, and adult bike helmets to give out to those in need. Despite the lack of formal advertising of this program, we continue to issue hundreds of helmets a year to needy riders.

Even with all of these programs, education, and the frequency of daily cycling, the overwhelming majority of cyclists continue to resist wearing their helmets and to violate well-known cycling safety practices. This may be attributed to the typical cyclist thought process of "I can only hurt and affect myself while I am riding my bike."

Another tool that is frequently used is a written warning. Essentially, these are "cites" (the term used by the officers) issued to the violator without the involvement of court or the corresponding fines. A written warning allows us to formally contact a violator and give them a hard copy reminder of their violation. These "cites" serve as a compromise between a verbal warning, which are often ignored or forgotten, and an actual citation, which often carries heavy fines and legal repercussions. The response from a written warning has been very positive and the cyclist is usually visibly relieved. These opportunities allow us to ask the violator to pass the newly learned lesson onto their friends, families, and roommates in order to avoid and limit future violations. These written warnings are then entered into our local computer system, but not into any county or state systems. This practice seems to add more formality to the bike stop than just a verbal warning, which I have found to be very effective.

In a city with so many cyclists, one can only imagine the difficulty and importance of making yourself visible and heard to avoid dangerous situations. Conspicuity during the day and at night while riding is a major safety concern for cyclists. The California Vehicle Code has many specific requirements for riding at night to help protect cyclists during times of reduced visibility. Similar to motor vehicles, bikes are required to have a front light

and reflectors visible from various directions. Most department store bikes meet these requirements when they are sold, but many custom or higher end bikes don't have them. No white headlights or rear red lights are the most commonly enforced lighting violations. Even in the bike capital of the U.S., most law enforcement officers are not aware of all of the specific requirements, which make enforcement difficult and unlikely.

Many students have an issue using a bike light. As a student, I knew of many friends who had their lights stolen while they were in class or getting a meal. Lights are usually quick-release or easy to remove from handlebars. Most lights are inexpensive and the market for "used" lights is not very active, so I can only assume that the thieves just needed a light for themselves. Many students also forget to bring one to campus and end up getting caught in a meeting, class, or a study session until after daylight. They are stranded without a light and usually decide to gamble on making it home before they are stopped. To them, walking is not an option because it takes too long to reach their destination. The reasons people take them off vary from the cool factor and the weight factor. I have had people tell me after being stopped at night that they don't leave any reflectors on because they don't ride at night. This is also a common response after being stopped for not having a white light on their bikes. Not having a light or reflectors while bicycling at night is a safety issue.

Although not a specific requirement in the vehicle code, many cyclists have a signaling device on their bike. A signaling device can be anything that makes noise such as a horn, whistle, or bell. Bells are definitely the most common of these devices due to their function and fashion. Supporters of signaling devices claim that they aid in alerting motorists and pedestrians of possible hazards and accidents. However, bells are not easily heard in a perfect environment and are unlikely to be heard in a normal setting. As a peace officer, we are exposed to sirens from our patrol vehicles and from nearby police cars. It is difficult to hear these loud sirens from a patrol car located less than 50 feet away while driving with the windows up. Most bike bells and horns cannot be heard right next to a stationary car with its windows up. So despite the common belief that signaling devices are vital to bicycle safety, they seem to be overrated.

The brakes are often neglected. California Vehicle Code states that a brake is required that allows a cyclist to skid to a stop. Despite this code being quite broad while allowing the many different types of brake options available, cyclists push the envelope. Sometimes brakes are broken on a bike and the cyclist doesn't know how to fix them or is unable to have someone do it for them. These are not the norm. Fixed gear cyclists intentionally remove or do not install brakes of any kind on their bikes. Fixed gear bicycles are bikes whose cranks are directly linked to the wheels. What this means is that if the bike is rolling, the pedals are turning in sync. Fixies, as they are called, are insistent that they can adequately stop by using the resistance of the cranks or placing one of their feet on the top of the rear wheel slowing or stopping the bike. These methods of slowing may be sufficient in some instances where the cyclists have adequate warning of an upcoming stop or hazard, but in a busy, dynamic, urban environment such as Davis it is an impractical and unsafe way to stop. The code requires a braking device and neither of the aforementioned methods of stopping meets that requirement.

Hand signals are another neglected and unknown requirement while cycling. The vehicle code requires signals prior to turns when and if it is safe to do so. While most people I contact know the actual signals, usage is almost zero (unless the cyclist sees me early enough). In most cases in downtown Davis, hand signal use is not reasonable. With the high frequency of controlled intersections and heavy traffic, it is often not safe for a cyclist to remove a hand from their bike in order to signal. In many cases taking a hand off of the handlebar is much more unsafe than neglecting to attempt a legal hand signal. Again, this is not a commonly enforced violation although the intent of the law is consistent with motor vehicle requirements.

The simplest and easiest way to alleviate the equipment and signaling violations lies with education and knowledge. Most cyclists are just not aware of the complex laws and most would be willing to obey them.

One of the most common responses is that the cyclist was not aware that the rule was even a rule. Many of these cyclists are just being reintroduced to the world of biking and haven't been on a bike since childhood. Some belonging to this group claim to have come from a city that failed to enforce any of the existing laws, and they ask if the violation is specific only in Davis. This group appears to be the most receptive to general education. They also appear to be comprised of college age undergraduate-level students. I use these stops not only for the purpose of educating the individual, but also to ask them to pass the information on to their roommates and friends. The social network and word of mouth is a useful and often overlooked advantage of the college scene when trying to spread the word about safety. Most are appreciative and thankful for the learning experience, and I rarely encounter repeat offenders

Some of the most revealing insights relevant to cycling attitudes come from my personal contacts during traffic stops. The volume of cyclists and my position as a full time bicycle officer means that my sample size of bicycle-related contacts is fairly large. Understanding the variety of backgrounds of the people that I stop does not lessen the surprise at the responses that I receive. Shock, disbelief, confusion, and anger are most commonly expressed during a bicycle stop. Whether the violation was running a stop sign, riding the wrong way, or weaving through traffic, people always have a reason and explanation for their actions.

Because of the large number of college students coming from all over the state, country, and world, there is a huge difference in cycling knowledge and experience. The most common response I receive from cyclists that appear to intentionally violate the vehicle code is "Where I come from, the cops never enforce these rules!" They tell me that they know the law, but they have never been stopped for it before. They say that they have been doing it since they started riding bikes. They feel that it isn't a big deal if the law is broken or that no one in law enforcement cares about it. A simple explanation about the safety and rationale is usually sufficient to correct the action, at least temporarily. There have been cases where I have stopped the same person, doing the same thing, in the same location. In these instances the rider is upset and usually can't believe that they were stopped again, which usually elicits the following responses: "Don't you have any real crime to worry about?" or "Don't you have anything better to do?" The natural answer from

an officer is “Actually, no I don’t or I would be doing it!” The rider in this case often appears confused about the severity of the situation. Almost all bike laws are focused on the safety of the cyclist, pedestrian, and the motorist. Cyclists wearing two headphones may think they are in no danger without realizing the intent of the law was to ensure that they could hear outside noises. Such noises as a car horn or a voice warning of an oncoming hazard are vital to hear. Cyclists are somewhat self-centered in this way. A pedestrian would not say that walking down the middle of the street is okay because it would only hurt them if they got hit. They realize that getting hit could hurt the car, traumatize the driver, and could cause a traffic jam. Because of this, well-balanced people don’t walk down the middle of the street and they shouldn’t intentionally violate bicycle safety laws either.

Since it is a college town, I get the opportunity to interact with people from both sides of the fence—students and locals. These groups mix on a regular basis, but also consider themselves separate. As a student I believed that the locals and their businesses existed only to serve and accommodate students. Later, as a local, I remember thinking the students were self-centered and over privileged. Now as a bike officer I get to hear what each side thinks about the other.

Student’s feelings toward law enforcement in general and bike stops specifically emerge in the most common response and attitude that I see, “You guys are just harassing the students because you need the money!” This of course couldn’t be further from the truth because very little money is made from a citation. Of course the bike stop and possible ticket are in the interest of safety and the level of consequence coincides with the severity of the offense. A simple explanation of the safety factor usually suffices, but sometimes a legitimate citation is warranted.

In contrast, long-time residents often have similar feelings directed in the opposite direction. During a stop I often hear “Why don’t you just worry about the students?” The permanent residents claim they are the ones riding safely, and sometimes say, “I have been riding here for so many years and I have never had a problem!” This exemplifies the perception that the other riders are at fault for all the safety issues that exist in the city. Unbeknownst to them, both groups are equally at fault and this law enforcement agency does not “target” or “harass” anyone. This group seems to be less responsive to any bike safety contact or education. Attitudes in general are negative and interaction is agitated and angry.

Regardless of the type of cyclist, the two main factors that increase the safety of riding on the streets are education and enforcement. Education helps those that are truly concerned about their safety and those around them while enforcement emphasizes the importance of safety to everyone else. Reporting bike accidents is also inconsistent. There were approximately 70 bike-motorist accidents last year and it is estimated that nearly 3 times that many were not reported. In most cases, only those accidents that had serious injuries or property damage were reported to the police department. It is difficult to accurately measure the impact that infrastructure, education, and enforcement have on bicycle safety.

With all of the programs, opportunities, and events that exist in the city and the region, Davis is always looking at ways to be progressive at promoting and encouraging even more cycling. One program the city offers is called the Bike Loan Program. This is a program

that the city offers to all of its employees that allows them to use a designated amount of money towards the purchase of a new bicycle. The intent of this program is to encourage bike commuting and recreation for city employees. There are some specific requirements in order to qualify for the loan, such as purchasing a light, a bike rack, and a bell. I have seen this program provide employees with an opportunity to purchase a modern bike that increases their enthusiasm for cycling. The benefits of riding are increased levels of exercise and decreased levels of stress.

“May Is Bike Month” is another program that is offered. This is an online, self-reporting website where users enter their total daily cycling mileage during the month of May. This mileage is accumulated throughout the month and totaled at the end. The individual sets a mileage goal at the beginning of the program that is then tracked and displayed on the website. Individuals can also join with their employers to create a team who then have a competition amongst other employers to see which group rides the most. There are random weekly drawings for small prizes offered as encouragement to reach your mileage goal. May is Bike Month has become a region-wide event that has steadily increased in popularity and participation.

The city offers safety rides to promote and introduce our bike paths. These safety rides are led by multiple organizations including the police department. The route and distance change from ride to ride, in order to offer variety to the participants. These rides allow law enforcement the opportunity to interact with casual riders, many times young children, and talk about helmets, crossing streets, and intersections. Stations are set up at specific points along the route and manned by different city departments or bicycle advocacy group personnel. The stations consist of a safety theme and include the necessary handouts, booth, or skill training course. Drinks and an adequate medical communication plan are always available. Children also receive a “Passport” and are encouraged to get stamps from all of the checkpoints along the route. Participation has varied on these rides depending on the weather, day, and time of day, but feedback has been positive.

At the Davis PD, we run an in-house safety program for all of the sworn peace officers that are interested in riding a bike. This course is required in order for officers to use our department issued bikes while on patrol. We currently have over a third of our patrol officers properly trained. The training includes all aspects of riding safely while on the streets along with bike patrol techniques. Obstacle avoidance and clearing are covered while riding in various road conditions. Riding on patrol is inherently dangerous for a couple of reasons. The first is that bike officers are trying to apprehend and stop criminals and violators like a normal patrol officer. In addition to those duties lies the responsibility of not getting injured. Factors such as heavy traffic, unaware motorists, and the necessity to ride in some uncomfortable situations make this type of riding both mentally and physically challenging. I have encountered countless situations when it was necessary to ride in obviously dangerous situations such as riding against traffic, through large crowds of protesters or partygoers, and even on the shoulder of a major interstate highway. Compound some of these situations with riding at night, and it is testament to our program that most officers have avoided injury. Our in-house bicycle training program was designed to give an officer the best chance possible to perform their duties both effectively and efficiently.

A recent program has been developed by the police department to use mountain biking as an outreach to low-risk teenagers. The Davis Mountain Riders (DMR) consists of 3 bicycle-trained officers and up to 15 youths. The intent of the DMR is to provide youths with an activity to focus their energy and attention on in order to keep them on the right social path. A variety of topics are covered including safety, basic maintenance, local bike ordinances, and codes. The rides vary from cross-country, downhill, and jumping disciplines. This group often travels outside of the city to encourage participation and to allow a change of scenery for the children. Transportation, liability, and instruction are coordinated between the department and the officers. Attendance has been steadily growing as the DMR has grown in popularity through word of mouth.

Davis has gone through many lengthy, time-consuming, and thoughtful phases concerning bike safety over the last few decades. Philosophies and beliefs have changed and evolved based on the latest studies and research about safety. The Davis Police Department also hopes to stay at the forefront of bike safety and education through an ever-improving safety program, state-of-the-art department bicycle unit, and innovative educational programs. We are in a special position to be able to reach a huge cycling community that is both youthfully energetic and historically experienced. Davis will continue to strive for excellence in cycling safety, skills learning, and education.

VI. BICYCLE SAFETY AND INFRASTRUCTURE IN BERKELEY, CALIFORNIA

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INTRODUCTION

In the effort to provide a safer environment for cycling, it is important to distinguish between two different approaches to safety: objective safety and subjective safety. The first concept is what we usually think of when we talk about traffic safety and strategies to prevent particular collision types. It is an approach based on the collection and analysis of safety and operational data in order to propose changes to the physical transportation environment with the goal of reducing the frequency and severity of collisions. At a municipal level this usually involves the analysis of traffic speeds and volumes and collision history at the intersection level in order to determine "Primary Collision Factors" for which new traffic safety control countermeasures can be proposed. The second concept of "subjective safety" is the result of a relatively new movement in transportation, which holds that people's perception of the relative safety of a transportation facility is also an important factor in overall safety. For example, people's perception of the safety of a roadway or bicycle facility plays a critical role in their decision whether or not to bicycle, which in turn can have a direct impact on their objective safety while using that facility, as will be discussed. Both objective and subjective safety can be quantified in meaningful ways for the transportation professional seeking to improve overall safety of transportation facilities.

In 1970, the Berkeley Planning Commission conducted a survey of local bicyclists to determine what factors prevented people from riding bicycles more in the city. This survey measured subjective safety by questioning riders about their perceptions of various types of bikeways and roadways in regard to cycling suitability. The results of that survey are consistent with those of other surveys nationally[272] as well as Colorado,[273] New York,[274] and San Francisco[275] during the past decades and as recently as 2008. Over and over again bicyclists said that they feel unsafe sharing the road with cars and trucks, and prefer separate bikeways designated for their use. Although not every bicyclist agrees—very experienced cyclists often state a preference for faster routes that may also carry heavy automobile traffic—all the surveys cited found that most bicyclists, and especially novice riders, feel more confident in some kind of clearly marked bicycle facility on a street with relatively light traffic.

The provision of appropriate bicycle facilities should aim to address both subjective and objective safety. A designated space in the public right of way can satisfy cyclists' stated preference for a relatively safe place to ride. At the same time, such a space can create a feeling of safety for cyclists, and encourage more people to try bicycling. More people on bikes may sensitize motorists to the presence of bicycles on the road and increase the safety of all riders. And the more people that ride, the more a culture of acceptance takes hold, and as a result, more people are willing to try riding, which can further increase both the safety *and* the numbers of cyclists.

The impetus for the 1970 Berkeley bicycle survey was a report by the Local Transit Study Committee on transportation alternatives for the automobile, which itself stemmed from concerns by residents and city government about the health impacts of car traffic throughout Berkeley. Residents complained of high traffic volumes, high speeds, and noise from cars and trucks on residential streets. Reducing automobile traffic, increasing transit use, and improving conditions for bicycles and pedestrians were goals promulgated by the city and incorporated into various traffic management strategies since that time. The *Berkeley Bikeways Plan* of 1971 was among the first attempts in the nation to outline a strategy for encouraging bicycle use through creation of a network of bike routes, and identifying key design principles for implementation and refinement of that network. Thirty years later the City of Berkeley completed development of its first modern Bicycle Plan, one of whose stated strategies was to increase bicycle use. It was based primarily on the concept of Bicycle Boulevards connected in a seamless network that provided conditions suitable for cyclists of all ages and experience levels. The city began implementing this strategy in 2000, constructing bicycle boulevards that frequently followed routes created by previous traffic calming efforts and older bicycle routes. Throughout the following decade, bicycle use in Berkeley has increased while accidents remained constant or decreased. The following sections provide a historical context for the development of Berkeley's Bicycle Boulevard network and describe the current state of safety analysis of Berkeley's network, including recommendations for next steps and further study.

