



PEDESTRIAN-DRIVER INTERACTIONS

For the past forty years, traffic safety officials in Washington State have worked to deter impaired driving, distracted driving, and speeding, which was justified as long as the percent of pedestrian traffic deaths remained low. From 1995 through 2009, pedestrians accounted for only 11 percent of statewide traffic fatalities. Since 2010, however, pedestrians accounted for nearly 16 percent of Washington traffic deaths, rising to 19 percent in 2017, nearly a fifth of fatalities that year. Moreover, roughly six of every ten pedestrians killed in Washington from 2015 through 2017 (58 percent) were either attempting to cross the road or waiting to do so. Pedestrians are highly vulnerable road users, thus far more likely to be killed or seriously injured in a crash than vehicle occupants. Safety advocates assert that pedestrians are rightful users of our public transportation system and have an innate right to cross roadways safely and with minimal delay. We must take them more seriously. Any technological or behavioral innovations that enable pedestrians to cross safely and readily are urgently needed.

Countermeasures for pedestrian crashes are mostly enforcement and engineering-based solutions. For instance, Washington's basic crosswalk law requires that vehicle drivers approaching either marked or unmarked crosswalks "shall stop and remain stopped to allow a pedestrian or bicycle to cross the roadway" except when a vehicle is "so close that it is impossible for the driver to stop" ([RCW 46.61.235](#)). A 2003 study of crossing sites in Washington State observed that only 40 percent of vehicle drivers in Bellingham and a mere 26 percent in Olympia yielded lawfully to pedestrians at marked crossings. This study also found that public messaging followed by targeted enforcement of Washington's crosswalk law raised driver compliance in Bellingham to 63 percent during the enforcement campaign, and to 74 percent in the week after enforcement had concluded. Clearly, more statewide police enforcement of this law would increase the rate of driver compliance, and enable a greater proportion of pedestrians to cross safely and speedily.

Vehicle speed is a huge factor in pedestrian deaths and injuries. A recent analysis of pedestrian crash data obtained in different time periods and different countries showed that a pedestrians' risk of dying when struck by a vehicle moving at 30 miles per hour (MPH) is fairly low: between seven and 14 percent. However, when struck by vehicles traveling 40 MPH, pedestrians are 3.6 - 4.2 times more likely to die than when hit at 30 MPH. In Washington, two-thirds of pedestrians killed while crossing or waiting to cross were struck on roads with posted speeds between 30 and 45 MPH. Traditional enforcement often fails to subdue vehicle speeds to levels that enable pedestrians to cross safely, particularly in cities. Since officers cannot be everywhere, a far more effective deterrent to speeding would be to implement automated speed enforcement programs throughout Washington.

Beyond enforcement, several engineering solutions are known to improve safety and mobility for pedestrians. The use of raised roadway medians and "refuge islands" in pedestrian crossings, and the installation of roundabouts to replace signed or signalized intersections have each shown to reduce pedestrian crashes by 60-75%. Other "traffic calming" approaches have also reduced vehicle speeds in areas with heavy pedestrian traffic.

Note: These research summaries are not implied to be the full extent of review that could be conducted on these topics. Research and review was focused on the most recent literature available, with attempts to identify appropriate meta-studies (a comprehensive review of many studies) that have already been conducted.



One additional countermeasure, largely unexplored, suggests that better crossing solutions may be accomplished through intentional and unintentional interactions between pedestrians and drivers. Without necessarily being aware that they are doing so, pedestrians and drivers in road-crossing scenarios often look to each other for vital information. Drivers, for instance, are more likely to yield to pedestrians when they are approaching slowly; when pedestrians make eye contact with or gesture to drivers; when pedestrians stand 0.5 meters or less from the roadway; when pedestrians cross in groups; when the crossing is at least 10 meters away; and when traffic volumes are low.

Pedestrians look for two major cues to decide whether or not they can cross safely: vehicle speed, as already indicated, and vehicle distance. Pedestrians at unsignalized crossings must gauge these two factors, calculate the risks, and then move to cross as quickly as possible when opportunities arise. The cognitive skills involved in this operation are not evenly spread across the pedestrian population. Young children, older adults, and impaired pedestrians are less adept at estimating vehicle speeds and distance, and they are also less able to move quickly across the road to take advantage of gap opportunities. Female pedestrians perceive greater levels of risk involved in road-crossing and consequently take less risk when calculating crossing gap opportunities.

