Effectiveness of Non Engineering Countermeasures to Reduce Bicycle, Pedestrian and Intersection Crashes

Tasks 4 & 5: Potential Strategies and Anticipated Effectiveness

Draft

Technical Memorandum No. 2

prepared for

Maricopa Association of Governments

prepared by

Cambridge Systematics, Inc.

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report

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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, 3 and 4 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, 3, and 4 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.[1] All crashes referred to as "injury crashes" in this report include crashes with a reported injury severity of A or B according to the

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

KABCO classification for injury crashes. All data in this report was 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

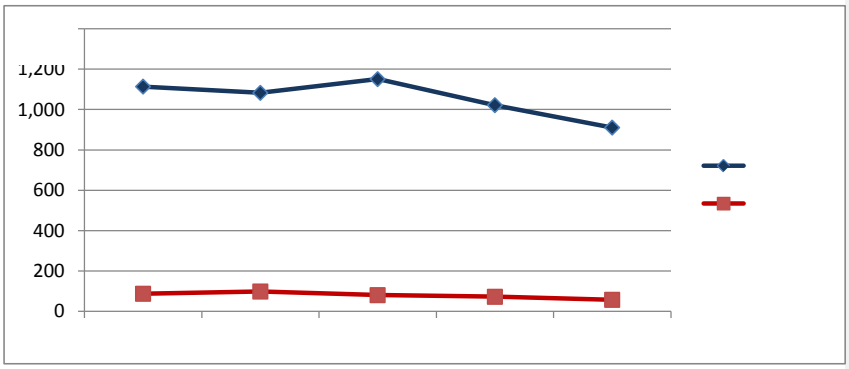
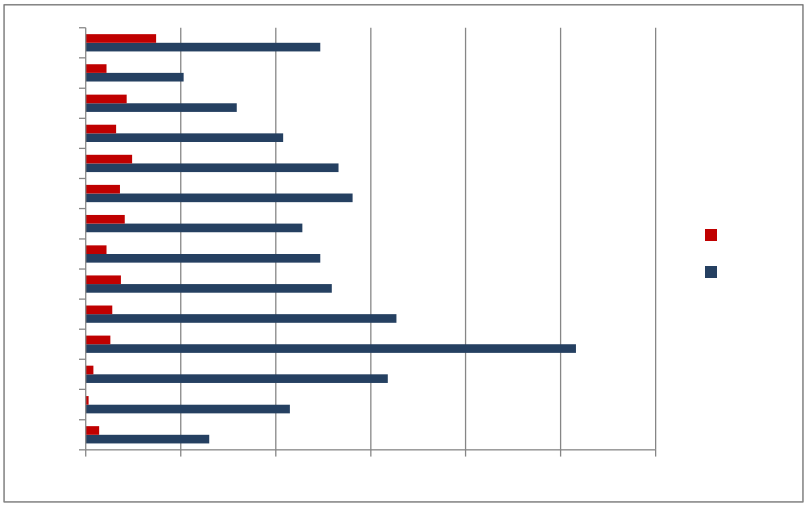


Figure 2.2 shows the age cohorts of pedestrians killed and injured. Over the five-year period, 25 children under the age of 16 were killed and 663 were injured. The age category with the largest number of fatalities was age 65 and older; however, it must be recognized that a large segment of the population 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[2]. 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

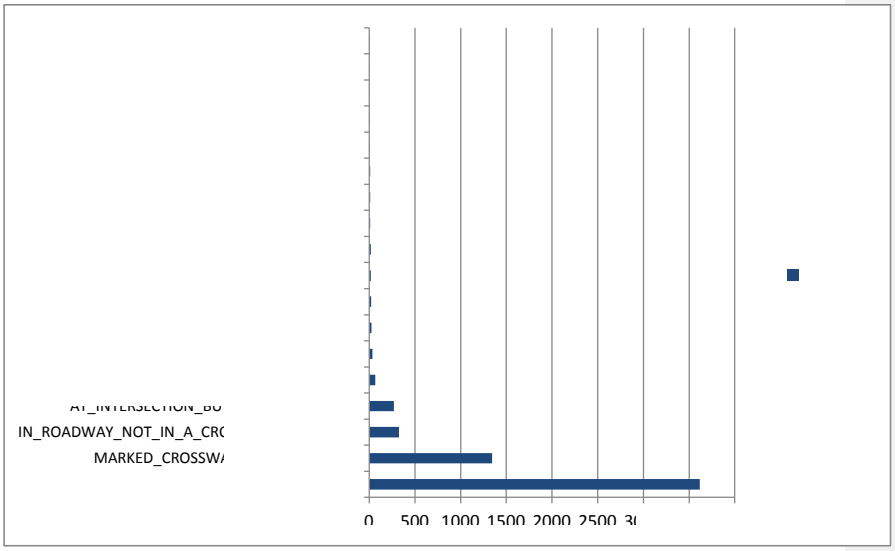


Males suffer the majority of pedestrian fatalities and injuries. From 2005 to 2009, more than two thirds (71 percent) of pedestrians killed were males. Two thirds of serious pedestrian injuries involved males.