BERKELEY BICYCLE BOULEVARD ORIGINS

Many of Berkeley's Bicycle Boulevard streets were established along opportunity corridors created by the neighborhood traffic calming efforts that preceded the 2000 Berkeley Bicycle Plan. In order to understand the process of developing the Bicycle Boulevard network, it is important to understand Berkeley's early bicycle planning and neighborhood traffic calming efforts of the 1970s.

Bicycle Use Survey

Two early 1970s projects laid the groundwork for Berkeley's current bicycle boulevards: the *Berkeley Bikeways Plan* (1971) and the *Neighborhood Traffic Study* (1974). Both plans were the outcome of concerns about volumes and speeds of automobile traffic in Berkeley and their effects on residents' quality of life. The *Bikeways Plan* quoted the 1968 *Berkeley Master Plan* as the source of one of its primary objectives, namely: "To reduce the dependence on the private automobile as the dominant mode of transportation by developing a fully integrated system of pedestrian, bicycle, local transit, and automobile facilities and by initiating innovative circulation experiments throughout Berkeley and the region."

The *Bikeways Plan* was created as a stand-alone measure to carry out the city's stated policy to develop a bicycle network. It was preceded by a report (*Bicycles in Berkeley*) on the 1970 Bicycle Use Survey. Aimed at bicyclists, the survey used police department bicycle registration information to send out surveys to 500 randomly selected bike owners, and also made surveys available to the public at libraries, cycle shops, markets, and City Hall. The response rate was almost 28 percent, with 834 replies received. The survey

itself was short, asking when and how often the respondent used a bike, for what purpose, which routes the rider usually followed, and which routes would make the best official bike routes. Then the survey asked for a ranking of those elements that inhibit bicycle riding (auto traffic, physical effort, weather, theft, bike storage, time, social pressures, and other). A space was left for comments and suggestions on how to encourage wider bicycle use and how to create bike routes throughout the city. A total of 832 comments and suggestions were tallied from the survey.

Conflict with auto traffic was by far the most often cited difficulty of cycling. Driver aggression, drivers "squeezing past" bicycles when there isn't enough room for them to safely pass, and cyclists driving poorly were mentioned as problems in the Berkeley surveys. The report concluded that "the difficulty of a motorist seeing a person on a bicycle seems to be the root of much of the conflict, and is one good reason for establishing visible bikeways where cyclists can be expected."[276] Interestingly, this remark (which seems to be based generally on the tone of the surveys, rather than on any specific bicyclist comments) was written well before Jacobsen's "Safety in Numbers" study.

The background study also included two maps, which became a basis for later traffic calming and bikeway planning efforts in Berkeley. The map of "Routes Presently Travelled" showed at a glance which were the most commonly used streets and routes in Berkeley, and which areas received the most bike traffic. Streets around the University of California and downtown show up on the map as very dark lines, meaning they were mentioned by many bicyclists. Also from this map it's clear that east-west bicycle traffic (between the hills and the flats) was fairly spread out, while north-south traffic tended to concentrate on several major streets, including Shattuck, Oxford, and College. At the time of the survey, few of Berkeley's current traffic calming measures were in place, so residential streets paralleling arterials sometimes carried high traffic volumes.

The second map showed graphically which streets bicyclists thought would make good bike routes. "Suggested Routes" showed a different pattern than the actual routes taken. North-south routes were more evenly distributed, and interestingly, Milvia Street (which would later become an important bicycle boulevard) was first suggested as a good route on this map. East-west routes were also chosen by more or less equal numbers of riders, although University Avenue, a main arterial, and Hearst—which parallels University and would also be home to an early bike lane—were both heavily preferred routes.

Berkeley Bikeways Plan

The *Berkeley Bikeways Plan* established certain goals that would (mostly) remain in place when the modern bike plan was developed in the 1990s. They include "the opportunity for safe, convenient, and pleasant bicycle travel"; official encouragement of the use of bicycles to provide "physical, environmental, and social benefits"; provision of facilities and services so that bicycles can "assume a significant role as a form or local transport and recreation"; and coordination and development of inter-city bike routes.

These goals were based on principles articulated in the plan that have, for the most part, formed the basis of future Berkeley bike plans as safety efforts. Bike routes "should be

located on streets with relatively low volumes of auto traffic," ideally in an exclusive, separated late, and if a separated lane is not possible, then "designated by painted stripes or markings." Planning bike routes should be considered in the design of all new or reconstructed streets—a precursor to the notion of "routine accommodation" later promoted by bicycle advocates at the local, county, regional, state and federal level. Other principles included use of the sidewalk "in areas of low pedestrian traffic if a safe bikeway is impossible by other means," but this would have required an amendment to the City Bicycle Ordinance; "lockable" bike racks installed at appropriate destinations (at the time, many bike racks consisted of low cement blocks with a wheel slot and an eye bolt, which were difficult to use); and "phasing" of bike route installation—a principle that would have been very useful a few years later, when Berkeley implemented its new traffic management study, as will be discussed later in this publication.

The *Bikeways Plan* also identified different kinds of bikeway facilities at the same time that statewide standards were being developed by Caltrans. Class 1 bike routes were to be "physically separated from auto and pedestrian traffic"; Class 2 bike lanes were striped lanes on roadways for the use of bicyclists; Class 3 routes would be "on sidewalks, malls, plazas, or other areas where the right-of-way is shared with pedestrians"; and Class 4 bike routes were designated on certain city streets where bicycles shared the right-of-way with autos, providing "adequate signage" to increase motorist awareness. These classes were later refined by Caltrans and subsequent Berkeley Bicycle Plans (2000, 2005) were updated—with the exception of Bicycle Boulevards and Class 2.5 bikeways—to be entirely consistent with contemporary Caltrans design standards.

The *Bikeways Plan* mapped out future bike routes in a complete network, and many, though not all, of those routes have become the basis for the current Bicycle Boulevards. Hearst and Delaware were designated as a connected route paralleling University; Milvia Street was to be a main north-south route through downtown; Channing Way paralleled the east-west Dwight arterial, and Russell paralleled Ashby Avenue, which is a state highway and main east-west auto route. The right-of-way following the old Santa Fe railroad tracks was also designated as a north-south route (a later study would focus exclusively on this route, although not all of it would be developed). The map also shows a crossing over the East Shore Highway for bikes just south of University Avenue, which was eventually constructed as the Berkeley Bicycle Pedestrian Bridge in 2002, crossing from Aquatic Park to the Marina. Another map shows streets on which parking would be removed to allow room for a bike lane to be put in.

Neighborhood Traffic Study

A second important document, the *Berkeley Neighborhood Traffic Study*, was published in 1974, not long after the *Bikeways Plan*. Its focus was on vehicle traffic in Berkeley, including the negative effects of nonlocal traffic on pedestrians and bicyclists on neighborhood streets. This study led to the current traffic management plan in Berkeley, including most of the barriers and diverters that discourage automobiles on neighborhood streets and force most through-traffic onto arterials. In an opportunistic synergy of past efforts and current safety needs many of the relatively lightly traveled streets resulting from the placement of barriers have since become Bicycle Boulevards.

The City of Berkeley had already clearly established its interest in reducing auto traffic on its streets. The Berkeley General Plan of 1968 had set a policy to discourage auto traffic, including the decision to build no new freeways even though state plans included two to be built through Berkeley; to avoid street widening; to restrict regional traffic to a limited number of city streets; and to decrease dependence on the auto and "encourage innovative experiments toward this end."[277] These revolutionary policy decisions were made at a time when other communities in the Bay Area were undertaking massive arterial roadway construction projects to create capacity for new development that in some cases was eventually never needed.[278] There had also been a discussion about severing the connection between Highway 24, which led to the Caldecott Tunnel and points east beyond the hills, and removing Ashby Avenue from the state highway system. This ultimately was not carried out, however, and today some of the most heavily congested areas in Berkeley are Ashby Avenue and the approach to Highway 24 along Tunnel Road. Ironically, Tunnel is also a major recreational bicycle route, and on weekend mornings bicycles can sometimes outnumber cars.

In addition to the General Plan policies, an amendment to the Berkeley Master Plan of 1968 clearly laid out policies to restrict automobile priority and called for integration of bicycles into the transportation system. Traffic diverters had already been installed in three Berkeley neighborhoods to prevent nonlocal traffic from cutting through them. Other neighborhoods wanted similar treatments. It became clear that diverting traffic from one street to another raised equity issues that needed further consideration, and the *Neighborhood Traffic Study* was commissioned to understand these traffic issues and to develop solutions for them.

Preliminary work on the *Traffic Study* involved a high level of community participation, with input from residents in every neighborhood in the city via almost sixty neighborhood meetings. All participants were welcome, from neighborhood leaders to temporary residents; neighborhoods were leafleted before meetings and the meetings arranged with the help of local neighborhood leaders. School principals and PTAs were asked to identify traffic problems; park employees were surveyed; the Berkeley Chamber of Commerce participated. The nature of public participation in Berkeley brought out many interested parties, outspoken community members dominated some meetings. The study gently refers to a vociferous "anti-auto" faction that demanded draconian measures, although it seems most residents of Berkeley were not prepared to give up cars completely.

Major issues that came up in the public meetings were discussed in a general way by the study. Traffic intrusions through neighborhoods were a main concern, caused largely by congestion on nearby arterials. The fact that many arterial and collector streets also had residences along them raised the question of whether high traffic volumes were inappropriate on them; noise and speed were also concerns. Community members wanted to de-emphasize automobiles in favor of improvements in transit and bicycle and pedestrian amenities. Commuter parking blocked residents from curb parking and was seen as contributing to neighborhood traffic problems. The University of California, a major traffic generator, was expected to take responsibility for its parking and land development policies affecting nearby neighborhoods, as well as to help improve local transit.

The need for improved bicycle and pedestrian amenities was also a concern raised at these meetings, although there was some controversy around it. For example, cyclists were criticized for the way they rode in traffic, and some residents complained that existing bike lanes weren't used even though parking had been removed to provide them. Given the discontinuity of bicycle facilities in existence at the time, it is not surprising that conflicts like these might arise, as cyclists could hardly be blamed for not wanting to use facilities that suddenly end short of the rider's destination.

According to Donald Appleyard, who included a chapter about Berkeley's experiments with traffic barriers in his influential book, *Livable Streets*, in general the community's expressed interests throughout the study process were both "concrete" and "parochial," with less concern about general concepts of traffic calming, but very high interest in individual solutions to specific problems. Therefore much of the *Neighborhood Traffic Study* is given over to detailed discussions of specific neighborhoods and particular streets, presenting alternative solutions in keeping with overall city goals and keeping in mind effects on the wider area surrounding the proposed changes.

The Experiment Begins

In the fall of 1975, as a result of solutions proposed in the *Neighborhood Traffic Study*, 41 new diverters were installed in the city, as well as 300 new stop signs and 18 traffic circles. Some 33 other diverters had been eliminated from the plan, and some of the installations would be removed or adjusted as time went on. Using inexpensive materials such as concrete bollards and metal guard rails, the barriers went up quickly—which may have been a mistake. People complained that they had not been given adequate warning, and suddenly driving across Berkeley became a tricky proposition, with customary routes no longer available. One major change was the closing of Fulton Street, which had been, with Ellsworth, a one-way pair carrying as many as 10,000 daily trips through the Le Conte neighborhood. Both streets reverted to two-way streets and were blocked at Ashby Avenue and Dwight Way.

Traffic volumes on the residential streets fell, and congestion on arterials, especially coming into town from the southeast, increased. People were angry that their routes were disrupted, and there were two hundred incidents of vandalism on the barriers (including some of them knocked over or broken) and thirty stop signs were stolen. Others, appreciative of the new calm on their streets, planted flowers at the barriers and put up signs asking people to respect them. Accidents related to the barriers increased in the first four months after they were installed, but then decreased as people got used to them. One barrier type caused particular problems. Where planners decided to block most of the street but left one lane open for emergency vehicles, a low bar was installed in the open lane that would allow vehicles with high clearance, such as fire trucks, to pass over them, but would catch on most cars. Quite a few people tried to pass over these barriers despite signs warning them against it, and damaged the undercarriage of their cars (or ripped out their oil pans) before drivers learned not to try the maneuver. Note that bicycles are not only able to pass these barriers easily, they are legally allowed to do so; even half-diverters that require right turns exempt bicycles from the rule.

By the end of the year, a community group calling itself “Citizens Against the Barricades” had formed and began collecting signatures for a ballot proposition to remove the new traffic devices. The next six months were a heady time in Berkeley; the new traffic diverters affected everyone, and everyone had an opinion about them. Residents who were enjoying newly quiet streets did not want to return to the previous situation. Opponents argued that motorists were unreasonably inconvenienced, that emergency vehicle access was compromised, that congestion increased dramatically on arterial and collector streets, and that safety in general was not served by the traffic scheme. They argued that traffic control devices should only be used to expedite, not impede, traffic flow.

The writers of the ballot proposition made several mistakes. One was to propose that all barriers and diverters be removed immediately, even ones that predated the recent traffic experiment. Further attempts at placing barriers would be also prohibited. The other mistake was to not take into account that the diverters had been built quickly and temporarily so the concept could be tested, and at the end of six months they were to be evaluated. The ballot proposition, if it passed, would have removed the barriers permanently no matter what the six-month evaluation concluded.

Proposition O, as it was called, was eventually defeated in the June 1976 election by 56 percent to 44 percent—somewhat close, but with a clear majority in favor of *not* removing the barriers. There was another ballot attempt the next year (Prop E), but it also failed, and in 1977 a lawsuit was filed against the city claiming that because they were not in the *Manual on Uniform Traffic Control Devices*, the diverters were illegal. A local judge ruled in favor of the suit, but the city’s appeal was upheld in 1980 and the case eventually went to the California Supreme Court, which ruled that diagonal diverters were traffic control devices not authorized by state law. This ruling became moot when the state legislature gave local governments the authority to block entry to or exit from any street by means of islands, curbs, traffic barriers, or roadway design features. The California legislature also excluded traffic calming measures from the definition of traffic control devices and hence from state regulation. Diverters are now considered roadway design features (California Vehicle Code 21101 (F)).

Evaluation

The same consultants who wrote the *Traffic Study* (De Leuw, Cather, and Company) followed up six months later with an evaluation of the effects of the traffic management program. Their findings were, on the whole, unsurprising. Changes did occur in traffic patterns, generally as expected: streets with diverters experienced much less traffic, and arterials and collector streets carried more traffic than they did before the diverters went in. A few of the local streets suffered from traffic increases, and several arterials actually benefitted with traffic decreases. Overall, traffic on most local streets decreased or remained unchanged, and increases on arterials did not cause serious congestion, partly due to improved traffic operations, which were able to absorb traffic shifts. The evaluation found that overall travel times in Berkeley did not change significantly, although some particular trips may have increased with the elimination of through-neighborhood shortcuts.

Traffic accidents and traffic fatalities decreased during the six months of the evaluation period, although injury accidents rose slightly. Appleyard points out, however, that these rates are all considered within the normal range, and the numbers are so small as to be statistically unreliable.

The evaluation also found frequent violations of the traffic devices, with drivers skirting diverters regularly but the devices were still effective. Undercarriage blocks were generally successful, although some cars successfully navigated over them and a few police cars were damaged while crossing at high speed. Shortcuts through traffic circles—drivers turning left in front of rather than going around the circles—were frequent enough to warrant replacement of several of the circles, since these were potentially highly dangerous violations.

There was little discernible effect on transit. Bus ridership increased, but that may have had nothing to do with the traffic plan. There was no evidence of delay for police, except for the damaged cruisers mentioned above, and crime statistics were too variable to be conclusive. Five emergencies involving fire trucks were reported, but nothing catastrophic. School bus route adjustments cost an estimated $10,000. According to Appleyard the Traffic Management Plan was generally beneficial.

