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Pedestrian Safety
in Maine

FINAL REPORT

TECHNICAL REPORT

June 28, 2002

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Pedestrian Safety in Maine

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ABSTRACT

The aim of this report is to suggest changes in geometric and physical layout, legislation, enforcement practices, training of children, and other educational activities to improve the safety of pedestrians in the State of Maine. The report includes a thorough review of literature and analysis of crashes, interviews with pedestrians of different ages and abilities as well as interviews with planners and engineers.

EXTENDED ABSTRACT

For a more thorough summary, see page 15.

Introduction

The primary objective of this project is to in-form the agency of how pedestrian traffic safety can be improved in the State of Maine. It should be remembered that there are extra-vulnerable road users, i.e., the very young, the very old, the visually impaired, the mobility impaired, and the mentally challenged who also have a right to get to their destinations as independently as possible.

The attractiveness of facilities is a different—and very important—factor in promoting walking as a mode of transportation. We know that people want direct, aesthetically pleasing and safe facilities.

Target Communities

Crash data from all of Maine was analyzed. Besides that, Bangor, Paris/Norway (Oxford Hills), Camden, Hallowell and Brunswick were selected as representative for the state and have been the focus of in-depth studies. Problems and solutions identified at these communities may be applicable to other towns as well.

Crash Data

A total of 1589 pedestrian crashes were reported in 1994 - 1998. A total of 81 people were fatally injured during that 5-year period. Ten percent of them were below the age of 18 whereas 42% were 65 or older.

Observed versus Expected Crash Numbers

Pedestrian crash numbers were predicted at 115 randomly chosen locations in the target communities. The results of this analysis are summarized in Table 1. The predicted numbers are calculated based on pedestrian and vehicle volumes only, as an average of one British and one Swedish model. In other words, if the locations were of "typical European standards" then the observed number should be close to the predicted one.

Table 1 Predicted and observed pedestrian crash numbers, Maine

Area	Predicted number of pedestrian crashes 1994-98	Observed number of pedestrian crashes 1994-98
Bangor, CBD	4.24	3
Bangor, outside CBD	2.70	7
University of Maine	3.44	2
Rest of Penobscot County	1.16	1
Hallowell	1.64	1
Camden	2.65	1
Brunswick	2.38	8
Oxford Hills	2.91	16
SUM Maine	21.1	39

It is clear that the 'randomly' chosen locations, on average, have more crashes than 'typical' European locations (with those traffic volumes) would have had. The difference between the observed total number and that predicted is statistically significant. However, the low-speed environments of downtown Bangor, Hallowell and Camden as well as the University of Maine campus have better safety than the models predict.

Table 2 shows the safety of different crosswalk layouts. Statistically significant deviances are found for only a few layouts. Clearly more dangerous than predicted are the wide, high-speed, unmarked locations and the wide, medium-speed, unmarked locations. Also more dangerous are high-speed, marked, wide locations and medium-speed, marked wide locations. Not statistically significant deviances were found for several layouts. Somewhat more dangerous than predicted are high-speed unmarked narrow streets and medium-speed unmarked narrow streets. All types of low-speed locations are safer than expected except for the signalized ones. It should be noted that there was not a

single pedestrian crash in an unmarked, low-speed location.

Table 2 Predicted and observed pedestrian crashes by typical speed, street width and control

	Speed	2-lane		>2-lane	
		Pred.	Obs.	Pred.	Obs.
Unmarked location	low	2.63	0	0.00	0
	med	0.08	1	2.21	9
	high	0.65	2	0.21	5
Marked crosswalk, no signal or barrel	low	5.43	3	0.20	0
	med	0.00	0	2.29	6
	high	1.04	1	0.53	5
Marked crosswalk w. barrel, no signal	low	1.76	1	1.11	0
	med	0.00	0	0.00	0
	high	0.00	0	0.00	0
Marked crosswalk, signal	low	0.00	0	1.52	3
	med	0.25	1	0.93	1
	high	0.22	0	0.11	1

Risk

In the previous section, vehicle volume was used as an explanatory variable for predicting if a layout is safer or less safe than 'average.' Table 3 shows the risk per crossing pedestrian without normalizing for vehicle flow. We can then see that the risk varies a lot between the different communities. It is very low on the University of Maine campus and for Route 1 through Camden, both low-speed environments. The risk is reasonably low in downtown Bangor and Hallowell as well as at most other locations studied in Penobscot county. However, the risk is high on the outer sections of State Street and Main Street in Bangor as well as for pedestrians crossing Maine Street in Brunswick. The risk is very high in Oxford Hills (for pedestrians crossing the Main Streets of Norway and South Paris).