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

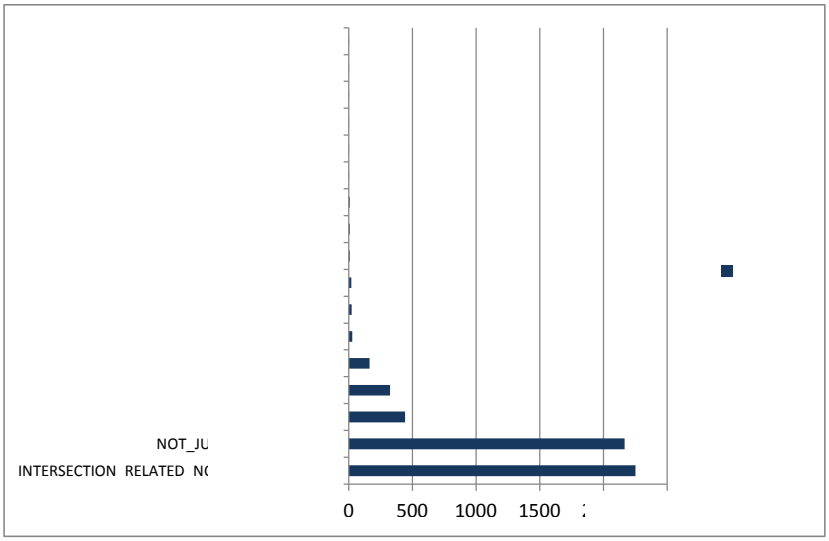
Figure 2.3 shows where pedestrians were located for crashes. Of the *known* locations, the greatest proportion of crashes is in a marked crosswalk at an intersection.

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 non-junction 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

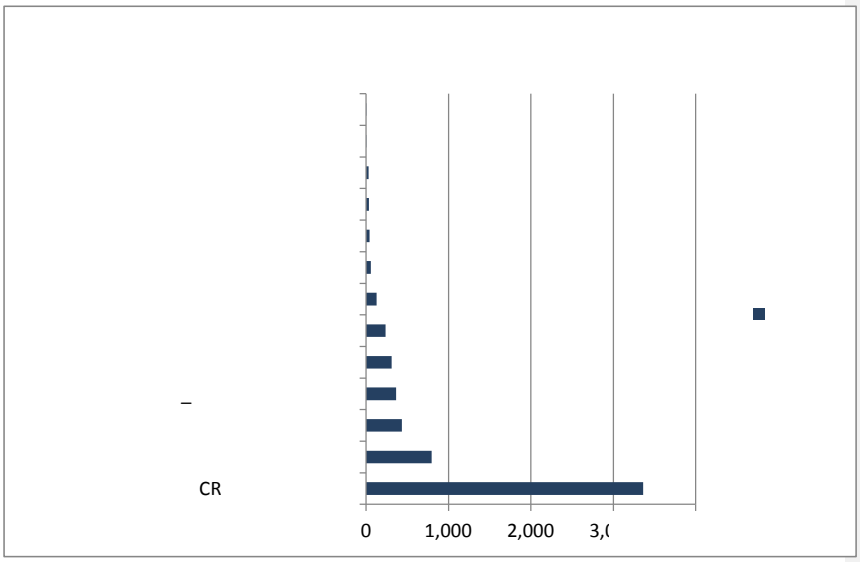


Figure 2.6 shows the driver violations when pedestrian crashes occurred. Failure to yield was the top violation. Inattention/distraction was a factor in 751 crashes. Given the lower visibility of pedestrians compared to vehicles, distraction may play an even more crucial role in their safety given the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