Studies analyzing the behavioral and linguistic gestures that pedestrians and drivers use to communicate with each other offer useful insights to planners, researchers, and pedestrians. Apart from vehicle speeds and distance, pedestrians also focus on factors like whether they can make eye contact with drivers; vehicle slowing or accelerating; vehicle volumes; and environmental conditions around the crossing location. Indicators of heightened risk to pedestrians include greater vehicle volumes; signs of driver speeding or distraction; a lack of traffic signs or signals; drivers who slow to allow a crossing but fail to fully stop; legal vehicle turns into the crosswalk; inadequate medians or pedestrian islands; poor views of approaching vehicles; bicyclists in the crosswalk; and vehicles passing too close to crossing pedestrians. Pedestrians report attempting to communicate their crossing intentions to drivers by making eye contact with them or by waving at them or by turning their gaze from eye contact with a driver to look purposefully across the street. Pedestrians also reported mouthing "thank you" and waving or smiling at drivers who allowed them to cross, and many of them reported that drivers communicated with them by flashing their headlights, nodding their heads, or by waving pedestrians across the road.

Finally, it is worth mentioning that pedestrian-driver observations gathered by the Washington Traffic Safety Commission (WTSC) showed that drivers are much more likely to yield when pedestrians made eye contact with them, when pedestrians step purposefully from the curb (but not into the traffic stream), and when pedestrians indicate their desire to cross with various hand gestures. If pedestrians in Washington were to cue drivers more frequently, and drivers became more used to acknowledging them, then pedestrian-driver conflicts and crashes could decrease significantly. This approach is certainly worth further exploration.

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Reference Summaries:

Ashmead D.H., Guth D., Wall R.S., Long R.G., and Ponchillia P.E. (2005). **Street crossing by sighted and blind pedestrians at a modern roundabout.** *Journal of Transportation Engineering*. 131: 812-821.

https://s3.amazonaws.com/academia.edu.documents/43430063/Street_Crossing_by_Sighted_and_Blind_Ped20160306-26568-1o1qa6j.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1529355057&Signature=CD%2FNFFllCxoADhN1BIlux1mo7iw%3D&response-content-disposition=inline%3B%20filename%3DStreet_Crossing_by_Sighted_and_Blind_Ped.pdf

This study used six sighted and six blind pedestrians to study pedestrian crossing opportunities, achieved and missed, at a two-lane urban roundabout in Nashville, Tennessee. Study results showed that blind pedestrians missed many more crossing opportunities than sighted pedestrians, waited about three times longer to cross than sighted pedestrians, and also engaged in more dangerous crossings, some of which necessitated intervention by observers to avert likely crashes. Drivers were found to be more willing to yield to pedestrians while driving into a roundabout than when exiting from it, possibly because they were slowing down to enter the roundabout.

Holland C. & Hill R. (2007). **The effect of age, gender and driver status on pedestrians' intentions to cross the road in risky situations.** *Accident Analysis and Prevention*. 39: 224-237.

<https://pdfs.semanticscholar.org/6a74/efe60a05427d6de40e10e406adf42ca1b61b.pdf>

Based on the theory of planned behavior, the authors of this article designed a questionnaire using demographic and traffic-user type differences to examine the relationship between perceived risk, and intention to cross the roadway. Several pedestrian crossing scenarios were presented to 293 subjects. The intentions and attitudes of participants were probed with questions such as, "How likely is it that you would cross the road as described in the situation?" and statements like "Crossing the road in this way would get me to my destination more quickly." The subjects responded to such prompts with choices on a seven-point Likert scale. The results showed a significant interaction between gender and age, with middle-aged women evaluating crossing scenarios as riskier than their male counterparts. In addition, middle-aged women were more willing to defer crossing in order to manage the risks they perceived. Overall, women generally perceived higher levels of potential risk than men, and so were more willing to wait for a safer opportunity to attempt a road-crossing.