Table 3 Observed pedestrian crashes per million pedestrians, Maine summary

Town	No. of crossing pedestrians per day	Observed crashes 1994-98	Crashes per million crossings
Bangor, CBD	6174	3	0.27
Bangor, outside CBD	1670	7	2.30
University of Maine	8333	2	0.13
Rest of Penobscot	1680	1	0.33
Hallowell	1863	1	0.29
Camden	3990	1	0.14
Brunswick	2000	8	2.20
Oxford Hills	1467	16	5.98
SUM Maine	27177	39	0.79
Connecticut	9320	40	1.21

Speeds

The number of fatal pedestrian crashes throughout the state was compared to the total number of pedestrian crashes for different speed limits. The ratio between the two numbers is the likelihood a crash will result in a fatality. Figure 1 presents these results.

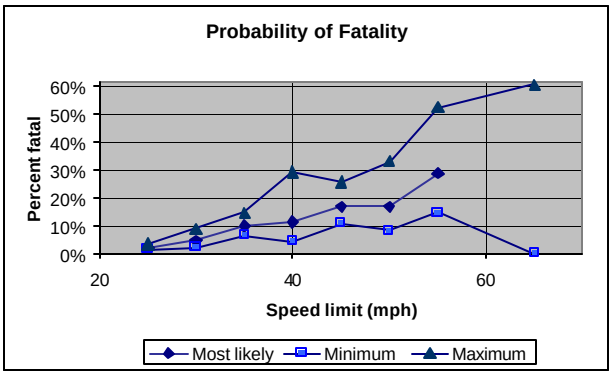


Figure 1 Speed limit and probability of a fatality with 95% level of confidence

Behavior

The traffic safety of a pedestrian who is crossing a street is influenced by many factors. If a pedestrian wishes to cross a street when there are many vehicles going by, he/she can either wait for

a 'safe' gap to occur, for a vehicle to slow down or stop for him/her, or just walk out into traffic hoping for the best. This third option is primarily chosen by intoxicated people—or by mistake by a visually impaired person. But a 'normal' person in a hurry may also choose that option. And very young children may do it because they do not realize the dangers. Measures to provide safety for people walking straight out into traffic may be different than measures aiming at providing safety for people choosing either of the other two options. It should be taken into account that introducing measures providing safety for the group "walking straight out into traffic," such as legislating pedestrian priority may increase the frequency of that behavior.

Survey of Students and Their Parents

A survey was administered in four of the five target communities. A total of 308 students and their parents participated. The percentage of people who always or frequently walk to school varies from 4% for Hallowell to 25% for Brunswick. The most common reason people do not walk or ride a bicycle to school is that it is too far or takes too long. Some people also report that it is too unsafe. The parents were asked "When (if) your child walks/rides a bike to school, do you worry that he/she may be a) involved in a traffic accident; b) assaulted by other child; c) assaulted by an adult. The responses are summarized in Table 4.

The parents were also asked about specific improvements. The answers show that parents want to give the highest priority to installing more crosswalks closely followed by the use of more barrels or other devices to make crosswalks more visible. To signalize more locations was a more common answer than adding more crossing guards.

Among other things, students were asked to point out dangerous locations in their community. Results are given in the main text.

Table 4 Portion of parents who frequently worry about their child's safety

	Traffic	Assault by child	Assault by adult
Oxford Hill's element.	19%	8%	11%
Oxford Hill's high school	9%	0%	4%
Hallowell (element.)	26%	9%	15%
Camden (K-5)	14%	0%	3%
Camden middle school	18%	4%	6%
Brunswick (2-8)	16%	4%	10%

Conclusions and Recommendations

It is human to make mistakes, no matter if you are a pedestrian or a driver. The consequences of mistakes can be deadly when vulnerable human beings are mixed with cars and trucks. It may even be human to break rules at times, and only in an ideal world could we regulate away all problems. Enforcement of existing rules governing safe behavior has some potential to improve pedestrian safety—but probably only marginally. That is both because intense enough police enforcement is expensive and because people break rules they typically follow when they need the rules the most; when they are in an extreme hurry, or under the influence of alcohol.

To a large degree, the pedestrian safety problem in Maine is focused to our arterials and major collectors, where highways pass through villages and towns. It is important that pedestrians are provided with safe locations for crossing these streets. Safe typically means one lane of traffic in each direction and low speeds.

Encouragement by rewarding people behaving safely (or legally) has similar problems as enforcement. It may be effective in theory, but in practice would be very hard to implement. Another type of encouragement that has more potential is to provide safe facilities to pedestrians. Then, hopefully, pedestrians will gravitate towards these facilities and away from dangerous locations.

Engineering, sometimes in combination with education and enforcement, is probably the way to clearly improved pedestrian safety. But not all engineering measures are effective. However, there are several measures that are very effective. That includes installation of refuge islands, adding warning signs that are activated only when a pedestrian is present, making the road narrower and reducing the travel speeds of, in particular, the faster vehicles. Also, in low-speed environments, barrels and cones in the roadway may act as good substitutes for refuge islands where it is impractical to install permanent islands. It is important that the use of such devices be standardized.

A pedestrian design guide will be published as a complement to this report.