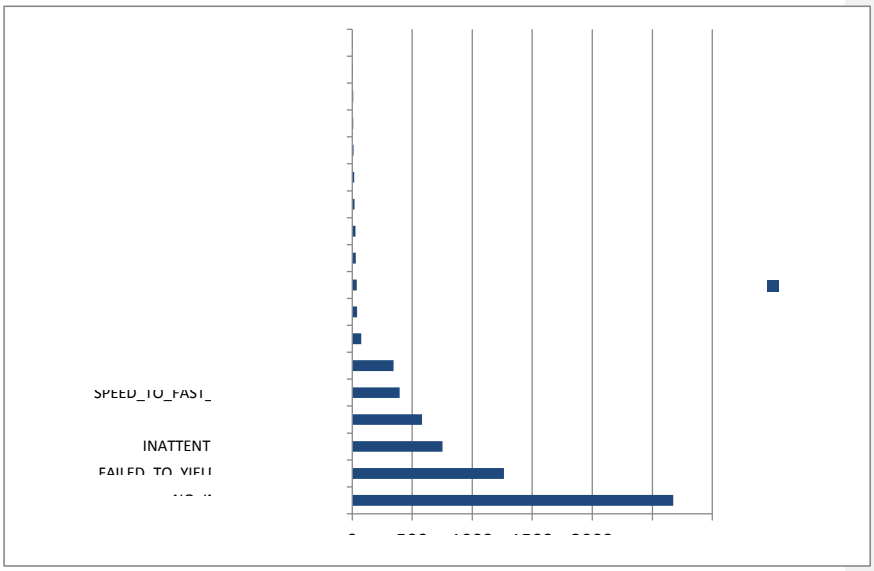
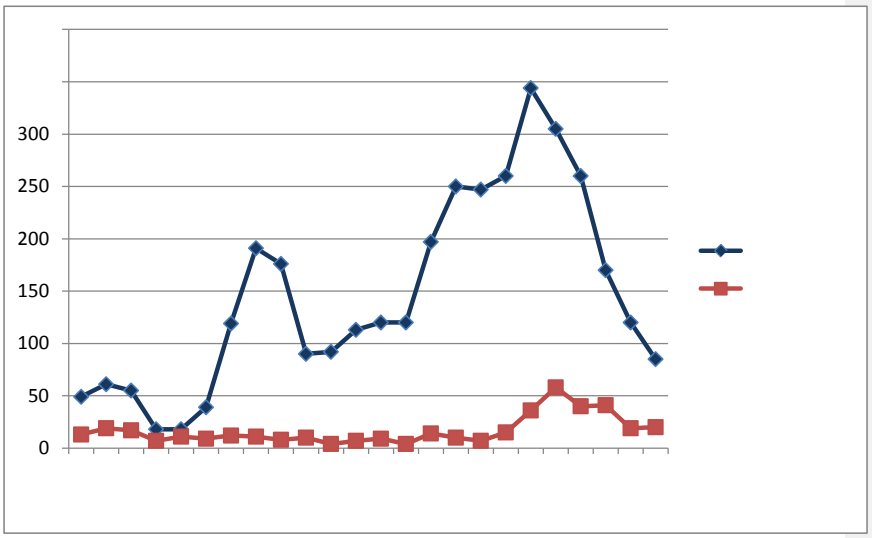


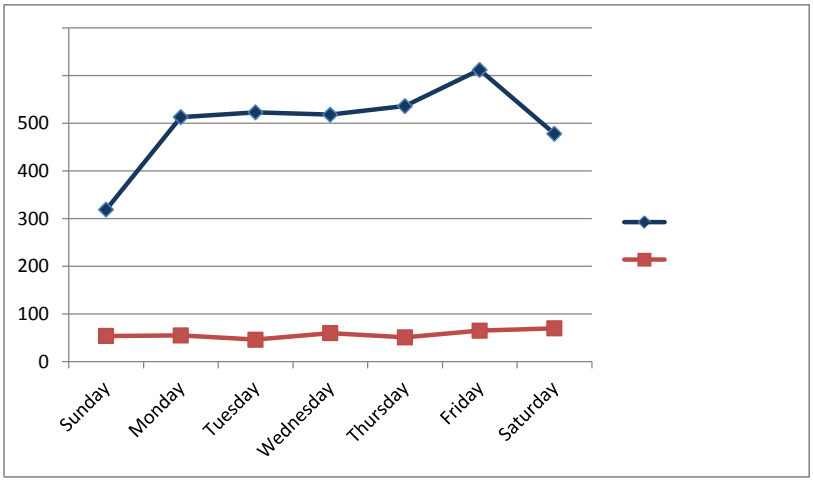
Figure 2.7 shows the time of day when pedestrian crashes occur. The peak hour for injury crashes is 6pm and for fatal crashes is 7pm. The bulk of fatal and injury crashes occur during the early evening hours. Depending on the time of year, some of these crashes may be occurring at dusk or after sunset 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. 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. For example, Gila Bend experienced 2 pedestrian fatalities from 2005-2009 but has a 2010 population of 1,922 so it had the highest rate of pedestrian fatalities. Gilbert also experienced 2 pedestrian fatalities during this time period but has a population of 208,000, so it was in the lowest category. These rates are also related to the amount people walk in various communities and the level of exposure pedestrians experience. Injury rates were similarly categorized and are displayed in Figure 2.10.