There were problems with the implementation strategy—notably its suddenness, which caused consternation and confusion for everyone. The installation was done in a hurry, and proper signage was not included in many places where it could have helped. There were also complaints about the devices being ugly. Supposedly temporary, they were not very aesthetically pleasing, although the thought was that the bollards could be used as planters. Residents over the years have painted them, planted in them, and recently covered them with bright mosaics, as well as filled some of them with trash. The idea was that once the experiment was finished, they would be replaced with something more permanent and landscaped—but that never came to pass.

Nonetheless, what Berkeley has ended up with is a complex maze of streets that actively prevents drivers from cutting through neighborhoods and keeps vehicles on major arterials, while allowing bicycles and pedestrians to travel along all the streets unimpeded. This means there are many quiet streets that create ideal conditions for Bicycle Boulevards.

BICYCLE BOULEVARDS

Berkeley's contemporary Bicycle Boulevard network is in many ways a direct outgrowth of its earlier bicycle planning and traffic calming efforts. In the final analysis, while both were incomplete, they laid the groundwork for future bicycle planning and implementation. The 1971 Bicycle Plan identified a system of bikeways that, although largely functional, was discontinuous, and turned out to be an insignificant inducement to encourage new riders. However, through its public outreach process and the identification of "suggested routes," it provided important insight into the origins and destinations of cyclist trips that would later inform the Bike Boulevard layout. And although many of the most radical suggestions of the 1974 Traffic Study were removed from the final traffic management plan, the corridors

that received significant traffic calming became many of the primary Bicycle Boulevards "arterial" bikeways.

The Berkeley Bicycle Plan, incorporated into the city's General Plan in 2000, was the result of an almost decade-long process. The first phase, begun in 1992, focused on evaluating existing conditions and gathering suggestions and comments from community members, including commonly used routes, existing problems, and ideas for potential solutions. The first meetings culminated in a Draft Bicycle Plan in 1994, which was presented in more public meetings that produced further community feedback.[279] Phase 2 began in 1997, when the city received grants to hire a consultant team. The team developed goals and policies as well as cost estimates and criteria for prioritizing elements of the final plan. Another draft of the plan was presented for public comment, and further refinements were made before the final Bicycle Plan was adopted and incorporated into the General Plan.

The purpose of the Bicycle Plan was to make Berkeley a model bicycle-friendly city, balancing bike use with other modes including walking, disabled transport, transit, and autos. While recognizing the benefits of the city's traffic management plan, which created lessened traffic volumes on many residential streets, the plan also acknowledged some of the problems caused by this system. For example, now that through-traffic was channeled to arterial and collector streets, the resultant increase in traffic volumes on some of those streets exacerbated bicyclists' difficulty in crossing them while riding on the quieter streets that had been identified as proposed bikeways in the 1971 Bike Plan. It was also much more difficult to ride on major streets in the city. Also, there were many stop signs along some of the quieter streets, which were meant to slow traffic down, but instead caused other problems, including cars ignoring the signs or speeding up between intersections to make up for lost time. Too many stop signs also cause bicyclists to expend more effort, making some routes less attractive to bicyclists. There were also a few traffic diverters, especially ones placed diagonally across intersections that bicycles were allowed to cut through, but that sometimes caused conflicts or confusion when car drivers weren't watching for them.[280]

Other problems the plan hoped to address included the discontinuity of the current routes outlined in the 1971 *Berkeley Bikeways Plan*. Although a bicyclist could get through most areas of town along a bike route, there were places where routes disappeared or were blocked. Also, in the area south of the University of California campus, where one-way streets prevailed, bicyclists were required to ride uphill out of their way in order to avoid going the wrong way; also, the existing routes did not meet up very well with entrances to campus. Access to the Berkeley Marina was difficult and confusing. In addition, bicycles were not detected at signals, bad pavement and potholes created dangerous conditions for bicyclists, and despite a program to add bike parking throughout the city and on campus, there was not enough of it.[281]

The plan delineates different possible types of bikeways, starting with the contemporary Caltrans classifications Class 1 (separate paths for bicycles, also shared with pedestrians), Class 2 (marked bike lanes), and Class 3 (signed bicycle routes). All three exist in Berkeley. With the exception of former railroad right of ways, there are limited opportunities to build Class 1 facilities as Berkeley is largely built out already. The Class 1 facilities that do exist

are shared-use paths that are popular with all kinds of users including walkers, joggers, and rollerbladers as well as bicyclists, and as such they are not as fast for bicycles as on-street routes). Many Berkeley city streets that would warrant bike lanes are too narrow to allow them and often the political will to remove parking is lacking, so the bike plan added a new facilities classification based on Berkeley's specific needs: Class 2.5, a "bikeway" or "shared roadway," which provides direct access and connections to major destinations on streets where bike lanes would not work.[282] These bikeways were to be improved for bicycle travel in a variety of ways and carry signs and pavement markings designating them as bikeways to improve driver awareness of the presence of cyclists.

Another new classification created by the plan was the "Bicycle Boulevard," which would serve as "bicycle arterials" roughly paralleling the main arterial streets in the city. Bicycle Boulevards provide safe, quiet conditions for bicycles while allowing emergency access. According to the plan, a Bicycle Boulevard is distinguished by low traffic volumes, discouragement of nonlocal auto traffic but free-flowing connections for bicycles, traffic controls at major crossings, and a distinctive look so both bicyclists and car drivers know they are traveling on a street engineered for bikes.[283] The Boulevards were to be placed on local streets that are *not* transit or truck routes, with very little commercial frontage and within a quarter of a mile of a major street. The streets would also need to be uninterrupted, or be able to connect to other similar streets, so they can provide an unbroken link to other Bicycle Boulevards and create a connected, convenient network for bicyclists. To that end, also, the Boulevards were to be spaced somewhere between three-quarters of a mile and a mile-and-a-half apart, similar to the distance separating the major auto streets in Berkeley, giving bicycle riders the same network advantages of cars within the city.[284]

Five streets were designated as Bicycle Boulevards in 1995: Delaware/Hearst paralleling University (this route was later changed to Virginia, a block further north); Channing, paralleling Dwight; Milvia, parallel to Martin Luther King Jr. Way and Shattuck Avenue; California Street, parallel to Sacramento; and Ninth Street, parallel to San Pablo Avenue. The plan soon added another north-south route (Hillegass/Bowditch south of the UC campus), and one more east-west route along Russell, just north of Ashby Avenue. Most of these routes had already received some form of traffic calming as a result of the *Neighborhood Traffic Study*, in most cases having at least one barrier and frequently many stop signs. All of the designated streets were already carrying less traffic as a result of the earlier study.

In part, the concept of the Bicycle Boulevards was born with the city's experiences with traffic calming Milvia Street. Milvia, between and parallel to two arterials, had already been converted to a "slow street" in 1989. Cars had been using it to avoid the traffic lights on Martin Luther King Jr. Way (then called Grove Street) and Shattuck Avenue, two of the main north-south routes through Berkeley. Urban Ecology, a Berkeley-based advocacy group, designed a street that would slow traffic by forcing it to follow a curving path, rather than relying on speed limits. They had found one precedent: "slow ways" in Australia, and because their main concern was with slowing down traffic, the concept—and name—stuck.[285] Community concerns about speeding added pressure to take action. Eventually an opportunity presented itself when the developer of a six-story office building along Milvia was prevailed upon to pay a fee to help mitigate its traffic impacts.[286] Using the money

from the development, the city built thirty curb bulbouts—at intersections and mid-block—along six blocks of Milvia, with planted islands and a serpentine roadway alignment that forced all traffic to follow a curvilinear, chicaned path of travel. Speed humps were added, and the entire road was repaved and new sidewalks put in.

A study from UC Berkeley a year later found that the number of pedestrians had increased 48 percent on one block and 126 percent on another; that traffic had decreased 18 percent on one block and 20 percent on another; and that 80 percent of local residents surveyed thought that pedestrian safety had increased along the slow street.[287] Perhaps the most dramatic result of the before-after study is the change in bicycle volumes. At one location observed volumes of cyclists during the p.m. peak commute hours increased by 117 percent and at another by 49 percent.

EFFECTIVENESS OF INFRASTRUCTURE SAFETY STRATEGY

Generally speaking, it is challenging to correlate changes in bicycle ridership and safety at a city-wide level to a particular program or project such as the Bicycle Boulevard Network. Many factors can affect bicycle usage and safety, including economic trends such as the price of gasoline or variations in employment levels, overall transportation activity, and other government efforts such as public safety education programs. And while planners and engineers utilize available data in making decisions about bicycle infrastructure, they frequently must also rely on the feedback of users (cyclists) and accepted engineering best practices in lieu of a complete dataset. Berkeley is no exception in this regard.

While it is difficult to establish a relationship of causality or correlation between Berkeley's Bicycle Boulevard Network and changes in usage and safety, we can still speak meaningfully about usage and safety trends that have taken place concurrently with the development of the network. Subjective safety measures that have to do with cyclists' perception of the cycling environment—such as rider route choice and other ridership trends—demonstrate that Bicycle Boulevards are desirable for cyclists and may encourage more bicycle use. Objective safety measures that have to do with available data such as changes in cyclist volumes and collisions demonstrate that as volumes have increased collisions have decreased. This suggests that the provision of facilities that are desirable to cyclists is in itself a safety strategy, insofar as it results in a safety in numbers effect.

Subjective Safety Evaluation

The Milvia Slow Street project—a progenitor of the modern Bicycle Boulevard—is an example of the effect that desirable infrastructure can have on route choice. Following the implementation of the Slow Street, one location observed volumes of cyclists during the p.m. peak commute hours increased by 117 percent and at another by 49 percent. A small portion of this increase might be accounted for by natural daily variation in bicycle travel, though this still leaves a significant change in bicycle volumes unexplained. It is reasonable to assume that a massive and sudden increase in overall bicycle activity did not occur during this time period in Berkeley, which means that cyclists must have been diverting from other, less inviting parallel routes such as Shattuck Avenue and Martin Luther King Jr. Way, and choosing to ride on the slower, calmer Milvia Street. This suggests that the character of the

roadway is a critical element in route choice and by extension, in the decision of whether or not to bicycle at all. Data from at least one study confirms this relationship between Bicycle Boulevards and levels of cycling, particularly among less experienced cyclists. Research indicates that bicycle boulevards may be more effective than bike lanes on arterials at encouraging more bicycling among groups of people who currently do not bicycle much.[288] These conclusions confirm the results of historic and contemporary surveys of cyclists in which comments are focused on the dangers of sharing the roadway with high volumes of fast-moving automobiles.

The City of Berkeley has conducted manual bicycle counts at approximately10 locations throughout the Bicycle Boulevard network on an annual basis since 2000. These counts, which take place in late September and early October, capture the number of cyclists during the two peak hours from 4-6 pm. The counts also capture observed gender, sidewalk riding, and helmet use. The city is currently analyzing the 10-year bike count data in order to prepare a public report of bicycling trends in Berkeley. The analysis provided below was conducted on the 2000-2009 data as part of the development of that draft report.

One of the goals of establishing on-street bikeways is the encouragement of cyclist compliance with traffic laws, such as riding in the correct direction on the roadway. If bikeways are successful in this regard, such behaviors should be reduced, producing a potential decrease in the types of collisions caused by these illegal behaviors. Data reflecting the number of cyclists riding on sidewalks was only recorded at three intersections—Bowditch & Channing, California & Russell and MLK & Russell—and only for the years 2000, 2003, 2005 and 2009. During the years it was observed, sidewalk riding decreased modestly on Bowditch & Channing, from 5 percent in 2000 to 3 percent in 2009. A larger decrease was observed at California & Russell from 10 percent in 2000 to 5 percent in 2009. MLK & Russell experienced a large decrease in sidewalk riding from 2000 to 2003, decreasing from 12 percent to 5 percent. Given that one of the design goals of the Bicycle Boulevard pavement legend is to identify the treated roadway as a bicycle priority street, it may be reasonable to assume a connection between these treatments and sidewalk riding behavior. During the years 2000 to 2002, the city was in the process of installing Bicycle Boulevard signs and markings throughout the network. This time period corresponds to the dramatic decrease in sidewalk riding at the intersection of MLK and Russell between 2000 and 2003.

At least one study has shown that women cyclists serve as “indicator species” for bike friendliness because women are more likely to go out of their way to use bike boulevards. In a study conducted by Portland State University, the stated and revealed preference data comparing men and women found that women are more likely to prefer to bicycle on low-traffic streets and bicycle boulevards, and less likely to prefer riding on busier streets with bike lanes. Similarly, less experienced bicyclists placed higher importance on factors that make the trip easier—routes with less traffic and requiring less physical effort.[289] In Berkeley, the gender ratio of cyclists using the Bicycle Boulevard system has become more balanced since the year 2000 when the male-female split was 70/30. In 2009, the male-female ratio observed was 60/40. This suggests that women have become more comfortable riding bicycles in Berkeley on the Bicycle Boulevard network and are accounting for a larger portion of the total pool of cyclists observed, in turn contributing

to the citywide increase for cyclists. According to the “indicator species” theory, this data also suggests that Bicycle Boulevards have been more effective at inviting both women and less experienced cyclists to use the network and contributing to the safety in numbers effect.

Objective Safety Evaluation

In an ideal situation, a data-driven analysis of the effectiveness of the Bicycle Boulevards at promoting safety would involve intersection-level analysis of bicycle volumes and collisions. This analysis would identify specific ways in which the Bicycle Boulevard treatments have served as a countermeasure to particular Primary Collision Factors (PCFs). However, there is not sufficient data at the intersection level to conduct such an analysis. As an alternative approach, the city is analyzing trends at a citywide level in order to identify network-level changes in absolute numbers of bicycle volumes and collisions and to identify—in a preliminary fashion—trends in the rate of collisions on the network. Note that given the small sample size, none of the trends identified below are considered statistically significant, pending further analysis.

Berkeley’s Bicycle Boulevard network counts show a 72 percent increase in levels of cycling from the year 2000 to 2010. Bicycling increased on average about 5 percent per year during that time period. The single biggest increase in bicycle usage on the network occurred between 2002 and 2003 when cycling rose by 11 percent within one year. The time period of September 2002-September 2003 corresponds with the installation of Bicycle Boulevard signs and markings through the city’s bike network.

Collisions at the bicycle count locations decreased by just over 5.5 percent during the same time period, 2000-2009, when cycling activity had increased 46 percent. From 2002 to 2003, following implementation of Bike Boulevard signs and markings and during the single biggest expansion of cycling activity, collisions decreased approximately 5.3 percent.

Bicycle volumes are collected only once per year, whereas collisions are compiled from state records from an entire year. For this reason, it is impossible to create a true rate of collisions per cyclist—the data are not complimentary. Keeping this in mind, the city created a safety factor, which is a ratio of available data (ratio of cyclist volumes to total collisions). The volumes to collisions factor decreased overall by 35.4 percent from 2000-2009, an average of 6.6 percent per year.

While the data and analysis provided above are preliminary and subject to further refinement, the trends are fairly clear. For the period of time from 2000-2009, absolute numbers of bicycles increased while absolute numbers of collisions decreased. Despite the fact that there were more cyclists on the road, numbers of collisions did not increase. Of particular interest is the trend during the years 2002-2003, when the Bicycle Boulevards were first implemented. From a before and after perspective, the dramatic change in absolute numbers of cyclists, and corresponding decrease in collisions, is compelling. Again, while it is difficult to establish any firm causality relationship, this correspondence is unlikely to be a mere coincidence.

CONCLUSIONS

Berkeley's experience implementing its Bicycle Boulevard network provides a number of lessons learned for communities wishing to undertake a similar project. No doubt Berkeley's success from a subjective safety perspective is largely attributable to the way the infrastructure safety strategy was based directly on cyclist preferences. Surveys dating back to the 1970s in Berkeley and elsewhere indicate cyclists' preference to use a facility separated from high-volume, high-speed automobile traffic. The Bicycle Boulevards, through their opportunistic use of existing traffic-calmed streets from the 1970 and new traffic calming measures, created an environment that matched cyclists' preferences. Bicycle volume data supports, at least in part, the success of this strategy at encouraging cycling. This further emphasizes the need for robust public outreach processes to assess cyclists' specific needs when planning effective bikeway networks.