Table of Content

Acknowledgments

It is now 25 years ago that I with a fresh Master's Degree was hired as a research assistant at the University of Lund. A project on pedestrian safety—the Effect of Scramble at Traffic Signals—was waiting for me. The intended principal investigator had just left, and there was no one else 'interested' in taking over the project. That project became a part of my Ph.D.-thesis "Pedestrian Safety at Traffic Signals," which I defended in the summer of 1982. I again want to thank the people who opened my eyes to pedestrian safety, especially my advisors Professor Gösta Lindhagen and Dr. Christer Hyden. Since then, I have had a more or less continuous interest in the many-faceted aspects of how we can make our environment safer for the most vulnerable of all road-user groups—the pedestrians.

I hope that the report you are just looking at will be used as a resource by people within the state of Maine and beyond; and I would like to thank everybody making this report possible. First of all, I want to thank the members of the Technical Committee for their guidance. This committee has been made up of Ms. Tracey McKenney, FHWA Maine Division, Mr. John Balicki, Mr. Peter Coughlan, Mr. Gerry Audibert and Mr. Dale Peabody, all of Maine Department of Transportation

I would also like to thank numerous other people involved in this project but to list them all would be impossible. However, I would like to mention Mr. Nicolas Bosonetto, graduate student at the University of Maine, Mr. Bob Stevens, of the Local Roads Center, Mr. Paul Ostrowski, undergraduate student at the University of Mane, Mr. Rick Urban of the Maine Transportation Safety Coalition, and Ms. Jennifer LeDuc of the Child Health Center in Norway for their assistance. And people with whom I have discussed these issues and received useful feedback, including Mr. Peter Lagerwey, Pedestrian Coordinator, Seattle, Washington; Dr. Charlie Zegeer at the Highway Safety Research Center at Chapel Hill, NC; Dr. Oliver Carsten, University of Leeds, England; Ms. Nicole Muhlrad, INRETS, France, Dr. John Ivan, University of Connecticut, Dr. Paul Ossenbruggen, University of California, Dr. Rune Elvik, TOI, Norway; Dr. Lars Leden, VTT, Finland; Mr. Leif Ourston, Santa Barbara, California; Dr. Lars Ekman, University of Lund; Professor Olof Gunnarson of Chalmers University, Sweden; and Ms. Cara Seiderman, City of Cambridge.

I would also like to thank the sponsors for making this study possible. The total grant from Maine Department of Transportation was for $43,915. Some of these funds came from FHWA safety money. Also, part of the studies presented in Chapter 8 were financed by the New England University Transportation Center through the joint University of Connecticut and University of Maine project "Finding Strategies to Improve Pedestrian Safety in Rural Areas." A total of $27,000 was awarded to the University of Maine for this work.

Finally, I would specifically want to thank my late wife, Eva Chimes, for encouraging me to do this research. She always supported me in my work. She was the one who encouraged me to put my research results together into a Ph.D.-thesis about 20 years ago. She was the one who encouraged me to apply for the position I currently hold with the University of Maine. Much of this report was written on my laptop with Eva next to me—at home and sometimes at Eastern Maine Medical Center. She was a warrior battling metastatic breast cancer years longer than she was expected to live. She finally gave up her battle on December 26, 2000. This report is dedicated to my Eva.

EXECUTIVE SUMMARY

Introduction

The primary objective of this project is to in-form the agency of how pedestrian safety can be improved in the State of Maine. Obviously, pedestrian safety cannot always be maximized. The safety of motorists may at times conflict with the safety of pedestrians, and efficiency of traffic movements as well as aesthetic and environmental concerns obviously also have to be considered. Naturally, installation and maintenance costs are other important factors when deciding on what to do to get cost-effective solutions.

The objective of the project is to focus on pedestrian traffic safety. Pedestrian security, i.e., how a layout may influence the risk of assault, rape, or other violent crimes, is also an important issue. The attractiveness of facilities is a different—and very important—factor in promoting walking as a mode of transportation. We know that people want direct, aesthetically pleasing and safe facilities. Making the facilities attractive can by itself promote safety. If drivers see many pedestrians along a street, they are more likely to slow down and yield to crossing pedestrians. On the other hand, making facilities attractive may lead not only to more pedestrians in an area but also to more pedestrian crashes.

The central task of this project is to assess the safety problems and the effect of different measures that possibly could be introduced in order to improve the safety of pedestrians in the state of Maine. Crash data can be used as an objective measure of safety—if we have sufficient numbers to be able to calculate averages and precisions. But there are alternative ways of studying safety. A problem in safety evaluations is that expected crashes may not actually have happened yet. By chance, a dangerous location may have been spared from crashes in the past, though the future may hold a less fortunate outcome. Conflict studies—using the FHWA or a Swedish technique—can be used for such evaluations, to estimate an expected accident rate. Observation of behavior may also be a possible avenue for assessing safety-related issues.