Figure 2.9 Pedestrian Fatalities Per Capita, 2005-2009

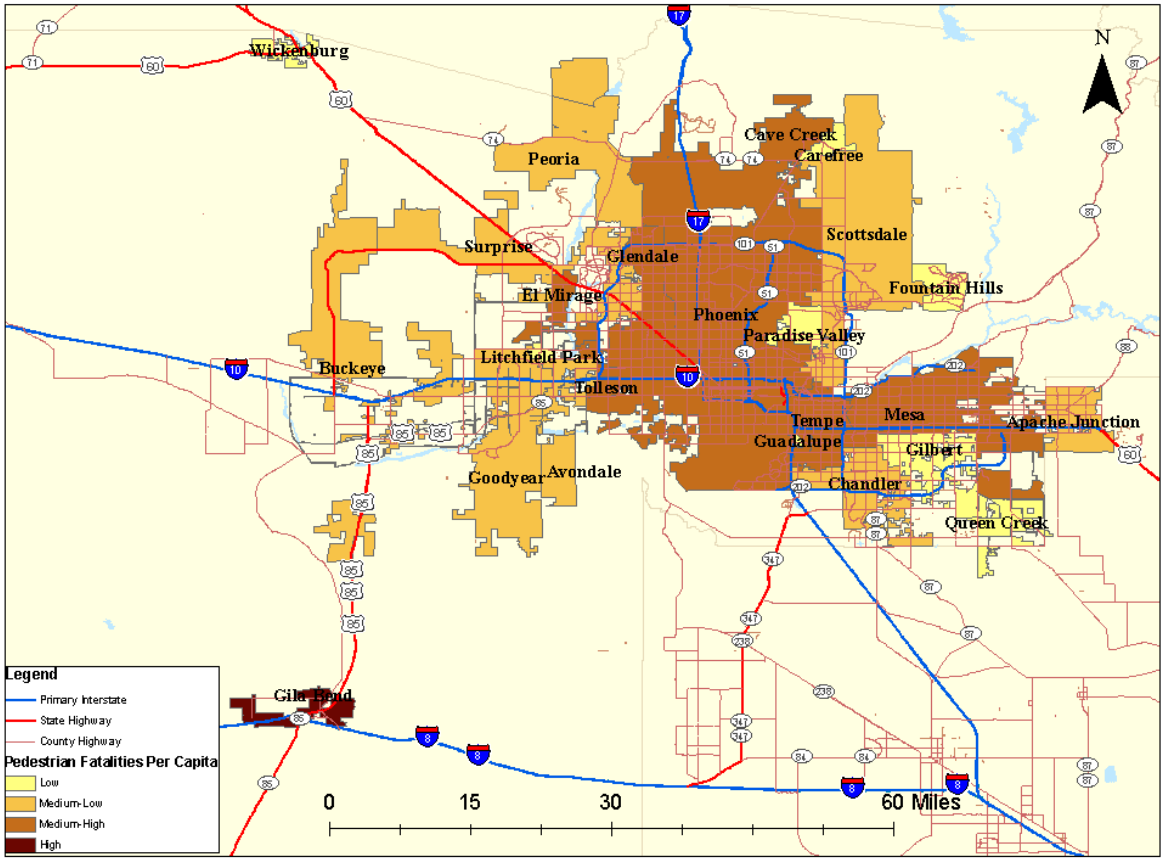
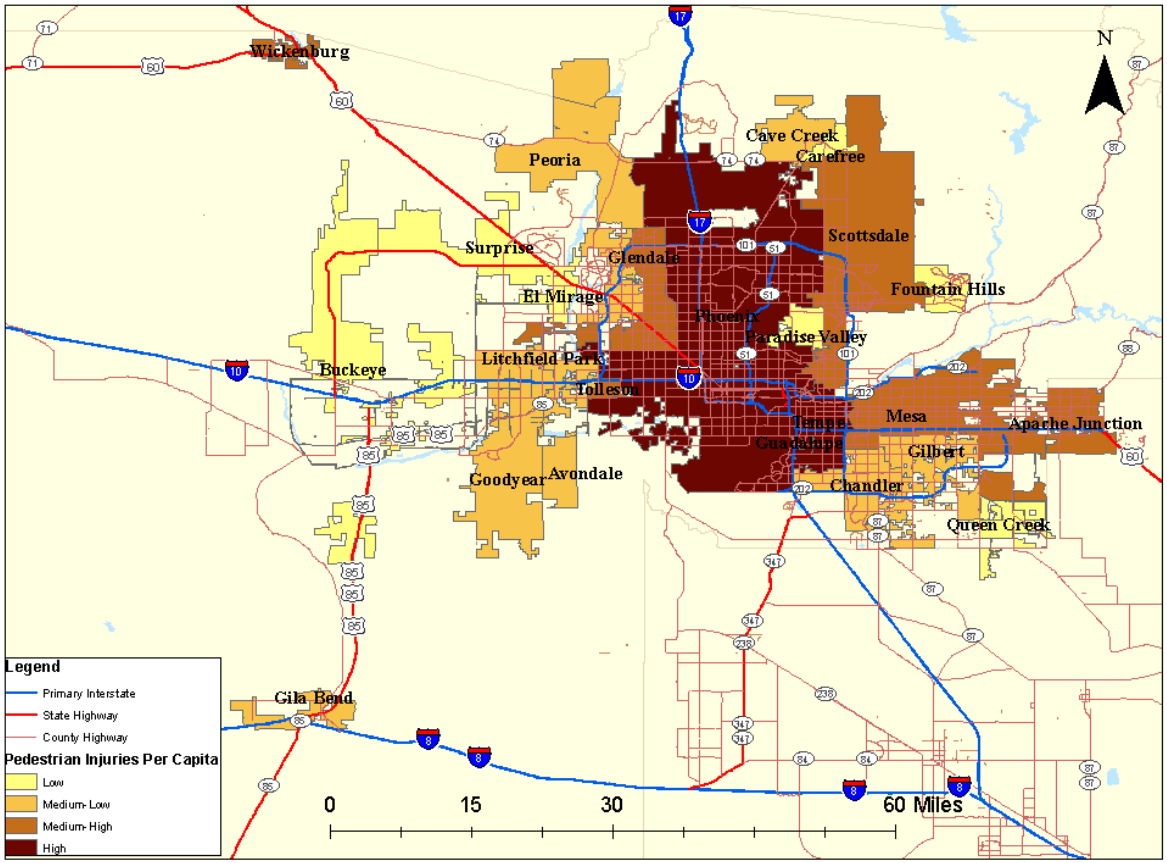


