Effectiveness of Non-Engineering Road Safety Countermeasures

prepared for
Maricopa Association of Governments

MARICOPA ASSOCIATION of GOVERNMENTS

prepared by
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CAMBRIDGE SYSTEMATICS

ON THE ROAD SAFETY BEGINS HERE

January 31, 2012

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1.0 Introduction

This is the final report for a study performed by the Maricopa Association of Governments (MAG) to identify the effectiveness of non-engineering road safety countermeasures. The study also identified strategies for implementing regional road safety initiatives that would utilize non-engineering road safety countermeasures to reduce the number and severity of bicycle, pedestrian, and intersection crashes.

MAG has in place a successful regional collaborative process with its Transportation Safety Committee (TSC). Historically this committee has focused on developing and implementing engineering safety countermeasures. As this committee, program, and process has matured, it has become possible for the committee to consider also becoming a forum to plan for and implement a non-engineering road safety countermeasure program at the regional level.

Currently there is no funding for such a program; however MAG could begin planning for and cultivating the support for funding. Ideas for the type of funding that might be available to MAG are discussed later in this plan. However, the intention is that TSC work toward implementing non-engineering road safety countermeasures at the regional and potentially municipal level to address bicycle, pedestrian, and intersection crashes.

Measurement of the impacts of each of these strategies is an important facet of the program. Given the limited data on effectiveness of some strategies, it is advisable to incorporate an evaluation program to determine the effectiveness of MAG safety efforts that are implemented in the future. This will also enable MAG to contribute to building industry knowledge about effective countermeasures. Section 2.0 provides a summary of regional safety data, which guides selection of countermeasures. Section 3.0 presents the recommended strategies along with recommended process and performance measures so progress can be evaluated.

The "pillars" of the overall approach to transportation safety are the 4 E's: education, enforcement, engineering, and emergency response. This effort has been defined to focus on non-engineering road safety countermeasures. While emergency response is an important aspect of the 4 E's of safety, this report focuses on developing a plan for education and enforcement countermeasures for the TSC to pursue at this time.

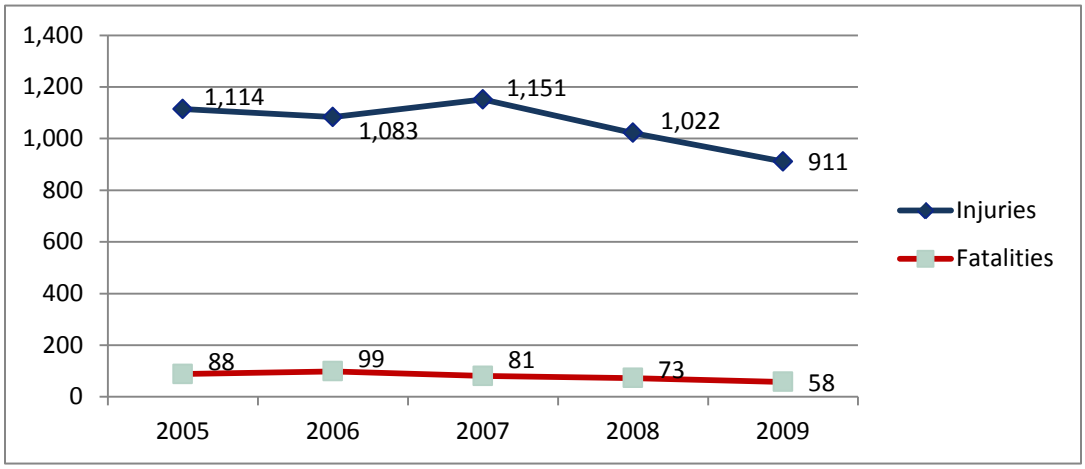
2.0 Data Overview

The plan addresses strategies to reduce pedestrian, bicycle, and intersection-related crashes, which were identified by MAG as key safety areas needing focus in the region. This section provides an overview of the safety data evaluation and summary of the critical issue areas related to pedestrian bicycle and intersection crashes. It further summarizes the types of issues that can be addressed at a regional level.

2.1 PEDESTRIAN CRASHES

Pedestrian crashes in the MAG region have declined from 2005 to 2009 (2009 is the most recent year for which data is available); however, there are still a significant number of deaths and injuries in the region as shown in Figure 2.1. While many drivers involved in pedestrian crashes were not reported as having made a violation, a significant number did violate the rules of the road. The largest categories of violations were failure to yield right-of-way, distraction, and speeding. These are target areas where education and enforcement to change driver behavior can be focused. The data also reveal that most pedestrians were hit while crossing the road and that for pedestrians, being in a crosswalk is not a guarantee of safety. Given the rates of failure to yield and speeding, pedestrians need to proceed with caution, and need to ensure they are crossing the street only when it is safe to do so. While fatalities among children are low, the high occurrence of pedestrian injuries among teens age 15 to 19 shows that this age group may need specific attention. The vast majority of fatalities, however, involved adults. Please see Appendix B for Technical Memorandum 2 with more detailed analysis of the MAG safety data.

Figure 2.1 Pedestrian Injuries and Fatalities in MAG Region
2005-2009



Source: MAG.

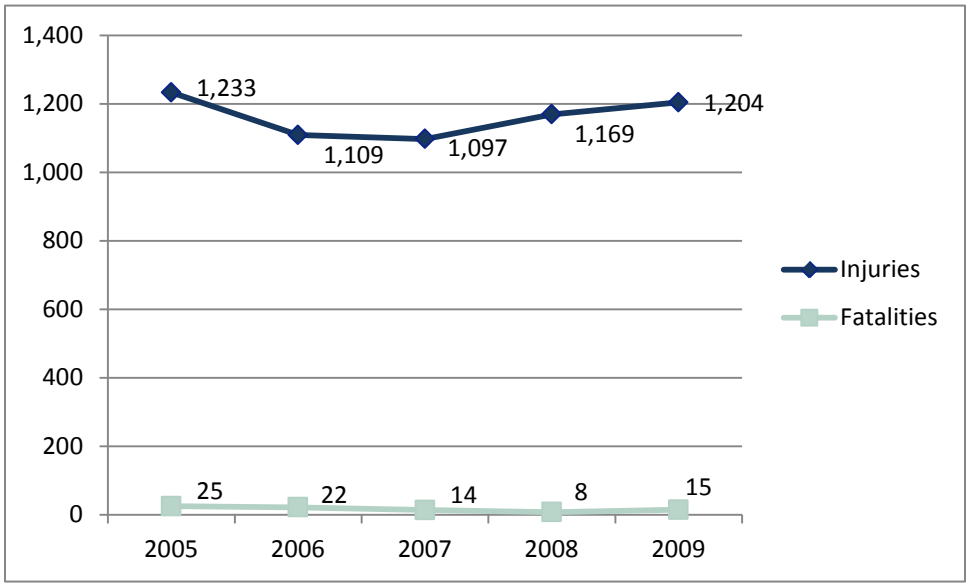
2.2 BICYCLE CRASHES

As shown in Figure 2.2, bicycle fatalities and injuries have fluctuated over the past five years. While fatalities had steadily decreased from 2005 to 2008 (Figure 3.1), the number increased to 15 in 2009. Bicyclist injuries declined in 2006 and 2007 but have since increased to nearly the levels of injuries experienced in 2005. This is likely at least partially related to increased exposure. The usage of bicycles for transportation based on bicycles carried on buses and light rail transit (LRT) shows an increase of 59 percent from 2008 to 2011[1]. The greater Phoenix LRT system opened in December 2008.

Bicycle safety data shows that both driver and bicyclist violations are components of the problem. Distraction and failure to yield are the top two reported driver violations. Additionally, bicyclists are frequently hit by vehicles while in a marked crosswalk. Therefore, vehicles yielding to bicycles in crosswalks would be a target for enforcement and education, as well driver distraction. Most bicycle crashes are near intersections, and many are at driveways, so these are key locations for improving safety. Given the number of crashes in the late afternoon and early evening, bicyclist visibility may be an area for improvement.

[1] LRT ridership numbers are from MetroRail. The observed 59 percent increase in bikes on transit is from MAG analysis.

Figure 2.2 Bicyclist Injuries and Fatalities
2005-2009

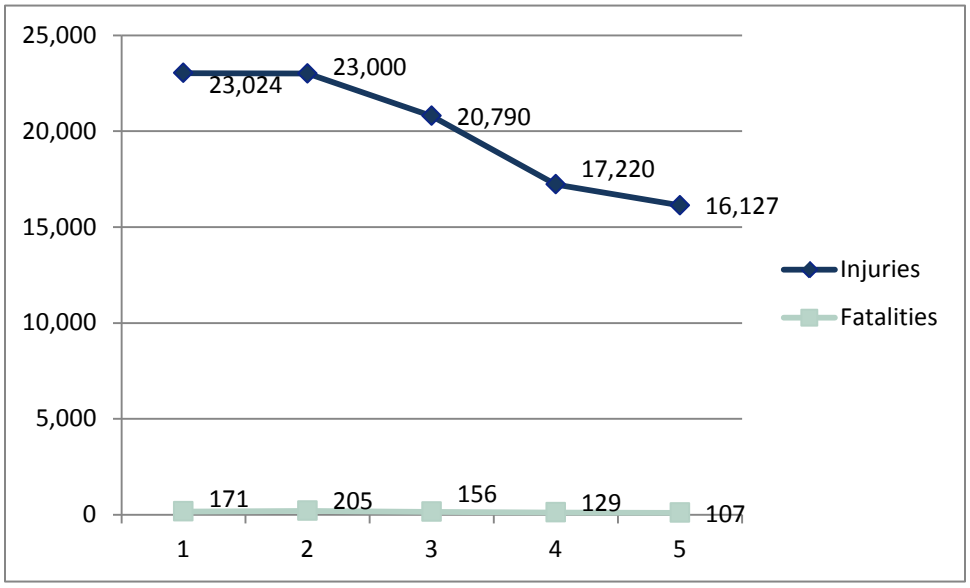


Source: MAG.

2.3 INTERSECTION-RELATED CRASHES

Injuries and fatalities due to intersection-related crashes have declined significantly from 2005 to 2009, as shown in Figure 2.3. However these types of crashes still represent a large proportion of the roadway safety problem. Intersection crashes are those that involve a motor vehicle in the vicinity of an intersection, and would include crashes involving a vehicle and pedestrian or bicyclist. Most intersection crashes are rear-end crashes, which often involve speed and distraction/inattention. However right-angle and opposite-angle crashes also represent a significant proportion of the total. Speed and distraction are top driver violations, so these are key issues to be addressed. Intersection crashes are highest among drivers ages 20 to 24, which is reflective of driver inexperience.

Figure 2.3 Intersection-Related Injuries and Fatalities
2005-2009



Source: MAG.

Table 2.1 provides a summary of key issues in the region related to these three emphasis areas.

Table 2.1 Key Regional Safety Issues

Pedestrian Issues	
Driver behavior in yielding right-of-way	Pedestrian behavior crossing street
Driver speed and distraction	Teenage and adult pedestrian safety
Bicyclist Issues	
Driver and bicyclist behavior in sharing the road	Bicyclist visibility
Driver behavior yielding to cyclists in crosswalks	Bicyclist and driver education about safely sharing the road when traveling through intersections
Driver speed and distraction	
Intersection-Related Issues	
Driver speed and distraction	Intersection crashes among young drivers

3.0 Plan

In early phases of the project a literature review was conducted to identify the array of countermeasures available (please see Technical Memorandum 1 in Appendix A) and that could subsequently address the issues under consideration by the MAG TSC. The TSC is focused on implementing countermeasures that have demonstrated effectiveness to ensure cost-effective investment. Among education and enforcement strategies, data are limited about effectiveness, especially as compared to engineering countermeasures. Typically, there are three categories of information about effectiveness: there may be quantitative measures of effectiveness, measures defined as "proven," or measures defined as "tried." Strategies with quantitative results have a crash reduction factor (CRF) or a percentage reduction in a type of crashes that can be expected from implementation. Proven strategies without a CRF are those that have resulted in definitive benefits; however, these may not be direct crash reduction results. For example, a helmet education program may have resulted in observation of more bicyclists wearing helmets or an education program may result in increased knowledge. Programs that have been tried are those that have been implemented and that seem to hold promise but for which definitive results are not available.

While the goal is to focus efforts on those strategies known to be effective, given the limited data on many strategies, it may be necessary to undertake countermeasures that have only been tried, or that logically address the identified safety needs. As possible, evaluation should be incorporated into implementation of strategies to inform MAG about what is working and should be replicated, as well as to add to the body of knowledge about effectiveness.

3.1 EDUCATION

Pedestrian

Awareness Campaign on Pedestrian Safety

An awareness campaign educating drivers about pedestrian safety and the need for increased attention could be an effective way to reduce pedestrian crashes. Several large metropolitan areas have undertaken such campaigns. For example, in Chicago, a multifaceted awareness campaign in the fall of 2011 involved public service announcements placed along the street at intersections where they are visible to drivers as shown in Figure 3.1. Additionally the campaign used mannequins dressed in t-shirts stating the number of pedestrians killed each year, as shown in Figure 3.2, which are designed to reach transit users who walk to and from stations. This type of campaign is designed to be hard-hitting, so that the public will take the issue seriously and change their behavior.

Figure 3.1 Pedestrian Safety Campaign Public Service Announcement

Figure 3.2 Chicago Public Awareness Campaign Mannequins

Other regions such as Metropolitan Washington, D.C. have used educational campaigns as well. The Street Smart campaign uses creative radio and television advertising in English and Spanish to reach drivers, pedestrians, and cyclists, while targeting them through outdoor and transit advertising on bus shelters and the sides of buses. In addition, law enforcement and local, county, and state agencies distribute handouts and tip cards to further spread awareness and educate drivers and pedestrians. Advertising conveys simple messages such as "Stop for Pedestrians" and "Cross Streets Carefully," while media events help publicize enforcement. A strong focus of the campaign is to reach the area's Hispanic residents through Spanish-language brochures and advertising outreach.[2]

School Pedestrian Safety Training

The rise of childhood obesity coupled with the growing number of advocacy groups for increased walking and bicycling could result in an increase in child pedestrian fatalities if children are not properly educated to safely negotiate traffic (NHTSA, 2009). There is general agreement among traffic safety professionals that children under the age of 10 should not cross traffic alone; however, research has shown that parents believe children as young as 7.6 years are old enough to cross a street (MacGregor, Smiley, and Dunk, 1999). While high numbers of crashes among young children did not show up in the data analysis, a youth program may be worth considering with the goal of developing lifelong safety behaviors.

Pedestrian safety training in schools has been proven effective at increasing knowledge among youth. Generally, effective programs include classroom and practical education. The MAG communities may wish to use a program that has already been developed and is proven effective or to develop their own programs. Figure 3.3 shows and example of educational materials developed by the City of Phoenix.

The Phoenix Children's Hospital provides education programming via its Street Survival: Hip Hop to Safety™ program to community groups and schools by emphasizing what families can do to make walking safer in their neighborhoods[3]

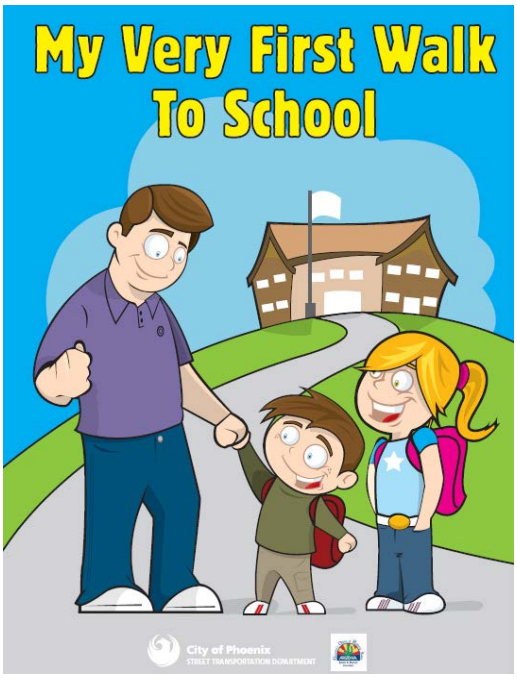
In Florida, a comprehensive program called WalkSafe was developed. This program involves classroom safety education in schools, enforcement and evaluation. In Miami-Dade County, the program led to a 41 percent decrease in pedestrian injuries among youth age 14 and under from 2001 to 2006. MAG communities may wish to implement the WalkSafe program, which is available at no cost. They could also adapt materials from other programs or develop their own edu-

[2] www.bestreetsmart.net.

[3] http://www.phoenixchildrens.com/community/injury-prevention-center/be-a-safe-walker.html.

cational strategies following the latest research on the types of programs effective at improving the safety of children's behavior near roads.

Figure 3.3 Pedestrian Safety Collaterals Targeting Children



Training can also cover specific aspects related to pedestrian safety that are particular concerns in the MAG region, such as youth darting in front of transit buses. This same issue was faced in Toledo, Ohio, where stakeholders developed a 15-minute safety video to be shown to schoolchildren. The video is shown annually to 4th and 5th graders. Children also receive brochures, handouts, and buttons bearing the same message, "Let the Bus Go, Then You Go." and interior advertising in buses displays a consistent message (Pedestrian and Bicycle Information Center, 2010).

Pedestrian Safety Zones

The objective of pedestrian safety zones is to increase efficiency by targeting limited resources to geographic areas and audiences where significant portions of the pedestrian crash problem exist (NHTSA, 2008). Pedestrian zone programs, including education, enforcement, and engineering measures, can target a full range of pedestrian crash problems within a limited geographic area or focus on particular types of problems that make up a large portion of the problem within a limited area. As the goal of this program is non-engineering countermeasures, the pedestrian safety zone strategy could be undertaken in key zones without engineering countermeasures or to boost the effectiveness of engineering improvements that have already been made.

Blomberg and Cleven (1998) implemented and analyzed an early pedestrian safety zone program in Phoenix, Arizona. Crash data were analyzed to identify areas where older pedestrian crashes occurred and "zones" were drawn around the high-incidence areas. Countermeasures were developed for the kinds of crashes that involved older pedestrians. The measures included signal timing changes, provisions for communication and outreach for both drivers and pedestrians living near the crash zones, and enhanced enforcement. The result was a significant reduction in crashes and injuries to older pedestrians in the target areas.

MAG municipalities can identify locations for increased education and enforcement in areas with large numbers of pedestrian crashes. Data analysis will help communities to define specific locations to target. These might be areas with high levels of teenage pedestrian activity, such as downtown areas and university districts.

MAG could produce materials for use by member jurisdictions to be distributed in pedestrian safety zones, such as flyers or posters. Materials directed at pedestrians should encourage them to cross streets with extra care. Local law enforcement should complement the education with increased enforcement of driver violations such as not yielding to pedestrians. Police should be encouraged to issue citations to reinforce the severity of violations that can result in pedestrian injury or death. Law enforcement could distribute materials to educate drivers at each traffic stop.

Bicycle

Awareness Campaign Targeting Drivers about Bicycle Safety (Share the Road)

The purpose of Share the Road programs is to increase drivers' awareness of bicyclists, as well as improve both bicyclist and driver compliance with relevant traffic laws. Poor behavior on the part of motorists can be due to ignorance of cyclists' needs, or a response to unexpected cyclist behavior. In many cases motorists do not have any experience cycling and therefore may not understand the situations that confront bicyclists in traffic.[4]

The Pima County-Tucson Bicycle and Pedestrian Safety and Education Program was designed to reduce roadway crashes and injuries among pedestrians and bicyclists, increase awareness of the responsibilities of pedestrians, bicyclists and motorists, and promote tolerance among all roadway users. The intent is to promote an overall "share the road" ethic within the community. This program includes television and radio public service announcements (PSAs) promoting pedestrian and bicyclist safety, educational videos for police training and for student safety classes, traffic safety guides and maps, posters, helmets, front and

[4] www.bicyclinginfo.org/ee/ed_motorist.htm.

rear bicycle light kits, and free cycling safety classes for the public. The program also entails close coordination with police and safety educators. Safety messages address motorist failure to yield to bicyclists and pedestrians, wrong-way bicycle riding, helmet use, use of bike lights at night, running stop signs and red lights by motorists and bicyclists, speeding, and other issues (Pedestrian and Bicycle Information Center 2010).

The Tucson initiative is focused on both bicyclists and pedestrians and includes a range of education and enforcement efforts. The Tucson effort could provide a model for the MAG region to develop an initiative that targets both groups. Additionally given that materials have been developed for an Arizona community MAG may be able to draw upon or adapt these materials. The Tucson program officially got underway in 2005 with Transportation Enhancement funding.

Education about Bicycle Helmet Use

The purpose of bicycle helmet promotions is to increase use of helmets and thereby decrease the number of severe injuries and fatalities to bicyclists involved in crashes. A future phase of data analysis can be to evaluate the number of bicycle injury and fatal crashes involving lack of helmets to verify that this is an area of need; this data was not available for this study. Bicycle helmet promotions are frequent, but are usually aimed only at child bicyclists, often through youth health organizations and schools. Promotions can target various barriers to helmet use, including lack of a helmet, lack of understanding of the importance of helmet use, and negative attitudes or beliefs about helmet use. Programs that provide helmets can include sponsoring organizations and often involve law enforcement and schools to deliver helmets and teach their proper use. Promotions can be conducted through single events or extended campaigns to promote helmet distribution and use. Expanding helmet promotions to include adults requires an expansion in focus, and perhaps different sponsors (GHSA, 2011). Bicycle helmet use can also be promoted via bicycle skill training courses as describe below.

Education Promoting Bicyclist Safe Riding Practices, Including Bicyclist Conspicuity

Tucson offers a range of free bicycle safety courses, including those targeting commuters, women, and beginning riders.[5] The program has developed down-loadable posters available for display in public settings to promote course participation by a wide range of riders. As part of each course riders receive free bike safety items, such as helmets and bicycle lights. Several train-the-trainers courses have been held for bicycle safety instructors, and the region now has a large number of League of American Bicyclists League Certified Instructors.

[5] http://bikeped.pima.gov/allsafetyclasses.html.

Given the large Hispanic population in the MAG region, stakeholders may wish to provide bicycle training in Spanish. For example, Amarillo, Texas has conducted bicycle instruction in Spanish for children (Pedestrian and Bicycle Information Center 2010); however, bicycle safety instruction could also be provided in Spanish to non-English-speaking adults who are often coming from another culture and may not be familiar with traffic laws governing bicyclists.

Intersections

Education about Yielding to Pedestrians in Crosswalks – State Law

The State of Arizona requires that vehicles yield to pedestrians in crosswalks. Yet all too often when vehicles are making a turn they try to get through the intersection before pedestrians walk fully into the crosswalk, sometimes at fairly high speeds. While Arizona does not require drivers to fully stop for pedestrians in crosswalks as is the case in some states (e.g., Massachusetts and Illinois), vehicles do need to yield. Drivers need to be reminded that pedestrians need to be provided a safe buffer area when crossing a street. These messages should be incorporated in to any education program targeting drivers. An education program about the driver's role with respect to pedestrians crossing the roadway will be most effective if increased enforcement to reinforce the importance of this safety behavior and the real impact on safety.

Distracted Road Users

Education about Hand-Held Cell Phone Use and Texting While Driving

The safety data show that distraction played a significant role in crashes at intersections as well as in crashes involving pedestrians and bicyclists. Use of a device while driving is a personal decision. Communications must make clear the risks involved when using a device and how it could play a role in distraction that results in a crash. When no laws are in place to prevent cell phone use or texting, communications about the issue are a bit more challenging, as there is no law to reference and enforcement cannot be used to complement the effort.

Nevertheless there are good existing materials that can be adapted such as pledges not to use a phone while driving and materials that highlight why the risk is just not worth the convenience. The Network of Employers for Traffic Safety has developed a campaign of materials focusing on distraction for its Drive Safely Work Week program. These materials can be adapted and can be used in an outreach campaign to employers, as was done in Cheyenne, Wyoming (Figure 3.4).[6]

[6] http://www.plancheyenne.org/Distracted%20Driving%20Campaign.html.

Figure 3.4 Distracted Driving Education Message

Funding

Several potential options exist for funding of educational efforts. Of the Arizona allocation of Federal Highway Safety Improvement Program (HSIP) funds, 10 percent can be "flexed" for use on non-engineering safety countermeasures. Currently, 20 percent of state HSIP funds are divided between MPOs and COGs in the State. MAG receives $1 million annually for engineering countermeasures, which has funded ongoing TSC engineering safety efforts. While MAG has not received flex funds to date, this is a potential area of opportunity.

MAG could pursue grant funding from the Governor's Office for Highway Safety for regional-level education activities.

Each state received Federal Transportation Enhancement (TE) dollars designated for non-motorized transportation. Typically communities write grant applications for the TE funding. This funding was used for the Tucson bicycle and pedestrian education campaign and could be a source for MAG.

MPO planning funds that support projects defined in the annual Unified Planning Work Program are also a potential source for educational safety efforts in the future. This is the planned funding source for future road safety audits (RSAs).

3.2 ENFORCEMENT

General

Regional Law Enforcement Summit

Police may not realize which types of crashes are contributing most to overall fatality and injury numbers. Often law enforcement does not have a clear understanding of the importance of crash data to the planning process for safety efforts. A regional safety summit targeting law enforcement would be an opportunity to communicate with officers who are in the field and dealing with safety on a daily basis. Data can be presented on key types of crashes and the extent of the safety problem. Police can be provided with data on locations of crashes to help inform their patrols. A safety summit can be a forum for leadership in law enforcement to communicate support "from the top" of enforcing specific types of violations such as those involving pedestrians and bicyclists.

Such an event can provide motivation to boost enforcement of crashes in specific emphasis areas by current law enforcement personnel. It can also provide a forum for officers to discuss barriers to enforcement and strategies to overcome such barriers. Materials can be developed to remind officers of key laws to enforce. Given that only a fraction of officers could attend a single summit event, the potential exists for developing an ongoing training program.