As has already been stated, there are serious difficulties in establishing a causal relationship between the establishment of bicycle boulevards and improvements in objective safety. However, it is difficult to discount the compelling increase in cycling and corresponding decrease in collisions that occurred during the period of the available data, especially during the years immediately before and after the signing and marking of the network. While the trends suggest promising outcomes for future Bicycle Boulevard improvements, additional data collection and study is needed to establish a statistical relationship of causality. For example, a more robust, year-round count program would correspond to the year-round collision data available from the state. Intersection level data and observations should be conducted to identify whether or not the characteristics of Bicycle Boulevards serve as effective countermeasures for specific Primary Collision Factors. In addition to collecting more robust volume and collision data at the intersection level on the Bike Boulevard network, such data should be collected on comparable segments and intersections off the network in order to provide a control for ongoing trend analysis.

A timeline of the significant milestones discussed above follows:

1968 The Berkeley General Plan set policy discouraging auto traffic, calling for "…a fully integrated system of pedestrian, bicycle, local transit…"
1970 The Berkeley Planning Commission conducted a survey of local bicyclists to determine what factors prevented people from riding bicycles.
1971 Berkeley Bikeways Plan among the first attempts in the nation to outline a strategy for encouraging bicycle use; first Berkeley bicycle network.
1974 Berkeley Neighborhood Traffic Study led to first traffic diverters; lays groundwork for future traffic-calmed Bicycle Boulevard Network.
1975 41 new traffic diverters were installed in the city, as well as 18 traffic circles, in an effort to reduce traffic impacts on residential neighborhoods.
1975 "Citizens Against the Barricades" had formed and began collecting signatures for a ballot proposition to remove the new traffic devices.
1976 Between 1976 and 1980 propositions against barricades were defeated, but proponents won in the Supreme Court. Then decision was rendered moot by legislation.
1992 Development began on a new Berkeley Bicycle Plan, drawing on the bicycle

network and policies established in the 1971 Berkeley Bikeways Plan.

1999 Berkeley held a series of public workshops to finalize the conceptual design of the Bicycle Boulevards, including signs, markings and traffic calming.

2000 Berkeley Bicycle Plan adopted by Berkeley City Council, including the Bicycle Boulevard Design Tools and Guidelines document.

2000 Berkeley City Council authorized staff to implement the bicycle boulevards, using the Design Tools and Guidelines Report as a guiding document.

2000 The City began constructing Bicycle Boulevards along opportunity corridors created by previous traffic calming efforts and older bicycle routes.

2001 First signs and pavement legends installed on Hillegass/Bowditch Bicycle Boulevard for demonstration/evaluation.

2002 Berkeley I-80 Bicycle Pedestrian Bridge constructed connecting Berkeley's neighborhood bikeways to the Marina and Bay Trail over Interstate 80.

2002 Traffic signals installed at Russell and Telegraph and Virginia and 6th Street to improve crossing for bicyclists; Russell & Piedmont diverter upgraded.

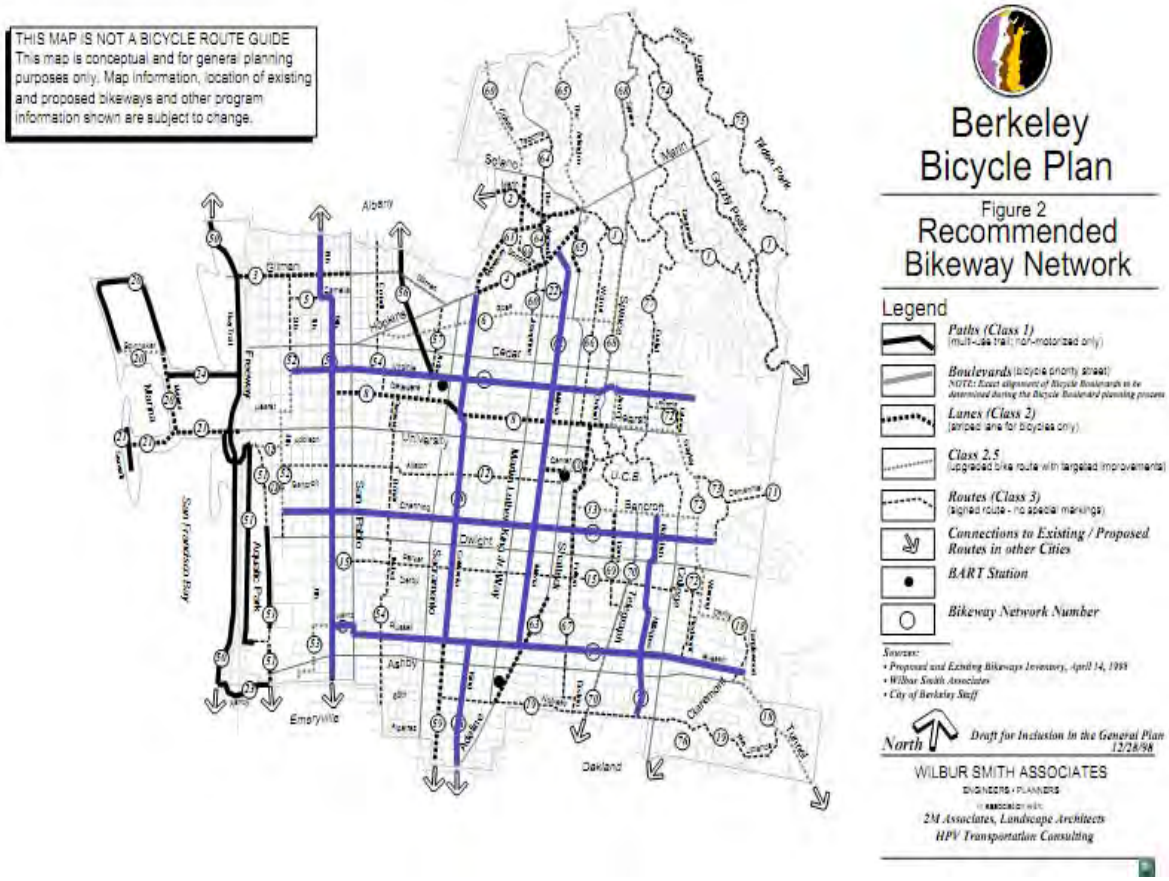
2003 Signs and pavement legends installed on remaining six boulevards, completing the first phase of Bicycle Boulevard implementation.

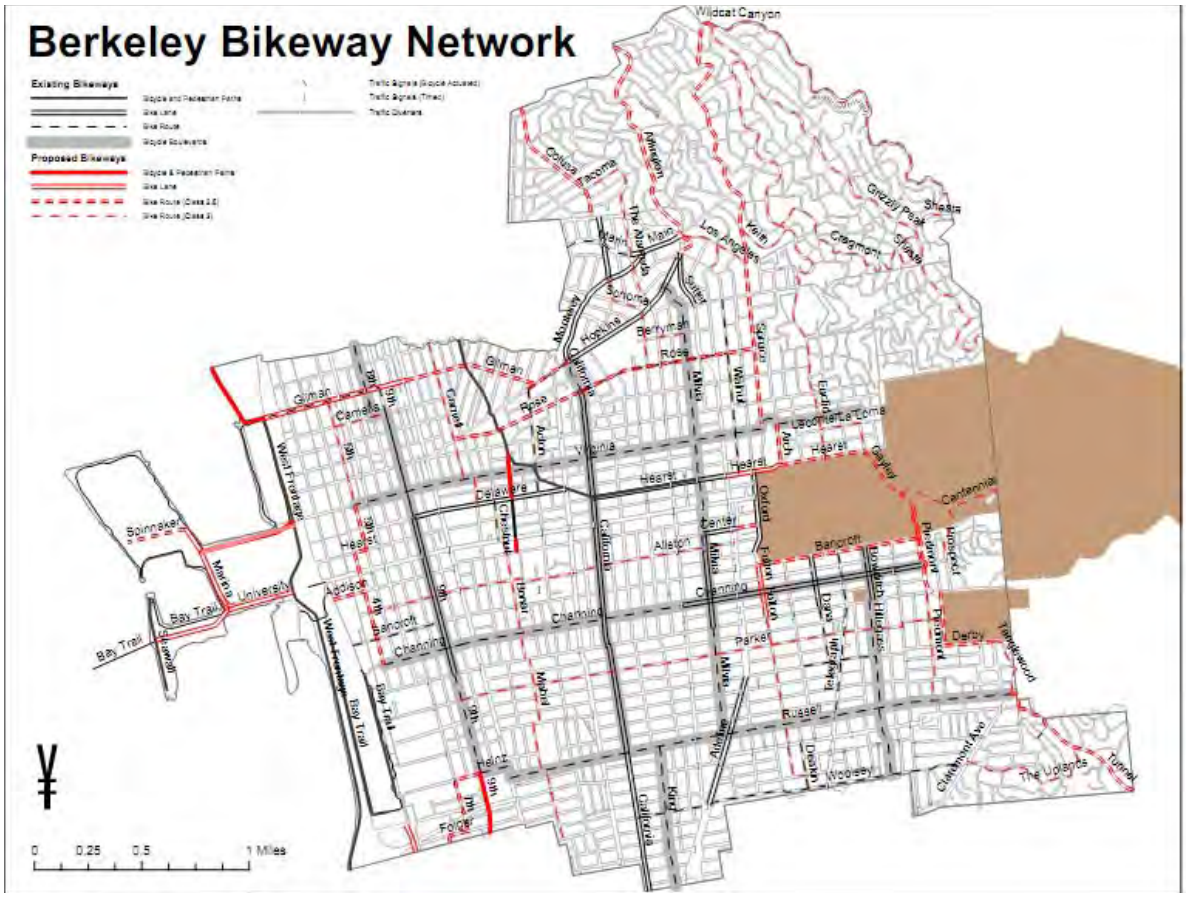
2005 Berkeley Bicycle Plan updated to be largely consistent with contemporary Caltrans design standards.

2009 The gender ratio of cyclists using Bicycle Boulevard network is approximately 60/40 (male/female), up from 70/30 (male/female) in 2000.

2010 Counts show a 72 percent increase in cycling between 2000-2010. Collisions at the bicycle count locations decreased by just over 5.5 percent between 2000 and 2009.

Maps describing the Berkeley Bicycle Plan, the Berkeley Bikeway Network, and Berkeley Bicycle Boulevard Network follow:


THIS MAP IS NOT A BICYCLE ROUTE GUIDE
This map is conceptual and for general planning purposes only. Map information, location of existing and proposed bikeways and other program information shown are subject to change.
Berkeley Bicycle Plan
Figure 2
Recommended Bikeway Network
Legend
Paths (Class 1)
(multi-use trail; non-motorized only)
Boulevards (bicycle priority street)
NOTE: Exact alignment of Bicycle Boulevards to be determined during the Bicycle Boulevard planning process
Lanes (Class 2)
(striped lane for bicycles only)
Class 2.5
(upgraded bike route with targeted improvements)
Routes (Class 3)
(signed route - no special markings)
Connections to Existing / Proposed Routes in other Cities
BART Station
Bikeway Network Number
Sources:
• Proposed and Existing Bikeways Inventory, April 14, 1998
• Wilbur Smith Associates
• City of Berkeley Staff
North
Draft for Inclusion in the General Plan 12/28/98
WILBUR SMITH ASSOCIATES
ENGINEERS • PLANNERS
2M Associates, Landscape Architects
HPV Transportation Consulting
Albany
Emeryville
Oakland
U.C.B.
Solano
Gilman
Cedar
University
Dwight
Ashby
Bancroft
Claremont
Alameda
Aquatic Park
San Francisco Bay


Berkeley Bikeway Network
Existing Bikeways
Bicycle and Pedestrian Paths
Bike Lane
Bike Route
Bicycle Boulevards
Proposed Bikeways
Bicycle & Pedestrian Paths
Bike Lane
Bike Route (Class 2.5)
Bike Route (Class 3)
Traffic Signals (Bicycle Actuated)
Traffic Signals (Timed)
Traffic Diverters
Wildcat Canyon
Colusa
Tacoma
Grizzly Peak
Shasta
Marin
Los Angeles
Keith
Cragmont
Sutter
Scenic
Monterey
Hopkins
Berryman
Rose
Gilman
Camelia
Carrol
Virginia
Hearst
Delaware
Cedar
Oxford
Euclid
Le Conte
Cantelmo
Spinnaker
Bay Trail
Marina
University
Ladybird
Bancroft
Channing
Dwight
Parker
Derby
Russel
Ashby
Woolsey
Claremont Ave
The Uplands
Tunnel
Folger
Hollis
Mabel
Adeline
Shattuck
Telegraph
Dana
Piedmont
Milvia
Sacramento
Grove
Walnut
Arch
Monroe
Hillside
Colusa
Tacoma
0 0.25 0.5 1 Miles

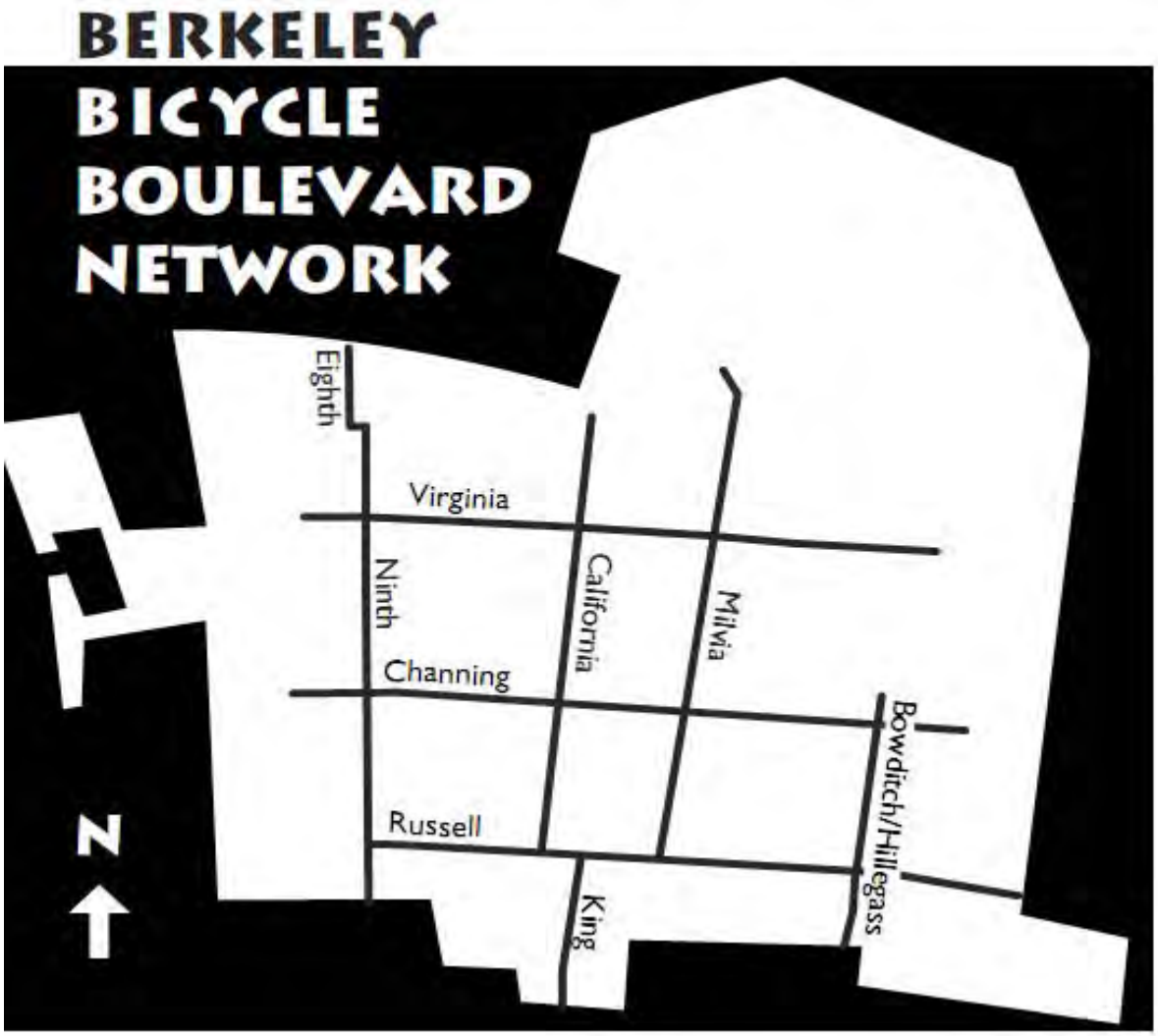


Figure 15. Berkeley Bicycle Plan, the Berkeley Bikeway Network, and Berkeley Bicycle Boulevard Network

VII. AN EVALUATION OF BTA ACTIVITIES ON BICYCLING IN OREGON

SECTION AUTHORS: JAY DEAN, LEEANNE FERGASON, GERIK KRANSKY, CARL LARSON, MARGAUX MENNESSON AND STEPHANIE NOLL

INTRODUCTION TO PORTLAND, OR (PLATINUM LEVEL COMMUNITY)

Portland, Oregon has seen "double digit" increases in cycling for 3 years in a row.[290] Cycling counts have tripled since 2000 and about 6 percent of residents use bicycles to commute to work.[291] Some neighborhoods boast bike commuter rates as high as 9 percent.[292] Between 1991 and 2008, trips on bike-friendly bridges have increased 410 percent while automobile counts have remained stable.[293]

Since the 1990s, the cycling network has grown from 60 to 260 miles of bike lanes, boulevards, and off-road trails.[294] Remarkably, bicycle use has quadrupled over the same period without any increase in crashes.[295] A number of infrastructure innovations are utilized to make the network safe and accessible to cyclists. Portland implements colored and buffered bicycle lanes, street integrated bicycle tracks, as well as expanding its collection of bicycle boulevards (currently over 30 miles).[296, 297] In response to six fatal car-bike crashes, the city deployed 14 bike boxes that give bikes priority over cars at selected high-risk intersections.[298] Bike parking is assisted through the deployment of on-street bicycle corrals, which offer 12 bike spaces for each car parking spot converted.[299]

Bicycle culture is rich with enforcement models, community education, and promotional events, and cycling is a recognized economic force in the private sector.