Figure 2.10 Pedestrian Injuries Per Capita, 2005-2009



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 15-19 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), 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, 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[3].

[3]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
Restrict parking near intersections to off-street	Prohibit parking near intersections	CRF=30 for pedestrian crashes	Process Measure • Number of locations treated Performance Measure • Number of Pedestrian Crashes, at treated locations	Desktop Reference for Crash Reduction Factors	Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects, Florida DOT, 2005 http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SF/FDOT_BD015_04_rpt.pdf	All intersection related pedestrian crashes
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 25-30% 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

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
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 enforcement 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, USDOT, 2007		Pedestrian crashes involving speeding
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	2- 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	Performance Measure: Number of vehicles yielding to pedestrians • Number of fatal and injury crashes within crosswalks Process Measure • Number of vehicle	Journal of Applied Behavioral Analysis, volume 37, No3, (fall 2004)	Chicago Crosswalk Enforcement Initiative: http://www.cityofchicago.org/city/en/2-15epts./cdot/provdrs/ped/svcs/crosswalk_enforcementinitiatives.ht	Crashes involving pedestrians in crosswalks and driver failure to yield

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
	enforcement flyer.	reduced. Yielding increased from 3 percent – 18 percent to 27 – 33 percent. (Van Houten and Malenfant, 2004)	stopped for violations • Number of locations with increased enforcement of vehicles yielding to pedestrians		ml Effects of Driver Enforcement Program on Yielding to Pedestrians, VanHouten and Malenfant, 2004: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1284509/pdf/15529891.pdf	
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+	Depends on issue targeted. Could address: driver violations (speeding, failure to yield, distraction). Could target pedestrians to promote safer behavior.