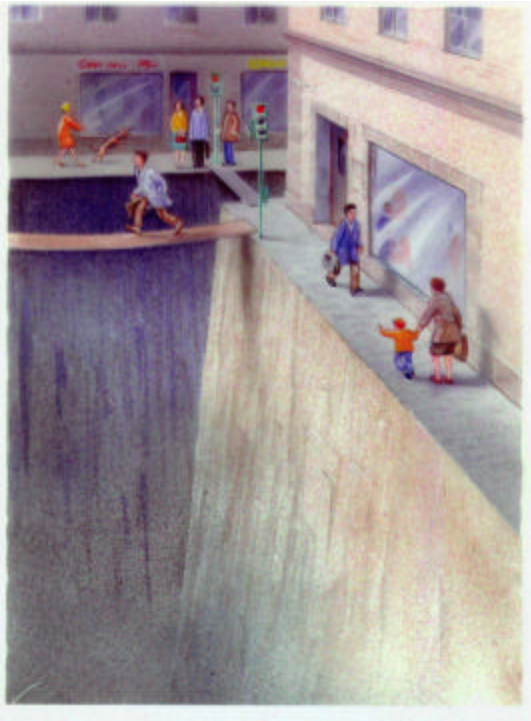
Walking is maybe the most natural way of getting from one place to another. If towns and cities were planned accordingly, many activities could be reached from a person's home by foot. And people can incorporate walking into their everyday activities even if they live far away from work and service centers, by walking, for example, from shop to shop. But safe, secure, unrestricted, and aesthetically attractive facilities are needed to persuade people to do that rather than to drive.

There are many health benefits connected to walking. Walking is probably the form of exercise that has the fewest negative side effects in the form of injuries—as long as injuries caused by collisions with motor vehicles are avoided. Carre' estimates that a person gains one hour of expected life for every hour he/she is engaged in moderate exercise, for example walking. If we extrapolate these findings, a person would live forever if he kept on walking. Obviously, that is not true. But the results do mean that "no time is wasted" when going by foot to and from activities.

There are obviously people with health problems who cannot walk, but if we include riding a wheelchair under the general umbrella of 'walking,' then most of us can and do walk, at least sometimes. But why do we not walk more? First, it takes time. Although as stated above, it does not really take time out of a person's life unless 'excessive' time is spent on walking. However, it is human nature that we do not want

to sacrifice minutes today for a gain later in life, and we often feel that we do not have time to spend fifteen minutes on walking when we can get there in two minutes by car.

Another reason people do not walk is safety. The focus of this study is on transportation safety. How do people perceive safety for themselves when walking, and what are the objective risks when walking in traffic? It is especially important that children are given safe and secure opportunities to walk to and from school. Walking may become a lifetime habit if it becomes the norm at an early age.



(Picture courtesy of Vision Zero, Sweden)

Figure 2 Is this how pedestrians should feel when walking along city streets?

Later in life, people also need to have 'inviting' environments to be encouraged to walk. People should not have to cross 'desert-sized' parking lots when walking to shops and restaurants. A building's entrance should be located close to the street with a safe, direct access directly from the sidewalk. Parking should be below, above, behind, or on the side of the building—not in front. It is also important for pedestrians to see others walking in that area. To have residences and businesses mixed—with restaurants and shops on the ground floor, offices one flight up, and apartments above that—means that there will be pedestrian activity both during the daytime and evening.

Target Communities

The following communities were selected as representative for the state and have been the focus of these studies.

- Bangor
- Paris/Norway (Oxford Hills)
- Camden (and Rockport)
- Hallowell
- Brunswick

They make up coastal tourist towns as well as inland "mill towns." Smaller towns as well as cities are included. Problems and solutions identified at these communities may be applicable to other towns as well. However, a couple of the communities were included because they had (Oxford Hills and Brunswick) or were perceived to have (Hallowell) abnormally high pedestrian crash rates.

Crash Data

Pedestrian crashes in Maine are discussed in Chapter 5. A total of 1589 pedestrian crashes were reported in 1994 through 1998. A more detailed analysis of crashes in the five target communities are presented in Chapter 7. An analysis of fatal crashes in the state is presented in Chapter 10. A total of 81 people were fatally injured in 80 pedestrian crashes during the 5-year period 1994-98. Ten percent of them were below the age of 18 whereas 42% were 65 or older.

Observed versus Expected Crash Numbers

Two different models were used for predicting crash numbers at 115 randomly chosen locations in the target communities. Pedestrian and vehicle volumes were gathered, prior to any knowledge of the crash data. Pedestrian counts, typically a minimum of two hours at each location, were expanded to approximate annual average daily volumes. Motor vehicle traffic counts were taken from Maine DOT's website. The results of this analysis can be summarized by Table 5.

Table 5 Predicted and observed pedestrian crash numbers, Summary for Maine

Area	Predicted number of crashes per five years, Swedish model	Predicted number of crashes per five years, British model	Observed number of pedestrian crashes 1994-98
Bangor, CBD	4.24	4.23	3
Bangor, outside CBD	2.12	3.27	7
University of Maine	3.36	3.52	2
Rest of Penobscot County	1.09	1.23	1
Hallowell	1.57	1.70	1
Camden	2.68	2.62	1
Brunswick	2.17	2.59	8
Oxford Hills	2.15	3.68	16
SUM Maine	19.4	22.8	39

The predicted numbers are calculated based on pedestrian and vehicle volumes only. If the locations were of "typical European standards" then the observed number should be close to the predicted one. Locations with (statistically significant) more actual crashes than predicted would have designs (or road-user behavior) that are less desirable than those having fewer observed crashes.