- 60 percent of police officers in the downtown are on bike.[300]
- Over 2,100 annual events, rides, and races draw over 40,000 participants annually.[301]
- Bicycle-related businesses provide over $100 million in commerce in the city.[302]
- "Share the Road" and "Eye to Eye" campaigns, as well as truck-underrun guard programs make safety a focus for community and commercial attention.[303]
- The Bicycle Transportation Alliance runs an exemplary Safe Routes to Schools program.[304]
- The Community Cycling Center outfits low-income adults with training, gear, and outfitted bicycles.[305]
- Portland hosts "Sunday Parkway" events, closing local streets to motor traffic from 8 a.m. to 2 p.m.[306]

SECTION SUMMARY

The Bicycle Transportation Alliance (BTA) is a non-profit membership organization working to promote bicycling and improve bicycling conditions in Oregon. Since 1990, the BTA has worked in partnership with citizens, businesses, community groups, government agencies, and elected officials to create communities where people can meet their daily transportation needs on bikes. The mission of the BTA is to create healthy, sustainable communities by making bicycling safe, convenient, and accessible. The vision is that bicycling transforms communities by reinventing transportation and offering solutions for the universal challenges facing health, livability, and the environment.

How does the BTA work to create healthy, sustainable communities by making bicycling safe, convenient, and accessible? What are the BTA's principle activities and goals? How does the BTA measure progress toward the mission? Is it successful? What are the challenges and how does the BTA adapt its activities to the changing transportation landscape?

This publication seeks to answer these questions by evaluating the BTA's major activities and impact. The discussion is intended to provide useful information to other individuals and groups that are attempting to achieve success in creating healthy, sustainable communities with world-class bicycle infrastructure, changing behavior, improving traffic safety, and building a movement for bicycling or other active transportation. It may potentially lead to further inquiry into the successes and failures of the effectiveness of the organization.

BTA HISTORY AND PROGRAMS

Since 1990, the Bicycle Transportation Alliance has grown from a group of activists sitting around a kitchen table to an organization with over 3,500 membership households, a full-time and part-time staff of twenty-one, and hundreds of community volunteers. Activities span a broad spectrum of advocacy, education, and encouragement programs to give cyclists the tools, confidence, and knowledge they need to be safe and accepted on the road.

Historically, the BTA has defined its activities and measured impact in three focus areas: advocacy, education, and encouragement. Currently, the BTA is in the process of developing a twenty year strategic plan that groups the BTA's activities into four focus areas: building a world-class bicycle network; improving safety; encouraging more people to ride bikes through education and social marketing; and building a bicycle movement.

Because this section looks back on the organization's activities and success so far, the evaluation and analysis has been organized into the three categories of Advocacy, Education, and Encouragement, although it may refer to the updated goals and activities in the new strategic plan at times.

THEORETICAL PERSPECTIVE & METHODS

The writers have chosen to carry out this analysis using the Nature Conservancy's model for measurement, which is based on impact, activity, and capacity.[307] Through this lens, this publication will discuss the impact of three activities of the BTA: Advocacy, Education and Encouragement.

As the Nature Conservancy found when developing its model, it is challenging to measure direct impact of social change organizations. In "Mission Impossible? Measuring Success in Nonprofit Organizations," authors John C. Sawhill and David Williamson discussed the difficulty of developing an effective model for organizational evaluation. The Nature Conservancy attempted to simplify and streamline a strategy for self-evaluation in order to make the process more effective and to drive their mission and goals forward.

According to Sawhill and Williamson, the Conservancy,

> [Adopted] a family of measures that would assess organizational performance in three main areas: impact, activity, and capacity. Impact measures would assess mission success, activity measures would focus on achieving goals and implementing strategies, and capacity measures would gauge the degree which the organization mobilized the resources necessary to fulfill the mission.[308]

The Family Measures model is shown below in Figure 17 with "the standard hierarchy of organization alignment."[309]

Figure 16. The family of Measures Model[310]

The BTA's "mission critical" work can be grouped under the umbrellas of advocacy, education, and encouragement. This evaluation model was used when assessing how the advocacy, education, and encouragement activities at the BTA create healthy, sustainable communities by making bicycling safe, convenient and accessible. While it is true that individual activities can often reside under one or more of the three umbrellas, for the purposes of this discussion they will be presented as distinct efforts.

FOCUS AREA: ADVOCACY

The majority of BTA advocacy work takes place in the state of Oregon, primarily in the Portland-metro region, but the BTA's reach extends to local communities throughout the state and national level. Nationally, the BTA serves on the boards of the Alliance for Biking and Walking and the League of American Bicyclists joining advocates and professionals at conferences taking place on the national level to share lessons learned and best practices and attending the National Bike Summit as part of the Oregon delegation. The question of geographic scope in relation to activities, impact, and capacity has arisen repeatedly throughout the organization's twenty-year history and remains a question today. The issue will be discussed later in the publication.

The BTA's advocacy work is focused on four outcome areas: increase funding, improve policy and safety, build safe and comfortable facilities, and expand the movement.

Outcome: Increase Funding

In order to improve access to active transportation and safe routes, the BTA aims to improve the physical bicycle and pedestrian network of streets, paths, lanes, and crossings. These improvements cost money. Already the amount of money designated for active transportation improvements is not enough, and the current budget crisis could make it even more challenging to secure funding. The BTA is making sure that active transportation continues to be a priority in funding decisions. This means ensuring adequate funding by protecting existing sources and getting creative about finding new funding.

Federal funding makes up a large share of all transportation dollars in the state. The BTA works to apply pressure and support for the federal Congressional Delegation to increase the amount of money available for active transportation. Examples include meeting with members of Congress during the National Bike Summit and writing letters of support for federal earmarks for active transportation projects and programs.

State-controlled funding includes federal dollars and state highway trust fund dollars. Currently, Oregon is required to spend a minimum of one percent of state funds on bicycle and pedestrian projects. With a total of about six million dollars every two years, this is woefully inadequate for creating a robust network. While working to increase the amount of money available though advocacy in support of new revenue, the BTA also aims to increase the amount of existing money spent on active transportation. The BTA works at all levels of government on project selection criteria ensuring bike projects will be particularly competitive.

Regional and local funding sources are controlled by entities such as the City of Portland, counties, and metropolitan planning organizations (MPOs). The BTA's work on this level includes policy and project advocacy and building relationships with local advocates, transportation planners, city staff, and policymakers to demonstrate the clear benefit of investing in bike projects. Armed with project lists and supportive constituents, the BTA works to get key projects included in regional plans and funded during annual budget cycles.

Outcome: Improve Policy and Safety

BTA advocacy aims to incorporate policies that promote active transportation and improve the decision-making framework and guidance at every level of government, making bicycling safer, more convenient, and more accessible. Policy goals expand beyond funding and include advocating for healthier streets. Examples include: better protections for vulnerable road users, stricter punishment for people who cause crashes, easier access to the citizen-initiated traffic citation process, and lower speed limits on select residential streets.

The BTA achieves these goals through a mixture of persuasion and pressure politics by researching our positions, bringing facts to the debate, making our case in clear language, building a base of support, lobbying elected leaders directly and through the media, and building and sustaining campaigns from start to finish.

Outcome: Build Safe and Comfortable Facilities

The BTA represents the voice of people who ride bikes in Oregon by analyzing current on-street bicycling conditions from a safety and ease-of-access perspective and providing feedback to transportation authorities, engineers, and planners. The BTA's goal is to help transportation agencies and local leaders improve poor conditions and design new road projects to the standard of Platinum level bike facilities, as defined by the League of American Bicyclists Bike Friendly Communities campaign.

Current examples include: the design and installation of a new bike route through SW Portland's Riverview Cemetery, installation of new bike lanes on Lombard Avenue in Beaverton, the recent completion of 15 miles of Neighborhood Greenway infrastructure around the city, and lane width and bike box improvements on the Burnside-Couch Couplet.

Outcome: Expand the Movement

The BTA works to recruit and train new leaders in bike advocacy by providing ample volunteer opportunities to bring new energy and capacity into advocacy work. For example, the BTA's internship program provides career growth and professional development opportunities for college and graduate students who are interested in jobs that relate to active transportation. For example, in 2010 the BTA worked with an advocacy intern to evaluate the City of Portland's progress implementing the Portland Bicycle Plan for 2030 on an annual basis. A second intern worked to analyze and report on the current bike amenities in the Columbia River Crossing project plans.

By building relationships with diverse coalition partners, organizations, and decision makers, the BTA grows its political power in order to achieve clear goals. Coalition partnerships include representatives in the public health sector, business, and freight industries.

The BTA works to leverage these relationships into improved partnerships with politicians. By demonstrating the broad appeal and community benefits of investments in safety and active transportation, the BTA helps bring new elected leaders into the fold. Also, by serving

as a reliable source of high quality information for decision makers, the BTA builds trust over the long term and improves our chances of passing priority issues.

Impact

The transportation landscape is an emergent system with many external factors, distinct individuals and groups, and layers of nested relationships influencing the outcomes. It is impossible to measure the direct impact of a single organization on such a complex system, even within focus areas as specific as those defined by the BTA. In the case of success (or failure), there is always the question of who takes or deserves credit, and how much? One argument proposed by Sawhill and Williamson is that "mission success is mission success and it does not much matter which organization or agency takes or deserves credit as long as progress gets made."[2] On the impact level, we must be satisfied with this. The *Blueprint for Better Biking* report also provides opportunities for evaluation on the activity level. The *Blueprint* is discussed in more detail below.

The BTA has played a consistent advocacy role at the state legislative level over the years and has engaged in distinct bike advocacy projects in several communities in Oregon. However, its strongest role has been in the Portland metro region, with a primary focus on the City of Portland proper. In Portland, the BTA is able to leverage strong and established relationships forged with political and community leaders, planners, and engineers during the past twenty years.

Over the years the BTA has also struggled to find a balance between proactive bike advocacy and the need to be reactive when projects or funding decisions threaten progress toward the BTA's mission. In seeking this balance, the BTA has served as lobbyist, litigator (with the help of legal counsel), outside advocate and agitator, and inside partner, colleague, and consultant. It has played these myriad roles with varying levels of success. While the BTA has earned recognition as a partner in various roles, this lack of focus has consistently brought its own capacity struggles.

Despite the lack of internal quantitative goals, the BTA has access to benchmarks for measuring progress toward the goals of "increasing safety" and "inspiring new bicyclists" using data collected by the City of Portland Bureau of Transportation (PBOT) and the Oregon Department of Transportation (ODOT).

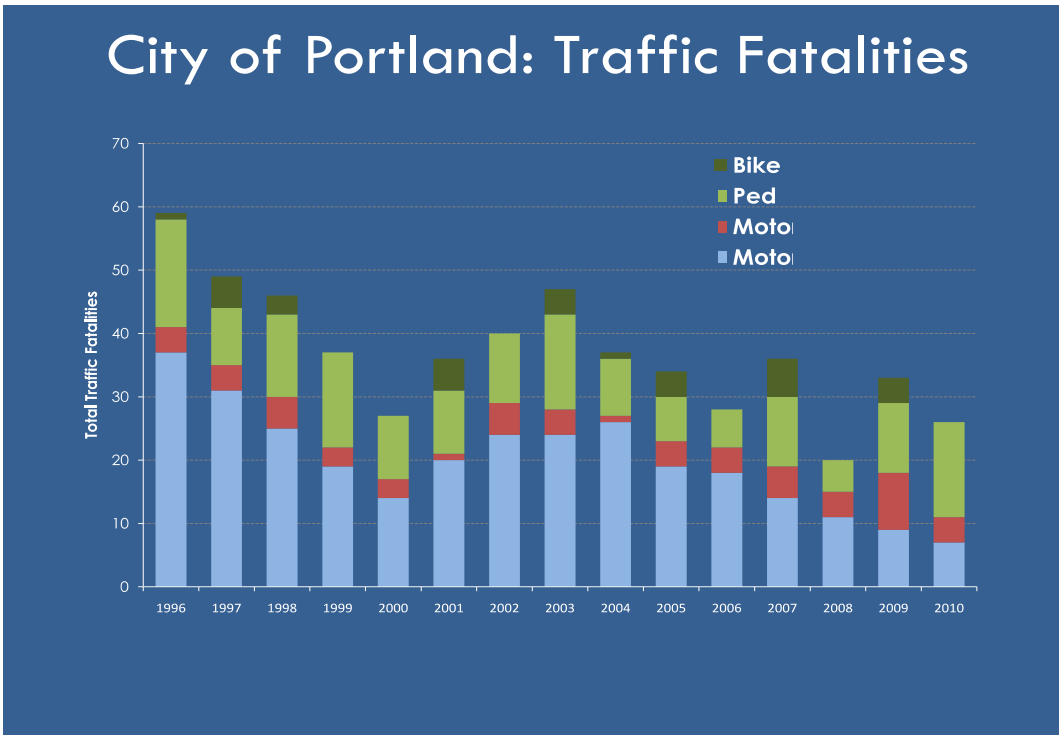


Figure 17. City Of Portland Data on Traffic Fatalities Shows an Overall Decrease in the Number of Bicycle Fatalities and Traffic Fatalities Overall, Although Pedestrian Fatalities have Increased Between 2005 and 2010. *Source*: Portland Bureau of Transportation

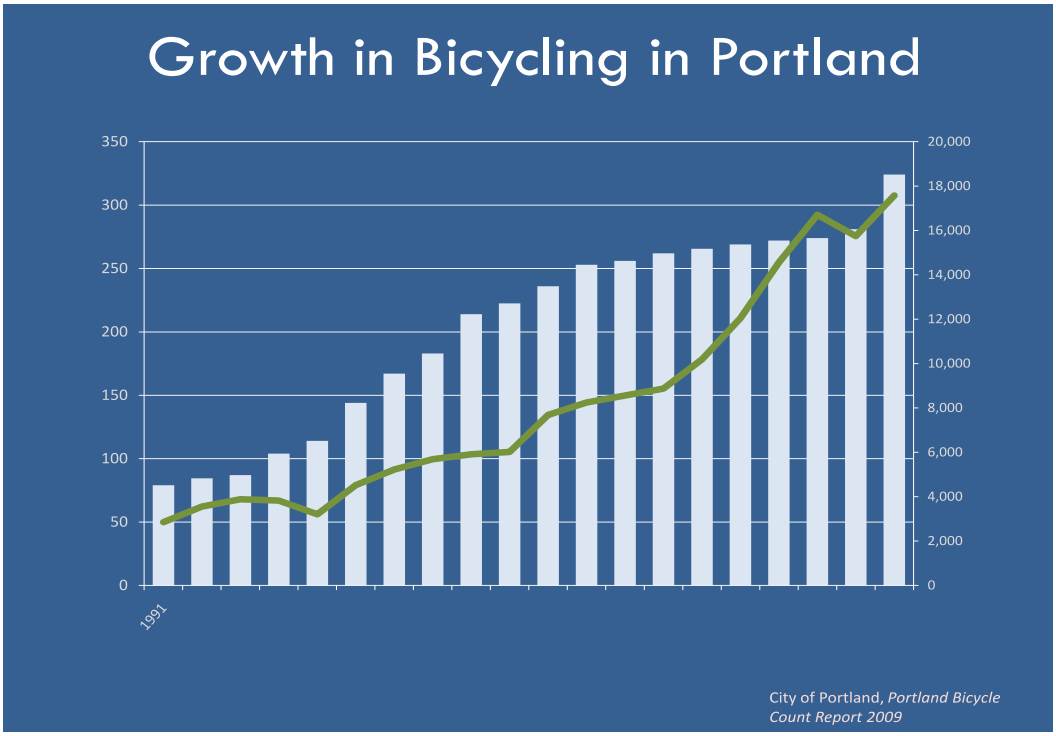


Figure 18. A Chart Showing the Growth in Ridership in Portland Juxtaposed with the Number of Bikeway Miles Shows a Correlation Between Infrastructure and Ridership. *Source*: Portland Bureau of Transportation

An increase in safety can be judged by changes in crash rates, and the inspiration of new cyclists can be measured through the City's annual bike counts. By these two measures the BTA's advocacy work has been effective on the impact level within the City of Portland.