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
					and+Learners	
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
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	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

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
	within a limited area.					
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		Crashes involving children ages 6-12
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, DC: 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 on-going, 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	Process Measure • Number of treated crosswalks Performance Measure • 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
		accidents between pedestrians and vehicles have been reduced.				
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	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	Process Measure • Incorporation of pedestrian education into driver training Performance Measures • Number of fatal and injury pedestrian crashes	Countermeasures That Work, 2011	NY Share the Road materials http://www.safeny.ny.gov/media/share-road.htm	All pedestrian crashes

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
	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	common types of crashes, and to improve drivers' anticipation of and interactions with pedestrians – as well as improve their behavior as pedestrians.				

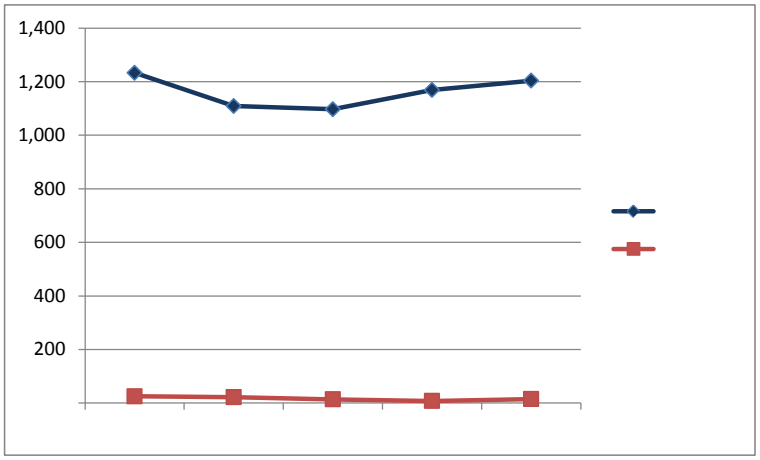
3.0 Bicyclists

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 10-19; 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

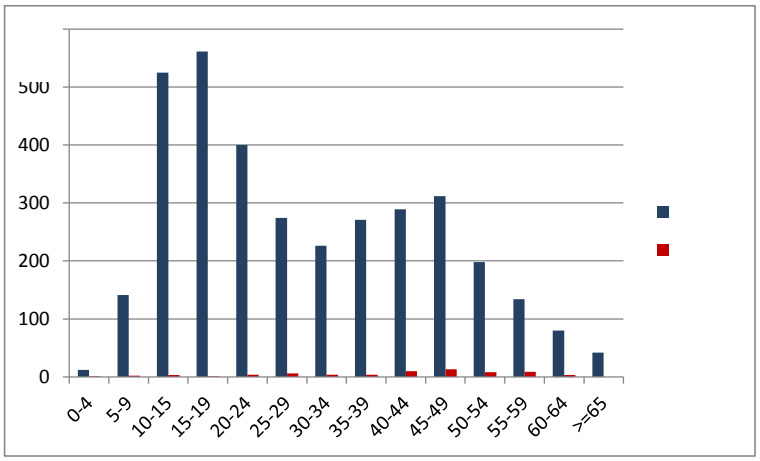
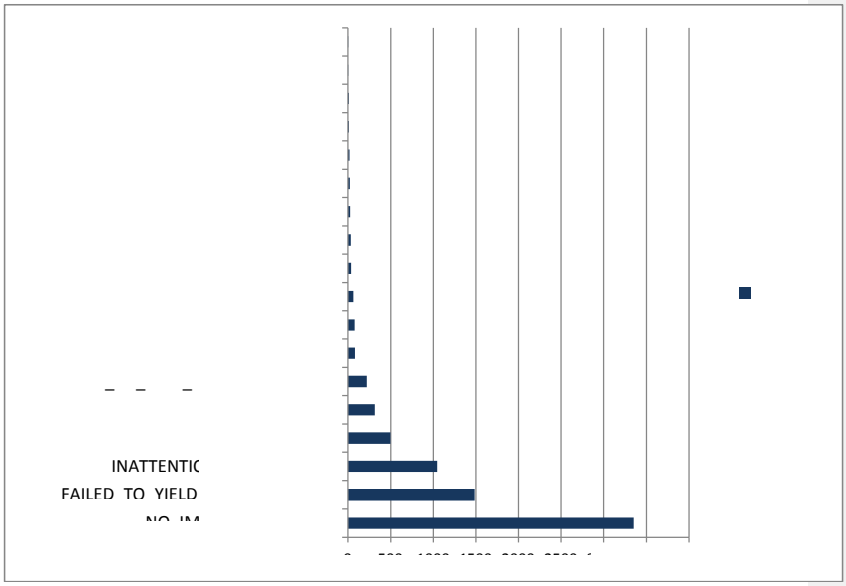