It is clear that the 'randomly' chosen locations (with a total of 39 crashes), on average, have more crashes than 'typical' European locations (with those traffic volumes). The difference between the observed total number and that predicted by the Swedish model is statistically significant (p=0.00005), so is the difference between the observed number and that predicted by the British model (p=0.001). The predictions by the two models themselves also deviate somewhat from each other, but this deviation (of approximately 17%) is far from statistically significant. In other words, the models (presented in detail in Chapter 8, starting on page 64) seem to perform well, it is the safety of the locations that is not so good. However, the low-speed environments of downtown Bangor, Hallowell and Camden as well as the University of Maine campus have better safety than the models predict.

Table 6 shows the safety of different crosswalk layouts. Statistically significant deviances are found for only a few layouts. Clearly more dangerous than predicted are the wide, high-speed, unmarked locations (p=0.000003) and the wide, medium-speed, unmarked locations (p=0.0005). Also more dangerous are high-speed, marked, wide locations (p=0.0002) and medium-speed, marked wide locations (p=0.03).

Not statistically significant deviances were found for several layouts. Somewhat more dangerous than expected (predicted) are high-speed unmarked narrow streets (p=0.14) and medium-speed unmarked narrow streets (p=0.08). However, the low-speed unmarked locations are safer than expected (p=0.07).

None of the signalized cells deviate from the predicted number in a statistically significant way. However, the low-speed signalized locations are somewhat more dangerous than expected whereas the non-signalized low-speed locations summed together are safer than expected (p=0.014). There was not a single pedestrian crash in an unmarked, low-speed location. In other words, the conclusion from my Ph.D.-thesis published in 1982 that low-speed non-signalized locations are safer for pedestrians

signalized locations are safer for pedestrians than signals has been supported by this study too.

Table 6 Predicted and observed pedestrian crashes by typical speed, street width and control

	Speed	2-lane		>2-lane	
		Pred.	Obs.	Pred.	Obs.
Unmarked location	low	2.63	0	0.00	0
	med	0.08	1	2.21	9
	high	0.65	2	0.21	5
Marked crosswalk, no signal or barrel	low	5.43	3	0.20	0
	med	0.00	0	2.29	6
	high	1.04	1	0.53	5
Marked crosswalk w. barrel, no signal	low	1.76	1	1.11	0
	med	0.00	0	0.00	0
	high	0.00	0	0.00	0
Marked crosswalk, signal	low	0.00	0	1.52	3
	med	0.25	1	0.93	1
	high	0.22	0	0.11	1

Risk

In the previous section, vehicle volume was used as an explanatory variable in trying to predict if a type of crossing is safer or less safe than it ought to be for such traffic volumes. In this section, the risk per crossing pedestrian is analyzed, see Table 7. We can see that the risk varies a lot between the different communities. It is very low (0-0.15 per million pedestrians) for people crossing the [studied] streets of the University of Maine campus and Route 1 through Camden, both low-speed environments. The risk is reasonably low (0.25 to 0.33 per million crossings) in the Central Business District of downtown Bangor and Hallowell as well as at most other locations studied in the Greater Bangor area. However, the risk is high (2-3 per million pedestrians) on the outer sections of State Street and Main Street in Bangor as well as for pedestrians crossing Maine Street in Brunswick. The risk is very high (above 5 per million crossing pedestrians) in Oxford Hills for pedestrians crossing the Main Streets of Norway and South Paris.

Table 7 Observed pedestrian crashes per million pedestrians, Maine summary

Town	No. of crossing pedestrians per day	Observed crashes 1994-98	Crashes per million crossings
Bangor, CBD	6174	3	0.27
Bangor, outside CBD	1670	7	2.30
University of Maine	8333	2	0.13
Rest of Penobscot	1680	1	0.33
Hallowell	1863	1	0.29
Camden	3990	1	0.14
Brunswick	2000	8	2.20
Oxford Hills	1467	16	5.98
SUM Maine	27177	39	0.79
Connecticut	9320	40	1.21

Speeds

The number of fatal pedestrian crashes throughout the state was compared to the total number of pedestrian crashes for different speed limits. The ratio between the two numbers is the likelihood a crash will result in a fatality. These results, with confidence intervals, are presented in Figure 3. There is a 2.5% statistical risk that the minimum value would not be reached and a 2.5% risk that the maximum value would be exceeded in the confidence intervals shown.