Crash forms do support bicycle related incidents but only when they involve a motor vehicle. Modification to the crash reporting system may be needed to better capture data on crashes involving bikes. The Arizona Department of Transportation (ADOT) Bicycle Safety Action Plan Working Paper 4 makes recommendations for improvements to the crash report form. [7]

Enhance Information on Pedestrian, Bicycle, and Intersection Safety in Police Academy Training

The only way to ensure that every law enforcement officer is conversant in pedestrian, bicycle, and intersection safety issues and law enforcement strategies is to include sufficient training on these topics in the police academy curriculum. Modification of the police training content will likely take significant effort and may be a longer-term strategy; however, the benefits will be significant. This strategy would involve an assessment of the current coverage of these issues, if any, and development of new or enhanced curriculum content. In Tucson, a police training video on bicycle and pedestrian legal issues and safety was developed (Pedestrian and Bicycle Information Center, 2010). Such information could be integrated into training at the police academy or integrated into the Summit or ongoing education discussed under the previous strategy.

Pedestrian

In certain areas of the country, drivers stop when pedestrians simply look like they are about to step off the curb into a crosswalk. In other regions, vehicles speed around pedestrians while they are in a crosswalk. Changing the driving culture in a region requires significant effort, and law enforcement is a key component. As noted under the education section, drivers must be reminded of the law that they must yield to pedestrians. To effectively change behavior, enforcement should complement this effort. Several regions have enacted "stings" where plainclothes police officers enter crosswalks and see if vehicles yield. Other members of the enforcement team are posted downstream from the site and issue citations to those who do not yield. Such efforts have been undertaken in Chicago[8] and other cities.

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[7] http://www.azdot.gov/mpd/systems_planning/PDF/BSAP/WP4.pdf, Section 2.6.

[8] http://www.cityofchicago.org/city/en/depts/cdot/provdrs/ped/svcs/crosswalk_enforcementinitiatives.html

Bicycle

Enforcement of Bicycle Buffer Law

In Arizona, the state law (ARS-28-735) requires a three-foot minimum buffer distance from cyclists by autos. However, this law has not been widely enforced in the MAG region. If an education campaign is conducted to raise awareness of this law, complementary enforcement should be undertaken. An enforcement campaign will likely need to be preceded by education of officers, potentially at a regional law enforcement summit. Enforcement of this law should be promoted by law enforcement leadership to ensure that it is clear officers are encouraged to conduct this type of enforcement. It also may be possible to bring in a speaker on this topic to the daily police "roll call" for a short briefing to raise awareness among law enforcement and encourage issuance of citations for this violation.

Intersections

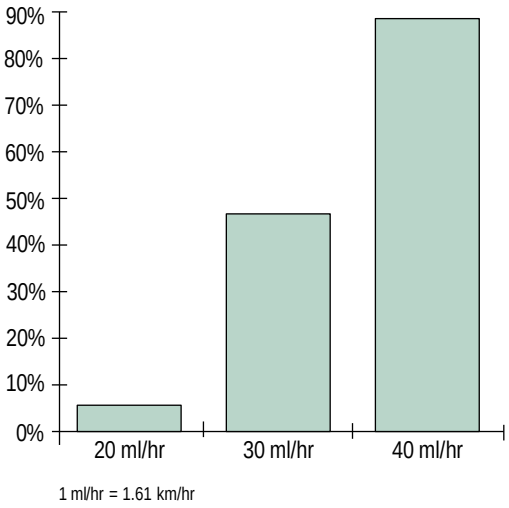
Traditional Red-Light Running and Stop Sign Enforcement

If police are made aware of the extent of injury occurring as a result of disobeying signals and signs at intersections, they may be willing to step up enforcement. Data analysis will be key to helping law enforcement target locations with the highest numbers of angle crashes, which are most likely to have been caused by this type of violation. To conduct enforcement at intersections, there will need to be a safe location where officers can wait in their vehicle and monitor traffic as well as a place to safety stop vehicles.

Traditional Speed Enforcement

Speed is directly related to crash severity. The higher speed the crash, the more likely it is that injuries are severe. When it comes to pedestrian and bicyclists, speed is an even more critical factor. As shown in Figure 3.5 for pedestrian crashes at 40 miles per hour, the chance of death is over 90 percent. If speed limits are over 40 miles per hour, then enforcement will not bring speeds down. However, if vehicles are approaching intersections at excessive speeds, enforcement can help ensure vehicles slow down more before entering an intersection where they may need to stop. While communities could seek to reduce posted speed limits, this strategy is not included here as that would entail engineering speed studies.

Figure 3.5 Fatalities Based on Vehicle Speed



Source: U.K. Department of Transportation, *Killing Speed and Saving Lives*, London, 1987.

Automated Enforcement of Red-Light Running and Speed

Photo enforcement of red-light running has been proven effective at reducing intersection crashes. Automated speed enforcement, particularly on intersection approaches, can also improve safety. This strategy must be implemented based on preventable crashes that occur at specific locations. Automated enforcement may be enacted for a period of time to change behavior and discontinued. This strategy would help at locations with significant numbers of angle crashes.

Funding

While currently funding does not exist for the programs recommended in this plan, MAG can pursue funding to implement countermeasures. Law enforcement efforts are typically handled by individual municipalities who maintain their own police forces. The first step is to increase awareness of the pedestrian, bicycle, and intersection safety issues in the MAG communities and to seek to have police increase enforcement as a part of their daily efforts. However, additional focus and time by officers will likely also be required. The state Governor's Office of Highway Safety (GOHS) is the recipient of grant funds from NHTSA that are to be spent to reduce crashes resulting from behavioral issues. Given that data analysis has been performed for the region, municipalities could develop grant applications to request funds for overtime enforcement, which can be directed specifically at pedestrian, bicycle, and intersection safety issues. MAG can provide additional support in the form of data analysis and expertise on how to write such grants. The Arizona GOHS office also provides guidance

on how to submit grant applications including a grant proposal guide and template.[9]

To provide funding for regionwide activities such as the law enforcement summit and educational materials for use by multiple jurisdictions, MAG can seek funding by GOHS that can be used to develop regional-level programs.

3.3 POLICIES

Distracted Road Users

Municipal Bans on Hand-Held Cell Phone Use and Texting

Talking on a hand-held cell phone while driving is banned in 10 states (California, Connecticut, Delaware, Maryland, Nevada, New Jersey, New York, Oregon, Utah, and Washington), and the District of Columbia. Utah has named the offense careless driving. Under the Utah law, no one commits an offense when speaking on a cell phone unless they are also committing some other moving violation other than speeding. The use of all cell phones by novice drivers is restricted in 30 states and the District of Columbia and the use of all cell phones while driving a school bus is prohibited in 19 states and the District of Columbia.[10]

Text messaging is banned for all drivers in 35 states and the District of Columbia. In addition, novice drivers are banned from texting in 7 states (Alabama, Mississippi, Missouri, New Mexico, Oklahoma, Texas, and West Virginia) and school bus drivers are banned from text messaging in 3 states (Mississippi, Oklahoma, and Texas).[11]

Many localities have enacted their own bans on cell phones or text messaging; for example, Chicago and Billings, Montana prohibit hand-held cell phone use. In some but not all states, local jurisdictions need specific statutory authority to do so.

Therefore, to reduce distraction among vehicle users, jurisdictions in the MAG region could consider enacting local ordinances banning device use. The City of Phoenix enacted a ban on text messaging by drivers in 2007. Two distracted driving measures, involving texting and cell phone usage, are advancing in the current session by the Arizona Legislature. While the Insurance Institute for Highway Safety[12] found no reduction in crashes from either of these laws, those

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[9] http://www.azgohs.gov/grant-opportunities/.

[10] http://www.iihs.org/laws/cellphonelaws.aspx, accessed November 14, 2011.

[11] Ibid.

[12] http://www.iihs.org/news/rss/pr092810.html and http://www.iihs.org/news/rss/pr012910.html.

studies did not focus on crashes involving bicyclists and pedestrians or at intersections. When driving in such environments where many bicyclists and pedestrians exist and where one must navigate multiple intersections, reduction in use of devices and the consequent distraction could be beneficial to safety.

Bicycle

Enact Ordinances Requiring Bike Helmet Use for Adults and/or Children

The purpose of bicycle helmet laws for children is to reduce the number of severe and fatal head injuries to children involved in bicycle crashes. Bicycle helmets, when used properly, reduce head injuries and fatalities. A helmet use law is a significant tool in increasing helmet use, but as with all laws effectiveness is related to implementation. Studies have shown a reduction in injuries and fatalities exceeding 60 percent[13]. Legislation effectiveness is enhanced when combined with supportive publicity and education campaigns (GHSA, 2011).

Law enforcement and other safety officials can reinforce the need to wear a helmet through positive interactions such as free or discounted helmet distribution programs and incentives for helmet use, child/parent education on helmet fitting and the importance of wearing a helmet on every ride may enhance effectiveness. Schools may also implement policies requiring helmet use by children riding to school.

The potential negative impact of a helmet law is that it could be perceived as an added inconvenience and disincentive to bicycle riding. Consequently, if such a policy should result in lower numbers of bicyclists on the road, the "safety in numbers" resulting from the higher visibility of cyclists could be diminished.

It is important to note, however, that Phoenix attempted to implement a bicycle helmet law and was unsuccessful. Additionally, given that there is not even a motorcycle helmet law in place in Arizona, a high level of public resistance may be anticipated.

Enact Complete Streets Policies

Many of the roadways in Arizona are designed primarily for motor vehicles. However, roadways have multiple users including bicyclists and pedestrians. Instituting a Complete Streets Policy ensures that transportation planners and engineers consistently design and operate the entire roadway with all users in mind - including bicyclists, public transportation vehicles and riders, and pedestrians of all ages and abilities[14]. Although the state of Arizona does not have a Complete Streets policy, local jurisdictions can adopt Complete Streets

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[13] Attewell, R. G., Glase, K., & McFadden, M. (2001). Bicycle helmet efficacy: a meta-analysis. *Accident Analysis and Prevention, 33*, 345-352

[14] http://www.completestreets.org, accessed January 23, 2012.

policies, as has been done in Scottsdale[15]. Further, MAG recently developed a Complete Streets Design Guide[16] that is an excellent resource for local jurisdictions. The local jurisdictions Scottsdale, Queen Creek, Gilbert and Buckeye, have already adopted Complete Streets policies.

A summary of recommended countermeasures by category is presented in Table 3.1.

Table 3.1 Recommended Countermeasures

Pedestrian	Bicycle	Intersection	Distraction
Education			
• Awareness campaign on pedestrian safety	• Awareness campaign targeting drivers and bicycle safety	• Education on yielding to pedestrians in crosswalks	• Hand-held cell phone use and texting education
• School pedestrian safety training	• Bicycle helmet use education		
• Pedestrian safety zones	• Safe riding practices and conspicuity education/training		
Enforcement			
• Enforce yielding to pedestrians	• Enforce state law requiring three-foot minimum distance from cyclist to auto	• Red-light running enforcement (traditional and automated)	
		• Speed enforcement	
Regional Law Enforcement Summit			
Police Academy Training			
Policies			
	• Helmet laws • Complete Streets policies		• Municipal bans on hand held devices

[15] ADOT Bicycle Safety Action Plan Working Paper 4 – Recommendations and Next Steps to Improve Bicycle Safety in Arizona, August 2011.

[16] http://www.azmag.gov/Documents/BaP_2011-01-25_MAG-Complete-Streets-Guide-December-2010.pdf

3.4 PERFORMANCE MEASUREMENT

Ongoing tracking of results of safety efforts is critical to ensure that the investments in safety are effective, and that crash frequency is decreasing and severity is minimized. The MAG TSC should be prepared to monitor safety trends in these three emphasis areas as countermeasures being to be implemented.

Two categories of performance measures are useful to track program performance:

1. **Output/Process Measures –** To track successful implementation of a countermeasure, such as the number of people reached with an educational campaign; and
2. **Outcome Measures –** To track the actual impacts on safety, generally reduction in number and severity of crashes.

Table 3.2 presents key process and performance measures for each of the countermeasures detailed in this report, as well as the effectiveness of each strategy. The process measures are likely to be more fully developed once specific countermeasures are identified and an action plan is developed. The process performance measures in an action plan might include identifying the stakeholders that will participate in implementation, resources (both funding and staff), multiple action steps, and timeframe. These measures do not provide direct information on the extent to which strategies are reducing the number or severity of crashes; however they are useful to ensure that a strategy is implemented correctly and the proper target audiences are being reached.

Once countermeasures are implemented, performance measures to track the outcomes of the strategies will help the MAG TSC and stakeholders evaluate whether the selected strategies are contributing to saving lives and reducing injuries. It is recommended that evaluation be included as part of the overall process so as to increase knowledge of effective strategies, particularly for the MAG region. Such information will enable MAG communities to try to replicate successful approaches and steer away from any strategies that are not effective. The most critical performance measures to track will be the number of fatal and injury crashes in the three emphasis areas. As action plans for implementation are developed, they will include countermeasures, specific process measures, and specific performance measures. For example if a pedestrian safety zone is implemented and its target is teenage children, the performance measure would be change in teenage pedestrian crashes in the identified pedestrian zone.

To measure the effectiveness of behavioral countermeasures, generally data is reviewed before and after the countermeasure is undertaken. For example, to track results of enforcement of vehicle behavior when pedestrians are present observational surveys are taken of the number of vehicles yielding to pedestrians during a defined time period in a specific location. Following the education and/or enforcement efforts, another observational survey is conducted in the same location to see if an overall improvement in this behavior has improved among drivers. For education programs such as trainings on safe bicycling, sur-

veys of the target audience can be taken after the course to evaluate the knowledge increase. Individualized evaluation programs will need to be developed for each countermeasure the MAG TSC intends to evaluate.

Overall program effectiveness results can also be measured. For example if a bicycle safety program including multiple education, training, and enforcement components were implemented, the results could be tracked in terms of overall crash results in that area. Performance measures would be the change in number and severity of bicycle crashes at the geographic level of implementation, e.g. local, sub-regional, or regional.

Details on the sources of the effectiveness measures listed in Table 3.2 can be found in Appendix B.

Table 3.2 Performance Measures

Strategy	Effectiveness (If Known)	Process Measures	Performance Measures	Source
Education				
Pedestrian awareness campaign	7.5% effectiveness	• Number of individuals reached with materials • Number of brochures distributed • Number of people clicking on an information link	• Number of fatal and injury pedestrian crashes	A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf
School pedestrian training	12% reduction in child pedestrian injuries	• Number of children participating in program • Number of person-hours of training delivered	• Number and severity of pedestrian crashes involving children ages 6 to 12	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures
Pedestrian safety zone	Properly designed and implemented pedestrian zone programs have been shown effective in reducing crashes and injuries for older pedestrians, for impaired pedestrians, and for child and adult pedestrian crashes in Miami-Dade County	• Number of pedestrian zones implemented • Number of citations issued within zone • Number of educational materials distributed within zone	• Number of pedestrian crashes in pedestrian zones • Number and severity of pedestrian crashes	Countermeasures that Work, 2011.
Awareness campaign targeting drivers about bicycle safety (share the road)	7.5% effectiveness	• Number of drivers reached with PSAs • Number of brochures distributed	• Number of fatal and injury bicycle crashes	A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf
Education promoting bicycle helmet use	7.5% effectiveness	• Number of helmets distributed • Number of educational brochures distributed	• Number of people observed wearing bike helmets • Number of crashes involving unhelmeted riders	A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf
Education about bicycle safety skills	7.5% effectiveness	• Number of people clicking on website materials • Number of people participating in training classes	• Number and severity of bicycle crashes • Number of crashes involving unhelmeted riders	A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf

Strategy	Effectiveness (If Known)	Process Measures	Performance Measures	Source
Education of drivers about pedestrian laws	7.5% effectiveness	• Number and frequency of different media used (radio ads, brochures, etc.) • Population exposed to the message • Level of expenditure on paid media	• Frequency and severity of pedestrian crashes	A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf
Education about risks of distracted driving	7.5% effectiveness	• Number and frequency of different media used (radio ads, brochures, etc.) • Population exposed to the message • Level of expenditure	• Frequency and severity of crashes involving distraction	A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf
Enforcement				
Regional law enforcement summit	Increases in citations for specific violations have been shown to occur after such summits	• Number of law enforcement members participating • Results on surveys about usefulness of summit information	• Number of citations issued for pedestrian, bicycle, and intersection violations following summit • Number of fatal and injury crashes involving targeted emphasis areas	Cheyenne MPO observed an increase in safety belt citations after Law Enforcement Summit on occupant protection
Increase police academy training on bicycle, pedestrian, intersection safety		• Amount of new curriculum added on bicycle/pedestrian safety (hours of training)	• Number of officers having received enhanced training • Proportion of all law enforcement having received new police academy training	
Enforce yielding to pedestrians	Reduction in violations is the typical result but may be short-lived	• Number of person-hours of targeted enforcement conducted • Number of citations issued for failure to yield	• Number of pedestrian crashes, especially in crosswalks and at intersections	Countermeasures that Work, 2011; Van Houten and Malefant (2004).

Strategy	Effectiveness (If Known)	Process Measures	Performance Measures	Source
Enforce three-foot driver clearance for bicycles		• Number of people reached with education • Number of citations issued for failure to yield to a bicycle	• Number and severity of crashes involving bicyclists	
Traditional red-light running, stop sign enforcement	Reduction in violations is the typical result but may be short-lived	• Number of citations issued for red light running and failure to stop at a stop sign	• Number of crashes involving red-light running, stop sign violations • Number of angle crashes	NCHRP Report 500 Volume 12: A Guide for Addressing Collisions at Signalized Intersections; NCHRP Report 500 Volume 5 A Guide for Addressing Collisions at Unsignalized Intersections
Speed enforcement	CRF = 70 for pedestrian crashes	• Number of speeding citations near intersections	• Number of crashes with speed as a factor	FHWA Desktop Reference for Crash Reduction Factors, 2007
Automated enforcement of red-light running, speed on intersection approach	Reduction in violations of 23 to 83 percent for red-light running. Average annual rate of all fatal crashes at signalized intersections decreased by 14 percent for cities with camera programs.	• Number of locations where automated enforcement is implemented • Number of citations issued	• Number of crashes involving red-light running, stop sign violations • Number of angle crashes	NCHRP Report 500 Volume 12: A Guide for Addressing Collisions at Signalized Intersections; NCHRP 622 Effectiveness of Behavioral Countermeasures.

Policies				
Municipal bans of hand-held cell phones and texting	The effectiveness of hand-held cell phone bans in reducing crashes is still unclear. No studies on results of texting bans have yet been conducted. Bans may reduce the incidence of cell phone use and texting. However bans provide an opportunity for public education on the risks of distraction and for communications by law enforcement.	• Number of MAG jurisdictions in which bans are enacted	• Number and severity of crashes involving distraction	Countermeasures that Work, 2011
Helmet laws for adults and/or children	15% reduction in fatalities involving children under age 12	• Implementation of ordinances • Number of warnings for non-use of helmets	• Number of fatal or injury crashes involving unhelmeted bicyclists	Grant, D. and Rutner, S.M. (2004). The Effect of Bicycle Helmet Legislation on Bicycling Fatalities. *Journal of Policy Analysis and Management* 23(3), 595–611.
Complete Streets Policies	Safety outcomes depend on which specific elements are implemented in any given location.	• Number of jurisdictions where a Complete Streets Policy has been enacted	• Number of fatal or injury bicycle crashes	http://www.completestreets.org/complete-streets-fundamentals/factsheets/safety/

3.5 IMPLEMENTATION

At the regional level, educational strategies and enforcement strategies can be led by the TSC. If the region should undertake a major comprehensive effort including education and enforcement, the TSC could centrally develop materials for use by all the local jurisdictions given that media and communications often cross jurisdictional boundaries. This pooling of resources could ensure that high-quality materials are developed and that consistent messages are distributed throughout the region. Additionally, multiple stakeholders can work to get messages into the public realm via the communications vehicles under their control.

Enforcement efforts are more often undertaken at a municipal level but regional collaboration can also play an important role. At the local level jurisdictions can work to boost enforcement of specific types of violations by law enforcement as part of current staff duties. Municipalities can pursue grant funding for specific enforcement efforts and then oversee implementation. Localities can also manage communications efforts and the local level, potentially using materials developed at the regional level. MAG members can draw upon the collective knowledge of the TSC for guidance and information sharing as countermeasures are implemented and experience is gained.

4.0 References

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Appendix A

Literature Review, Case Studies and Performance Metrics

The Effectiveness of Non-Engineering Road Safety Countermeasures

1.0 Introduction

Motor vehicle crashes can be attributed to many contributing factors including human behavior, vehicle engineering, and roadway engineering with the resulting outcome dependent on the quality of available medical care. For this reason, focusing solely on improvements in one of these areas will not be sufficient to achieve the crash frequency reductions necessary to proclaim a "safe" system. The maximum results will be achieved through a multidisciplinary approach encompassing the 4Es of safety (engineering, enforcement, education, and emergency response).

The state of the practice in safety has advanced rapidly in recent years with the emergence of new tools and processes for improving the analysis behind investment decisions and across the 4Es of safety. However, the measurement and prioritization of behavioral countermeasures remains a consistent challenge.

The Maricopa Association of Governments (MAG) Transportation Safety Committee (TSC) seeks to identify effective non-engineering safety countermeasures for consideration in the greater Phoenix region. Based on literature reviews, this memorandum summarizes proven or tried countermeasures that have high potential for effectiveness. Additionally, four case studies are presented to show the types of strategies being implemented by peer metropolitan planning organizations (MPOs) and the performance metrics utilized to gauge the success and effectiveness of effective non-engineering safety countermeasures.

1.1 STUDY PURPOSE

The ultimate goal of this study is to recommend non-engineering countermeasures for implementation the MAG region, identify performance metrics for evaluation of these countermeasures, and provide the results in a final report. This study includes six tasks:

1. Literature review on non-engineering safety countermeasures;
2. Case studies documenting success;
3. Identify performance metrics;
4. Recommend potential non-engineering strategies for MAG region;
5. Countermeasure evaluation methods; and
6. Develop final report.

This technical memorandum documents the results of Tasks 1 through 3, which were conducted concurrently.

2.0 Literature Review

This section documents a literature review conducted to identify successful implementation of non-engineering countermeasure projects focused on red-light running, intersection crashes, as well as pedestrian and bicycle crashes. Countermeasures, known effectiveness and potential associated performance measures are shown in Table 2.1. The table also lists potential performance measures for each countermeasure; performance measures are discussed further in Section 4.0.

It is important to recognize that many crashes involve multiple factors. For example, fatal and serious intersection crashes may involve impairment, aggressive driving, distraction, young or old drivers, or other factors. Therefore, as part of its safety analysis, MAG may wish to identify other contributing factors for these types of crashes and potentially address some of those factors as well.

While many non-engineering countermeasures have been implemented, particularly to increase safety of pedestrians and bicyclists, few have been formally proven effective or have crash reduction factors developed. Additionally, with non-engineering countermeasures, every application will differ somewhat based on the nature of the community, partners, messages and implementation tactics. Therefore, definitive proof of such efforts' effectiveness is difficult to obtain. Additionally, given that non-engineering efforts are often implemented in conjunction with one another (i.e., education programming and enhanced enforcement), and potentially implemented concurrently with infrastructure improvements, it is challenging to isolate the benefits of specific programs.

For the most part, the list in Table 2.1 includes strategies with some evidence of likely effectiveness. The majority of countermeasures identified in this memorandum are from the following publications.

1. Countermeasures that Work, Governors Highway Safety Association, 2011;
2. NCHRP 622: Effectiveness of Behavioral Highway Safety Countermeasures, Transportation Research Board, 2008;
3. NCHRP 500 Series Report Volume 5: A Guide for Addressing Unsignalized Intersection Collisions, Transportation Research Board, 2003;
4. NCHRP 500 Series Report Volume 12: A Guide for Reducing Collisions at Signalized Intersections, Transportation Research Board, 2004;
5. NCHRP 500 Series Report Volume 10: A Guide for Reducing Collisions Involving Pedestrians, 2004; and
6. NCHRP 500 Series Report Volume 18: A Guide for Reducing Collisions Involving Bicycles, 2008.

The Crash Modification Factors Clearinghouse (Crash Modification Factors Clearinghouse (www.CMFClearinghouse.org) was consulted but none of the countermeasures in the pedestrian, bicycle or intersection categories was non-engineering-oriented.

The following provides a distillation of the findings related to intersection crashes (including red-light running), pedestrian crashes, and bicycle crashes.

2.1 INTERSECTION CRASHES

The majority of countermeasures proven to reduce crashes at intersections are infrastructure-oriented. However a number of behaviors can contribute to intersection crashes. Red-light running is one of the key contributors to serious intersection crashes. Enforcement is a primary strategy to reduce red-light running, and is generally accomplished through automated or traditional law enforcement at key locations. Automated enforcement has been proven effective at reducing red-light running, but in some studies it has been shown to increase rear-end crashes.

Additional key strategies include reduction of speeding on intersection approaches, which can also be addressed by automated speed enforcement. Intersection crashes involving pedestrians and bicyclists are primarily addressed in the next sections.

2.2 PEDESTRIAN CRASHES

A wide range of activities have been undertaken to improve pedestrian safety; however most of them are not conclusively proven to reduce crashes. Many strategies have been tried and are widely implemented in certain communities, as discussed in the Case Studies in section 3.

Strategies include increasing conspicuity, especially at night, increasing enforcement of laws such as yielding to pedestrians in crosswalks, and education – particularly of children. While Crash Modification Factors were identified for Safe Routes to School programs in the CMF Clearinghouse, these were not included given that the majority of efforts are likely to include infrastructure improvements as a component of the program.

2.3 BICYCLE CRASHES

Implementation of bicycle safety strategies is becoming more prevalent as more communities increase bicycle infrastructure and actively seek to increase the share of trips by bicycle. Bicycle countermeasures include increasing the use of safety equipment such as helmets and lights, enforcement of bicycle-related laws, and bicyclist education. As is the case with pedestrian countermeasures, many strategies seem likely to increase safety and have been tried, but are not yet fully proven to reduce bicycle crashes.