Blueprint for Better Biking

One of the best tools the BTA has to evaluate its impact in the advocacy arena in recent years is the *Blueprint for Better Biking: 40 Ways to Get There* report published by the BTA in 2005. The stated goal of the report is "to identify a consistent set of bicycling facilities, policies, and programs that [would] drastically increase bicycling among a wide range of users including adults, elderly, and youth."[311] The BTA further ties the report to its mission to "create healthy and sustainable communities by making bicycling safe, convenient, and accessible," in the assertion that by implementing the recommendations in the report, communities would "increase the safety, accessibility, and convenience of all major bike routes, inspire new bicyclists by making cycling a viable option for all types of transportation trips and recreational and fitness purposes, and increase the quality of experience for cyclists."

By invoking the mission of the organization in its stated goals, the *Blueprint* becomes an effective surrogate for evaluating the impact of BTA's Portland advocacy work. If the BTA is successful in achieving the goals of the *Blueprint*, it is succeeding in its mission. However, it is noteworthy that the BTA did not establish quantitative goals related to the Blueprint at the time of its publication. Thus determining how much of an increase in the above arenas constituted success has been somewhat subjective.

The *Blueprint for Better Biking* contains a list of forty priority projects. Most of them are infrastructure focused, but the list also includes items such as enforcement campaigns, education campaigns, and car-free events. The infrastructure projects vary from identifying a specific section of trail that the BTA wants to see built to more general goals such as building more low-speed/low-volume bikeways. The *Blueprint* did not name a specific timeline in which projects should be completed, instead declaring simply that the findings would define the future direction of the organization's advocacy efforts in coming years.

In 2011, the BTA published a status report on the top forty projects identified in the 2005 report, assigning one of four statuses to each project: success, in progress, static, or denied. At publication, twelve (30 percent) projects were judged successes, eighteen (45 percent) projects were in progress, seven (17.5 percent) projects were static, and 3 (7.5 percent) projects were denied.

Of the forty projects, the BTA identified a top ten list.[312] The projects are presented here.

PROJECT 1: SELLWOOD BRIDGE

The biggest barrier identified by Portland area, the Sellwood Bridge is nearly uncrossable. Bicyclists cannot legally use the narrow sidewalks, and the busy traffic lanes are narrow. The bridge is over three miles from a safe alternative.

Status: In Progress. A replacement for the existing 85-year old span will be open in 2015. The preferred option was approved by the federal government in September 2010 to include two 12-foot travel lanes, two 6.5-foot bike lanes, as well as two 12-foot sidewalks. That means 60 percent of the bridge's width will be dedicated to bicycle and pedestrian uses—more than the entire width of the existing 31-foot wide Sellwood bridge! This is a huge success for east-west access and will make for a much safer and more enjoyable route soon.

PROJECT 2: CENTRAL CITY BICYCLE PLAN

Getting to and around Portland's central city is a challenge for cyclists. The downtown Bicycle Plan update will target Westside access and accommodations for less-experienced cyclists. Other issues include: access to and from Waterfront Park; north-south bikeways; signs and markings; and bicycle parking.

Status: In Progress. Due to the density of destinations and heavy traffic, Downtown Portland can be an intimidating place to ride. To make it more enjoyable, the city has improved bicycle routes in the downtown core with new north-south lanes on Naito Parkway, which alleviates congestion and reduces conflicts with pedestrians on the Waterfront Park path. Broadway Avenue has been improved with a city-first cycle track. Other low-traffic routes in NW such as Flanders, Johnson, Overton and Raleigh Streets provide comfortable routes east-west. A lane on each of SW Stark and Oak has been converted to a buffered bike lane. Code revisions now require 1.5 bicycle parking spaces for each dwelling unit downtown. Connections across the bridges have improved, but significant work remains, including treatment of 9th and Park Avenues to provide low-traffic boulevard options along the Park Blocks. The central core has been designated a "Bicycle District" in which bicycle and pedestrian mobility is of high importance.

PROJECT 3: NORTH/NE PORTLAND – NEW EAST-WEST BIKEWAYS

North and Northeast Portland lack high-quality, connective low-traffic bikeways running east-west (such as SE Ankeny and SE Lincoln/Harrison). Improvements can be made on existing routes such as NE Tillamook or Knott; a new set of bicycle boulevards are recommended (for example, N Failing, N Mason, and N Bryant).

Status: In Progress. As a part of the city's annual 15-mile expansion of the bicycle boulevards network, low-speed routes will be greatly improved in north and northeast Portland. Tillamook and Going Streets Bike Boulevards are finished, and now N Wabash, N Concord, NE Klickitat, N Central and NE Holman are all in design. As of January 2011, the Portland Bureau of Transportation is awaiting word on a $2.33 million grant of Federal Flexible Funds to build the "Going to the River" project, which would provide a link from NE 72nd Street all the way to the Willamette River and Swan Island employers. Construction is expected to begin June 2012.

PROJECT 4: HIGHWAY 43 AND WILLAMETTE SHORELINE TRAIL

Cyclists going between West Linn-Lake Oswego and Portland face Highway 43, one of the most dangerous and challenging gaps in the region. The "Willamette Shoreline" corridor might include an updated streetcar line and a high quality bicycling route.

Status: In Progress. The original hope to build the Willamette Shore Trail parallel to a streetcar transit extension from Portland to Lake Oswego has become impossible due to narrow rights-of-way and high costs. Metro made $110,000 available to study the Shore Trail in the corridor from Dunthorpe to Elk Rock.

PROJECT 5: TONQUIN TRAIL

The Tonquin Trail is a proposed 19-mile path linking Wilsonville, Tualatin, and Sherwood. The Mt. Scott-Scouter's Loop Trail is a proposed trail that would link Happy Valley and the Sunnyside Road area to future development in Pleasant Valley, Damascus, and the Sunrise Corridor.

Status: In Progress. The Tonquin Trail will be a 19-mile multi-use path connecting the cities of Wilsonville, Sherwood and Tualatin. Small sections of the trail are already complete as of 2010, bolstered by Metro's new Graham Oaks Park, which opened September 2010.

PROJECT 6: LOW-TRAFFIC SUBURBAN ROUTES

To increase cycling among suburban residents, well-marked low-traffic bicycle networks must be developed. Even among current cyclists, many suburban riders develop their own circuitous neighborhood routes. A formalized network will creatively identify existing routes and mark them with high-visibility treatments.

Status: In Progress. The City of Beaverton has worked to identify an extensive network of low-traffic routes and worked in conjunction with Washington County to mark the routes and implement the plan. A new "Bike Beaverton" map includes route ratings similar to Metro*'s* "Bike There" map in coordination with all jurisdictions.

PROJECT 7: FANNO CREEK TRAIL

Beginning at Willamette Park, this trail will stretch 15 miles southwest through Beaverton, Tigard, and Durham, ending at the Tualatin River. With half of the trail complete or under construction, this trail network will provide access to other north-south trails and the Willamette River Greenway trails.

Status: In Progress. In April 2010, Metro secured two easements, which will begin to close the one-third mile long gap between Woodard Park and downtown Tigard. Residents of the City of Tigard approved a $17 million parks bond in November 2010, some of which will be used to improve the trail. The Fanno Creek Trail, which is about half complete in the beginning of 2011, will travel 15 miles from the Willamette River in Southwest Portland through Beaverton and Tigard to the Tualatin River, at its confluence with Fanno Creek.

PROJECT 8: LOW-SPEEDS / LOW-VOLUME BIKEWAYS

Portland's neighborhood greenways are a successful street treatment that reduces speeds in residential neighborhoods and provide cyclists with excellent cross-town routes. Building more of these facilities will be a cost-effective way to attract new riders.

Status: In Progress. The City of Portland has made it a priority to construct 15-miles of new bicycle boulevards—recently renamed 'neighborhood greenways'—each year, for each of the four years following 2010. These new low-traffic routes (championed by the BTA) provide comfortable and safe cycling, walking, and running opportunities for residents. The program has been a successful collaboration of the Bureaus of Transportation and Environmental Services to redesign streets to slow vehicular traffic, provide transportation options, as well as, mitigate storm water runoff and to recharge aquifers. These new miles will be a huge addition to the 30.3 miles of existing and funded bike boulevards identified in the 2030 Bike Plan.

PROJECT 9: ENFORCEMENT CAMPAIGNS

Enforcement campaigns targeting the most dangerous violators will increase safety.

Motorist violations include running red lights, aggressive and drunk driving, failure to yield, and speeding in low-speed zones. Cyclist violations include riding the wrong-way, improper lights, and running red lights. Police liaisons will help facilitate community-based enforcement and coordinate with engineers. Diversion programs will increase public acceptance.

Status: Success. The BTA, in conjunction with the Willamette Pedestrian Coalition, the Portland Bureau of Transportation and Portland Police Bureau signed the Community Policing Agreement in 2009. Each organization agrees to increase communication, to a collaborative approach to public and traffic safety, designation of priority locations for improved safety, and improved data collection. The Bureau of Police will provide targeted enforcement based on high crash locations and has assigned an Officer as a bureau liaison.

Additionally, beginning in March 2007 the BTA became a partner along with Multnomah County Circuit Court, the Portland Police Bureau, and the Emanuel Legacy Trauma Nurses in teaching the bimonthly Share the Road Safety Class, a diversion class offered to residents receiving citations when driving, biking, or walking. At the end of 2010, 10,000 Multnomah County residents had attended the class.

PROJECT 10: SAFE ROUTES TO SCHOOL

Safe Routes to School programs, to increase bicycling and walking to school, which include engineering, education, encouragement, and enforcement components. Programs engage schools, parents, children, and community groups.

Status: Success. Portland Safe Routes to School has been instituting the "Five Es"—Education, Encouragement, Enforcement, Engineering, and Evaluation in local schools since 2005. The program assists kids to get to school actively and involves parents, students, and community groups in more than 80 elementary and K-8 schools in Portland during the 2010-11 school year. The program has succeeded in shifting over 1,500 daily trips from family vehicles to walking or biking. When kids walk or bike to school, they arrive healthier, more focused, and ready to learn.

CAPACITY

Historically, very little of the BTA's advocacy work has been supported by grants or contracts, but rather has been supported by membership dollars and other general fundraising. The numbers below represent the Advocacy expenses and the revenue of BTA membership and individual donations for the years 2001, 2005, 2006, 2008, and 2009, taken from the BTA's annual reports.

Table 13. BTA Advocacy Expenses and Revenue by Year

Advocacy Expenses		Advocacy Revenue: Membership and individual donations	
Year	Expenses Amount	Year	Revenue Amount
2001	$72,100	2001	$84,633
2005	$137,601	2005	$186,677
2006	$149,323	2006	$273,462
2008	$237,809	2008	$215,392
2009	$151,521	2009	$150,194

These numbers have not been consistently tracked in the organization as it grew and changed. The numbers in these years can be compared accurately because the data was reported in a way that allows comparison.

FOCUS AREA: EDUCATION

The BTA's work in the education and encouragement arenas has not been defined by any such planning exercise as the *Blueprint* served for the organization's advocacy work. On the level of impact, the BTA's education work is focused almost entirely on the "making bicycling safe" piece of the organization's mission. Encouragement work is focused on making bicycling accessible by encouraging more people to bike, to bike more often, and to bike for more types of trips. Admittedly though, the BTA has not historically identified a way to evaluate the impact of its education and encouragement work on overall community safety and mode share, and therefore has only evaluated its work in these arenas on the activity level.

Activity: Youth Education

The BTA has had programs in place to teach youth the fundamentals of bike safety and pedestrian safety. The cornerstone of the BTA's youth safety education is the *Safe Routes*

for Kids curriculum, a ten hour, in-school program of both in-classroom and on-the-bike lessons. The BTA teaches the course in 4th-7th grade classrooms in eight Oregon cities, meeting numerous curriculum benchmarks mandated by the state of Oregon. Schools within the City of Portland can request the program through the city's Safe Routes to School program for which the BTA serves as a contractor. Interested schools outside of Portland apply directly to the BTA.

The Bicycle Safety Education Program brings resources into schools, including a trained instructor, a fleet of 30 bikes, helmets, video, and other equipment. Lessons include helmet fitting, bike and personal safety checks, bike handling skills, rules of the road, right-of-way, and lane positioning. All courses include on-street intersection practice and community rides. The BTA emphasizes that the 10-hour curriculum and opportunity to practice in the real setting of community streets, complete with real traffic, are essential components in teaching cycling skills to youth. As the curriculum requires on-street training, the BTA does not teach the course to students younger than 4th grade, since younger students are not consistently developmentally ready either physically or mentally for the responsibilities of on street riding.

The BTA also created a two-hour pedestrian safety curriculum geared towards second grade students. In the Portland Safe Routes to School program, the BTA teaches this program as an educational building block to bike safety. The curriculum teaches students how to safely navigate their neighborhood streets. Through classroom activities and community walks, students learn to follow traffic rules and regulations and cross streets safely. In the 2009-2010 school year this program reached approximately 3,000 students.

The BTA has evaluated the youth bike safety education program by tracking the number of schools, classes, and students receiving the program and by evaluating student learning using pre- and post- course tests. During the 2009-2010 school year the BTA taught more than 5,000 students at 64 schools in eight different Oregon communities. In the 2009-2010 school year students receiving the 10-hour bike safety education program at 40 schools across Portland demonstrated an increase of approximately 100 percent in understanding of the bike safety principals taught in the course. For the pre-test, students scored an average of 42 percent correct and scored 81 percent correct in the post-test.

As of early 2011 the BTA is both streamlining the application process for schools interested in receiving instruction from the BTA and offering training opportunities for school district staff to offer the curriculum directly. This process was implemented as the capacity for programming remains constant, but the need to educate students grows.

CAPACITY

The BTA's youth bike safety education program has been funded primarily by government contracts: one since 2005 with the City of Portland Bureau of Transportation, which houses the City's Safe Routes to School Program, and one since 2001 with the Oregon Department of Transportation utilizing National Highway Traffic Safety Administration dollars. As of the 2010-2011 school year both of these funding sources had remained static for three years allowing for no further expansion of the program. The BTA further

supports the program through a mix of small local grants, donations from individuals, and fee-for-service programming. This additional fundraising has fluctuated since 1998, but in the past three years has also remained relatively static.