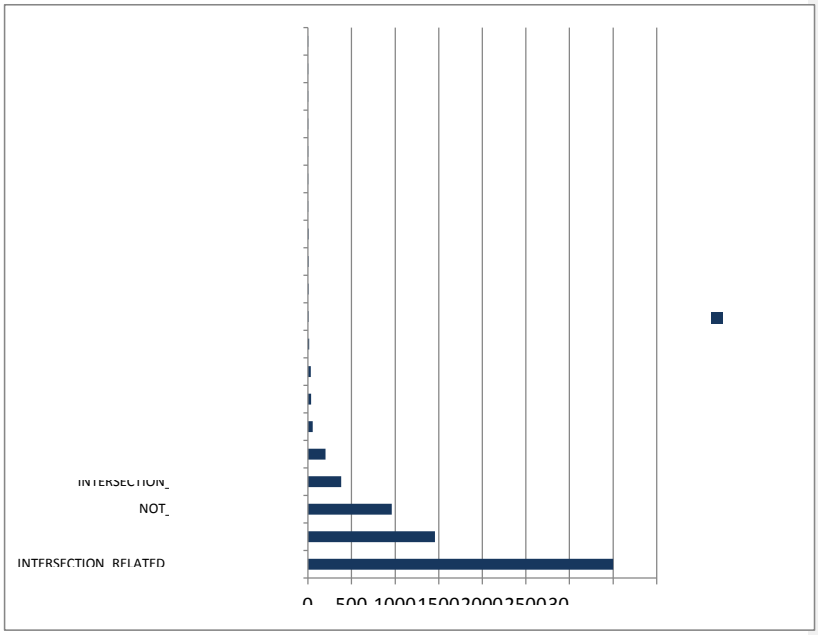
Figure 3.3 shows that vehicle drivers failed to yield right of way in nearly 1,500 crashes with bicyclists. Distraction was a factor in more than 1,000 crashes. As noted in the pedestrian section, driver distraction may play an even more crucial role in the safety of pedestrian and bicycle crashes give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

Figure 3.3 Driver Violation for Bicyclist Crashes, 2005-2009



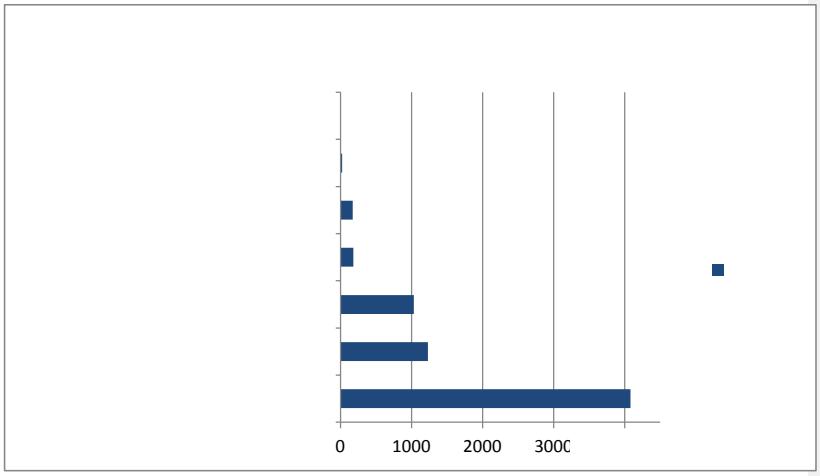
The majority of crashes with bicyclists occurred at intersections, as shown in Figure 3.4. Therefore safety efforts related to intersections should also benefit bicyclists.

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. 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. Therefore most crashes occur at or near intersections when bicycles are traveling in the same direction as vehicles.

Comment [sj1]: What is the logic used here to conclude that most crashes are at intersections?