Table 2.1 Non-Engineering Countermeasures – Intersections, Pedestrians, Bicyclists

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Intersections – General				
Eliminate parking that restricts sight distance	This strategy targets crashes related to parking on intersection approaches. The parking, though currently permitted, may present a safety hazard by blocking sight distance (and contributing to angle crashes) or due to parking maneuvers (contributing to rear-end and sideswipe crashes). On-street parking can decrease pedestrian safety if parked vehicles block drivers' and pedestrians' views of each other. Curb extension can be constructed where pedestrians cross streets, and parking should not be permitted on approaches to crosswalks.	The ITE *Traffic Engineering Handbook* (Pline, 1999) states that based upon a review of crash data, 20 percent of non-freeway crashes in cities are in one way or another related to parking. Midblock crash rates on major streets with parking stalls that are used about 1.6 million hours per year per kilometer could be expected to decrease up to 75 percent after parking is prohibited.	Process Measures: • Number of signalized intersections for which parking has been prohibited on the approaches. • Number of approaches on which parking has been restricted. • Number of parking spaces eliminated by restrictions. • Percent of problem parking spaces eliminated by restrictions.	NCHRP Report 500 Volumes 5 and 12
Provide public information and education	The target for this strategy is crashes related to drivers either being unaware of, or refusing to obey, traffic laws and regulations that impact traffic safety. Crashes related to red-light running, speeding, and not yielding to pedestrians could be reduced with PI&E campaigns. Use of trained public information specialists is important for program success. Establishing good relationships with media representatives will be extremely helpful for maximizing coverage and impact.	The estimated impact of mass media road safety campaigns is likely to vary depending on the measure of effect used. Across all measures the effect has been estimated as a 7.5% reduction in the relevant outcome measure.(Delaney, 2004)	Process Measures: • Number and frequency of different media used (radio ads, brochures, etc.). • Population exposed to the message. • Level of expenditure. Performance Measures: Frequency and severity by crash type.	NCHRP Report 500 Volumes 5 and 12 A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Intersections – Signalized				
Improve operation of pedestrian and bicycle facilities at signalized intersections	• Crossing guards for school children. • Public information or signs that educate pedestrians regarding use of push buttons (specifically, that they will not receive the walk signal immediately). • Technology to show a push button is working (such as a button that lights up, similar to an elevator). Providing pedestrian push buttons may facilitate safe pedestrian roadway crossings at signalized intersections (versus midblock crossings), However, pedestrian push buttons at an intersection are often obscured by roadside furniture or other items. Providing visible signs alerting pedestrians to the presence of push buttons and anticipated wait time for the crossing signal may increase the use of existing pedestrian push buttons.	Unknown	Process Measure • Number of locations where strategies are implemented. Performance Measure • Number and severity of crashes involving bicycles or pedestrians at signalized intersections.	NCHRP Report 500 Volume 12: A Guide for Addressing Collisions at Signalized Intersections

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Provide targeted conventional enforcement of traffic laws	Traffic law enforcement agencies will often select locations for targeted enforcement when crash, citation, or other sources of information suggest that the site is unusually hazardous due to illegal driving practices, such as speeding or red-light running. It is important to correctly identify intersections that would benefit from enforcement. Care should be taken to first ensure that the existing signals are operating properly, are visible, and meet MUTCD requirements, as well as that timing plans – including clearance intervals – are appropriate. Analysis of crash statistics can help with this process, as can spot speed or conflict studies. In some cases, public input or observations by law enforcement personnel may suggest that a location should be targeted for enforcement. Police officers providing targeted enforcement of red-light running can be aided by "tell-tale" or "tattle-tale" lights. These lights are placed at traffic signals, but facing away from oncoming traffic. Police officers are able to wait in their vehicles on the downstream side of the traffic signal` and view the tattle-tale light. This way, they are able to pursue red-light runners without also running through the red light themselves (and possibly into vehicles entering the intersection from the cross street).	Studies report the reduction of traffic law violations when enforcement is used (*Traffic Engineering Handbook*, Pline, 1999). Effectiveness is usually short-lived. Periodic enforcement may be necessary to sustain the effectiveness of the strategy	Process Measure: • Number of citations issued at targeted intersections. Performance Measures: • Number and severity of crashes at targeted locations before and after strategy implementation.	NCHRP Report 500 Volume 12: A Guide for Addressing Collisions at Signalized Intersections

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Implement automated enforcement of red-light running (cameras)	Successful red-light camera programs have generally begun as safety improvement programs. Programs that are perceived as revenue generators (i.e., through collection of fines) are generally not well-accepted.	The automated enforcement programs in NCHRP Report 500 Volume 12 experienced a range of reduction in violations of 23 to 83 percent. The average annual rate of all fatal crashes at signalized intersections decreased by 14 percent for cities with camera programs and increased slightly (2 percent) for cities without cameras. After controlling for population density and land area, the rate of fatal red-light running crashes during 2004-08 for cities with camera programs was an estimated 24 percent lower than what would have been expected without cameras. 16% reduction in all injury crashes, 24% reduction in right-angle crashes, no significant increase in rear-end crashes (Aeron-Thomas, A.S. and Hess, S. (2005). *Red Light Cameras for the Prevention of Road Traffic Crashes (Review)*. The Cochrane Database of Systematic Reviews, 2, Art. No. CD003862.pub2. Hoboken, N.J.: John Wiley & Sons Ltd.	Process Measure • Number of cameras installed. • Number of citations issued. Performance Measure • Number, type and severity of crashes at targeted intersections.	NCHRP Report 500 Volume 12: A Guide for Addressing Collisions at Signalized Intersections Hu et al., Effects of Red Light Camera Enforcement on Fatal Crashes in Large U.S. Cities, Insurance Institute for Highway Safety, February 2011 NCHRP 622: Effectiveness of Behavioral Countermeasures

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Implement automated enforcement of approach speeds (cameras)	The target for this strategy is drivers who speed on approaches to signalized intersections. Crash types related to these actions include angle and rear-end crashes. Automated enforcement of speeds may provide a longer-term effect than on-site enforcement by police officers. It is not feasible to provide officers to constantly enforce speed limits, but a camera is more flexible regarding the duration it can operate. PI&E is needed to make automated enforcement successful. Public opinion and acceptance can "make or break" an automated enforcement program. Information and awareness efforts and materials typically include the following information: 1) documentation of the problem (in nontechnical terms), 2) objectives of the automated enforcement program, 3) advantages of automated enforcement or conventional enforcement, 4) general locations or areas of automated enforcement systems, 5) uses of revenue generated by automated enforcement, and 6) information on what to do when a citation is received in the mail.	Speed cameras: on average, 20-40% reduction in crashes, based on studies in Canada, Australia, and Europe (Pilkington, P. and Kinra, S. (2005). *Effectiveness of Speed Cameras in Preventing Road Traffic Collisions and Related Casualties: Systematic Review*. British Medical Journal 330 (7487), 331-334.)	Process Measures: • Number of intersection approaches on which automated speed enforcement is applied. • Number of citations issued from the program, and number of traffic convictions resulting. Performance Measure • Number and severity of crashes at intersections treated.	NCHRP 622: Effectiveness of Behavioral Countermeasures
Unsignalized Intersections				
Provide targeted enforcement to reduce stop sign violations	The target for this strategy should be intersections where stop sign violations and patterns of crashes related to stop sign violations have been observed. Crash types potentially related to stop sign violations include right-angle and turning collisions.	This strategy is known to be effective in reducing traffic law violations. Programs within the United States have been found to result in decreases in violations between 23 and 83 percent (Pline, 1999). However, the safety effectiveness of such decreases in violation rates has not been quantified. Enforcement agencies have. generally found that the effectiveness of increased enforcement at specific locations has a relatively short duration of effectiveness – measured in days or weeks, rather than months or years.	Process Measures: • Number of intersections where increased enforcement is applied. • Number of officer hours of targeted enforcement provided. • Number of additional citations issued. • Reduction in violation rate. • Resulting number of additional convictions.	NCHRP Report 500 Volume 5: A Guide for Addressing Unsignalized Intersections

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Provide targeted speed enforcement	The target for this strategy are intersections where speed violations and patterns of crashes related to speed violations are observed. Crash types potentially related to speed violations include right-angle, rear-end, and turning collisions. A key to the success of this strategy is planning the enforcement and prioritizing the intersections demonstrating greatest need(*TRB Special Report 254,* 1998). Such intersections should have a combination of high speed-violation rates and related crash patterns. In some cases public input, or observations by law enforcement personnel, may suggest that a location should be targeted with enforcement.	The effectiveness of this strategy has been established by numerous studies (Accident Analysis and Prevention, Volume 126, Issue 6, *An Experimental Study to Evaluate the Effectiveness of Different Methods and Intensities of Law Enforcement on Driving Speed on Motorways*, De Waard and Rooijers, 1994).	Process Measures: • Number of intersections at which targeted speed enforcement is applied. • Number of officer hours of targeted enforcement provided. • Number of additional citations issued. • Resulting number of additional convictions. Performance Measure: • Number and severity of intersection crashes.	NCHRP Report 500 Volume 5: A Guide for Addressing Unsignalized Intersection
Pedestrian				
School pedestrian training,	Education of children ages 6 to 12 years old	12% reduction in child pedestrian injuries	Process Measures: • Number of children participating in program. • Number of person-hours of training delivered. Performance Measure: • Number and severity of pedestrian crashes involving children ages 6-12.	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Pedestrian Safety Zone	The idea is to strive for large decreases in pedestrian crashes and injuries by more effectively targeting resources to problem areas. Specifically, the objective of pedestrian safety zones is to increase efficiency by targeting limited resources to geographic areas and audiences where significant portions of the pedestrian crash problem exist (NHTSA, 2008). Pedestrian zone programs, including education, enforcement, and engineering measures, can target at a full range of pedestrian crash problems within a limited geographic area or focus on particular problems that make up a larger portion of the problem within a limited area.	Properly designed and implemented pedestrian zone programs have been shown effective in reducing crashes and injuries for older pedestrians, for impaired pedestrians, and for child and adult pedestrian crashes in Miami-Dade County.	Process Measure: • Number of pedestrian zones implemented. Performance Measure: • Number of pedestrian crashes in pedestrian zones. • Number and severity of pedestrian crashes.	Countermeasures that Work, 2011
Conspicuity Enhancement	The purpose of enhancing conspicuity for pedestrians is to increase the opportunity for drivers to see and avoid pedestrians at night. Pedestrians who are more visible are less likely to be struck. Retroreflective materials are built into many shoes, including children's and athletic shoes. Other accessories, such as arm or leg bands, gloves, vests, and caps are available from sporting goods stores and other vendors. Light sources, including strobes and other flashing lights, are also available. Many have been designed for bicyclists but are equally applicable to pedestrians. The difficulty with most of these devices is that the user must decide in advance to take and use them. Because of this extra step, and because most of the conspicuity enhancements do not look like "normal" clothing, they are very much underused. Light-colored clothing, a longtime recommended solution, actually does little to improve conspicuity (NCHRP, Vol. 10 (2004). *A Guide for Reducing Collisions Involving Pedestrians*. Washington, D.C.: Transportation Research Board)	Widespread use of retroreflective materials would increase the ability of drivers to detect pedestrians in time to avoid crashes. Pedestrians wearing good retroreflective materials, particularly materials that highlight a person's shape and extremities, can be detected hundreds of feet farther than can pedestrians in normal clothing, even with low-beam illumination.	Process Measure: • Number of retroreflective or lighted items distributed to pedestrians. Performance Measure: • Number and severity of pedestrian crashes.	Countermeasures that Work, 2011

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Reduced speed limits for pedestrian safety	Reduction in speed limit from 60 km/hr (37 mph) to 50 km/h (31 mph) in urban areas	Reduction of 25-30% in pedestrian fatalities	Process measure: • Lane miles of roadways with reduction in speed permitted. Performance Measure: • Number and severity of pedestrian crashes.	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures
Bicycle				
Restrict right turn on red (RTOR) movements	The primary purpose of this strategy is not to restrict RTOR at all signalized intersections in an area or local jurisdiction. Rather, the purpose is to restrict RTOR movements at certain signalized intersections throughout the entire day or during portions of the day (e.g., during periods of peak bicycle activity). At signalized intersections with a history of bicycle/motor vehicle crashes resulting from RTOR movements, an analysis of the time of day of the crashes may provide justification for restricting RTOR movements throughout the entire day or during specified hours of the day.	Approximately 3 to 4 percent of all bicycle/ motor vehicle crashes occur during a RTOR maneuver, and 6 percent of these crashes result in serious or fatal injuries (Tan, 1996). The expected number of bicycle/motor vehicle crashes that may be reduced by implementing this strategy is difficult to assess because it is an experimental treatment for improving bicycle safety. However, this strategy has been recommended for improving pedestrian safety based upon a field study (Retting, R. A., Nitzburg, M. S., Farmer, C. M., and Knoblauch, R. L. (2002). Field Evaluation of Two Methods for Restricting Right Turn on Red to Promote Pedestrian Safety. *ITE Journal* 72).	Process Measure: • Number of intersections at which RTOR is prohibited during some portion of the day. Performance Measure: • Number and severity of bicycle crashes involving RTOR movements.	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles
Implement speed enforcement	See *Provide Targeted Speed Enforcement* strategy			

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Provide bicyclist skill education	This strategy is intended to teach bicyclists of all ages safe bicycling skills, including how to interact with motorists in traffic. Education programs should teach bicyclists the importance of having a bike that fits, maintaining a bike in good condition, and always wearing a helmet when riding. Bicycle safety training programs are based on the premise that behavior by bicyclists contributes to the risk of crashes and injuries, and that this behavior can be changed through training programs. Several studies have shown that most crashes were primarily due to some form of human error and very few were due to environmental conditions (Clarke, A., and Tracy, L. (1995). *Bicycle Safety-Related Research Synthesis.* Report No. FHWA-RD-94-062. Washington, D.C.: Federal Highway Administration).	NHTSA's 1993 report indicated that the most common crashes were due to bicyclist's failure to yield (21.8 percent), improper crossing of roadway or intersection (12.6 percent), and failure to obey traffic signs, signals, or a police officer (8.6 percent) (Clarke and Tracy, 1995). Reports on a state level have similar data suggesting that the five leading contributing factors attributed to bicyclists in bicycle/motor vehicle crashes were: 1) failure to yield right-of-way, 2) nonmotorist error, 3) disregard for traffic control devices, 4) driver inattention/ distraction, and 5) improper/unsafe lane use (*Minnesota Bicycle Transportation Planning and Design Guidelines* Minnesota Department of Public Safety, 2005).	Process Measure: • Number of educational programs conducted. Performance Measure: • Number and severity of crashes involving bicycles.	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles
Improve enforcement of bicycle-related laws	This strategy directly targets activities of law enforcement officers as they relate to bicycling and indirectly targets behavior of bicyclists and motorists.	The ultimate goal of this strategy is to prevent crashes and enhance traffic safety. Many crashes can be avoided if both bicyclists and motorists follow the rules of the road. Heightened awareness among law officers of these rules can lead to: enforcing of laws, modeling of good behaviors, and recognizing and taking advantage of opportunities to educate both bicycles and motorists.	Process Measure: • Number of citations issued for violations of bicycle-related laws. Performance Measure: • Number and severity of crashes involving bicycles.	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles
Bike helmet law for children	Requirement for bike helmet use for children under age 12	15% reduction in fatalities involving children under age 12	Process Measures: • Implementation of law. • Number of warnings for non-use of helmets among children under 12. Performance Measure: • Number of fatal or injury crashes involving unhelmeted juvenile bicyclists.	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures

Strategy	Description	Effectiveness	Process/ Performance Measures	Source
Bike helmet law for adults	Requirement for bike helmet use for adults	Likely to be effective; actual effectiveness unknown	Process Measures: • Implementation of law. • Number of citations for non-use of helmets among adults. Performance Measure: • Number of fatal or injury crashes involving unhelmeted adult bicyclists.	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures
Increase rider and bicycle conspicuity	This strategy targets the behavior of bicyclists who are riding at night near motor vehicle traffic, but also affects motorists by making bicyclists more conspicuous.	Bicyclists that are more visible are expected to be involved in fewer crashes during low light conditions. Although no studies have been identified that indicate this outcome, bicyclists that are more easily seen are likely to be more easily avoidable, as well. In addition, the use of headlights may provide bicyclists with better visibility of roadway conditions.	Process Measure: • Number of retroreflective or lights distributed to bikers. Performance Measure: • Number and severity of bicycle crashes at night.	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles

3.0 Case Studies

The study team conducted Internet and telephone research to identify MPOs that had implemented non-engineering safety countermeasures in the areas of intersection, bicycle and pedestrian safety. The majority of efforts were focused on education and enforcement to address bicycle and pedestrian safety. Four case studies are presented here from the MPOs in the Miami, Kansas City, Washington, D.C., and Nashville regions.

3.1 MIAMI-DADE MPO

The Miami Dade MPO has led or coordinated multiple pedestrian-oriented safety countermeasures over the past decade to address the high number of pedestrian crashes experienced in the area. In 2001, just before the pedestrian safety efforts began, Florida was the fourth-largest State in terms of population (16.4 million), but ranked first in the number of pedestrian fatalities (489). In Florida, Miami-Dade County (in 2001) led the State in pedestrian deaths and injuries.

The most significant pedestrian effort has been the WalkSafe Program, which is a juvenile pedestrian safety education program in partnership with the University of Miami Miller School of Medicine. The MPO used planning resources to help develop the program and transportation enhancement funds for ongoing operation. Initiated in 2003, this program's three-day curriculum was used to reach 140,000 people in 2010. With its public health model, this is a very research-based program. More information is available on the program's web site at: www.walksafe.us.

The Miami-Dade MPO has begun to fund and develop a BikeSafe education effort through the school of medicine's public health staff. The agency seeks to do a parks-based program in partnership with the parks and recreation department, versus a school-based program as was done with WalkSafe. The MPO is seeking to take more of an entrepreneurial approach given that some bicycle education can pay for itself, e.g., the League of American Bicyclists' basic adult class is $75. The desire is to use MPO resources to establish the program and rely on other resources to sustain the program in the long term.

The MPO has facilitated police training on enforcement of failure to yield to pedestrians. The training program involved the use of decoy pedestrians. A spotter with a radio flagged violators to officers who stop the vehicles and issue warnings or citations. This effort has proven very successful and garnered significant community support.

Leveraging its relationship with the transit agency, the MPO was able to secure free advertising space to place public service announcements (PSAs) on pedestrian safety. The MPO developed and printed the materials and coordinated placement.

The MPO has supported enforcement of red-light running violations. Staff educated law enforcement about crash data, and provided data on locations of speeding and red-light running. Law enforcement were then redeployed to high-crash locations.

Evaluation and Performance Measures:

In 2008, a study undertaken by NHTSA was published: *Evaluation of the Miami-Dade Pedestrian Safety Demonstration Project.* This study evaluated the multiple pedestrian countermeasures undertaken in the region.

WalkSafe program evaluations have shown that in the nine years since the program was initiated, juvenile emergency room admissions have been reduced by 51 percent.

Generally, the MPO tracks pedestrian crashes and their severity.

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3.2 MID-AMERICA REGIONAL COUNCIL

From 2005 to 2007, the Kansas City region experienced 699 fatalities and 5,309 disabling injuries associated with motor vehicle crashes. To address the regional safety problem MARC has assembled a coalition of members called Destination Safe to focus on non-infrastructure safety programming. The committee accepts applications for projects and programs on an annual basis. All infrastructure requests for safety projects go through the MPO's program committees.

MARC has developed a Safety Blueprint plan that is updated every three years, to align updates with the states' strategic highway safety plans. The Blueprint identifies emphasis areas and countermeasures, which include Pedestrians and High-Risk Users, including red-light runners.

Efforts supported through Destination Safe have included:

1. Be Bright at Night – distribution of flashing lights for evening walkers/ bikers;
2. Share the Road Safety Task Force education and enforcement – Task Force identified locations with large numbers of pedestrians and conducted education two to three weeks before an enforcement campaign via distribution of

literature to shop owners and all people in area (motorists, pedestrians, bicyclists). Three weeks later, enforcement of vehicles not yielding to pedestrians and other violations was conducted. As part of the effort staff briefed county courts and judges on the rationale for the program so citations were not thrown out of court;

3. Radio PSAs with messages on several emphasis areas; and
4. Support of legislation and local ordinances that allow the use of red-light running cameras at high-risk intersections, as well as support of increased law enforcement of these violations at key locations.

Evaluation and Performance Measures

The primary measure used to track progress is fatal and injury crashes in the emphasis areas. The MPO develops a quarterly safety report to track trends. Overall the trend is that crashes are going down, but it is difficult to isolate the reason for the improvement when simultaneously multiple infrastructure and behavioral efforts may be underway.

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3.3 METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

Approximately 2,700 pedestrians and bicyclists are injured every year in the Washington region, and 89 are killed. Pedestrian and bicyclist fatalities accounted for 25 percent of the total traffic fatalities in the District of Columbia, suburban Maryland and northern Virginia from 2006 to 2010.

Sponsored by the Metropolitan Washington Council of Governments (COG) and the National Capital Region Transportation Planning Board (TPB), the Street Smart public awareness and enforcement campaign is aimed at reducing the number of pedestrian and cyclist injuries and deaths in the Washington metropolitan area. The campaign uses creative radio and television advertising in English and Spanish to reach drivers, pedestrians and cyclists, while targeting them through outdoor and transit advertising on bus shelters and bus sides. In addition, law enforcement and local, county and state agencies distribute handouts and tip cards to further spread awareness and educate drivers and pedestrians.

The Street Smart pedestrian safety effort focuses on the "three E's": education, enforcement, and evaluation.

1. **Education** targets pedestrians and drivers, and uses recurring waves of radio, bus advertising, Internet ads, hand-outs and posters to get the message out. Advertising conveys simple messages such as "Stop for Pedestrians" and "Cross Streets Carefully," and while media events help publicize enforcement. A strong focus of the campaign is to reach the area's Hispanic residents through Spanish-language brochures and advertising outreach.
2. **Enforcement** provides an incentive for residents to heed the campaign messages, and a focus for media attention.
3. **Evaluation** is vital to understanding the awareness level for the message and the future direction of the campaign.

The campaign was created by the Bicycle and Pedestrian Subcommittee of the Transportation Planning Board in 2002. The District of Columbia, Maryland, Virginia, and the Washington Metropolitan Area Transit Authority provide major funding, with contributions from Arlington County, Montgomery County, and the City of Alexandria. More information is available about Street Smart at www.bestreetsmart.net.

Evaluation and Performance Measures

Process measures include the number of warnings and citations issued during enforcement periods.

To validate the campaign and judge effectiveness of the efforts, area motorists are surveyed before and after each campaign. Survey results from spring and fall 2010 show people are hearing and remembering the Street Smart messages.

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3.4 NASHVILLE MPO

Between 2003 and 2007, 2,076 reported crashes involving a pedestrian or bicyclist occurred within the MPO, 107 of which resulted in a fatality. The Nashville MPO has identified in its 2035 long-range plan that in addition to developing comprehensive regional bicycle and pedestrian facilities, it will provide support for ongoing education for local law enforcement and the public to increase the safety of walking and bicycling. The region has recently undertaken several bicycle and pedestrian safety programs.

Bicycle Training Program

The Nashville Area MPO in partnership with local bicycle advocacy group Walk/Bike Nashville developed a two-hour bicycle training program called Bicycle Street Smarts. The training program is designed to teach the basics of

bicycle fit, maintenance, laws, hand signals and skills for a bicyclist to ride safely on the roadway or greenway. The class is offered to community groups upon request at no charge, depending on instructor availability. Instructors are certified by the League of American Bicyclists as League Certified Instructors.

Walking and Bicycling Safety Education to P.E. Teachers

In the summer of 2009, the Nashville Area MPO staff worked with the Program Director of Walk/Bike Nashville to develop a two-week Walking and Bicycling Safety curriculum to be taught by elementary school P.E. teachers to their students.

The project was funded by a grant from the Robert Wood Johnson Foundation, Active Living by Design program. The two-week curriculum is written to the Tennessee Department of Education Standards for Physical Education for Elementary School students.

To date, over 75 P.E. Teachers in Davidson and Williamson Counties have been taught the curriculum in day-long in-service trainings. Plans are underway for the curriculum to be taught to several hundred additional P.E. Teachers throughout the Nashville Area MPO Region.

The curriculum covers pedestrian laws and safety including how and where to cross the street. The curriculum also covers basic bicycle maintenance, parts of a bicycle, bicycle fit, helmet fit and rules of the road for bicyclists. The training concludes with sessions on the bicycle where teachers learn firsthand the bicycle safety skills drills they will teach to their students.

Law Enforcement Refresher on Bicycle and Pedestrian Laws

In conjunction with the Knoxville Transportation Planning Organization, the Nashville MPO offers one-hour refresher training to law enforcement officers on laws pertaining to pedestrians and bicyclists.

The training covers Tennessee state law and provides a review of rules of the road pertaining to walking and bicycling. The session includes pedestrian rights at unmarked crosswalks, how bicyclists signal lane changes and turns, and where a bicyclist is legally allowed to ride on the roadway. The training also covers tips for law enforcement officers when citing either vehicular motorists who violate the rights of pedestrians or bicyclists, or who cite pedestrians and bicyclists for failing to follow the laws and rules of the road for their particular mode of travel.

The training, which started in 2009, has been offered to officers from across Tennessee at the Tennessee Lifesavers Conference, and through the Franklin Police Department Bicycle Police Training Academy, including Franklin Police, Rutherford County Sheriff's Department and Murfreesboro Police Department.

Performance Measures:

The MPO tracks total and fatal crashes involving pedestrians and bicyclists.