Hyden C. & Varelyi A. (2000). **The effects on safety, time consumption and environment of large scale use of roundabouts in an urban area: a case study.** *Accident Analysis and Prevention*. 32: 11-23.

https://s3.amazonaws.com/academia.edu.documents/44976604/The_effects_on_safety_time_consumption_a20160421-7113-a8c0rn.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1536263519&Signature=76PrWnglsINJDdf1aeePOvBbQcE%3D&response-content-disposition=inline%3B%20filename%3DThe_effects_on_safety_time_consumption_a.pdf

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This study examined pedestrian crashes in a mid-sized Swedish city at signalized intersections before and after their conversion to roundabouts. Before this project, the city conducted a comprehensive inventory of city streets, intersections, and other environmental features (e.g., schools and land-use patterns), as well as traffic counts, crashes, and conflicts. The authors conducted speed measurements to obtain 100-car samples at all conversion locations before, during, and after the project was finished. Crash reports and data were obtained from the National Health and insurance companies, and crash survivors as well as non-crash-involved drivers and nonmotorists, including school children, were interviewed as part of the project. A pre-post analysis was conducted of crashes and conflicts at treatment and control sites, and results showed that average vehicle speeds were significantly reduced at roundabouts (presumably owing to the angular deflection forced upon drivers by the new configuration) so that “speeding at these junctions was practically eliminated” (15). Crash risk at the treatment sites was reduced by approximately 44 percent in the post-treatment period.

Jacobsen P.L., Racioppi F., & Rutter H. (2009). **Who owns the roads? How motorised traffic discourages walking and bicycling.** *Injury Prevention*. 15: 369-373.

https://www.researchgate.net/profile/Harry_Rutter/publication/40446727_Who_owns_the_roads_How_motorised_traffic_discourages_walking_and_cycling/links/0fcfd50d481ee8e1f8000000.pdf

This review article briefly summarizes research literature pertaining to the negative impacts of motor vehicle traffic on walking and bicycling in urban areas of the U.S. and Europe. The authors observe that, while vehicle volumes and speeds on public roads have both increased enormously over time, the amount of walking and biking in many countries has decreased steadily over several generations. For example, several studies have reported that children are far less likely to walk or bike to school now compared to forty or fifty years ago. Pedestrians and bicyclists avoid traveling along roads in urban areas for various reasons, including the injury risks they face from motor vehicles, not to mention the delays and inconveniences that vehicle congestion breeds. Walking and bicycling are enhanced by the presence of marked crosswalks, sidewalks, two-lane (versus four-lane) roads, the prevalence of other nonmotorists (the “safety in numbers effect”), and other factors.

Retting R.A., Ferguson S.A., and McCartt A.T. (2003). **A review of evidence-based traffic engineering measures designed to reduce pedestrian-motor vehicle crashes.** *American Journal of Public Health*. 93: 1456-1463. <https://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.93.9.1456>

This is a succinct review of the effectiveness of various engineering approaches to improving the safety of pedestrians in traffic, especially solutions that enhance the crossing ability of pedestrians as well. The authors focused on four types of countermeasures: those meant to control vehicle speeds, those meant to separate pedestrians from vehicles temporally, those meant to separate pedestrians from vehicles spatially, and those intended to increase the conspicuity of pedestrians.

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Installing roundabouts, replacing traffic signals at intersections with multiway stop signs, and traffic-calming roadway designs were all found to be highly effective for reducing vehicle speeds as well as pedestrian crashes. Among measures meant to separate pedestrians temporally from vehicles, exclusive pedestrian signal-phases, automatic pedestrian-detection devices, in-pavement flashing lights, pedestrian prompting signals, and early-release signals were all found (with variable levels of success) to be effective for reducing vehicle-pedestrian conflicts. For spatial separation of pedestrians and vehicles, sidewalks, pedestrian overpasses, pedestrian barriers and fences, advance stop-lines, and refuge islands or raised medians were all found to reduce pedestrian-vehicle crashes. Finally, measures found to successfully increase pedestrian conspicuity included increasing the intensity of roadway lighting, relocating bus stops, and installing diagonal parking designs.

Richards D.C. (2010). **Relationship between speed and risk of fatal injury: pedestrians and car occupants.** London: Department for Transport, Road Safety Web Publication No. 16.
https://brage.bibsys.no/xmlui/bitstream/handle/11250/192781/relationship_between_speed_and_risk.pdf?sequence=1

This study reviews three previously-published estimates of fatality risk according to striking-vehicle speed: one from cases in 1976, one with cases from 1999 through 2007, and one with cases from 2000 through 2009. After cleaning and ‘normalizing’ these pedestrian crash datasets to remove obvious inappropriate cases (such as pedestrians who had been struck and killed while lying in the road), data from each was analyzed using logistic regression to further control for confounding variables. The results revealed a clear decrease in fatality risk across time, suggesting that design improvements to front bumpers and other vehicle features reduced the level of trauma severity for pedestrians struck at given vehicle speeds, thereby improving their chances for survival. Adjusted analysis of the 1976 data showed that pedestrians struck by vehicles traveling 30 MPH incurred a 14% probability of dying as a result, while those who were struck by vehicles traveling at 40 MPH incurred a 60% risk of dying. Corresponding risk estimates for the 1999-2007 data were 7% at 30 MPH and 25% at 40 MPH, and estimates for the 2000-2009 data were 9% at 30 MPH and 33% at 40 MPH.