The actual speed at the time of collision, or prior to an evasive maneuver, may not coincide with the speed limit. Drivers involved in these crashes may be typical drivers, meaning that they like 'most' drivers in Maine exceed the speed limit by at least 5 or 10 mph when they are driving on non-congested roads. It is also a fair assumption that some of the drivers involved in crashes may be driving faster than typical drivers do. This is supported by the fact that many of the drivers involved in the fatal pedestrian crashes had received speeding tickets during the last couple of years indicating that they exceed speed

limits by more than 10 to 15 mph at least sometimes. (For details, see Section 10.6 starting on page 86.) Some of the drivers also have multiple crash involvement in the years leading up the fatal crash. One driver had three crashes within the month of the fatal crash. But, there are also many drivers with no crash or violation records. Some of the crashes these drivers have involve pedestrians with extensive violation records as habitual offenders and abusers of alcohol. Finally, there are crashes where none of the involved parties have any demerit points or crash involvement prior to this event. In summary, some groups of people seem more prone to being involved in fatal pedestrian crashes than others, but no one is completely immune against this risk.

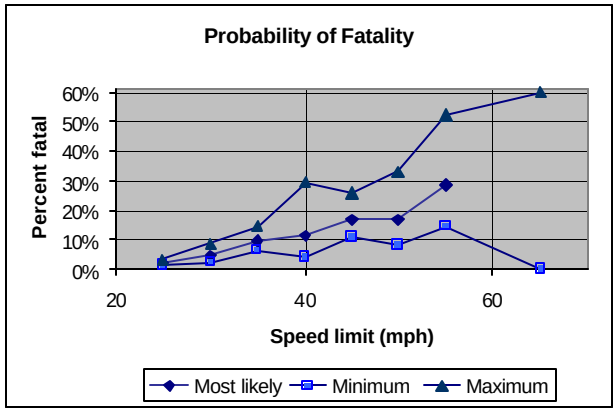


Figure 3 Speed limit and probability of a fatality with 95% level of confidence

Behavior

The traffic safety of a pedestrian who is crossing a street is influenced by many factors including his/her own behavior. If the pedestrian crosses when there are no vehicles close by, he/she will obviously be safe. If the pedestrian wishes to cross a street when there are vehicles going by, he/she can either wait for a 'safe' gap to occur, for a vehicle to slow down or stop for him/her, or just walk out into traffic hoping for the best. This third option is primarily chosen by intoxicated people and possibly by people in great stress or with mental handicaps—or by mistake by a visually impaired person. But a 'normal' person in a hurry may also choose that option. And very young children may do it because they do not realize the dangers. Measures to provide safety for people walking straight out into traffic may be different than measures aiming at providing safety for people choosing either of the other two options. Also, it should be taken into account that introducing measures providing safety for the group "walking straight out into traffic," such as reducing speed or legislating pedestrian priority may increase the frequency of that behavior.

Studies from around the state indicate that the higher the driving speed, the lower the percentage of drivers who stop and yield to pedestrians in crosswalks. This relationship can be illustrated with results from the University of Maine campus at Orono, see Table 8. These studies were carried out in the Fall of 1998. The yield behavior has improved some since then. But still, a clear majority of drivers do not stop when the speed exceeds 20 mph.

Table 8 Speed and yield behavior

Speed (mph)	% yielding
0-10	100%
11-15	28%
16-20	23%
21+	17%

Survey of Students and Their Parents

As part of this project, a survey was developed to interview children and their parents. It was administered in four of the five target communities. The Bangor school department did not participate with the motivation that this was not a core-curriculum priority, and that the school district's policy is to not participate in these types of activities.

The survey in Oxford Hills targeted high school students as well as younger students. In the other communities, only grades K-8 were included.

A total of 308 students and their parents participated. Results are presented in the main body of this report, in Chapter 12, starting on page 97. Below follows some results.

The frequency with which students choose different modes of getting to school was studied. In all the towns, except for high-school students in Oxford Hills, a majority of students always or frequently take the school bus. About 30% are always or frequently driven by car. The highest percentage of people frequently riding a bicycle to school is in Brunswick, with 4%. The percentage of people always or frequently walking to school varies between 4% for Hallowell to 25% in Brunswick. It is 13% in Camden as well as in Oxford Hills (for both elementary school students and high-school students). The most common reason people do not walk or ride a bicycle to school is, according to the students themselves, that it is too far or takes too long. Some people also report that it is too unsafe.

Students were asked about their crash experiences. Fifty-three students reported having had a bicycle crash, many needing medical attention. Only two of the crashes involved an automobile. Twenty-six students reported walking/running accidents, some of them requiring medical attention. None involved motor vehicles. There were six accidents involving students riding school busses. In half of them, the person slipped when getting on or off or got caught in the door. The other three were crashes between the bus and another vehicle.

The parents were asked "When (if) your child walks/rides a bike to school, do you worry that he/she may be a) involved in a traffic accident; b) assaulted by other child; c) assaulted by an adult. The responses are summarized in Table 9 showing that traffic is the biggest worry to most parents.

Table 9 Portion of parents who frequently worry about their child's safety

	Traffic	Assault by child	Assault by adult
Oxford Hill's element.	19%	8%	11%
Oxford Hill's high sch.	9%	0%	4%
Hallowell (element.)	26%	9%	15%
Camden (K-5)	14%	0%	3%
Camden middle school	18%	4%	6%
Brunswick (2-8)	16%	4%	10%

With respect to crosswalk usage, very few students answered 'no' to the question "Have you been told to always use a crosswalk (if there is one) when crossing a street on foot?" Typically students indicated a parent as one source of the information. Many also indicated that school personnel had told them and some indicated other people such as friends, scout leaders and policemen.