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4.0 Performance Measures

General performance measures are indicators that enable decision-makers and other stakeholders to monitor changes in system condition and performance. Typical safety performance measures relate to the number and rate of fatalities and/or crashes and incidents, emergency response times, public perceptions of safety, etc., for the various transportation modes. Performance measures are typically tracked for an emphasis area generally, e.g., number of pedestrian fatal and serious injury crashes.

Given the temporal nature of many non-engineering countermeasures, the fact that they may not be targeted to a specific geographic location, and that they may be undertaken in combination with other strategies, it can be challenging to isolate the results of a single non-engineering countermeasure in terms of reduction in number or severity of crashes. In some cases, however it may be possible to conduct before and after surveys about awareness of public education or conduct other measurements before and after implementation to gauge effectiveness. For example if a program is targeted at a specific age group in one emphasis area, e.g., bicycle helmet use by children, it could be possible to track fatal and serious bicycle crashes involving helmet non-use among those age 12 and under.

Process measures are helpful to ensure that the countermeasure is being properly implemented and the audience is being reached. For the most part these measures do not directly measure effectiveness in terms of crash reduction but may measure an interim level of effectiveness. For example, for an enforcement effort, the number of citations can be measured, which would be expected to result in a reduction future violations and improved public awareness of a safety issue, and consequently reduced crashes. Other process measures are those that track the number of people reached with a specific effort, such as the number of people participating in a training course, the number of public service announcements placed, or the number of materials distributed. As noted in Table 2.1, process measures can be identified for most efforts.

5.0 Next Steps

Given the limited number of non-engineering countermeasures proven effective, NCHRP 622 notes that an agency may wish to engage in countermeasures that have not been fully developed or widely implemented, and consequently have not been evaluated. Potential strategies may be categorized as Voluntary Actions; Laws, Regulations, Policies; Laws Plus Enhancements; or Sanctions and Treatments. Then, applying the same principles as for known existing countermeasures, an agency can estimate how the implementation of such countermeasures is likely to affect the fatality, injury, and cost aspects of its traffic safety problem. As described in NCHRP 622, some of the most important characteristics, requirements, and opportunities associated with the above listed categories are as follows:

Voluntary Action

- Must be of high quality and intensity;
- Works best when:
  - Targeting children;
  - Allowing communicator some control over audience;
  - Communicating new knowledge; and
  - Serving as part of some larger community-based effort.

Laws, Regulations, Policies

- Must be well known to the public;
- Must be enforceable, based on easily observable and objective criteria; and
- Must apply to entire targeted population, not to just a subset of the population.

Laws Plus Enhancements

- Enhancement must be well publicized;
- May involve special equipment to aid officers, prosecutors, probation officers, etc.; and
- Generally involves intense selective and concentrated enforcement.

Sanctions and Treatments

- Sanction must be well known to violators;
- There must be an immediacy and certainty to imposition of the sanction; and
- There should be a high degree of intrusiveness to the violator (either through penalty or extent of mandated treatment).

Additionally, it is likely that further analysis will reveal that additional factors are involved in substantial number of intersection, bicycle, and pedestrian crashes. For example, it is likely that distraction may play a role in intersection crashes given the rise in use of electronic devices in vehicles. Impairment may play a role in intersection and pedestrian crashes. If such determinations are made, MAG may wish to consider a broader range of countermeasures to address these crashes.

5.1 RESOURCES

Several recent safety plans have been developed that serve as excellent resources for identifying analytical methods and potential future strategies, although many strategies are thus far unproven.

1. *The New York City Pedestrian Safety Study and Action Plan*, New York City Department of Transportation, August 2010
2. *Hillsborough County Bicycle Safety Action Plan*, April 2011
3. *Pedestrian Safety in the NYMTC Region*, New York Metropolitan Transportation Council, September 2007
4. *Kansas City Regional Transportation Blueprint*, Mid-America Regional Council Transportation Department, 2009

6.0 References

Blakey, L. *Red-Light Cameras: Effective Enforcement Measures for Intersection Safety*, ITE Journal, March 2003

Garber, N., Miller, J., Abel E., Eslambolchi S., and Korunkonda S., *The Impact of Red Light Cameras (Photo-Red Enforcement) on Crashes in Virginia*, Virginia Transportation Research Council, 2007.

Retting R. *Two Decades of Photo Enforcement in the United States: A Brief Summary of Experience and Lessons Learned*, ITE Journal, November 2010.

Appendix B

Pedestrian, Bicyclist and Intersection Crashes

The Effectiveness of Non-Engineering Road Safety Countermeasures

1.0 Introduction

The Maricopa Association of Governments (MAG) safety committee has identified reducing pedestrians, bicycle, and intersection crashes as a key focus. This memorandum provides insight into the factors affecting pedestrian, bicycle and intersection crashes and identifies countermeasures to reduce their toll on the region. Sections 2.0, 3.0, and 4.0 describe the range of attributes of crashes in each of these categories. A more detailed understanding of the populations, locations, and other information related to these types of crashes provides guidance to select countermeasures that have the greatest potential to reduce the numbers of fatal and injury crashes.

Within Sections 2.0, 3.0, and 4.0 enhanced tables of proven and tried/emerging countermeasures are provided, building on those identified through the previous task. Efforts were made to identify proven, quantitative countermeasures; however in many cases data did not exist to prove effectiveness, or data was not sufficient for development of crash modification factors with which to calculate the projected reduction in fatal or injury crashes when implemented. Therefore, potentially useful strategies that have been tried or are emerging are also listed, although data does not exist on their anticipated quantitative impact on fatal and injury crashes. MAG communities will be able to draw upon a range of options to address the crash types detailed in the data analysis.

2.0 Pedestrians

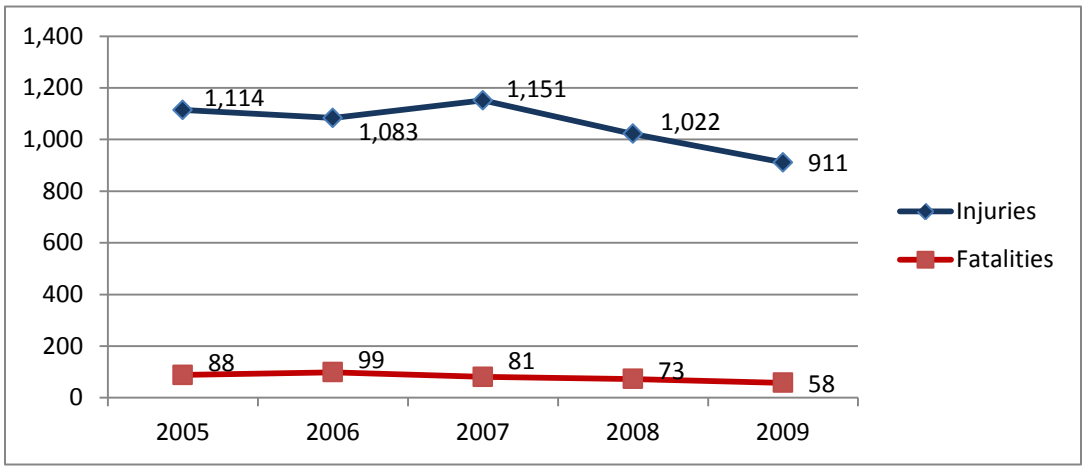
This section describes various aspects of pedestrian crashes in the MAG region from 2005 to 2009 to provide insight into the array of factors that may be contributing to these crashes. Understanding these contributing factors informs the range of countermeasures that may be most effective at reducing pedestrian crashes.

Some of the crash data includes information on severity of injuries sustained by persons involved in the crash, as reported by law enforcement officer at the scene of the crash. This is known as the KABCO crash injury severity classification, defines as: K – fatality, A – incapacitating injury, B – non-incapacitating injury, C – possible injury, 0 – no injury.[17] All crashes referred to as "injury crashes" in this report include crashes with a reported injury severity of A or B according to the KABCO classification for injury crashes. All data in this report were provided by MAG.

2.1 Pedestrian Crash Analysis

Pedestrian crashes in the MAG region have declined from 2005 to 2009 (2009 is the most recent year for which data is available). Pedestrian fatalities have decreased from a high of 99 in 2006 to a low of 58 in 2009, as shown in Figure 2.1.

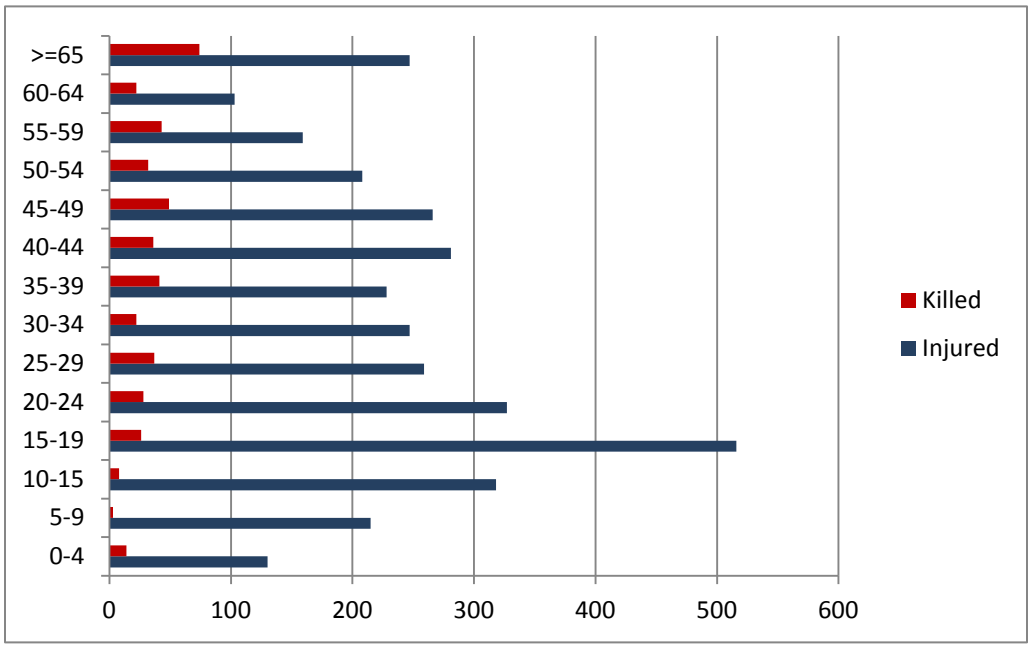
Figure 2.1 Pedestrian Injuries and Fatalities in MAG Region, 2005-2009



[17] Model Minimum Uniform Crash Criteria, 3rd Edition, 2008. http://www.mmucc.us/sites/default/files/2008MMUCCGuideline.pdf.

Figure 2.2 shows the age cohorts of pedestrians killed and injured. Over the five-year period, 25 children under the age of 16 were killed and 663 were injured. The age category with the largest number of fatalities was age 65 and older; however, it must be recognized that a large segment of the population in the MAG region is in this age category. Additionally, the elderly suffer higher rates of injuries and fatalities from crashes than other age groups due to their physical fragility.[18] The next largest age cohorts in terms of fatalities were age 45 to 49 with 49 fatalities, and age 55 to 59 with 43 fatalities.

Figure 2.2 Pedestrians Killed and Injured by Age, 2005-2009

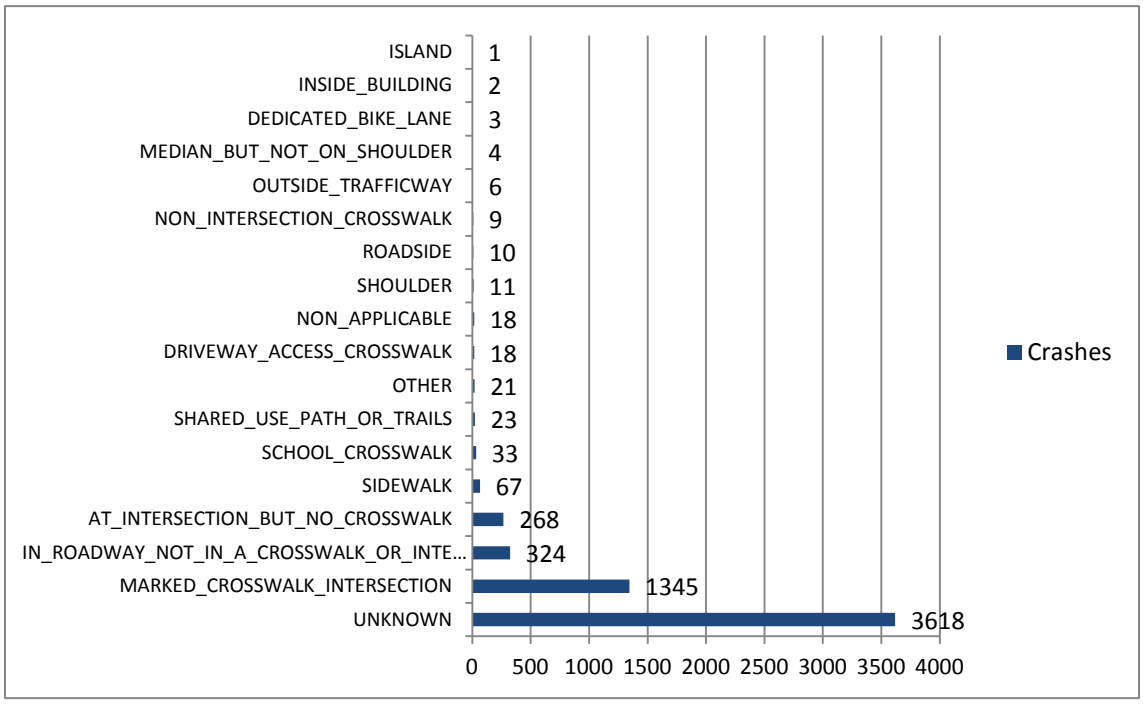


Males suffer the majority of pedestrian fatalities and injuries. From 2005 to 2009, more than two thirds (71 percent) of pedestrians killed were males. Two thirds of serious pedestrian injuries involved males.

[18] AARP Public Policy Institute, Older Drivers and Automobile Safety, http://assets.aarp.org/rgcenter/il/fs51r_drivers.pdf.

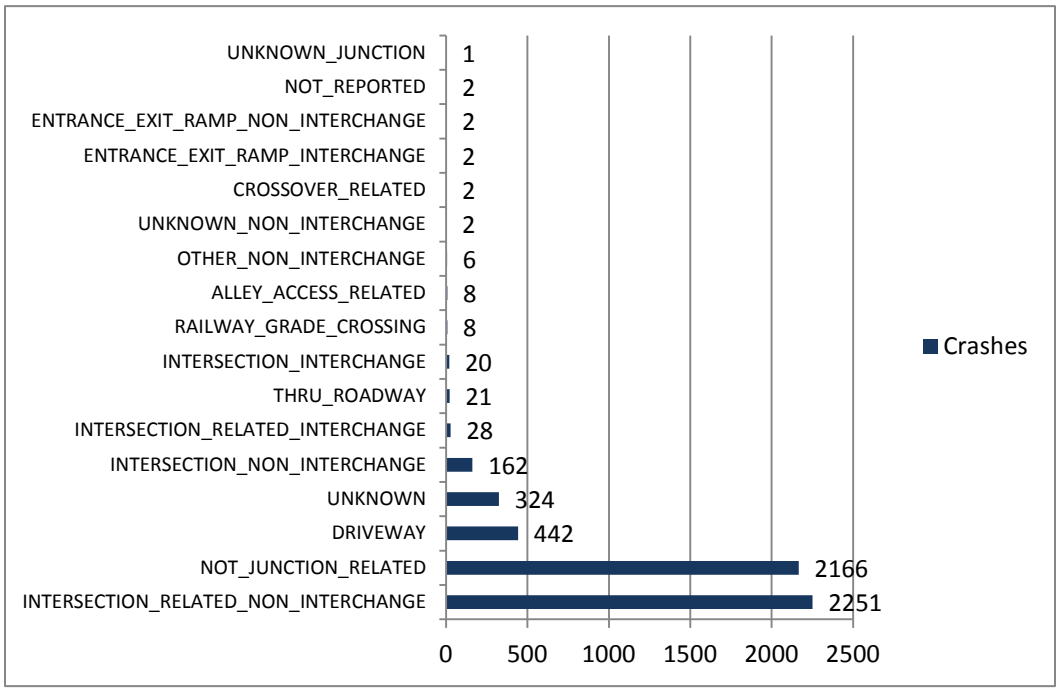
Figure 2.3 shows where pedestrians were located for crashes. Of the *known* locations, the greatest proportion of crashes is in a marked crosswalk at an intersection.

Figure 2.3 Pedestrian Crash Location, 2005-2009



As shown in Figure 2.4, most crashes occurred at an intersection. However 40 percent of crashes occurred at nonjunction locations – places not near an intersection – most likely reflecting crashes involving mid-block crossings.

Figure 2.4 Pedestrian Crashes – Relation to Junction, 2005-2009



As shown in Figure 2.5, most pedestrians were crossing the roadway when involved in a crash.

Figure 2.5 Pedestrian Action, 2005-2009

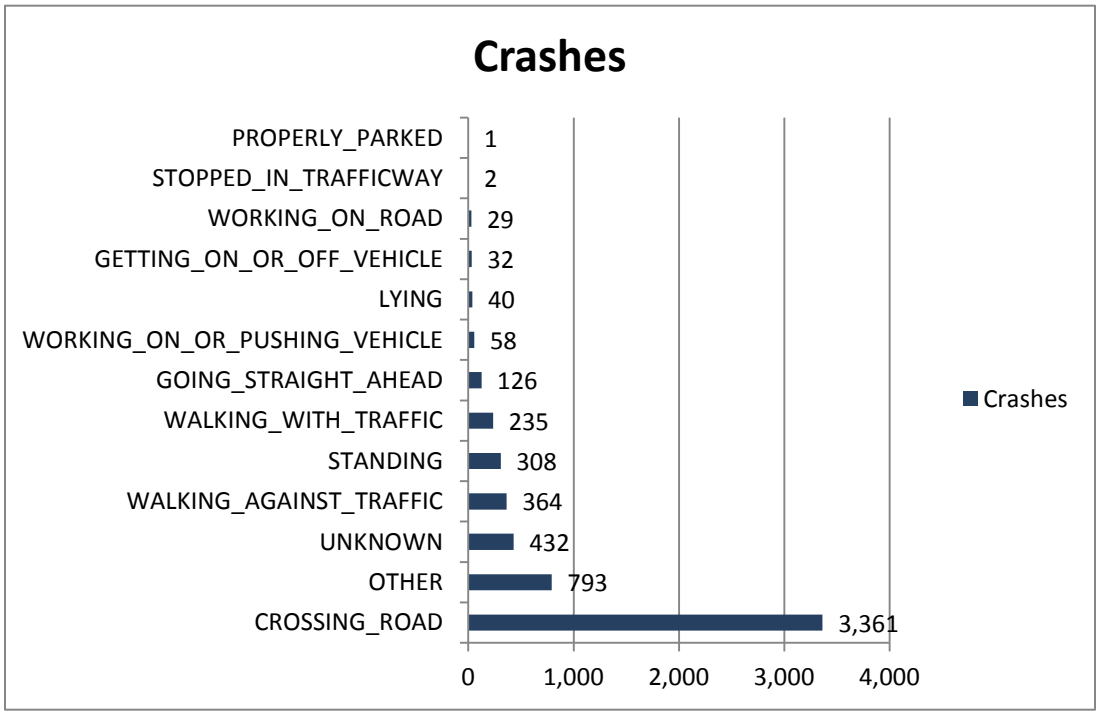


Figure 2.6 shows the driver violations when pedestrian crashes occurred. Failure to yield was the top violation. Inattention/distraction was a factor in 751 crashes. Given the lower visibility of pedestrians compared to vehicles, distraction may play an even more crucial role in their safety given the lower margin for error to avoid injury. Speeding was a factor in nearly 400 crashes.

Figure 2.6 Driver Violation in Pedestrian Crashes, 2005-2009

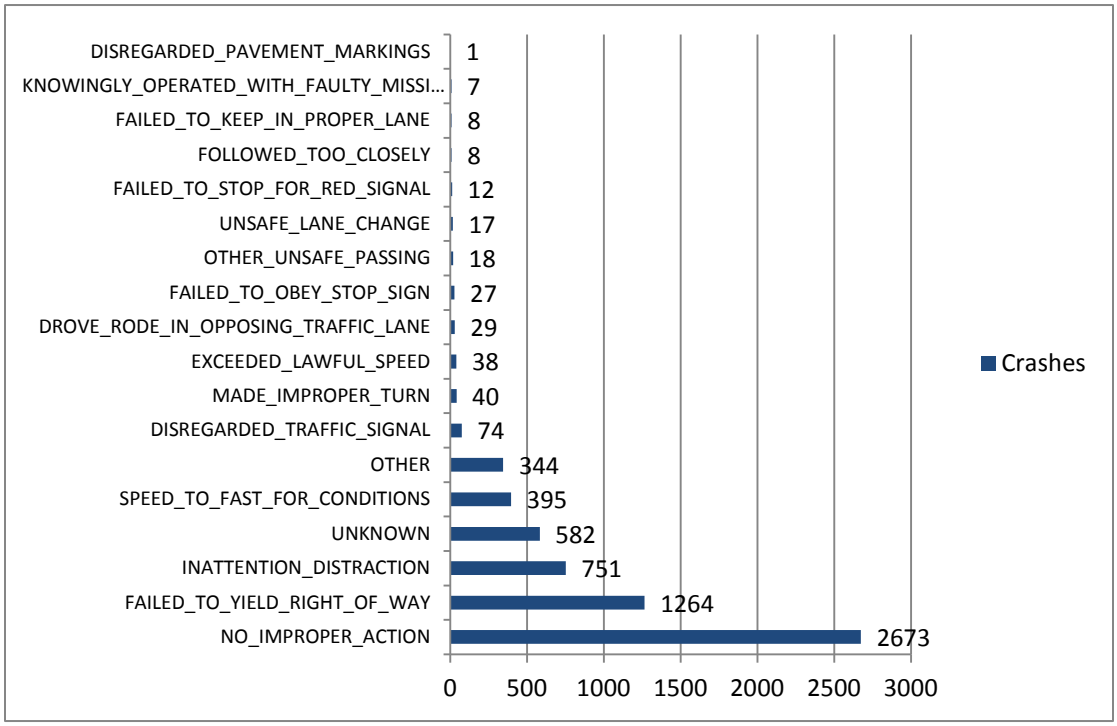
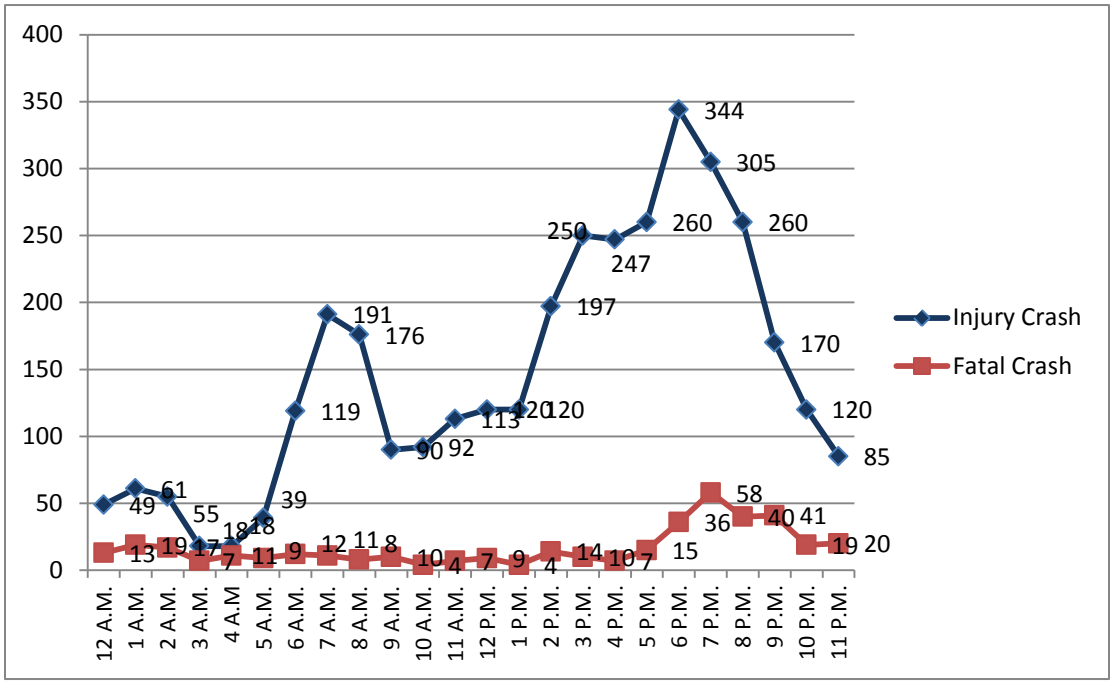


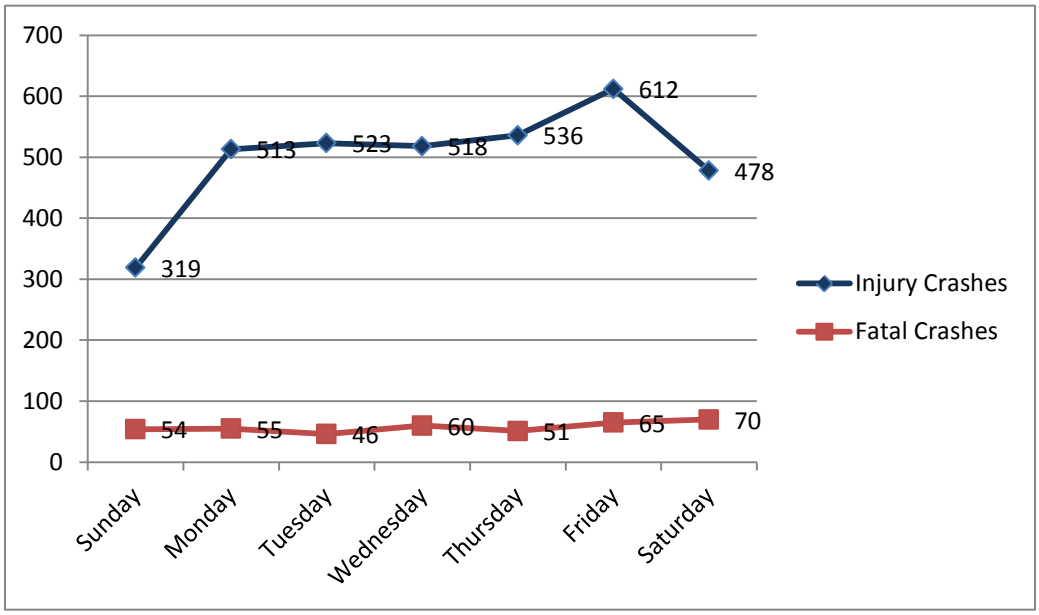
Figure 2.7 shows the time of day when pedestrian crashes occur. The peak hour for injury crashes is 6pm and for fatal crashes is 7pm. The bulk of fatal and injury crashes occur during the early evening hours. Depending on the time of year, some of these crashes may be occurring at dusk or after sunset when visibility is diminished.