Activity: Adult Education

LEGAL CLINICS

The BTA's adult bike safety education efforts are more varied, as the adults don't present the same "captive audience" as children enrolled in schools. Therefore, the BTA aims to reach adults in shorter formats in a variety of settings. The longest running adult education programs of the BTA have been the organization's legal clinics and bike commute workshops.

Legal clinics are offered in one to two hour format in partnership with a local traffic attorney, Ray Thomas, author of the book, *Pedal Power: A Guide for Oregon Bicyclists*. The BTA has been offering the clinics as a free bi-monthly service for several years with an average of 15-20 attendants per session. Topics covered include laws related to cycling, laws related to driving around cyclists, insurance issues, and what to do in the event of a crash.

BIKE COMMUTE WORKSHOPS

Bike Commute Workshops are offered almost exclusively on-site at workplaces as one-hour presentations, most commonly as lunch hour "brown bags." The workshop is requested at workplaces by a bike advocate on staff, a safety or wellness committee, or general employee education coordinator. Topics include laws and skills for safely and confidently biking with traffic, route finding, and the basics of gear and maintenance for a safe and comfortable commute. While it proves challenging to fit all the content into a one-hour presentation, the BTA has found that far few people opt into longer format opportunities. Post-presentation surveys indicate that attendees, whether experienced or novice cyclists, find the workshops valuable for increasing their confidence and knowledge. The BTA's education staff taught approximately seventy-five workshops, primarily in the Portland metro area, in 2010.

SHARE THE ROAD SAFETY CLASS

In early 2007 the BTA found an opportunity to reach people beyond the audience that is likely to attend an optional lunch hour presentation at their workplace. The BTA became a partner in offering the Share the Road Safety Class, a diversion program offered at a local hospital in cooperation with both the Multnomah County court system and the Portland Police Bureau. Most traffic citations received by people on foot and on bike are automatically eligible for reduction or dismissal with completion of the course, and many citations received by drivers are eligible at the discretion of the ticketing officer. The two-hour course covers laws and safe practices for all road users related to operating vehicles safely in a mix of modes. At the end of the 2010 more than 11,000 had successfully completed the course with overwhelming positive feedback.

EYE TO EYE

The last way the BTA aims to educate adults is through broad campaigns including public events, media, articles, and online videos. In August 2008 the BTA launched the Eye to Eye campaign, aimed at educating all roadway users about safe cycling issues including using lights at night, being aware of blind spots of large vehicles, and safely and courteously sharing multi-use paths with pedestrians.

Figure 19. Eye to Eye Campaign Banner

CAPACITY

While the BTA's advocacy efforts are supported out of the organization's general fund, adult program work has been sustained through fees for service, business partnerships, and grants. The legal clinic program is supported through the in-kind donations of the local law firm Swanson, Thomas, and Coon. The BTA solicits business support for the Bike Commute Workshop program by recommending that hosting workplaces make a $100 donation to support the outreach work. The program is further subsidized as part of a grant from Portland's metropolitan planning organization of federal Congestion Mitigation and Air Quality (CMAQ) dollars. The BTA's participation in the Share the Road Safety class is supported directly through a contract with the Legacy Emanuel Hospital trauma nurses. The Eye to Eye campaign work is supported through public and private partnerships dedicated to bike safety.

FOCUS AREA: ENCOURAGEMENT

Encouragement work is focused on making bicycling accessible by encouraging more people to bike, to bike more often, and to bike for more types of trips.

Activity: Adult Encouragement

The BTA's primary program for encouraging adults to bike more is the organization's Bike Commute Challenge, a month-long friendly competition between workplaces to try to get the most employees commuting by bike. The program began in the mid-nineties with workplaces faxing in physical tally sheets before moving to its online home at www.bikecommutechallenge.com in 2003. The website went through another major overhaul in 2008-2009.

Any individual can register for the challenge. If they are the first person from their workplace to register, they register their workplace as a team and become the default team captain. The size of their team is the total number of employees at their workplace, so the goal is to get as many people as possible to bike. Workplaces compete in size and type categories, with the workplaces with highest possible percentage of trips made by bike getting recognized at a post-event awards ceremony. Individuals at workplaces with low participation still have motivation to play as they can issue challenges to other individuals or workplaces more 'in their league' and they can qualify for weekly prize drawings.

The program operates statewide with just over 80 percent of total participants working in the Portland metro area. Throughout the month participants log in to a personal trip calendar page where they can log their trips, make changes to their work schedule or daily mileage, and view their personal stats (commute rate, mileage, calories burned, CO2 saved), the stats of their team, and those of anyone to whom they have issued a challenge.

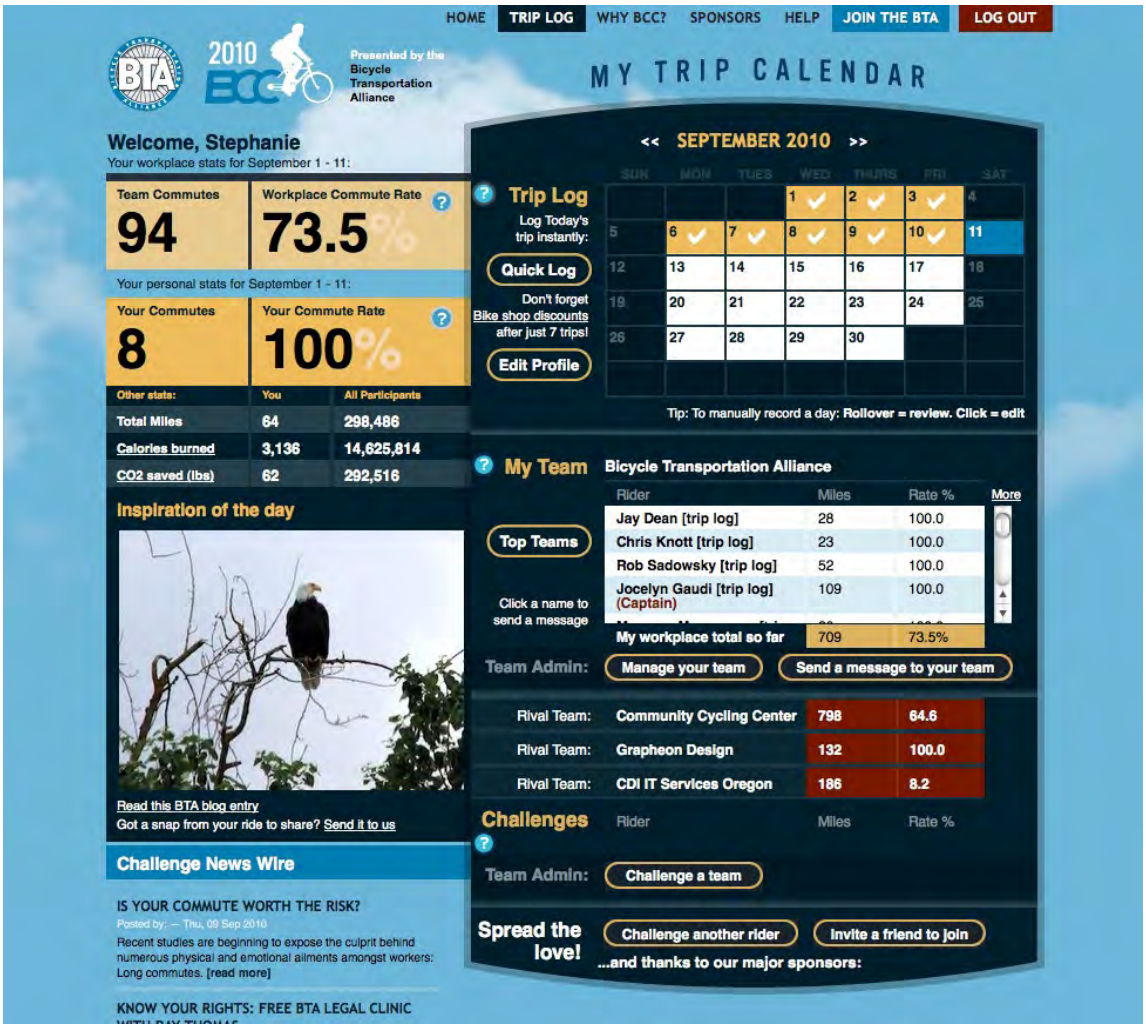


Figure 20. Bike Commute Challenge Website Circa 2010. Each Individual Participant's Dashboard Displays a Personal Calendar-Style Trip Log, List of Teammates, and Challengers.

The program grew from 83 workplaces participating in 1998 to almost 11,000 individuals from 1,283 workplaces in 2010. Additionally, during each of the last several years, about

2,500 of participants identified themselves as new bikers. The program thrives on a fun-to-use web platform, the energy of workplace bike advocates, and the sense of competition and positive peer pressure easily fostered at participants' workplaces.

CAPACITY

Since 2006 the Bike Commute Challenge has been supported 30 percent by federal CMAQ dollars through the local metropolitan planning organization, 50 percent by business sponsors, and in 2009 and 2010, 20 percent by an Oregon Department of Energy reimbursement program called the Business Energy Tax Credit. With no fixed cost for adding more participants or workplaces to the program, the program could easily serve more people on the same budget, and is limited only by the level of awareness and interest. The program grew to its 2010 level without the help of any major media partners.

Activity: Youth and Family Encouragement

The BTA's chief activity for encouraging youth and families is a school-based program called Walk + Bike. Since 2003, the BTA, with the help of a statewide committee, has been the lead organizer for International Walk + Bike to School Day in the state of Oregon. The annual event is held in early October at schools around the globe. The Walk + Bike program encourages Oregon elementary and middle schools to participate. A parent, teacher, school administrator, or community member can register their school with the BTA to receive a package containing event coordination tips, safety information, and incentives to give away to students. Popular incentives have included stickers, energy bars, and shoelaces for all participants, and multi-sport helmets for prize drawings.

The BTA works with partners to coordinate a big media event at one of the participating schools in Portland. Local communities around the state are encouraged to organize media events. The BTA requests stories, photos, and participation data from all schools to share with participants and on the BTA website after the event. In 2006, the BTA also began publishing a regular newsletter with tips and ideas for promoting walking and biking to school throughout the year.

Figure 21. Walk + Bike Challenge Student Poster Contest Submission.

In May 2008, the BTA launched the first Walk + Bike Challenge Month, a month-long competition between K-8 schools modeled after the Bike Commute Challenge. Coordinators use the same website (walknbike.org) to register their school, and receive a program packet of information and incentives. Students receive scorecards for tracking their walking, biking, and scooter/skateboard trips throughout the month. School coordinators receive a package of incentives like stickers, temporary tattoos, and award ribbons to distribute however they see fit throughout the month. In 2010, the BTA began offering additional larger prizes for school prize drawings—things like bike helmets and book bags—as incentives for coordinators to send in photos and stories throughout the month for the blog and e-newsletter.

At the end of the month, students turn in their scorecards to the school coordinator. The coordinators tally the school's final results and submit them to the BTA. The BTA announces winners at a final awards event. In its first three years, the Walk + Bike Challenge grew from 30 participating schools to more than 130 with about 50 percent of schools participating from outside of the Portland metro area. While the Challenge has been hugely effective in generating excitement about walking and biking to school, the BTA has found it difficult to collect data from school coordinators so close to the end of the school year.

CAPACITY

For the last few years, the BTA's Walk + Bike programs have been supported at 50 percent by state Safe Routes to School dollars in a direct grant from the state Department of Transportation, at 25 percent by the City of Portland's Safe Routes to School program, and 25 percent by business sponsorships.

LIMITATIONS AND OPPORTUNITIES

Limitations

The lack of effective self-evaluation completed by the BTA until this point is a limitation. The BTA had not attempted to systematically measure its success based on its goals and mission, or had not reported on any such efforts. Protocol was not set in place for evaluation of overall advocacy, education, or encouragement initiatives.

A second challenge was determining the best method of evaluation. After reviewing many different evaluation strategies, the BTA realized the best course of action was to follow the Nature Conservancy's recommendation to "keep it simple." The study was therefore focused on evaluating the organization's impact, activity, and capacity in the areas of advocacy, education, and encouragement.

The final limitation was the lack of clear measurable benchmarks to judge impact and successes. These benchmarks, as discussed earlier, are being developed through a process of BTA community involvement. When the Strategic Plan is finalized, the BTA will be able to move forward with more effective evaluation in terms of positive (successful) and negative (unsuccessful) impact on the bicycling community and infrastructure in the City of Portland and the state of Oregon.

Twenty-Year Strategic Plan

Between 2009 and 2010, the Bicycle Transportation Alliance experienced significant changes in staffing, organizational structure, and a realignment of measurable goals. Executive director Rob Sadowsky was hired in July of 2010, and since then has been working towards a positive future for the BTA's sustainability and stability as an organization, and ultimately, its effectiveness in terms of advocacy, education, and encouragement. In the late summer of 2010, Sadowsky, with the support of board members, began the process of what will eventually become a twenty-year strategic plan.

The planning process has included instrumental staff, board, membership, and stakeholder support. Public and private meetings have been held regarding the Strategic Plan in order to properly gauge community expectations for Oregon's most prominent bicycle advocacy organization.

The Strategic Plan itself is organizationally divided up into several categories: advocating for a world-class network; encouraging people to ride bicycles through social marketing and education while reducing crashes through safety education, social marketing, and enforcement; and building a movement around bicycling. Goals are then categorized chronologically at 5 years, 10 years, and 20 years for each major and sub-category. The development of the sub-categories was based on several meetings with community members, stakeholders, and staff. The chronological goals, or expected outcomes, were based on staff and board input. The process has been fluid and transparent from the outset. This can be attributed to Sadowsky's effective leadership in terms of creating organizational expectations internally and externally.

In the past, the lack of clear benchmarks from which to measure goals and outcomes has hindered the BTA's ability to create an effective evaluation strategy. With the completion of the Strategic Plan, goals will be solidified, impact will be measurable, activities will be effective, and capacity will be expanded.

CONCLUSION

The Family Measure Model of impact, activity, and capacity clearly details the BTA's activities in advocacy, education, and encouragement highlighting known impacts and shows the BTA at capacity. Through advocacy, education, and encouragement, staff have developed activities and found funding for those activities with the mission of the organization in mind. However, with the development and finalization of the Strategic Plan, the BTA will have tested and measurable goals from which to produce activities, gain capacity, and allow the organization to fully understand its impact.

The Advocacy department's *Blueprint* serves as a template from which to measure its impact, through activity and capacity. Currently, this department is working with over 40 projects that impact the BTA's mission. The Education and Encouragement department does not have a document similar to the *Blueprint* from which to measure its goals against the mission. This publication demonstrates how the lack of such evaluation tools makes it challenging to successfully analyze and understand the organization's impact and progress toward its mission.

Although the Advocacy department is one step the closer with the *Blueprint*, both departments will benefit from the development of the Strategic Plan. The writing of the Strategic Plan will solidify the BTA's approach to understanding itself based on measurable goals and positive and negative impacts as they relate to its goals. It will encourage effective planning that is aligned with the overall mission of the organization and develop a greater capacity to expand the activities of the organization and better serve Oregon's bicycling community.

ABOUT THE BICYCLE TRANSPORTATION ALLIANCE

The Bicycle Transportation Alliance (BTA) is a 501(c)3 non-profit membership organization working to promote bicycling and improve bicycling conditions in Oregon. Since 1990, the BTA has worked in partnership with citizens, businesses, community groups, government agencies, and elected officials to create communities where people can meet their daily transportation needs on a bike. The mission of the BTA is to create healthy, sustainable communities by making bicycling safe, convenient, and accessible.

VIII. CONCLUDING COMMENTS

We conclude that cycling should be encouraged because as the number of cyclists increases, so does the attention of motorists, and safety improves providing that a proper infrastructure exists. The 5 Es provides a holistic and comprehensive view of the planning process; it is an established, robust framework. One important caveat is that planners need to strive for a better engineered infrastructure and they should not permit encouragement by advocacy groups to put cyclists in harm's way ahead of the creation of that safe infrastructure. The risks to cyclists are injury and death when one or more of the 5 Es fails.