Helmet use among bicycling students is presented in Chapter 12.

The parents were asked about health benefits of walking: "Do you believe it would be good for your child's health to walk more?" Most parents answered 'yes' but a few said 'no.' The most common reason given for a negative answer is that "they get enough exercise anyway."

Parents were asked: "Do you allow your child to walk to nearby destinations, other than the school (such as a convenience store, a friend's house or the park)? The majority said 'yes' though several parents specified conditions.

Parents were also asked, "Do you allow your child to be out walking in your community without adult supervision during normal daylight hours? Roughly half answered 'yes' and half said 'no." There were frequently stipulations added to the yes or no answer. Not surprisingly, older children have more freedom to be out by themselves than younger children.

Students were also asked to point out dangerous locations in their community. Results are given in the main text.

The parents' responses to the question, "What could the town do to encourage you to walk more on, or along, public streets and roads?" showed that most parents want sidewalks constructed and paved shoulders. Other frequent responses were more streetlights and more police enforcement.

The parents were asked: "Do you think that your town should a) add many more crosswalks; b) use barrels, cones, or other devices to make crosswalks more visible; c) signalize more locations; and d) use more crossing guards?"

The answers show that parents want to give the highest priority to more crosswalks closely followed by the use of more barrels. (In Brunswick, barrels were given higher priority than crosswalks.) More signals is a more common answer than more crossing guards.

Parents were also asked to give "other suggestions for how to make your community safer for pedestrians and bicyclists?" Those results can also be found in the main text.

The parents were finally asked about their knowledge of code. Results for each community are presented in the main text and a summary for all communities is given in Table 10. It is obvious that many parents—read motorists—are not very familiar with the code. It may not seem important that a wide majority of motorists believe that they must yield to pedestrians still on the sidewalk at a crosswalk. However, the 20 to 30% of drivers who know that they do not have to may be a safety hazard to the vast majority (of pedestrians) who believe that motorists must stop and yield to them.

Table 10 Survey of parents: Percent correct answers

	Brunswick	Oxford Hills	Hallowell	Camden
Motorists must yield to peds in x-walk	86%	93%	91%	98%
Motorists must yield to peds still on sidewalk at x-walk	31%	19%	20%	27%
Motorists must yield to peds still on sidewalk away from x-walk	53%	46%	50%	63%
Should you walk with or against traffic if there are no sidewalks?	75%	78%	85%	87%
When may you begin crossing at a signalized crosswalk with a pedestrian display?	53%	62%	51%	63%

Overall Results and Conclusions

Detailed results are given in Chapters 15, 16 and 17. Brief conclusions based on the result chapters are given in Chapter 18 and these are summarized below.

It is human to make mistakes, no matter if you are a pedestrian or a driver. The consequences of mistakes can be deadly when vulnerable human beings are mixed with cars and trucks, especially if those vehicles move at high speeds. It may even be human to break rules at times, and only in an ideal world could we regulate away all problems. Enforcement of existing rules governing safe behavior has some possibilities to improve pedestrian safety—but probably only marginally. That is both because intense enough police enforcement is expensive and because people break rules they typically follow when they need the rules the most, when they are in an extreme hurry, or under the influence of, e.g., alcohol.

To a large degree, the pedestrian safety problem in Maine is focused to our arterials and major collectors, where highways pass through villages and towns. (Rural roads may be at least equally dangerous for pedestrians, but since so few people walk there, the safety problem is typically not manifested. However, one reason people do not walk there may be that they are perceived as too unsafe.) There are at least three possible ways of dealing with the problem of pedestrians and vehicles sharing the same space. The first approach was practiced about a hundred years ago in many communities. That was to give pedestrians true priority. A man carrying a red flag had to walk ahead of any motor vehicle, and the speed obviously would be modest. The driver typically would have to yield to (go around) any obstacle. The second approach—still practiced in some jurisdictions—is that drivers have absolute priority, especially on rural roads but also on arterials going through built-up areas. To be safe, pedestrians must stay away from roads, at least when cars are approaching. Crossing a street is a risky business of which the pedestrian must take full responsibility. Reality today, is close to this second approach even if pedestrians formally have the right of way at marked crosswalks and at signalized intersections. To have the practical right of way in a crosswalk only some of the time means that a pedestrian always must wait for all nearby cars to come to full stops before it is safe to step into the crosswalk. The third approach is one where drivers and pedestrians are equal partners. The pedestrian is no longer seen as a nuisance or adversary to vehicular traffic and the pedestrian therefore does not need to be protected from drivers. In everyday life, for example in a grocery line, we do not push our way ahead just because we are heavier or more powerful. Why could it not be the same way in traffic—in areas were pedestrians and cars have equal rights—as they, in my opinion, should have on Main Street in a village center? And rather than compete for space the two groups ought to voluntarily offer each other space as civilized human beings do. To make this interaction possible—and likely—vehicle speeds must be very low.