Figure 2.7 Pedestrian Crashes by Time of Day, 2005-2009



The highest numbers of pedestrian fatal crashes occur on Fridays and Saturdays, and the highest number of injury crashes is on Fridays, as shown in Figure 2.8

Figure 2.8 Pedestrian Crashes by Day of Week, 2005-2009



Figures 2.9 and 2.10 show the number of pedestrian fatalities and injuries per capita in the communities in the MAG region. Per capita fatality and injury rates were calculated using 2009 Census Population Estimates data. While it would be expected to see the majority of incidents in Phoenix where the majority of population is located, looking at the number of fatalities and injuries per capita helps understand where the rate of pedestrian crashes is relatively higher or lower in the region. This information is useful to show locations in the region where more attention to this issue may be needed. Phoenix had the highest rate of pedestrian fatalities with 244 fatalities from 2005 to 2009 for its population of 1.6 million. These rates are also related to the amount people walk in various communities and the level of exposure pedestrians experience. Seven jurisdictions experienced no pedestrian fatalities. Injury rates were similarly categorized and are displayed in Figure 2.10.

Figure 2.9 Pedestrian Fatalities Per Capita, 2005-2009

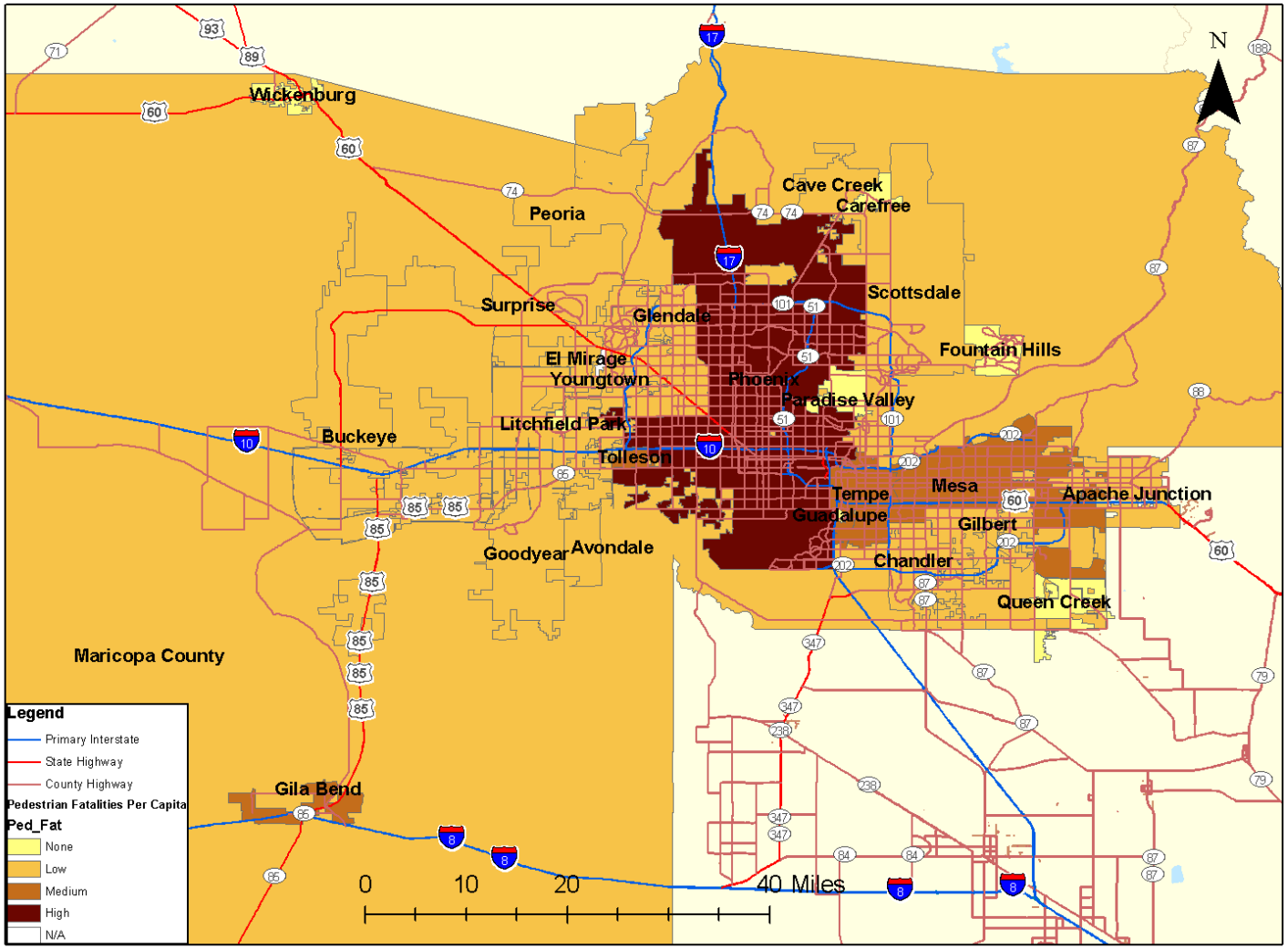
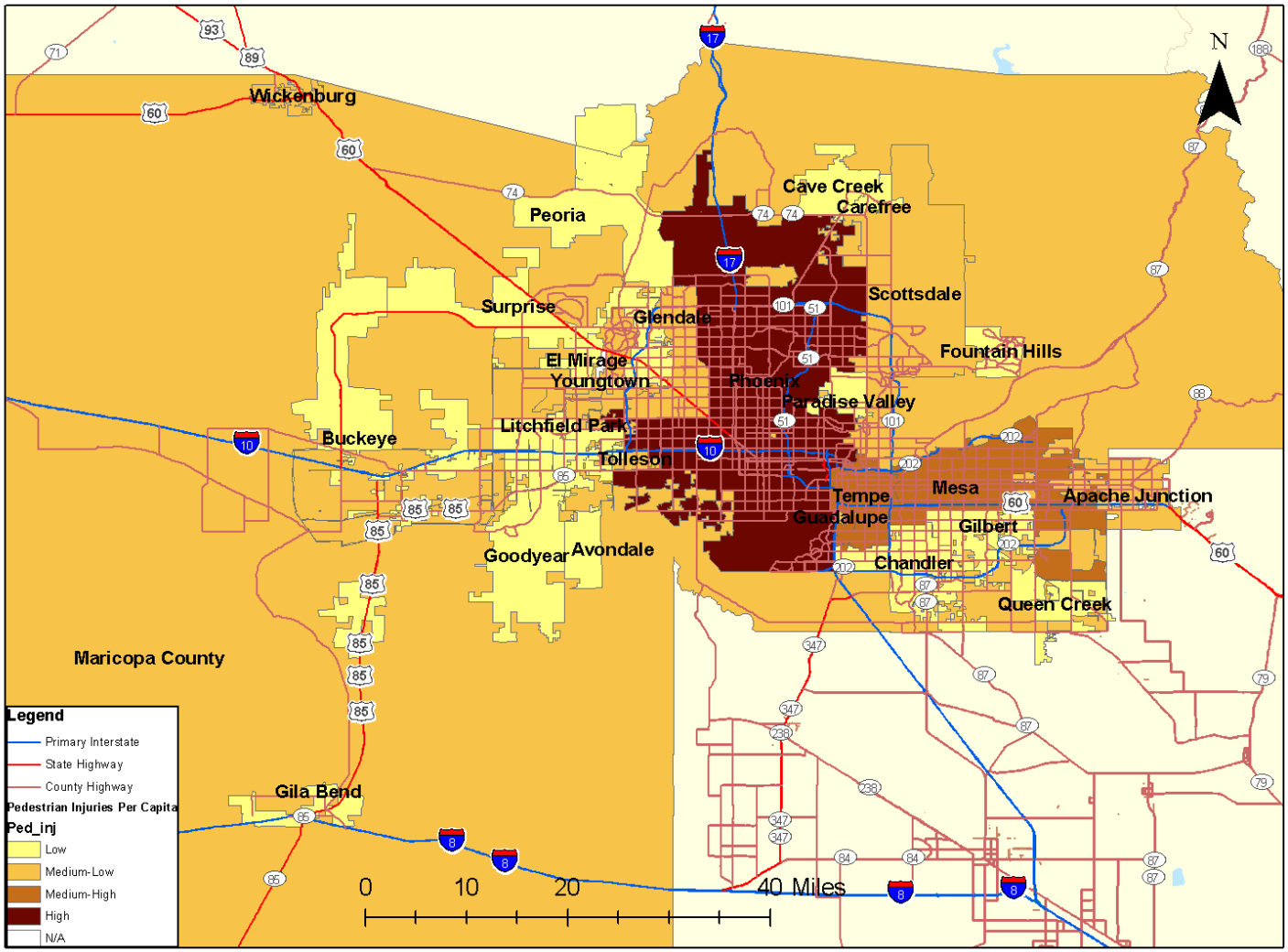


Figure 2.10 Pedestrian Injuries Per Capita, 2005-2009



Conclusions

While many drivers involved in pedestrian crashes were not reported as having violations, a significant number did violate the rules of the road. The largest categories of violations were failure to yield right-of-way, distraction and speeding. These are target areas where education and enforcement to change driver behavior can be focused. The data also reveals that for pedestrians, being in a crosswalk is not a guarantee of safety. Given the rates of failure to yield and speeding, pedestrians need to proceed with caution, and need to ensure they are crossing the street only when it is safe to do so. While fatalities among children are low, the large rate of injuries among teens age 15 to 19 shows that this age group may need specific attention. The vast majority of fatalities, however, involved adults. This analysis also reveals that a significant amount of data is missing for certain factors, (e.g., pedestrian crash location in Figure 2.3), which provides insight into areas for improvement in data collection.

2.2 PEDESTRIAN COUNTERMEASURES

Section 2.2 provides a range of countermeasures that may be used to address pedestrian fatal and injury crashes in the MAG region, building on the previous literature review. As possible, proven strategies were included – these are shown in Table 2.1 and listed in priority order considering the extent to which they address the identified safety problems and their anticipated effectiveness. However, given the number of tried or emerging strategies for which little quantitative outcome data is available (Table 2.2), unproven strategies may also be considered. If unproven strategies are implemented, it is recommended that they include an evaluation element to add to the body of knowledge of what works.

The safety data should guide the manner in which strategies are implemented. For example, if a public education campaign is selected to address pedestrian behavior, it should be appealing to males given the preponderance of males involved in pedestrian crashes. Given that large number of crashes involved pedestrians in marked crosswalks at intersections and that a key driver action was failure to yield, enforcement of drivers yielding to pedestrians in crosswalks would be a likely strategy to pursue.

Given the proportion of the population that is Spanish speaking in the MAG region, efforts to reach out to this population should also be considered. NHTSA notes that when Hispanic immigrants arrive in the U.S., they often rely on walking and/or bicycles as a primary means of transportation. However, they often are unfamiliar with U.S. traffic signs, signals, and practices. The language barrier may also affect their ability to understand how to travel safely. For these

reasons, Hispanics are at a higher risk of being involved in pedestrian and/or bicycle crashes. Hispanic adult men, in particular, may be at an even higher risk.[19]

[19] www.nhtsa.gov/Driving+Safety/Bicycles/Pedestrian+and+Bicycle+Safety+among+Hispanics.

Table 2.1 Proven Pedestrian Safety Countermeasures

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Reduced speed limits for pedestrian safety	Reduction in speed limit from 60 km/hr (37mph) to 50 km/h (31 mph) in urban areas	Reduction of 25 to 30% in pedestrian fatalities	Process measure: • Lane-miles of roadways with reduction in permitted speed Performance Measure: • Number and severity of pedestrian crashes involving speeding	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures		All pedestrian crashes
Targeted Enforcement	The purpose of targeted enforcement is to increase compliance with appropriate traffic laws by both pedestrians and motorists. Behavioral pedestrian safety initiatives require drivers or pedestrians to change their walking or driving actions and habits. Once pedestrians and drivers are informed of the changes needed and why they are important, enforcement often is necessary to encourage compliance.	Because implementation varies widely, effectiveness is difficult to determine	Process Measure • Amount of targeted enforcement hours • Number of locations at which targeted enforce-ment is conducted Performance Measure • Fatal and injury pedestrian crashes involving a traffic violation	Countermeasures that Work, 2011		Crashes involving violations being enforced
Increased enforcement to reduce speed	This strategy involves ensuring drivers adhere to posted speed limits.	CRF = 70 for pedestrian crashes	Process Measure • Number of targeted enforcement hours Performance Measure • Number of pedestrian crashes involving speed	Desktop Reference for Crash Reduction Factors, U.S. DOT, 2007		Pedestrian crashes involving speeding

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Enforcement of vehicles yielding to pedestrians in crosswalks	Program in which decoy pedestrian crosses the when other pedestrians were not present and a spotter who radioed failure-to-yield violations to other officers who flagged the violators and gave them a verbal warning or citation and an enforcement flyer.	Two-week intensive enforcement program increased yielding to pedestrians at sites where enforcement was implemented and that this increase was sustained over the course of a year even though the level of enforcement was greatly reduced. Yielding increased from 3%-18% to 27%-33% (Van Houten and Malenfant, 2004).	Performance Measure: Number of vehicles yielding to pedestrians • Number of fatal and injury crashes within crosswalks Process Measure • Number of vehicle stopped for violations • Number of locations with increased enforcement of vehicles yielding to pedestrians	Journal of Applied Behavioral Analysis, Volume 37, No. 3 (fall 2004)	Chicago Crosswalk Enforcement Initiative: http://www.cityofchicago.org/city/en/epts/cdot/provdrs/ped/svcs/crosswalk_enforcementinitiatives.html Effects of Driver Enforcement Program on Yielding to Pedestrians, Van Houten and Malenfant, 2004: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1284509/pdf/15529891.pdf	Crashes involving pedestrians in crosswalks and driver failure to yield

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Public Information and Education	Public awareness campaign of pedestrian safety issues. May include education of adults/ caregivers on the need for supervision of children under 10 near traffic	The estimated impact of mass media road safety campaigns is likely to vary depending on the measure of effect used. Across all measures the effect has been estimated as a 7.5% reduction in the relevant outcome measure.(Delaney, 2004)	Process Measure • Number of individuals reached with materials Performance Measure • Number of fatal and injury pedestrian crashes	Countermeasures that Work, 2011 A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf	FHWA Pedestrian Safety Materials http://safety.fhwa.dot.gov/local_rural/pedcampaign/ Pedestrian Safety for Hispanics http://www.nhtsa.gov/Driving+Safety/Bicycles/Pedestrian+and+Bicycle+Safety+among+Hispanics Spanish Bicycle Safety for English Learners: http://www.nhtsa.gov/Driving+Safety/Pedestrians/For+English+as+Second+Language+(ESL)+Teachers+and+Learners	Depends on issue targeted. Could address: driver violations (speeding, failure to yield, distraction). Could target pedestrians to promote safer behavior.
Improve speed limit compliance	Speed Monitoring Displays (SMD): An SMD is a speed monitoring radar combined with an LED sign that informs approaching drivers at what speed they are traveling. Typically the speed limit is also included. A Utah study found that they reduced both average speeds and the percent of vehicles over the speed limit in school zones.	SMDs helped improve school zone safety by decreasing speeds and increasing speed compliance	Performance Measure • Number of speed-related pedestrian crashes Process Measure • Number of locations/days receiving treatment	Increasing Speed Limit Compliance in Reduced Speed School Zones, Saito, 2005 for Utah Department of Transportation	http://www.udot.utah.gov/main/uconowner.gf?n=200511010945391	Crashes involving speeding

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Pedestrian Safety Zone	The idea is to strive for large decreases in pedestrian crashes and injuries by more effectively targeting resources to problem areas. Specifically, the objective of pedestrian safety zones is to increase efficiency by targeting limited resources to geographic areas and audiences where significant portions of the pedestrian crash problem exist (NHTSA, 2008). Pedestrian zone programs, including education, enforcement, and engineering measures, can target at a full range of pedestrian crash problems within a limited geographic area or focus on particular problems that make up a larger portion of the problem within a limited area.	Properly designed and implemented pedestrian zone programs have been shown effective in reducing crashes and injuries for older pedestrians, for impaired pedestrians, and for child and adult pedestrian crashes in Miami-Dade County	Process Measure: • Number of pedestrian zones implemented Performance Measure: • Number of pedestrian crashes in pedestrian zones • Number and severity of pedestrian crashes	Countermeasures that Work, 2011		Pedestrian crashes in high-crash areas
School pedestrian training,	Education of children ages 6 to 12 years old	12% reduction in child pedestrian injuries	Process Measures: • Number of children participating in program • Number of person-hours of training delivered Performance Measure: • Number and severity of pedestrian crashes involving children ages 6 to 12	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures		Crashes involving children ages 6 to 12

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
WalkSafe program	Three-day educational program with 1.5 contact hours of education	Proven to increase knowledge gain by students		Hotz et al, Journal of Trauma, Injury, Infection and Critical Care, Vol. 66, No 3, 2009	http://www.walksafe.us	Crashes involving elementary age children
Ice Cream Vendor Ordinance	The ordinance requires that drivers come to a complete stop before passing an ice cream truck that is stopped to vend. Drivers may proceed when it is safe at no more than 15 mph and must yield to all nearby pedestrians. The ice cream truck must be equipped with flashing signal lamps and a stop signal arm, similar to those found on school buses, which can be activated when the truck is stopped for vending.	When tested in Detroit, crashes to pedestrians going to or from ice cream trucks were reduced by 77% (Hale et al., 1978).	Process Measure • Development and passage of ice cream vendor ordinance Performance Measure • Number of pedestrian crashes involving walking to/from ice cream truck/ vendor	Countermeasures that Work, 2011	Hale, A., Blomberg, R. D., & Preusser, D. F. (1978). *Experimental field test of the model ice cream ordinance in Detroit.* Publication No. DOT HS 803 410. Washington, D.C.: National Highway Traffic Safety Administration.	Crashes resulting from children running to or from ice cream vendors

Table 2.2 Tried/Emerging Pedestrian Safety Strategies

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Children's Safety Clubs	The purpose of children's safety clubs is to help parents and caregivers become more involved in educating young children about safe walking techniques through books and activities on road safety. Related goals are to help promote ongoing, age-appropriate training and safe attitudes towards traffic.	Undetermined: different methods of implementing this countermeasure produce different results Results in the UK: -49% reduction in pedestrian casualties -20% reduction in casualties involving children emerging from behind parked vehicles -12% fewer overall road casualties than non-members of clubs	Process Measure • Establishment of clubs and size of membership Performance Measure • Number of fatal/injury pedestrian crashes involving children under age 12	Countermeasures that Work, 2011	*Teaching Children to Walk Safely as They Grow and Develop: A Guide for Parents and Caregivers*, http://guide.saferoutesinfo.org/graduated_walking/index.cfm London Children's Traffic Club http://www.tfl.gov.uk/corporate/projectsandschemes/2455.aspx http://www.trafficclub.org/	Crashes involving young children
Crosswalk Flags	At crosswalks where treatment is present, pedestrians pick up a bright orange flag and carry it with them while crossing and leave it on the other side	No studies have been undertaken; however Salt Lake City staff has noted a dramatic increase in the willingness of drivers to yield to pedestrians carrying orange flags. Informal observations and discussions with pedestrians also instill confidence that the numbers of near miss accidents between pedestrians and vehicles have been reduced.	Process Measure • Number of treated crosswalks Performance Measure 1. Number of fatal/injury crashes in crosswalks	Salt Lake City Department of Transportation	http://www.slcgov.com/transportation/Pedestrian/pdf/CrosswalkFlagsBrochure11_05.pdf	Crashes at marked crosswalks

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Safe Routes to School	SRTS programs examine conditions around schools and conduct projects and activities that work to improve safety and accessibility, and reduce traffic and air pollution in the vicinity of schools	SRTS material can be effective in teaching children and their parents how to evaluate and choose the safest routes for walking or bicycling to and from school. Strategies are derived from analyses of types of crashes associated with to/from school trips, but it has not been possible to evaluate their effect on preventing crashes and injuries. Dumbaugh and Frank (2007) found many of the safety benefits of SRTS countermeasures are assumed rather than known.	Process Measure • Number of sites having implemented SRTS improvements Performance Measure • Pedestrian Crashes involving School Age Children	Countermeasures That Work, 2011	http://www.saferoutesinfo.org/ Dumbaugh, E., & Frank, L. D. (2007). Traffic safety and Safe Routes to Schools: Synthesizing the empirical evidence. Transportation Research Record: Journal of the Transportation Research Board, 2009, 89-97.	Crashes involving school aged children
Driver Training	The purpose of pedestrian safety-related driver training is to increase the sensitivity of drivers to the presence and characteristics of pedestrians. Current training for new drivers typically includes relatively little information on other road users. Information on pedestrians can be significantly strengthened. One way driver training can incorporate pedestrian and bicyclist concerns for new drivers is through "Share the Road" concepts and programs	Driver education has not been shown to reduce overall crash rates. The objective for adding more pedestrian information would be to increase knowledge and desire to share the road safely with pedestrians, of how to avoid the most common types of crashes, and to improve drivers' anticipation of and interactions with pedestrians – as well as improve their behavior as pedestrians.	Process Measure • Incorporation of pedestrian education into driver training Performance Measures • Number of fatal and injury pedestrian crashes	Countermeasures That Work, 2011	ADOT educational materials: http://www.azbikeped.org/education.html *Sharing the Road with Pedestrians:* http://www.azbikeped.org/images/adotpedguide308.pdf	All pedestrian crashes

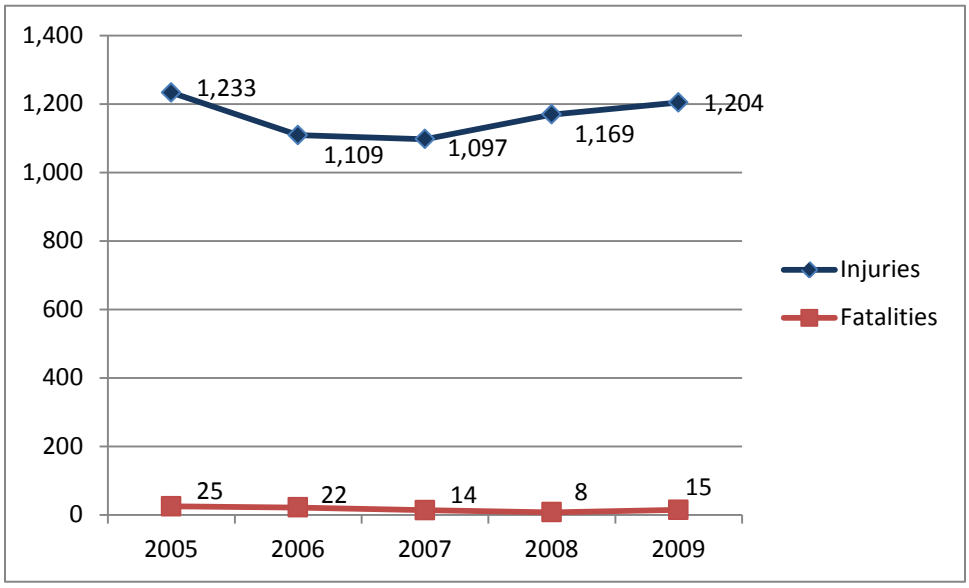
3.0 Bicyclists

This section describes various aspects of bicycle crashes in the MAG region between 2005 and 2009 to provide insight into the range of factors that may be contributing to these crashes. Understanding these factors provides insight into the types of countermeasures that may be most effective at reducing bicycle crashes.

3.1 Bicyclist Crash Data Analysis

Bicycle fatalities and injuries have fluctuated over the past five years. While fatalities had steadily decreased from 2005 to 2008 (Figure 3.1), the number increased in 2009 to 15. Bicyclist injuries declined in 2006 and 2007 but have since increased to nearly the levels of injuries experienced in 2005.

Figure 3.1 Bicyclist Injuries and Fatalities, 2005-2009



The largest number of bicycle fatalities was experienced by individuals in their 40s and 50s (Figure 3.2). Bicyclist injuries were highest among children and teens aged 10 to 19; fortunately, however, fatalities were low for youth under age 19. The bicycle safety impacts are experience primarily by males, with 91 percent of deaths and 78 percent of injuries involving males. This likely reflects a higher proportion of males using bicycles for transportation or recreation in the MAG region.