Salzberg P.M., Moffat J.M., and Doane R.B. (2000). Unpublished data from trials examining the effects of pedestrian behaviors on driver yielding behavior at marked crosswalks in Olympia, WA.

Results showed that when the subject pedestrian made eye contact with drivers, when pedestrians stepped from the curb into the crosswalk, and when pedestrians used several specific hand and arm gestures, and particularly when all cues were combined, drivers were significantly more likely to yield to pedestrians crossing the roadway.

Salzberg P.M. & Moffat J.M. (2003). **Evaluation of “Targeted Pedestrian Enforcement”** (Agency Report). Olympia, WA: Traffic Research & Data Center, Washington Traffic Safety Commission (WTSC).

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This study used a pedestrian decoy to test whether (and under what conditions) drivers would yield the right-of-way and enable safe crossing at marked crosswalks on urban streets with posted speeds of 25 MPH. Several treatment and control sites in Bellingham and Olympia were observed to establish baseline driver compliance rates, which were 40 percent in Bellingham and 26 percent in Olympia. Bellingham treatment sites received intensive enforcement of the crosswalk law, which requires that vehicle drivers “shall stop and remain stopped to allow a pedestrian or bicycle to cross the roadway” except when the vehicle “is so close that it is impossible for the driver to stop.” The study presented public messaging in advance of the intensive enforcement campaign, and measured compliance at intervals during the public education and enforcement periods. The authors concluded that driver compliance at treatment sites in Bellingham increased to 63 percent during the enforcement campaign, and rose to 74 percent in the week after enforcement ended. The study also found mild spillover effects in Bellingham, likely from the public messaging, but not in Olympia, where messaging was not broadcast.

Sucha M. (2014). **Road users’ strategies and communication: driver-pedestrian interaction.** *Transport Research Arena (TRA) 2014 Proceedings*. Paris, France: April 14-17.
http://www.ictct.org/migrated_2014/ictct_document_nr_1039_Sucha.pdf

This paper aimed to describe pedestrian and driver behaviors at several marked road-crossing locations, to discover strategies unique to each group and those common to both drivers and pedestrians, and identify communications between pedestrians and in order to identify pedestrian, driver, and road-design factors predictive of crashes. Instead of merely analyzing data related to pedestrian-driver crashes, the author decided to record near-miss incidents with a video camera, to conduct focus groups with pedestrians and drivers, and to conduct on-site interviews with some of the pedestrians involved in these events, specifically in order to discover their road-crossing strategies. Two hundred such interviews were completed, from which selected follow-up interviews were conducted. Results of focus groups and interviews revealed that both drivers and pedestrians regularly communicated with each other, pedestrians with eye contact, hand waves, and other gestures, and drivers with light-flashings and hand-waves. The results also showed that pedestrians routinely focus on vehicle speed and distance (gap), speed changes (acceleration or deceleration), eye contact with drivers, and vehicle density. Drivers, on the other hand, see risk in the form of running or jaywalking pedestrians, sudden pedestrian movements, and pedestrians paying little or no attention to vehicles in the road. Results showed that drivers were much more likely to yield to pedestrians who were younger or older, when police were present, when crossings were signalized, and when pedestrians were already crossing and at a distance from the vehicle.

Sucha M., Dostal D., & Risser R. (2017). **Pedestrian-driver communication and decision strategies at marked crossings.** *Accident Analysis and Prevention*. 102: 41-50.
https://www.researchgate.net/profile/Matus_Sucha/publication/314244113_Pedestrian-driver_communication_and_decision_strategies_at_marked_crossings/links/58f23589a6fdcc11e569eb56/Pedestrian-driver-communication-and-decision-strategies-at-marked-crossings.pdf