Bicycle accidents that involved a motor vehicle constitute a small percentage of all bicycle accidents; however, it is the vast majority of *fatal* bicycle accident. In 2008, traffic crashes killed 716 cyclists in the U.S. and injured 52,000. Over the period 1998-2008, the number of cyclist killed each year has fluctuated between 600 and 800. Half of the cyclists killed were 45 or older. Of the cyclists killed in 2008, 87 percent were male. Alcohol was involved (either on the part of the driver or the cyclist) in over one third (37 percent) of the fatal crashes. Also, according to the NHTSA, "fatalities occurred more frequently in urban areas (69 percent), at non-intersection locations (64 percent), between the hours of 5 p.m. and 9 p.m. (28 percent)."[314]

We discussed the Health Belief Model's key elements above in the context of education, but these concepts could be applied to other 5 Es as well. For example, perceived susceptibility relates to risk analysis cyclists consider prior to using a given roadway. A more detailed discussion is included in the Appendix A.

The literature review covering the 5 Es was followed by a concise primer on safety. A variety of bicycle safety education resources exist. Most take the form of training curricula or media campaign resources. Very little quantitative outcomes analysis exists to determine which tools are most effective in changing behaviors. Experiences to date suggest repeated and continual long-term exposure to bike safety education materials is critical to sustained behavior change.

The full-time bicycle officer wrote the case study on Davis, which is of interest because cycling has been popular for years and the infrastructure is well developed. Officer Faeth adds to the literature with his candid and personal descriptions of enforcement, the 5 E perhaps most neglected in the literature. He described, "On any given day, I can sit at any of the stop signs, in a full police uniform and on my black and white police bike, in plain view, and observe countless violations." Another interesting observation regarding Davis is the absence of school buses. This promotes riding to school for many students.

Berkeley's experience implementing its engineered infrastructure offers insight into the planning and execution process. Berkeley began the process in 1968. Surveys from the 1970s indicated the preference of riders for a facility separated from high-volume, high-speed automobile traffic. Bicycle volume data supports the success of this strategy at encouraging cycling. This further emphasizes the need for robust public outreach processes to assess cyclists' specific needs when planning effective bikeway networks. The results thus far have been a large increase in cycling and corresponding decrease in collisions.

The Bicycle Transportation Alliance (BTA) is a non-profit membership organization working to encourage bicycling and improve bicycling conditions in Oregon. It works with assorted stakeholders to create communities where people can meet their daily transportation needs on a bike. Through education and encouragement (often referred to as advocacy), staff have developed activities and found funding for those activities with the mission of the organization in mind.

Future research could determine if and under what conditions the above social psychological perspective contributes to effective design and execution of the 5 Es.

Another critical area for future research is the role of enforcement. What are the most effective ways to get cyclists to follow the rules? Cycling clubs seem effective in fostering peer pressure first among members to obey the rules, but could they perform more outreach to get more cyclists involved? If so, how? And in what ways can effective outreach be done to foster a culture of adherence to the rules?

APPENDIX A: APPLICATION OF MODELS TO 5 ES

One can enhance the planning process of the 5 Es by applying the following concepts from social psychology:

HEALTH BEHAVIOR MODEL

Perceived Susceptibility

Engineering: Separate bike facilities are perceived as safer by many riders than riding in vehicular traffic.

Education: Educational campaigns may choose to avoid discussing the risks associated with cycling because fear could keep people from cycling. However, awareness of the risks could make cyclists more vigilant to a host of problems they could encounter. Safety taught with integrity requires transparency and full disclosure of risks; American roads are generally perilous for cyclists. If they understand the risks, they might be more likely to vote for bonds and measures designated to improve the engineered infrastructure.

Enforcement: Cities faced with fiscal problems may not have the funds to police cyclists. Bicycle clubs that have group rides develop norms of riding in accordance with the rules of the road.

Encouragement: Advocacy groups can be zealous; one experienced traffic engineer told the principal investigator that he once had to dissuade an advocacy group from attempting to permit cyclists on freeways.

Evaluation: Surveys can measure the perceived susceptibility of cyclists to injury and death. Problems can then be mitigated to reduce the perceived threats.

Perceived Severity

Engineering: Speed impacts the severity of injuries. Planners post speed limits on trails, but cyclists may or may not respect the limit. Traffic calming measures designed to enhance safety by slowing traffic down can be perceived as a mitigating factor on the severity of injuries, but some cyclists express annoyance at being slowed down. A holistic approach to include education and enforcement can optimize the benefits of proper engineering.

Education: Cyclists may think that a fall while riding slowly is not dangerous. However, if one hits one's head on the pavement at any speed traumatic brain injury (TBI) can result. Helmets are essential to avoiding TBI. Data could indicate that drivers are more careful in the presence of perceived inexperienced cyclists and that large numbers of cyclists riding without helmets may have lower accident rates than in other areas where more people wear helmets. However, one has to be cautious in drawing inferences from correlations. Protecting one's head from a hard surface requires a helmet even at a very slow speed.

Engineering: An important barrier applicable to all the 5 Es is lack of funding. Bicycle projects do not enjoy high priority in some jurisdictions, but the futility of building more and more roads could become more apparent as GHG emissions climb and road congestion worsens.

Education: Safety programs routinely give away helmets, but the expense of a helmet is probably not the most important barrier to use. Cities, police departments, and schools may lack the resources to educate cyclists.

Enforcement: It is tempting to see aggressive enforcement and the ensuing fines as a source of revenue, but voters become enraged when they perceive enforcement as too aggressive. Yet a significant barrier to enforcement is not having enough police to patrol cyclists. Again, the cycling clubs are an essentially free resource, in terms of public expenditures, that can foster norms of conduct to promote respect of the rules of the road.

Encouragement: Advocacy groups organized as 501(c)3s can raise funds through grants and charitable contributions, but competition is stiff in the U.S. for donations, especially during economic downturns when people may still have the disposable income to donate, but perceive themselves as worse off than before.

Evaluation: It is expensive to assess or evaluate bicycle projects. Budgeting evaluation funds up front can make it more likely that evaluation will be done.

Cues

Engineering: Proper signage on bicycle paths and sidewalks where riding is permitted can serve as reminders to yield to pedestrians and to announce when passing pedestrians, so that they do not drift into one's path. The Hawthorne Bridge in Portland has clear lanes for cyclists and pedestrians. In Hamburg, Germany the bicycle lane on the sidewalk is a different color to remind pedestrian as they are walking and looking down to stay out the colored cycle lane.

Education: Cyclists need to be aware of the cues they give to motorists. For example, cyclists using recumbent bicycles sit so low that they use flags to cue motorists of their presence. Parents provide poor examples when they do not wear helmets. Knowing when one has the right of way can help the cyclist avoid hesitation when crossing, thereby signaling one's intent to motorists.

Enforcement: The presence of police officers on bicycles can warn cyclists to respect the rules of the road.

Encouragement: Bicycle clubs can model desired behaviors by maintaining brakes in good working order, respecting the rules of the road, modeling conspicuity in dress and lights, and providing support to novice riders as they gain experience.

Evaluation: Maintaining feedback loops from cyclists to planners through surveys, publications, focus groups and the like can show users that planning is approached in a methodical manner.

Self-Efficacy

Engineering: A proper infrastructure will enable novice cyclists to gain the experience and self confidence to make cycling a routine mode of transportation.

Education: Mastery of the rules of the road and safety techniques used by cyclists can enhance self confidence.

Encouragement: Membership in a bicycle club and regular participation in collective and guided rides can encourage people to ride because of the enjoyment they derive from friends and also the feeling of accomplishment after completing rides.

THEORY OF PLANNED BEHAVIOR

Whereas the Health Behavior Model relies upon six predictors of health behaviors, the Theory of Planned Behavior relies upon three predictors: attitudes towards the behavior, perceived social pressures for behavior, and perceived behavioral control. We'll equate behavioral control with self-efficacy discussed above and not discuss it here. Since these are behavioral, application to Engineering is focused on the attitudes and behaviors of planners and decision makers.

Attitudes Towards Behaviors

Engineering: Berkeley began planning for its bicycle infrastructure in 1968, well ahead of other communities because of the importance planners gave to cycling. Later, voters approved the controversial implementation of barriers.

Some engineers would like to see the infrastructure precede large scale cycling. However, in the car centric culture of the U.S., cycling usually has to grow in popularity in the community before some planners will make cycling a priority. When civic leaders are also serious cyclists, the engineering process is given a boost. Engineering takes place in a social context so the attitudes of planners and civic leaders are important factors in supporting cycling.

Perceived Social Pressures

Engineering: Cities compete to win awards as bicycle-friendly places; leaders experience this competition as social pressure. Elected officials need to respond to voters and if they want better cycling infrastructure, social pressure is exerted in the political process. Planners hold public hearings to discuss infrastructure and need to deal with controversy, such as the barriers in Berkeley.

Education: In bicycle clubs, one would likely feel out of sync without conspicuous clothing, working brakes and lights, and a helmet. Educational cohorts create peer pressure for conformity, which can support good safety behaviors or the reverse if people convince one another that fixies without brakes are fine or that helmets are not fashionable.

Enforcement: Where the norm is to abide by the rules, people tend to do so. Where chaotic circumstances prevail, such as crossing against a light when traffic is light, dangerous following-the-crowd behavior can result in accidents if those behind simply follow those ahead, thinking it is okay to cross the street. This behavior is exacerbated in the presence of children, the mentally disabled, the elderly or others that might not pay attention to the traffic and just follow the lead of others. Unfortunately all too often the norm amongst cyclists is not rigid adherence to the rules of the road. Socialization through bike rodeos, scout troops, and bicycle clubs to abide by the rules of the road can lead to conformity in respecting the rules of the road.

Encouragement: Advocacy groups rely on social pressure to motivate members to work toward the established goal, which in the case of cycling could be a better infrastructure. In the process of working on this goal, members could develop positive relationships with peers.

QUESTIONNAIRE

Using the framework discussed above and the 5 Es, we shall now create a brief questionnaire to exemplify questions that planners could use when considering bicycle issues. Planners are expected to modify the questions and add new ones to suit their needs.

Perceived Susceptibility

Engineering: What specific types of local infrastructure give cyclists the perception of feeling safe? What local road and traffic conditions make them feel vulnerable? What demographic or skill and experience level differences exist between different groups of cyclists regarding these perceptions in your area?

Education: Does your safety education program inform students about the risks of cycling? Does your education cover the other 5 Es relevant to your area? Does it explain where the infrastructure is deficient (for instance, accidents or perceived susceptibility)? Do police officers responsible for enforcement address your audience? Do representatives of advocacy groups or clubs address your audience? Is there immediate evaluation of the program? Is there follow-up evaluation of your program?

Enforcement: How many urban police officers patrol on bicycle? Assuming funds are limited, could interns or volunteers be used to cite violators in areas where cyclists are concentrated (for instance, downtown, universities, and schools)? Are local clubs and cycle shops included in campaigns to raise awareness regarding enforcement?

Encouragement: Do planners and officials responsible for cycling activities in the jurisdiction participate in advocacy groups and bicycle clubs? Do they make contact with bicycle shops

that are also active as advocates? Do planners routinely hold public hearings or reach out to various stakeholders when considering changes to any of the 5 Es?

Evaluation: Are local universities and colleges involved in evaluation efforts? Are student interns and clubs integrated into evaluation projects? Are technological innovations such as GPS signaling, photo surveillance and the like part of the evaluations?

Perceived Severity

Engineering & Evaluation: Are posted speed limits respected? What traffic calming measures have been effective? What barriers or traffic calming projects have met with resistance from drivers or cyclists and how were these problems addressed?

Education & Evaluation: Who does not use helmets and why? When legally required, do children wear helmets? What groups tend not to wear conspicuous clothing and why? What groups do not use lights and why?

Perceived Benefits of Preventative Behavior

Engineering & Evaluation: How have perceptions of the infrastructure changed over time in the cycling population?

Education & Evaluation: What perceived benefits of safety education have proven motivating for attendees? Do cycling clubs create norms focused on preventative behavior?

Enforcement & Evaluation: What enforcement measures have proven effective? What measures have met with public outcry or stiff resistance? What factors influence behavior in the short-term and long-term?

Encouragement and Evaluation: To what extent do bicycle clubs and advocacy groups create norms and expectations of sound preventative behavior? How do they do this? Do advocacy groups cross the line and campaign for access to dangerous routes? How do planners and officials deal with such campaigns when more routes are requested, but they appear less than safe?

Perceived Barriers

What are the perceived barriers to planning and implementing any of the 5 Es?

Engineering: Under what conditions are bicycle infrastructure projects given comprehensive consideration by planning groups? Are stakeholders routinely consulted before planning is undertaken?

Education: What are the barriers to implementing effective safety programs? How have such obstacles been addressed? What resulted from prior efforts to address barriers?

Enforcement: What barriers exist to enforcement and how has the jurisdiction attempted to address these in the past? What resulted from prior efforts? What measures have authorities taken to overcome funding and staffing limitations? Can volunteers or interns be used effectively? If volunteers have been deputized, so to speak, to permit them to issue citations, how have citizens responded?

Encouragement: What barriers have the various clubs and advocacy groups highlighted? How did officials address their concerns? What methods were used to ensure that stakeholder involvement was adequate?

Evaluation: If formal evaluations done by experts are too costly, how have officials integrated evaluation into their projects? Are evaluations routine parts of project feedback? Are universities and colleges integrated where possible?

Cues

Engineering: Has proper signage on bicycle paths and sidewalks been implemented and evaluated? Have clear cues been used where possible on paths or sidewalks to separate cyclists from pedestrians, as is the practice in Germany and even the U.S. (for example, Hawthorne Bridge in Portland, OR)?

Education: Are cyclists taught about the cues they give to motorists, either consciously (for instance, recumbent bicyclists' use of flags) or unconsciously (for instance, motorists give less clearance to expert riders than riders that to be novices)?

Enforcement: Does the presence of police officers on bicycles warn cyclists to respect the rules of the road?

Encouragement: Do bicycle clubs model desired behaviors by maintaining brakes in good working order, respecting the rules of the road, modeling conspicuity in dress and lights, and providing support to novice riders as they gain experience?

Evaluation: Does the planning system establish and maintain feedback loops from cyclists to planners?

Self-Efficacy

Engineering: Does the infrastructure enable novice cyclists to gain the experience and self confidence to make cycling a routine mode of transportation?

Education: Does cyclists' mastery of the rules of the road and safety techniques enhance self confidence?

Encouragement: Does membership in a bicycle club and regular participation in collective and guided rides encourage people to ride?

Attitudes Towards Behaviors

Engineering: Do planners and elected officials share the goal of making their jurisdiction bicycle friendly?

Perceived Social Pressures

Engineering: Do planners and elected officials desire to compete to have their city win awards as bicycle-friendly places? Do leaders experience this competition as social pressure? Elected officials need to respond to voters and if voters want better cycling infrastructure, social pressure is exerted in the political process. Planners hold public hearings to discuss infrastructure and need to deal with controversy, such as the barriers in Berkeley.

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Since 2001, John Brazil has served as the Bicyclist & Pedestrian Program Coordinator for the City of San José, California, a city of 945,000 residents. John manages several capital improvement programs including development of a 400 mile on-street bikeway network and expansion of a citywide public bike parking network. In additional to capital project development, John also oversees programs such as San José's recently launched Employee Bike Fleet. As a nationally certified League Cycling Instructor, John has taught more than twenty Bicycling Skills Classes using the League of American Bicyclists Smart Cycling curriculum. John's work also includes funding development, and he has won several million dollars in grant funds. John oversaw development of the City of San José's Bike Plan 2020, which was unanimously approved by city council. He has presented at several

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BTA: JAY DEAN, LEEANNE FERGASON, GERIK KRANSKY, CARL LARSON, STEPHANIE NOLL, & MARGAUX MENNESSON

The Bicycle Transportation Alliance (BTA) is a non-profit organization working to make bicycling safe, convenient, and accessible in Portland and throughout the state of Oregon. The BTA represents 3,000 member households statewide. Since 1991, the BTA has advocated for infrastructure and policies that today make Portland a leading U.S. bicycle city. The BTA teaches award-winning bicycle and pedestrian safety curriculum to 4,000 Oregon students annually. Authors Jay Dean, Carl Larson, LeeAnne Fergason and Stephanie Noll work in the education programs department at the BTA. Gerik Kransky, BTA Advocacy Director, and Margaux Mennesson, BTA Communications Director, also contributed to the chapter.

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