Figure 3.2 Bicyclist Fatalities and Injuries by Age, 2005-2009

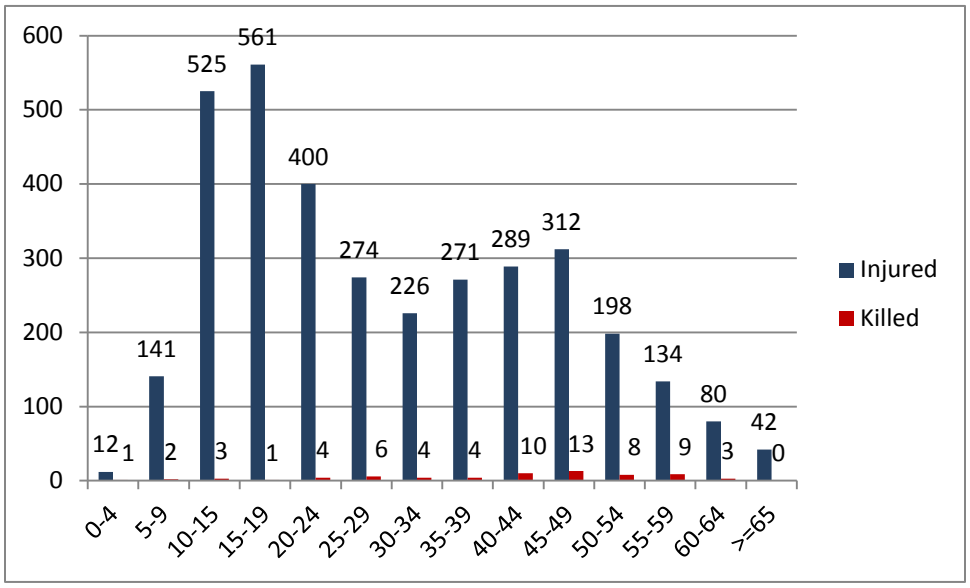


Figure 3.3 shows that vehicle drivers failed to yield right-of-way in nearly 1,500 crashes with bicyclists. Distraction was a factor in more than 1,000 crashes. As noted in the pedestrian section, driver distraction may play an even more crucial role in the safety of pedestrian and bicycle crashes give the higher potential for injury as compared with crashes involving only vehicles.

Figure 3.3 Driver Violation for Bicyclist Crashes, 2005-2009

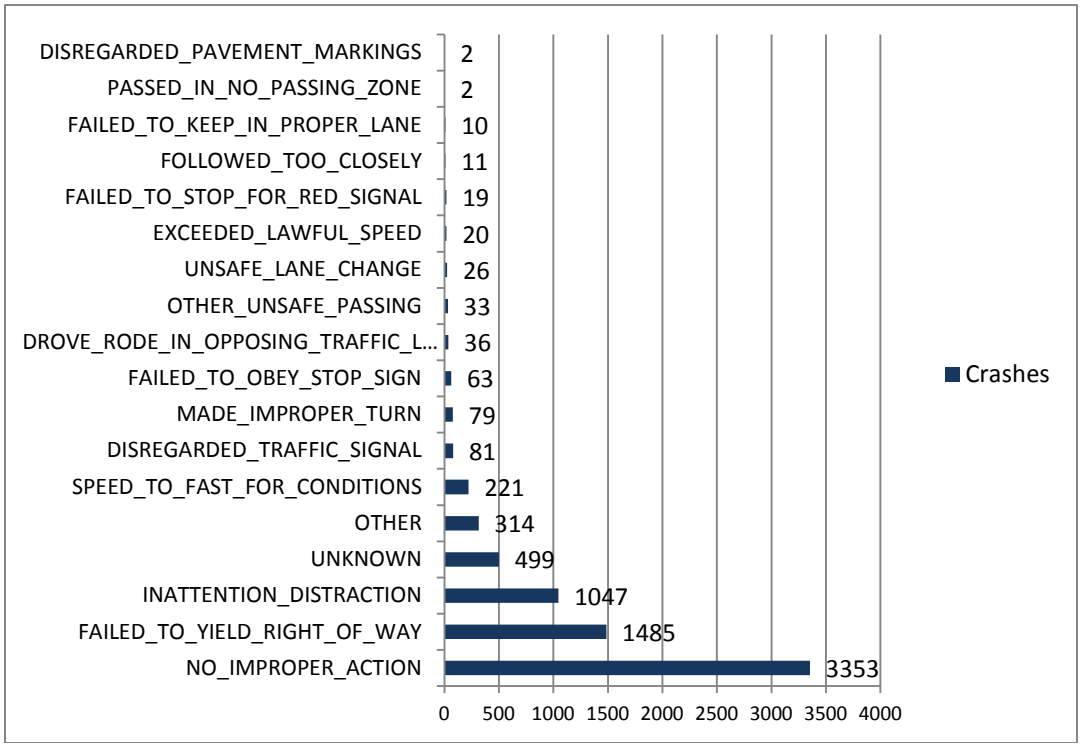


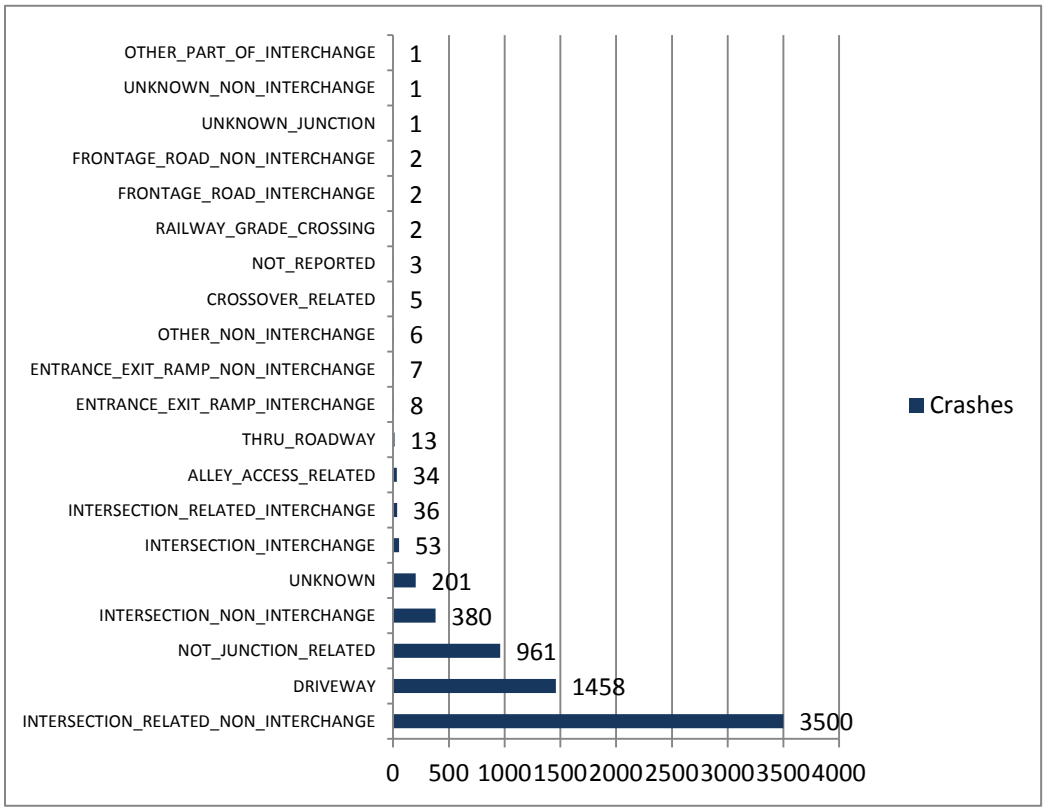
Table 3.1 Bicyclist Violations

Bicyclist Violation 1	Bicycle Facility Present					
	Bicycle Lane	Multi-use Path	None	Paved Shoulder	Wide Curb Lane	Row Total
Did Not Use Crosswalk	0	0	1	0	1	2
Disregarded Traffic Signal	7	2	109	3	1	122
Drove in Opposing Traffic Lane	13	1	222	13	0	249
Failed to Yield Right-of-Way	3	1	58	5	1	68
Inattention	3	0	23	2	1	29
Knowingly Operated with Faulty or Missing Equipment	0	0	3	0	0	3
Made Improper Turn	1	0	4	1	0	6
No Improper Action	15	8	150	30	1	204
Other	1	0	0	0	0	1
Other Unsafe Passing	0	0	1	0	0	1
Passed in No Passing Zone	0	0	3	0	0	3
Ran Stop Sign	0	0	6	0	0	6
Speed Too Fast for Conditions	0	0	8	0	0	8
Unknown	0	0	36	1	0	37
Unsafe Lane Change	0	0	6	1	0	7
Total	43	11	630	56	5	746

Source: ADOT Bicycle Safety Action Plan Working Paper 3: State Highway Priority Crash Locations and Countermeasures, April 2011.

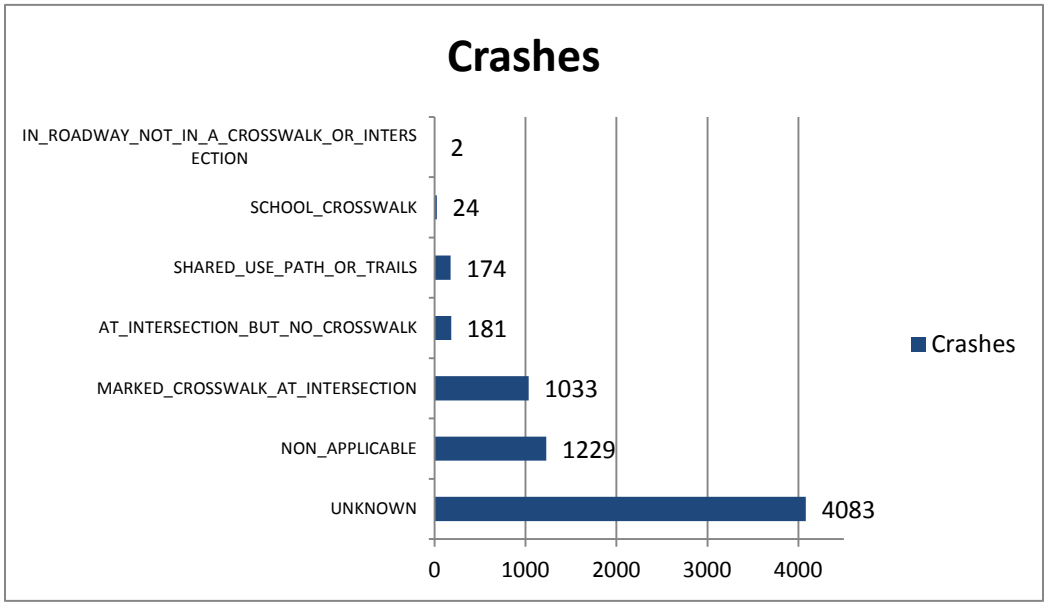
Table 3.1 shows bicyclist violations, with the greatest problem being riding in the opposing traffic lane. Another major issue is disregarding traffic signals. The majority of crashes with bicyclists occurred at intersections, as shown in Figure 3.4. Therefore safety efforts related to intersections should also benefit bicyclists.

Figure 3.4 Location of Bicyclist Crash as Related to Junction, 2005-2009



The majority of crashes involve a bicyclist in a marked crosswalk at an intersection as shown in Figure 3.5. It is likely that many of those involved were riding on the sidewalk prior to entering the crosswalk. Bicyclists on a sidewalk or bicycle path incur greater risk than those on the roadway, most likely due to blind conflicts at intersections. Wrong-way sidewalk bicyclists are at even greater risk, and sidewalk bicycling appears to increase the incidence of wrong-way travel[20]. Pedestrian crashes were also prevalent in crosswalks.

Figure 3.5 Location of Bicyclist



Data also show that bicyclists were traveling straight ahead at the time of the crash in the majority of cases, as shown in Figure 3.6.

[20] http://www.bicyclinglife.com/Library/Accident-Study.pdf

Figure 3.6 Bicyclist Action Involved in Crash, 2005-2005

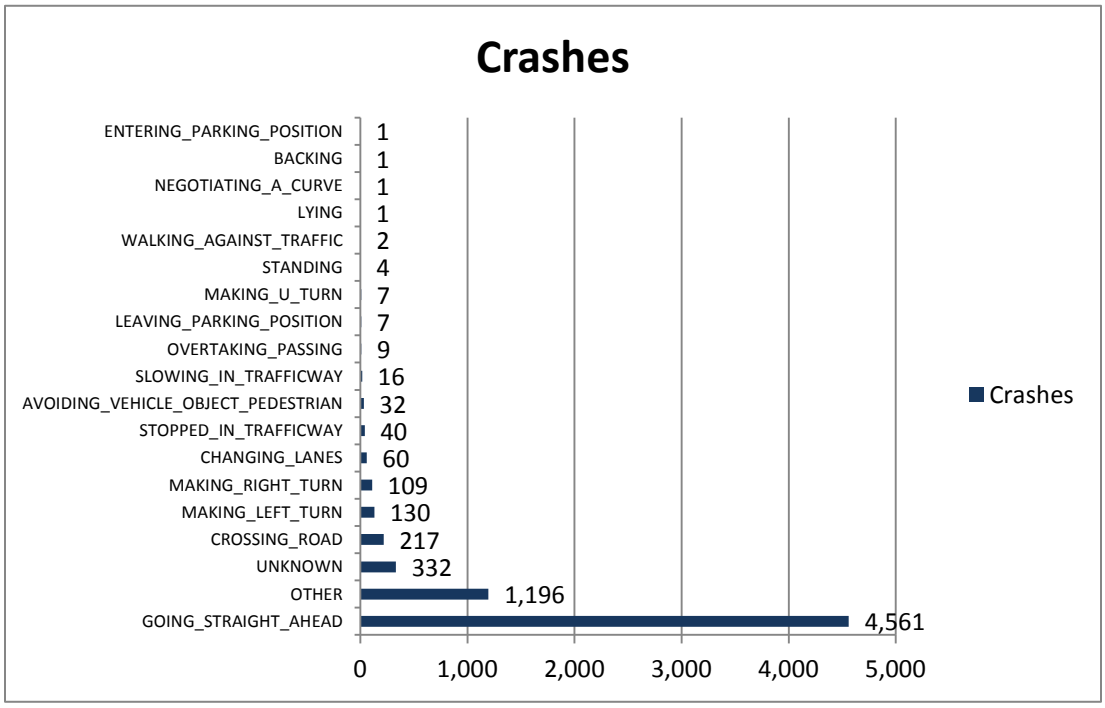


Figure 3.7 shows that the highest numbers of fatal and injury crashes occur in the late afternoon to early evening. There is also a peak at 7a.m., which could reflect crashes during commuting or recreation before work.

Figure 3.7 Bicycle Crashes by Time of Day

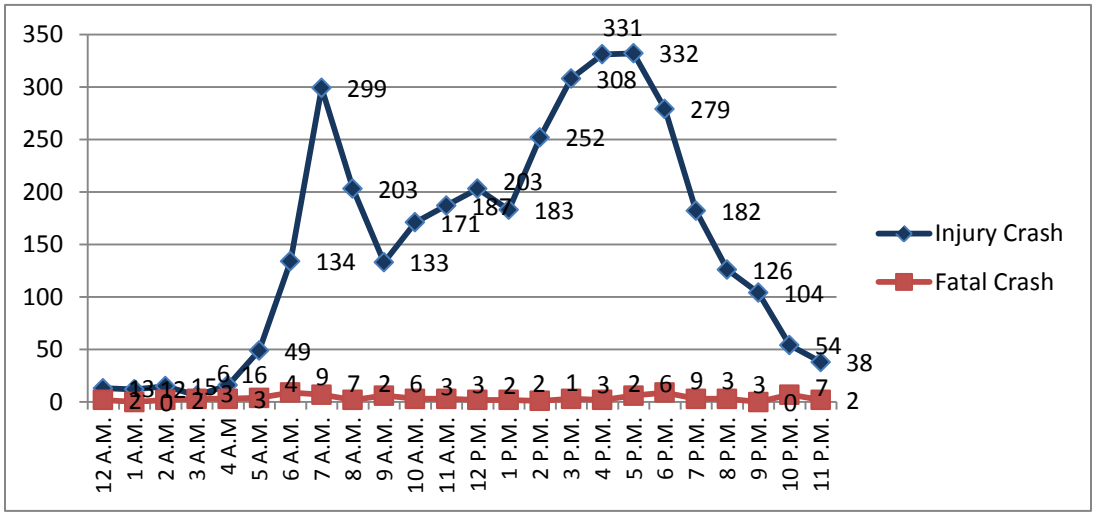
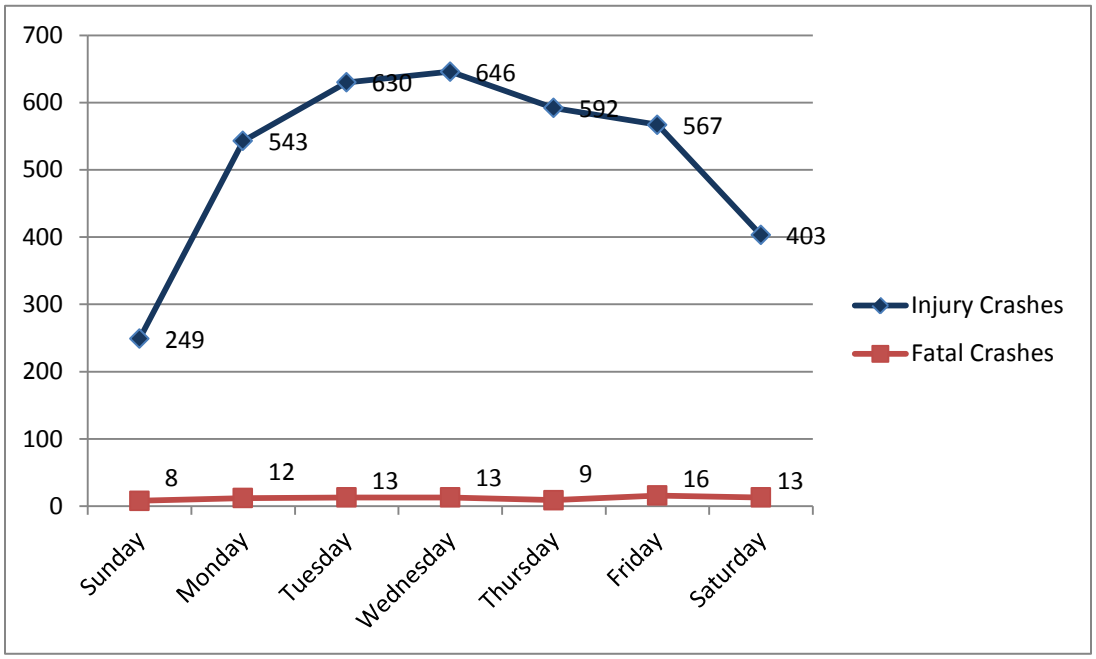


Figure 3.8 Bicycle Crashes by Day of Week



Fatal bicycle crashes are fairly evenly dispersed during the week, while injury crashes are more prevalent on weekdays (Figure 3.8). Figures 3.9 and 3.10 show the relative rates of bicycle fatalities and injuries in the region. Unincorporated Maricopa County and Litchfield Park had the highest fatal crash rates, with Maricopa County experiencing 11 bicycle fatalities for a population of 230,979 and Litchfield Park having 1 bicycle fatality with a population of 5,178. However, 15 municipalities experienced no bicycle fatalities during this period.

In terms of injuries, the highest rate was in Tempe, with 803 bicycle injuries for a population of 178,519. . The differing rates can reflect varying rates of bicycling in various communities due to community characteristics, as well as how well reported crashes are by law enforcement in various municipalities.

Figure 3.9 Bicycle Fatalities Per Capita, 2005-2009

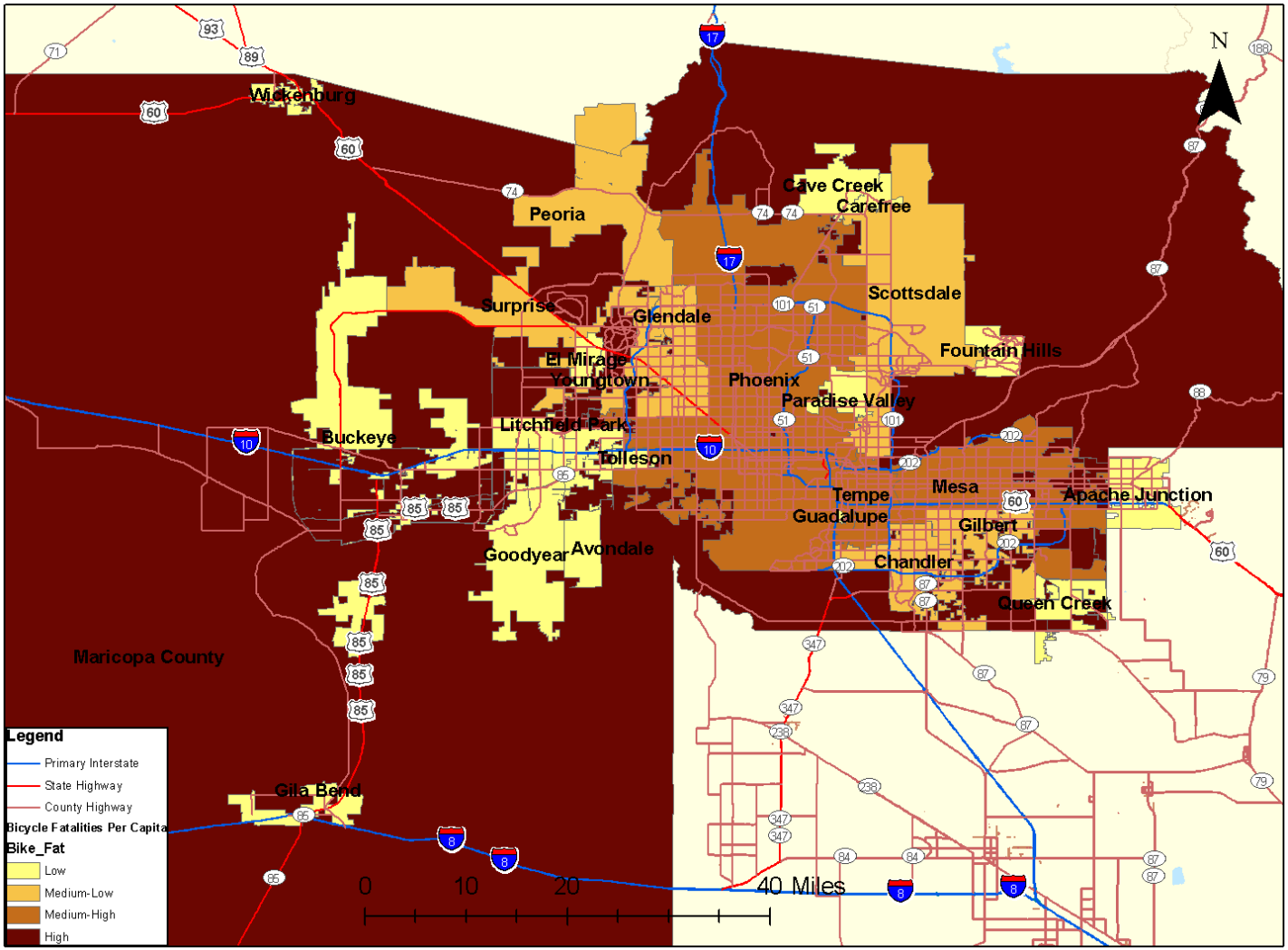
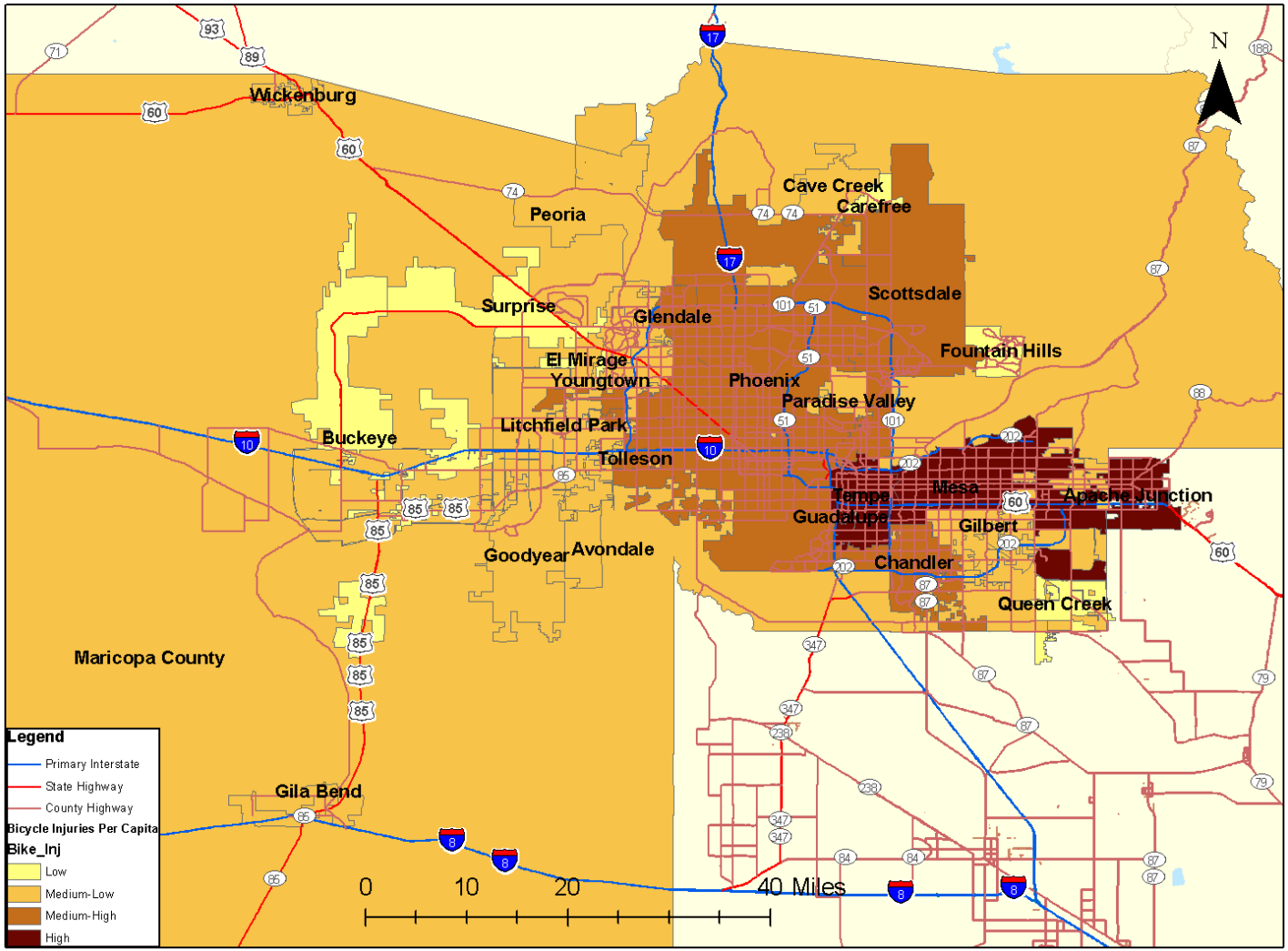


Figure 3.10 Bicycle Injuries Per Capita, 2005-2009



Conclusions

Bicycle safety data shows that driver violations are a component of the problem, with distraction and failure to yield being the top two reported violations. Additionally, bicyclists are frequently hit by vehicles while in a marked crosswalk. Therefore, vehicles yielding to bicycles in crosswalks would be a target for enforcement and education, as well driver distraction. Bicyclists need to be educated on the increased risk of riding on sidewalks and through crosswalks. Most bicycle crashes are near intersections, and many are at driveways, so these are key locations for improving safety. Given the number of crashes in the late afternoon and early evening, bicyclist visibility may be an area for improvement. It would also be useful to review crash factors in rural versus urban settings to help distinguish between those affecting urban commuter/transit riders compared to those in school areas and recreational riders, as the countermeasures may differ for these groups.