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This study observed and analyzed pedestrian-driver encounters and behavioral strategies at marked but unsignalized road crossings in urban areas of the Czech Republic. More specifically, the authors filmed pedestrian-driver interactions and recorded other behaviors and environmental factors in order to understand what leads to driver decisions to yield the right-of-way to pedestrians. The study builds on several theoretical concepts. The fundamental one holds that traffic users act mainly according to what they expect other road users to do. Another concept is that such expectancies are based on both formal and informal traffic rules, as well as current prevalent patterns of road user behavior. Of course, when a driver expects that the pedestrian waiting to cross will simply yield in the interest of safety (an informal rule), and the pedestrian expects that the driver will slow and stop to allow the pedestrian to cross (formal and legal rule), then a potentially fatal traffic conflict is more likely to emerge. Results of their observations showed that drivers were more likely to yield when pedestrians were within 0.5 meters of the road; when multiple pedestrians were present; when drivers slowed as they approached the crosswalk; when pedestrians moved toward or even into the roadway; when they gestured to drivers with hands or facial expressions; when the approaching vehicle was further away; and when pedestrians waited less than five seconds before starting to cross.

Van Houten R. & Malenfant L. (2004). **Effects of a driver enforcement program on yielding to pedestrians.** *Journal of Applied Behavior Analysis*. 37: 351-363.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1284509/pdf/15529891.pdf>

In this article the authors describe an enforcement project in Miami which aimed to increase vehicle driver compliance with Florida laws requiring them to yield to pedestrians at eight marked and unmarked crosswalks, four in the west corridor and four in the east corridor. Sites were selected for treatment only if they had histories of high-volume pedestrian traffic and recent pedestrian crashes. Baseline driver compliance rates in the two treatment corridors ranged from 3.3 percent of drivers at west-corridor sites to 18.2 percent of drivers at east-corridor sites. During the intensive enforcement period these rates increased to 27.6 and 33.1 percent, respectively. In the one-year follow-up period, during which police mounted brief enforcement operations every six weeks, driver compliance rates at treatment sites increased to 27.8 percent in the west corridor and 34.1 percent in the east.

Várhelyi A. (1998). **Drivers' speed behaviour at a zebra crossing: a case study.** *Accident Analysis and Prevention*. 30: 731-743.

<https://www.sciencedirect.com/science/article/abs/pii/S0001457598000268>

This study showed that only five percent of drivers yielded to a pedestrian attempting to cross a two-lane road at a non-signalized mid-block "zebra crossing" in Lund, Sweden – in violation of traffic laws. Not only did the vast majority of drivers fail stop as required by law, but three-fourths either maintained or increased approach speeds well above the posted speed limit. Many appeared to speed up in response to seeing pedestrians attempting to cross, presumably in order to force the

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pedestrians to yield. The study further showed that drivers who are less than 50 meters from the crosswalk were least likely to yield. The author also developed a sophisticated theoretical social-interactive model to explain his findings.

Zegeer C.V., Stewart J.R., Huang H.H., Lagerwey P.A., Feaganes J., & Campbell (2005). **Safety effects of marked versus unmarked crosswalks at uncontrolled locations**. Publication Number HRT-04-100. McLean, VA: Office of Research and Development, Federal Highway Administration.
<https://www.fhwa.dot.gov/publications/research/safety/04100/04100.pdf>

The authors of this report begin with the following premise: “Pedestrians are legitimate users of the transportation system, and they should, therefore, be able to use this system safely and without unreasonable delay.... Pedestrians have a right to cross roads safely, and planners and engineers have a professional responsibility to plan, design, and install safe and convenient crossing facilities” (1). The report describes a series of evaluation studies of driver and pedestrian behaviors at marked and unmarked crosswalks (1,000 of each) in 30 cities across the U.S. Each of the marked (treatment) crossing sites was matched for comparison with a nearby unmarked but frequently used mid-block crossing location. None of the sites were controlled, and almost none had special markings or supplemental pedestrian warning signs. Prior to starting data collection, researchers gathered detailed information for each of the 2,000 sites, including pedestrian crash history, daily pedestrian and vehicle volumes, number of lanes, posted speed, area type, midblock or intersection, median type (if present), crosswalk marking patterns, and other site data. None of the sites featured traffic-calming or other special measures (e.g., pedestrian-initiated flashing lights). Results of the study showed that pedestrian crossings with raised medians were safer, that marked crosswalks on two-lane roads were no safer than unmarked ones, that on high-volume, multi-lane arterials marked crossings showed higher pedestrian crash rates than unmarked ones. In fact, they appeared to draw particularly high-risk pedestrians to them (e.g., over age 65), thereby increasing fatality rates.

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