It becomes obvious that long-distance travelers and long-haul freight operators will get frustrated if they frequently have to interact with slow-moving pedestrians. The goal should therefore be that our National Highway System (NHS) and other major arterials should have alternative routes bypassing town and village centers. However, many travelers along these roads will want to access businesses in those towns and villages, and business [road] alternatives should therefore also be easily reached. Junctions should be built so that it is equally easy to head onto the bypass as onto the business alternative. One junction type offering this quality is the modern roundabout. Cost limitations, and sometimes environmental concerns, will mean that many bypasses probably will not be built in a foreseeable future.

Pedestrians and bicyclists are sometimes referred to as vulnerable road users. It should be remembered that there are also extra-vulnerable road users, i.e., the very young, the very old, the visually impaired, the mobility impaired, and the mentally challenged who also have a right to get to their destinations as independently as possible.

Pedestrians often share space with motorists. When walking along highways and streets, pedestrians at least sometimes have adequate sidewalks or shoulders, but pedestrians often need to cross roadways in order to reach desired destinations. It is important that pedestrians are provided with safe locations for such crossings. And those locations must be along the shortest route for the pedestrian; else a substantial number will cross away from the intended locations. For example, at the roundabout in Little Falls, Gorham, constructed in 1997, marked crosswalks are located approximately 15 to 20 meters (50 to 65 ft) upstream from the respective yield lines. This means that the crosswalks were roughly that same distance away from the shortest path when

walking along US 202. Only 23% of observed pedestrians took the detour to the marked crosswalk. It may be possible to increase that percentage with education and enforcement but, basically, it is very hard to restrict pedestrian movements without putting up physical barriers. And pedestrians have a tendency to get through or around even such barriers.

A high percentage of urban pedestrian accidents occur in marked crosswalks. Marked crosswalks have the advantages of telling pedestrians where it is 'safe' to cross and telling drivers where they can expect pedestrians. Still, the risk of a crash may actually be just as high in marked crosswalks as away from them. The reason is that many motorists do not even notice a crosswalk, and if they do, they do not modify their behavior in a substantial way. Many pedestrians, however, feel secure in the crosswalk and assume that all approaching drivers will yield to them. Some towns put up barrels or cones to notify drivers that they are approaching a crosswalk. Most of these devices are not approved by MUTCD. Also, such devices may cause injuries if they are hit by a vehicle and 'torpedoed' at pedestrians or other traffic. However, they may also improve the safety by making drivers notice the existence of a crosswalk as well as provide a refuge area in the middle of the street. The positive safety effects most likely dominate over the negative ones. There are alternatives to barrels. Flashing lights and the recently MUTCD-approved fluorescent signs may also make crosswalks noticed by a majority of drivers, but these devices do not provide for a refuge area where pedestrians feel that they 'safely' can wait rather than hurry across in front of vehicles on the second half of the road.

So what can be done to further improve pedestrian safety in Maine? There are the four E's to work with. That is education, enforcement, encouragement and engineering. These concepts can be applied individually or in some type of combination.

When it comes to education, my belief used to be very optimistic. But my review of literature within this project has shown that there are very few evaluated programs indicating any clear benefits. I could summarize my present belief with that it is possible to sell ideas and products, e.g., Nordic Track ®, to people but very hard to make people actually use such equipment consistently. In the same way, we can have people 'buy' into good behavior, but they may not follow those recommendations when there is significant resistance to it; when it is easier not to. And especially not when they are in a hurry.

I still believe that enforcement has potentials. Unfortunately, high-level enforcement is very expensive and enough of a focus on pedestrian safety to have enforcement make significant improvements is unlikely.

Encouragement by rewarding people behaving safely (or legally) has similar problems as enforcement. It may be effective in theory, but in practice would be very hard to implement. Another type of encouragement that has more potential is to provide safe facilities to pedestrians. Then, hopefully, pedestrians will gravitate towards these facilities and away from dangerous locations.

Engineering, sometimes in combination with education and enforcement, is probably the way to clearly improved pedestrian safety. But not all engineering measures are effective. It is known, e.g., that rumble strips prior to crosswalks do not seem to be beneficial. On the other hand, several measures are very effective. That includes installation of refuge islands, adding warning signs that are activated only when a pedestrian is present, making the road narrower and reducing the travel speeds of, in particular, the faster vehicles. Also, in low-speed environments, barrels and cones in the roadway may act as good substitutes for refuge islands where it is impractical to install permanent islands. It is important that the use of such devices be standardized in similar ways as already done by the States

of New York and New Hampshire. And the text on signs probably should reflect current legislation accurately. For example, the word 'stop' should not be used if the law states 'yield. State guidelines should be presented in a Pedestrian Design Guide. Some ideas of what could be included in such a guide is presented in Chapter 19, see page 237. A first draft of such a guide is currently being produced.