3.2 BICYCLE SAFETY COUNTERMEASURES

Section 3.2 provides countermeasures that may be used to address bicycle fatal and injury crashes in the MAG region. Only two strategies shown in Table 3.2 were proven, and one provided a crash reduction factor. Table 3.3 presents tried/emerging strategies, which address various aspects of the bicycle safety problem. Therefore, it is likely that tried or emerging strategies for which little outcome data is available should be considered. If unproven strategies are implemented, it is recommended that an evaluation element be included to add to the body of knowledge of what works.

Safety data informs the selection of strategies and also should be useful in determining how strategies are tailored for the region. For example, if a public education campaign is selected to address bicycle safety it should explicitly target male bicyclists as they are by far the dominant gender involved in bicycle crashes. Children and teens ages 10 to 19 experience high numbers of bicycle injuries and may be a target for safety education as well as middle aged adult males. Additionally, efforts to combat distracted driving may result in improvements to bicyclist safety.

Table 3.2 Proven Bicycle Safety Countermeasures

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue addressed
Bike helmet law for children	Requirement for bike helmet use for children under age 12	15% reduction in fatalities involving children under age 12	Process Measures: • Implementation of law • Number of warnings for non-use of helmets among children under 12 Performance Measure: • Number of fatal or injury crashes involving unhelmeted juvenile bicyclists	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures		Bicycle crashes involving children under 12

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue addressed
Promote bicycle helmet use with education	The purpose of bicycle helmet promotions is to increase use of helmets and thereby decrease the number of severe and fatal injuries to bicyclists involved in crashes.	Bicycle helmets are proven to reduce fatalities and serious injuries. Helmet promotions are successful in getting more helmets into the hands of bicyclists. Rouzier and Alto (1995) describe a comprehensive program of presentations, media coverage, messages from doctors to patients, as well as low-cost helmet availability, which significantly increased helmet purchases and use for all ages. A peer-led, social marketing program on a medium-sized college campus also raised observed helmet use, at least for the short term (Ludwig, Buchholz, & Clarke, 2005). A school-based injury-reduction program targeting 13- and 14-year-olds based on the theory of planned behavior and incorporating opportunities for instruction, demonstration, rehearsal, feedback, social reinforcement and practice was associated with a 20% increase in observed rate of helmet use among this challenging target age group at 6 months follow-up (Buckley et al., 2009).	Process Measures: • Number of people reached with education • Number of helmets distributed Performance Measures • Number of crashes involving unhelmeted riders	Countermeasures That Work, 2011	Rouzier, P., & Alto, W. A. (1995). Evolution of a successful community bicycle helmet campaign. Journal of the American Board of Family Practitioners, 8, 283-287. Ludwig, T. D., Buchholz, C., & Clarke, S. W. (2005). Using Social Marketing to Increase the Use of Helmets Among Bicyclists. Journal of American College Health, 54, 51-58. Buckley, L., Sheehan, M., & Chapman, R. (2009). Bicycle helmet wearing among adolescents: Effectiveness of school-based injury prevention countermeasure. Transportation Research Record, *2140*, 173-181.	All bicycle crashes

Table 3.3 Tried/Emerging Bicycle Safety Countermeasures

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
Restrict right turn on red (RTOR) movements	The primary purpose of this strategy is not to restrict RTOR at all signalized intersections in an area or local jurisdiction. Rather, the purpose is to restrict RTOR movements at certain signalized intersections throughout the entire day or during portions of the day (e.g., during periods of peak bicycle activity). At signalized intersections with a history of bicycle/motor vehicle crashes resulting from RTOR movements, an analysis of the time of day of the crashes may provide justification for restricting RTOR movements throughout the entire day or during specified hours of the day.	Approximately 3 to 4% of all bicycle/motor vehicle crashes occur during a RTOR maneuver, and 6% of these crashes result in serious or fatal injuries (Tan, 1996). The expected number of bicycle/ motor vehicle crashes that may be reduced by imple-menting this strategy is diffi-cult to assess because it is an experimental treatment for improving bicycle safety. However, this strategy has been recommended for improving pedestrian safety based upon a field study (Retting, R. A., Nitzburg, M. S., Farmer, C. M., and Knoblauch, R. L. (2002). *Field Evaluation of Two Methods for Restricting Right Turn on Red to Promote Pedestrian Safety*. ITE Journal 72)	Process Measure: • Number of intersections at which RTOR is prohibited during some portion of the day Performance Measure: • Number and severity of bicycle crashes involving RTOR movements	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles		Bicycle crashes at intersections

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
Improve enforcement of bicycle-related laws	This strategy directly targets activities of law enforcement officers as they relate to bicycling and indirectly targets behavior of bicyclists and motorists.	Many crashes can be avoided if both bicyclists and motorists follow the rules of the road. Heightened awareness among law officers of these rules can lead to: enforcing of laws, modeling of good behaviors, and recognizing and taking advantage of opportunities to educate both bicycles and motorists.	Process Measure: • Number of citations issued for violations of bicycle-related laws Performance Measure: • Number and severity of crashes involving bicycles	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles, Countermeasures That Work, 2011	Information on training of law enforcement personnel to improve bicyclist safety NHTSA's *Enhancing Bicycle Safety: Law Enforcement's Role*: www.massbike.org/projects new/law-officer-training www.nhtsa.gov/Driving+Safety/Bicycles/Enhancing+Bicycle+Safety:+Law+Enforcement's+Role Safe Routes to School's *Enforcement: Role for Law Enforcement in SRTS*: www.saferoutesinfo.org/resources/enforcement_role-for-law-enforcement.cfm	Crashes involving driver and bicyclist violations

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
Provide bicyclist skill education	This strategy is intended to teach bicyclists of all ages safe bicycling skills, including how to interact with motorists in traffic. Education programs should teach bicyclists the importance of having a bike that fits, maintaining a bike in good condition, and always wearing a helmet when riding. Bicycle safety training programs are based on the premise that behavior by bicyclists contributes to the risk of crashes and injuries, and that this behavior can be changed through training programs. A bicyclist is "granted all the rights and is subject to all the duties applicable to the driver of a vehicle" under ARS 28-812. Bicyclist should ride on the right, stop for red lights and stop signs, and use lights at night. Bicyclists should ride defensively and have an "escape route: to seek to avoid a crash. Training can be cosponsored by Coalition of Arizona Bicyclists and/or other agencies. Studies have shown that most crashes were primarily due to some form of human error and very few were due to environmental conditions (Clarke, A., and Tracy, L. (1995). *Bicycle Safety-Related Research Synthesis.* Report No. FHWA-RD-94-062. Washington, D.C.: Federal Highway Administration.)	NHTSA's 1993 report indicated that the most common crashes were due to bicyclist's failure to yield (21.8%), improper crossing of roadway or intersection (12.6%), and failure to obey traffic signs, signals, or a police officer (8.6%) (Clarke and Tracy, 1995). Reports on a state level have similar data suggesting that the five leading contributing factors attributed to bicyclists in bicycle/motor-vehicle crashes were: 1) failure to yield right-of-way, 2) nonmotorist error, 3) disregard for traffic control devices, 4) driver inattention/ distraction, and 5) improper/ unsafe lane use (*Minnesota Bicycle Transportation Planning and Design Guidelines* Minnesota Department of Public Safety, 2005).	Process Measure: • Number of educational programs conducted Performance Measure: • Number and severity of crashes involving bicycles	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles	www.azleg.state.az.us/ars/28/00812.htm *Arizona Bicycling Street Smarts* www.azbikeped.org/azbss.htm MAG Strategic Transportation Safety Plan http://www.azmag.gov/Documents/pdf/cms.resource/strategic_safety_plan226438.pdf http://www.bicyclingambassadors.org/about.html Bicycle and *Pedestrian Safety Resource Guide*, NHTSA, 2006. Available at: http://www.nhtsa.dot.gov/people/injury/pedbimot/bike/BikePedestrian/ Bicycle Information for Hispanics: http://www.nhtsa.gov/Driving+Safety/Bicycles/Pedestrian+and+Bicycle+Safety+among+Hispanics Spanish Bicycle Safety for English Learners: http://www.nhtsa.gov/Driving+Safety/Pedestrians/For+English+as+Second+Language+(ESL)+Teachers+and+Learners	All bicycle crashes

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
Bicycle Rodeos, fairs, skill clinics	A cycling skills clinic, bike fair, or rodeo is an event that provides children an opportunity to learn and practice bicycling skills. A clinic typically has several stations for specific skills and also includes bicycle and helmet inspections	While rodeos can result in increases in knowledge and skills, the research literature does not reveal any studies that document crash and injury reduction, at least not in isolation.	Process Measure • Number of participants in bicycle education event Performance Measure • Fatal and injury crashes involving school-age children	Countermeasures That Work, 2011	League of American Bicyclists (www.bikeleague.org) Road I and Road II adult education courses teach bike safety	Bicycle crashes involving children and adults
Safe Routes to School	SRTS programs examine conditions around schools and conduct projects and activities that work to improve safety and accessibility, and reduce traffic and air pollution in the vicinity of schools	SRTS material can be effective in teaching children and their parents how to evaluate and choose the safest routes for walking or bicycling to and from school. Strategies are derived from analyses of types of crashes associated with to/from school trips, but it has not been possible to evaluate their effect on preventing crashes and injuries. Dumbaugh and Frank (2007) found that many of the safety benefits associated with SRTS countermeasures are assumed rather than known.	Process Measure • Bicycle Crashes involving School Age Children Performance Measure • Number of sites having implemented SRTS improvements	Countermeasures that Work, 2011	Safe Routes to School web site: http://www.saferoutesinfo.org/ Dumbaugh, E., & Frank, L. D. (2007). *Traffic Safety and Safe Routes to Schools: Synthesizing the Empirical Evidence*. Transportation Research Record: Journal of the Transportation Research Board, *2009,* 89-97.	Bicycle crashes involving school-age children
Bike helmet law for adults	Requirement for bike helmet use for adults	Likely to be effective; actual effectiveness unknown	Process Measures: • Implementation of law • Number of citations for non-use of helmets among adults Performance Measure: • Number of fatal or injury crashes involving unhelmeted adult bicyclists	NCHRP 622: Effectiveness of Behavioral Safety Countermeasures		Reduction in severity for all adult bicycle crashes

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
Increase rider and bicycle visibility	This strategy targets the behavior of bicyclists who are riding at night near motor vehicle traffic, but also affects motorists by making bicyclists more conspicuous and visible.	Bicyclists that are more visible are expected to be involved in fewer crashes during low light conditions. Although no studies have been identified that indicate this outcome, bicyclists that are more easily seen are likely to be more easily avoidable, as well. In addition, the use of headlights may provide bicyclists with better visibility of roadway conditions.	Process Measure: • Number of retroreflective or lights distributed to bikers Performance Measure: • Number and severity of bicycle crashes at night	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles.		Bicycle crashes during low light conditions
Implement speed enforcement	See *Increased Enforcement to Reduce Speed* under Pedestrians					Crashes involving speeding
Share the Road Awareness Program	The purpose of Share the Road programs is to increase drivers' awareness of bicyclists, as well as improve both bicyclist and driver compliance with relevant traffic laws.	Share the Road awareness materials can be effective in increasing knowledge and appropriate attitudes, but there is no evidence of behavior change or reductions in crashes	Process Measure: • Number of drivers reached with educational materials Performance Measure • Number of fatal and injury bicycle crashes	Countermeasures That Work, 2011	Arizona Bicycle and Pedestrian Program Education Plan http://www.azbikeped.org/education.html Pedestrian and Bicycle Information Center http://www.bicyclinginfo.org/education/motorists.cfm ADOT Share the Road Guide for Bicyclists and Motorists http://www.azbikeped.org/images/adot%20STR061208.pdf	All bicycle crashes

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
Driver Training	The purpose of addressing bicycle safety as part of driver education is to increase the sensitivity of drivers to the presence and characteristics of bicyclists and how to safely share the road with them. It is the law in Arizona that to be granted a drivers license drivers must show knowledge of safe driving practices and the traffic laws of the state, including those practices and laws relating to bicycles, per ARS 28-3164.	Driver education has not been shown to reduce overall crash rates. The objective for adding more bicycle information would be to increase knowledge and desire to share the road safely with bicyclists, of the most common crash types and hazards and to improve new drivers' anticipation of and interactions with bicyclists – as well as improve their behavior as bicyclists. The challenge is that once a driver has a license, no retesting occurs to ensure knowledge of new laws since the license was granted.	Process Measure • Inclusion of improved content on bicycle safety in driver education materials Performance Measure • Number of fatal and injury bicycle crashes	Countermeasures That Work, 2011	ADOT Bicycle Safety Action Plan Working Paper 4 – Section 2.8 http://www.azdot.gov/mpd/systems_planning/PDF/BSAP/WP4.pdf Share the Road: A Guide for Bicyclists and Motorists http://www.azbikeped.org/images/adot%20STR061208.pdf www.azleg.state.az.us/ars/28/03164.htm Pedestrian and Bicycle Information Center http://www.bicyclinginfo.org/education/motorists.cfm	All bicycle crashes

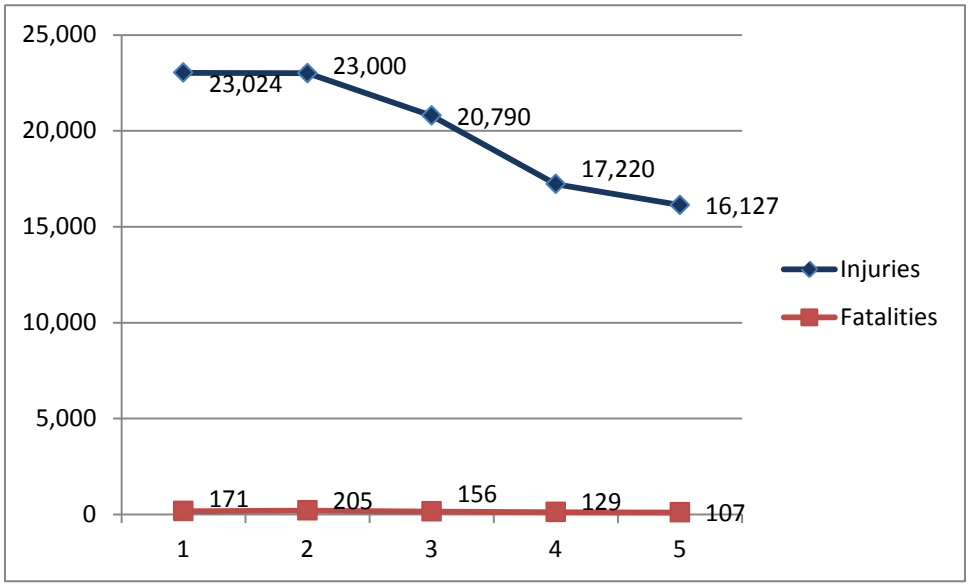
4.0 Intersections

This section presents key information about factors related to intersection crashes that can help in selection and tailoring of countermeasure strategies. Intersections are often a target area for roadway safety improvement given these are the locations where there is the greatest opportunity for conflict between vehicles, as well as with pedestrians and bicyclists.

4.1 Intersection Crash Data Analysis

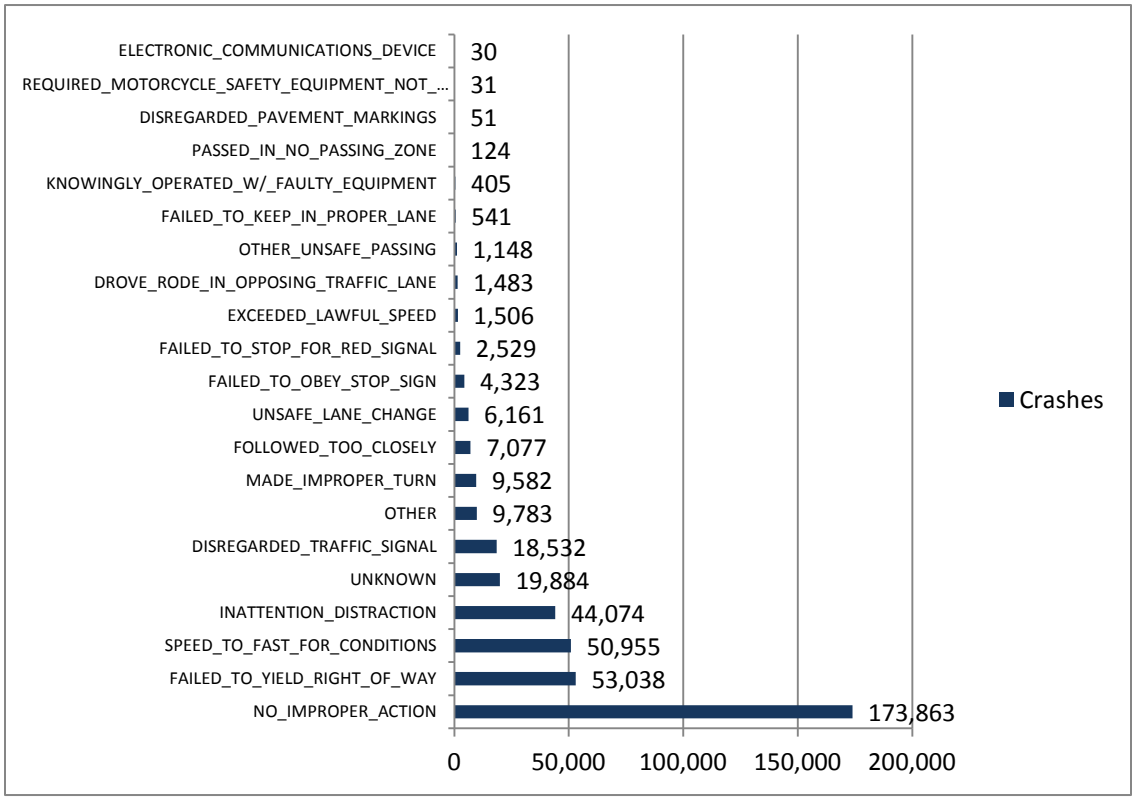
Intersection injuries and fatalities have declined significantly from 2005 to 2009, as shown in Figure 4.1. However these types of crashes still represent a large proportion of the roadway safety problem.

Figure 4.1 Intersection Injuries and Fatalities, 2005-2009



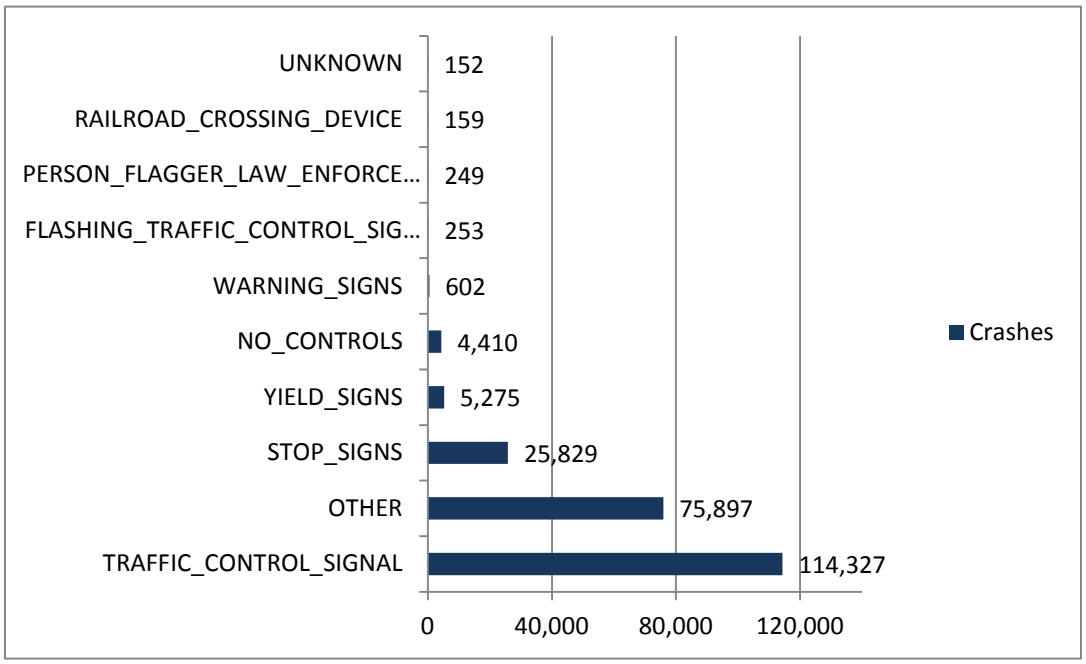
As shown in Figure 4.2, the top three driver violations are failure to yield right-of-way, speeding, and inattention/distraction. Distraction was a top factor in pedestrian and bicycle crashes as well; therefore, targeted countermeasures to reduce distraction are an area of opportunity for improving safety among all three modes of travel.

Figure 4.2 Driver Violations – Intersection Crashes, 2005-2009



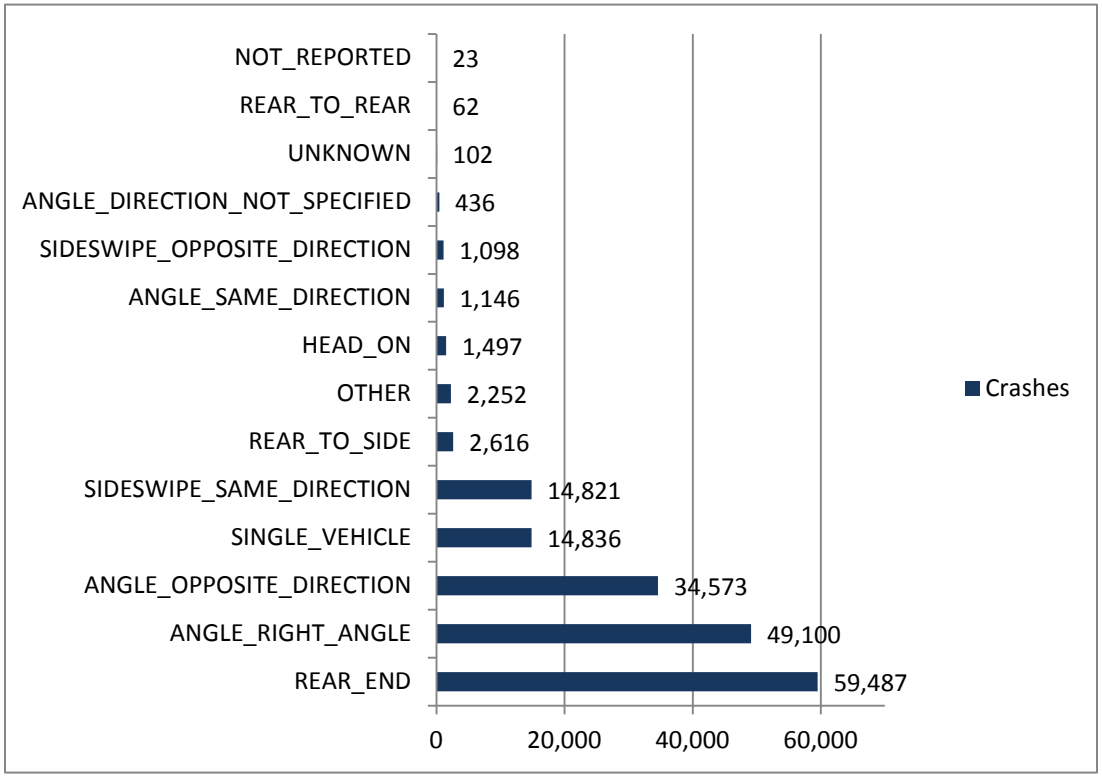
The majority of crashes occur at signalized intersections; however a significant number of crashes do occur at intersections with stop signs, as shown in Figure 4.3. This breakdown of intersection crash types may be proportional to the number of these types of intersections in the region.

Figure 4.3 Intersection Traffic Control Type, 2005-2009



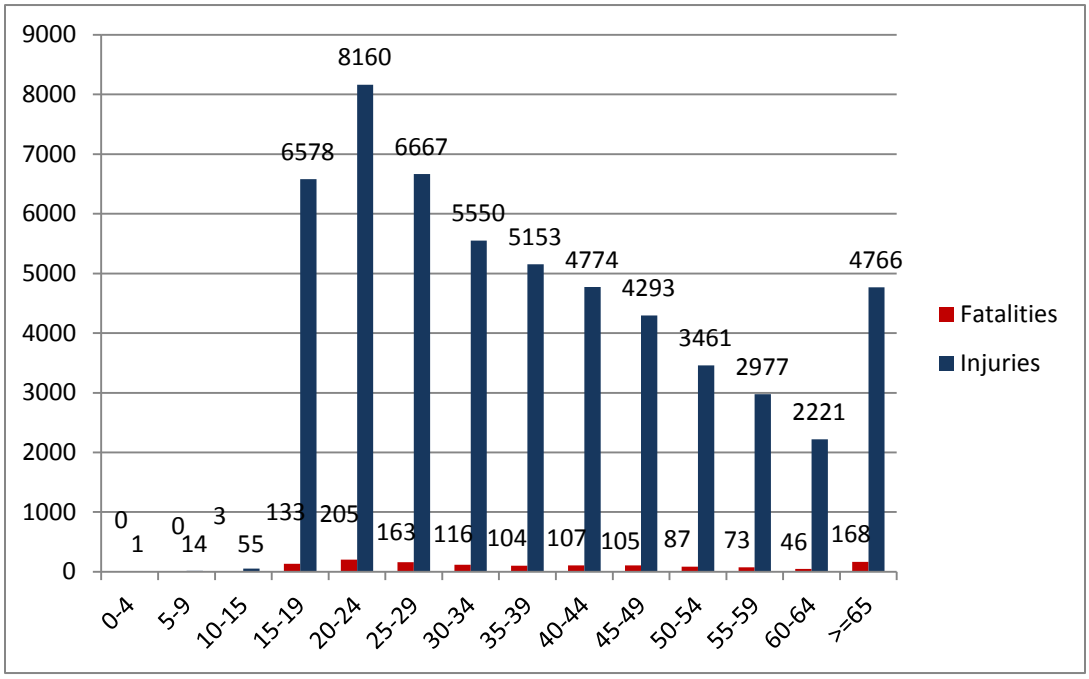
As shown in Figure 4.4 the most prevalent crash type is rear-end crashes, which is often related to high approach speeds and inattention by the driver. The next two most common crash types are angle crashes, which occur with turning movements.

Figure 4.4 Intersection Crash Type, 2005-2009



As shown in Figure 4.5, the highest number of intersection injuries and fatalities is among drivers ages 20 to 24, with the next highest age groups being age 15 to 19, 25 to 29, and over 65. Intersection crash frequency steadily drops with age, and increased driving experience, until age 65. At older ages, reaction time can decrease making intersections harder to navigate[21].

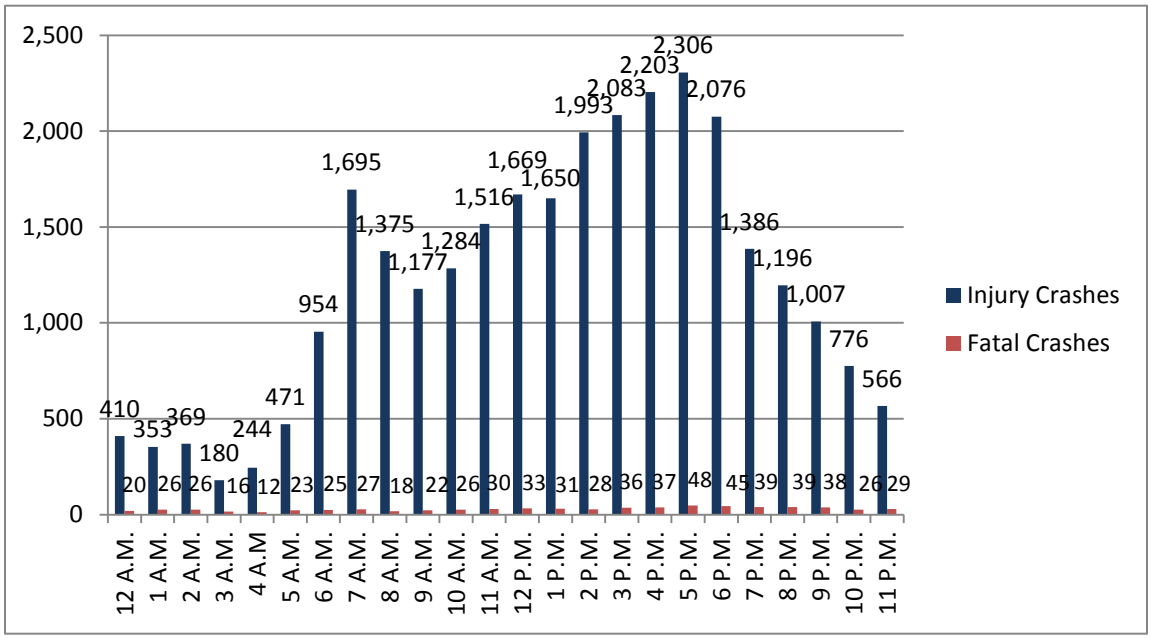
Figure 4.5 Intersection-Related Fatalities and Injuries by Age, 2005-2009



[21] NCHRP Report 500 Volume 9: A Guide for Reducing Collisions Involving Older Drivers.

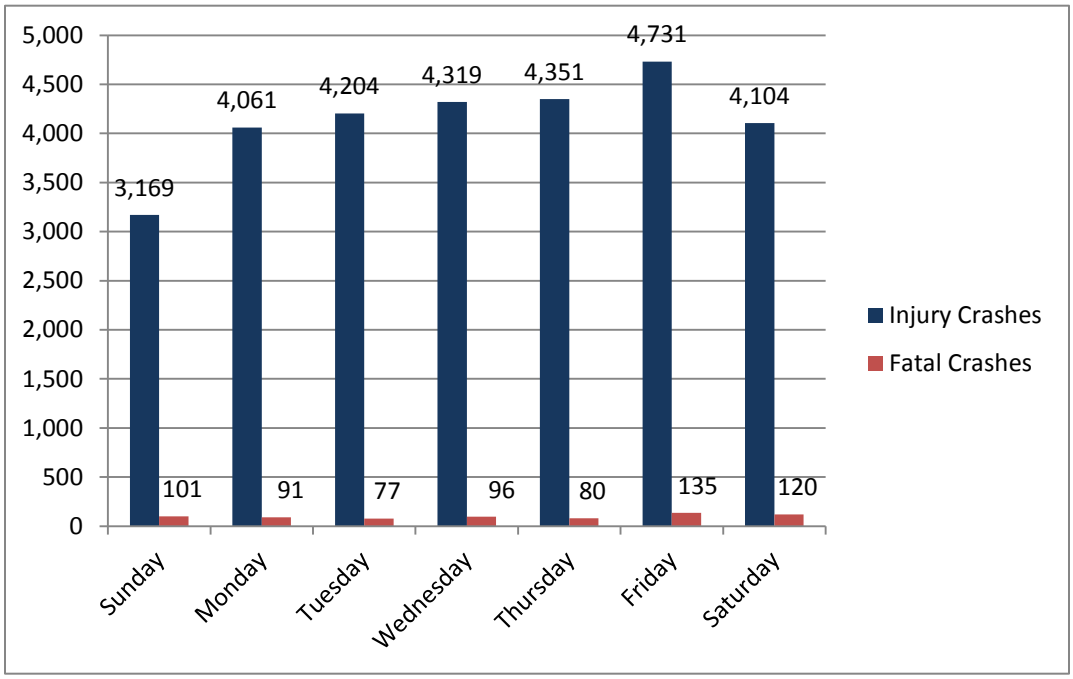
Figure 4.6 shows that intersection fatal and injury crashes peak during the PM rush hour.

Figure 4.6 Intersection Fatal and Injury Crashes by Time of Day



Weekend days are those with the highest numbers of intersection fatalities, as shown in Figure 4.7. This may be related to the influence of alcohol.

Figure 4.7 Intersection Crashes by Day of Week



Figures 4.8 and 4.9 show the intersection fatal and injury crashes per capita by jurisdiction in the MAG region. Tolleson and unincorporated Maricopa County had the highest rates of fatal crashes. Tolleson also had the highest rate of injury crashes. These rates provide an idea of relative importance of the issue by community. The number of intersection crashes is also impacted, of course, by the number of intersections in each municipality and the volumes of traffic at intersection locations.

Figure 4.8 Intersection Fatal Crashes per Capita

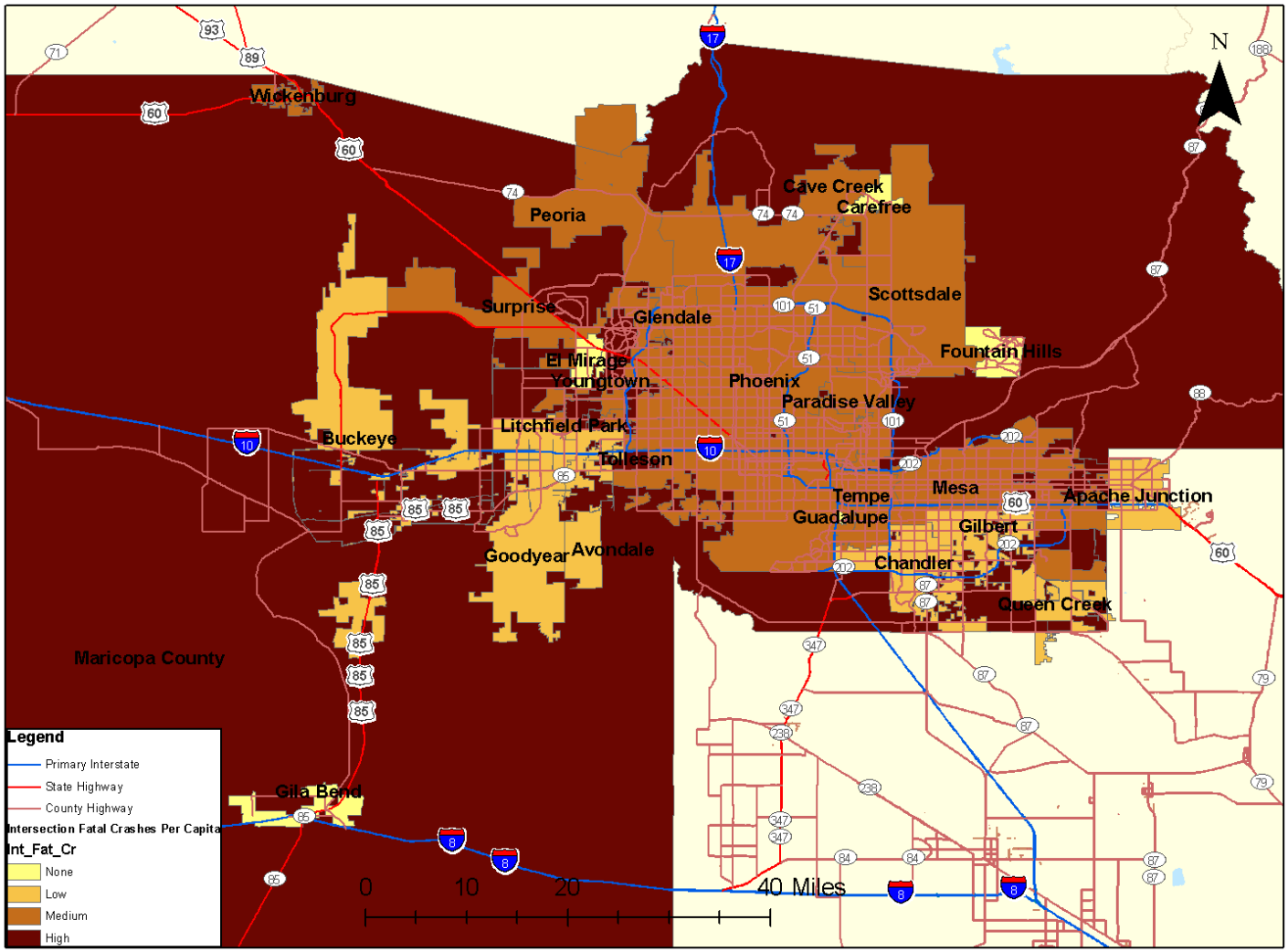
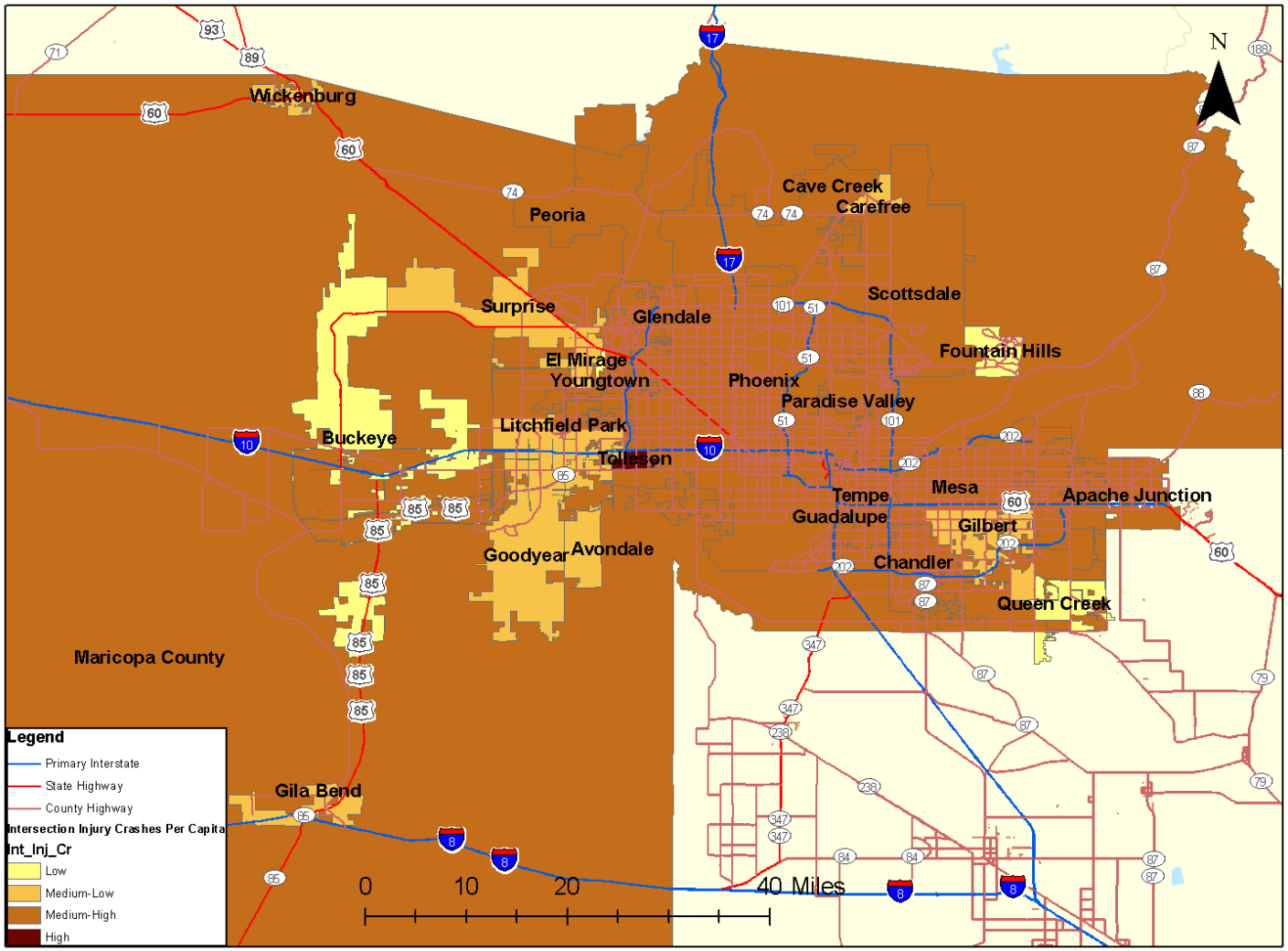


Figure 4.9 Intersection Injury Crashes Per Capita



Conclusions

Most crashes are rear-end crashes, which often involve speed and distraction/ inattention. Speed and distraction are also top driver violations, so these are key issues to be addressed. Intersection crashes are highest among drivers ages 20 to 24, which reflect driver inexperience and could also be related to these drivers having early experiences drinking alcohol.

4.2 INTERSECTION SAFETY COUNTERMEASURES

Table 4.1 lists proven intersection safety countermeasures and provides crash reduction factors if possible; CRFs are available for a number of these strategies. The crash data in the previous section can help guide the selection of countermeasures. For example, given the higher rate of crashes at signalized intersections, strategies addressing these types of crashes may be more effective at improving the region's safety performance.

Other information can guide how strategies are implemented. For example if radio public service announcements about good driving practices were broadcast, they should be placed during the afternoon peak period to reach drivers during the most vulnerable time period for intersection crashes, which would also benefit safety of bicyclists. Outreach efforts could be targeted to young drivers as fatal and injury intersection crashes are more prevalent among those age groups.

Table 4.1 Proven Intersection Safety Countermeasures

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Intersections – General						
Provide public information and education	The target for this strategy is crashes related to drivers either being unaware of, or refusing to obey, traffic laws and regulations that impact traffic safety. Crashes related to red-light running, speeding, and not yielding to pedestrians could be reduced with PI&E campaigns. Use of trained public information specialists is important for program success. Establishing good relationships with media representatives will be extremely helpful for maximizing coverage and impact.	The estimated impact of mass media road safety campaigns is likely to vary depending on the measure of effect used. Across all measures the effect has been estimated as a 7.5% reduction in the relevant outcome measure.(Delaney, 2004)	Process Measures: • Number and frequency of different media used (radio ads, brochures, etc.) • Population exposed to the message • Level of expenditure Performance Measures: Frequency and severity by crash type.	NCHRP Report 500 Volumes 5 and 12 A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf		Crashes involving driver violations
Intersections – Signalized						
Implement automated enforcement of red-light running (cameras)	Successful red-light camera programs have generally begun as safety improvement programs. Programs that are perceived as revenue generators (i.e., through collection of fines) are generally not well-accepted.	Desktop Reference for Crash Reduction Factors – *refer to source directly for details on all CRFs, roadway volumes, and crash types.* Examples: -CRF =11 for all crash types (Scottsdale) -CRF=45 for left turn -CRF =20 for right angle -CRF= -45 for rear end	Process Measure • Number of cameras installed • Number of citations issued Performance Measure • Number, type and severity of crashes at targeted intersections	NCHRP Report 500 Volume 12: A Guide for Addressing Collisions at Signalized Intersections	Hu et al., Effects of Red Light Camera Enforcement on Fatal Crashes in Large U.S. Cities, Insurance Institute for Highway Safety, February 2011. NCHRP 622: Effectiveness of Behavioral Countermeasures	Signalized intersection crashes involving red-light running

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Implement automated enforcement of approach speeds (cameras)	The target for this strategy is drivers who speed on approaches to signalized intersections. Crash types related to these actions include angle and rear-end crashes. Automated enforcement of speeds may provide a longer-term effect than on-site enforcement by police officers. It is not feasible to provide officers to constantly enforce speed limits, but a camera is more flexible regarding the duration it can operate. PI&E is needed to make automated enforcement successful. Public opinion and acceptance can "make or break" an automated enforcement program. Information and awareness efforts and materials typically include the following information: 1) documentation of the problem (in nontechnical terms), 2) objectives of the automated enforcement program, 3) advantages of automated enforcement or conventional enforcement, 4) general locations or areas of automated enforcement systems, 5) uses of revenue generated by automated enforcement, and 6) information on what to do when a citation is received in the mail.	Speed cameras: on average result in 20 to 40% reduction in crashes, based on studies in Canada, Australia, and Europe (Pilkington, P. and Kinra, S. (2005). *Effectiveness of Speed Cameras in Preventing Road Traffic Collisions and Related Casualties: Systematic Review*. British Medical Journal 330 (7487), 331-334.) Therefore CRF = 20.	Process Measures: • Number of intersection approaches on which automated speed enforcement is applied • Number of citations issued from the program, and number of traffic convictions resulting Performance Measure • Number and severity of crashes at intersections treated	NCHRP 622: Effectiveness of Behavioral Countermeasures		Signalized intersection crashes involving high approach speeds (rear-end crashes)

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Provide targeted conventional enforcement of traffic laws	Traffic law enforcement agencies often select locations for targeted enforcement when crash, citation, or other sources of information suggest that the site is unusually hazardous due to illegal driving practices, such as speeding or red-light running. It is important to correctly identify intersections that would benefit from enforcement. Care should be taken to first ensure that the existing signals are operating properly, are visible, and meet MUTCD requirements, as well as that timing plans – including clearance intervals – are appropriate. Analysis of crash statistics can help with this process, as can spot speed or conflict studies. In some cases, public input or observations by law enforcement personnel may suggest that a location should be targeted for enforcement.	Studies report the reduction of traffic law violations when enforcement is used (*Traffic Engineering Handbook*, Pline, 1999). Effectiveness is usually short-lived. Periodic enforcement may be necessary to sustain the effectiveness of the strategy	Process Measure: • Number of citations issued at targeted intersections Performance Measures: • Number and severity of crashes at targeted locations before and after strategy implementation	NCHRP Report 500 Volume 12: A Guide for Addressing Collisions at Signalized Intersections		Intersection crashes involving driver violations

Strategy	Description	Effectiveness	Process/ Performance Measures	Source	Resources	Safety Issue Addressed
Unsignalized Intersections						
Provide targeted enforcement to reduce stop sign violations	The target for this strategy should be intersections where stop sign violations and patterns of crashes related to stop sign violations have been observed. Crash types potentially related to stop sign violations include right-angle and turning collisions.	This strategy is known to be effective in reducing traffic law violations. Programs within the U.S. have been found to result in decreases in violations between 23 and 83%. However, the safety effectiveness of such decreases in violation rates has not been quantified. Enforcement agencies have generally found that the effectiveness of increased enforcement at specific locations has a relatively short duration of effectiveness – measured in days or weeks, rather than months or years.	Process Measures: • Number of intersections where increased enforcement is applied • Number of officer hours of targeted enforcement provided • Number of additional citations issued • Reduction in violation rate • Resulting number of additional convictions	NCHRP Report 500 Volume 5: A Guide for Addressing Unsignalized Intersections		Crashes at unsignalized intersections with stop signs
Provide targeted speed enforcement	The target for this strategy is intersections where speed violations and patterns of crashes related to speed violations are observed. Crash types potentially related to speed violations include right-angle, rear-end, and turning collisions. A key to the success of this strategy is planning the enforcement and prioritizing the intersections demonstrating greatest need(*TRB Special Report 254,* 1998). Such intersections should have a combination of high speed-violation rates and related crash patterns. In some cases public input, or observations by law enforcement personnel, may suggest that a location should be targeted with enforcement.	The effectiveness of this strategy has been established by numerous studies (Accident Analysis and Prevention*,* Volume 126, Issue 6, *An Experimental Study to Evaluate the Effectiveness of Different Methods and Intensities of Law Enforcement on Driving Speed on Motorways*, De Waard and Rooijers, 1994.)	Process Measures: • Number of intersections at which targeted speed enforcement is applied • Number of officer hours of targeted enforcement provided • Number of additional citations issued • Resulting number of additional convictions Performance Measure: • Number and severity of intersection crashes	NCHRP Report 500 Volume 5: A Guide for Addressing Unsignalized Intersection		Intersection crashes involving speeding

5.0 Anticipated Effectiveness of Sample Strategies in MAG Communities

In cases where a crash reduction factor is available for a countermeasure, it is possible to calculate the expected effectiveness of implementing the strategy. While education and enforcement strategies are less clear-cut than engineering strategies, the CRFs are useful guides to how effective a strategy may be.

Below are three *examples* of how safety countermeasures identified above could result in reductions in certain types of crashes in MAG communities.

1. Implementation of public education and information effort focused on pedestrian safety in Phoenix.
    - Phoenix experienced 3,088 pedestrian crashes over 5 years, or an average of 617 pedestrian crashes per year.
    - It is estimated that public information and education campaigns result in an average of a 7.5 percent reduction in the effectiveness measure, in this case, pedestrian crashes.
    - Therefore, it would be expected that pedestrian crashes in Phoenix would be reduced by 46 crashes per year with implementation of this strategy.
    - However, there are many variables with any type of public education effort – how well is the campaign developed – does it effectively reach the target audiences? How long does it run – for the entire year? How significant is the investment – will each Phoenix resident hear the message multiple times. Therefore, the 7.5 percent reduction is only the best estimate based on results of other public information and education programs and must be understood as such.
2. Installation of red-light running cameras.
    - The assumption is that at a single intersection, a community experienced 100 crashes per year.
    - The CRF for all crashes is 11, which means an 11 percent reduction in crashes is expected from this improvement. However, given that several MAG member municipalities have experience with this countermeasure, data from their experience could be used as well.
    - Therefore, with installation of a red-light running camera at the intersection, a reduction of 11 crashes would be estimated to occur in the next year.

6.0 Conclusion

Crash data reveal useful information about factors involved in these types of crashes, including overall trends, ages and gender of those involved, driver and victim's actions, etc. This information not only helps in selection of strategies but can help communities tailor approaches to their specific conditions.

Relatively few non-engineering safety countermeasures have been identified to reduce pedestrian, bicycle and intersection crashes. Of those even fewer have been proven to the extent that crash reduction factors have been developed. Therefore, it may be necessary to implement of mix of proven and tried/ emerging strategies. When implementing unproven strategies it is recommended that evaluation be included as part of the overall process so as to increase knowledge of effective strategies, particularly for the MAG region. Such information will enable MAG communities to try to replicate successful approaches and steer away from any strategies that are not effective.

Even if it is not possible at the outset to calculate the anticipated benefit of strategies, the region can consider that implementation of safety efforts in the community will work toward supporting a "culture of safety" where people begin to have higher expectations for safe behavior for themselves and those that share the road with them. Hearing repeated safety messages can work toward collective expectation that the risk of a crash is not the cost of mobility and that each individual plays a role in contributing to operation of a safe transportation system.