Figure 3.6 Bicyclist Action Involved in Crash, 2005-2005

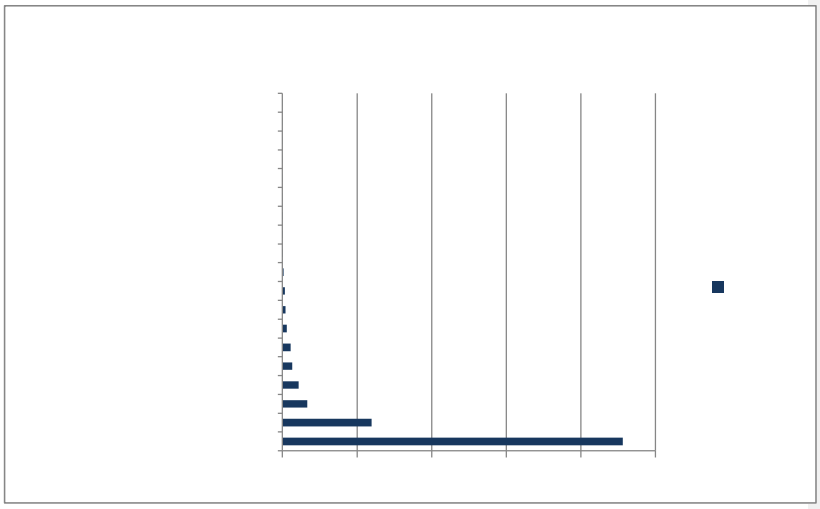


Figure 3.7 shows that the highest numbers of fatal and injury crashes occur in the late afternoon to early evening. There is also a peak at 7a.m., which could reflect crashes during commuting or recreation before work.

Figure 3.7 Bicycle Crashes by Time of Day

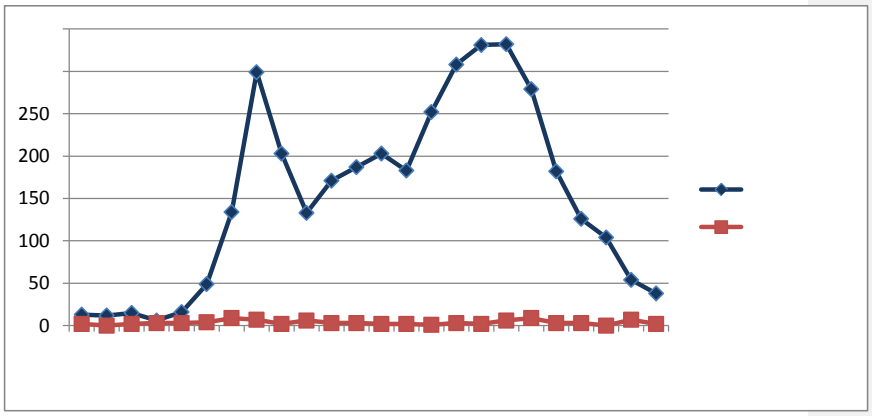
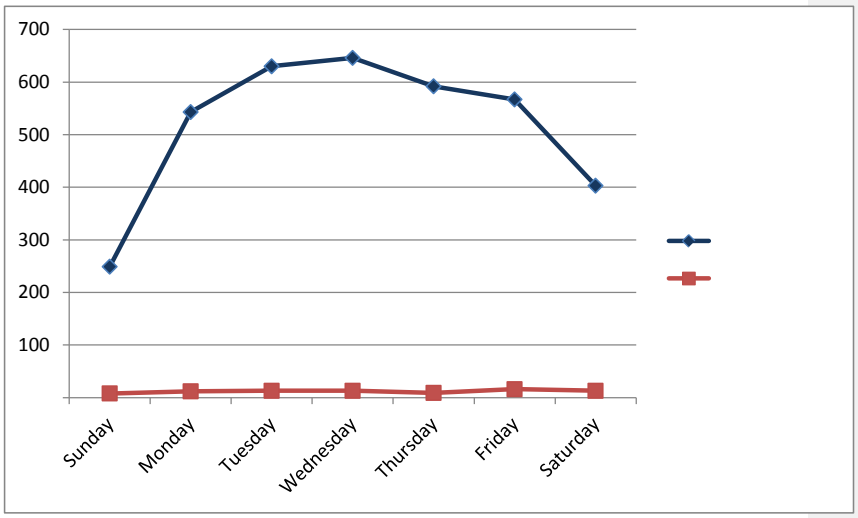


Figure 3.8 Bicycle Crashes by Day of Week



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. For example, Phoenix experienced 38 bicycle fatalities from 2005 to 2009 and Mesa experienced 16 fatalities. 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 161,719. 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

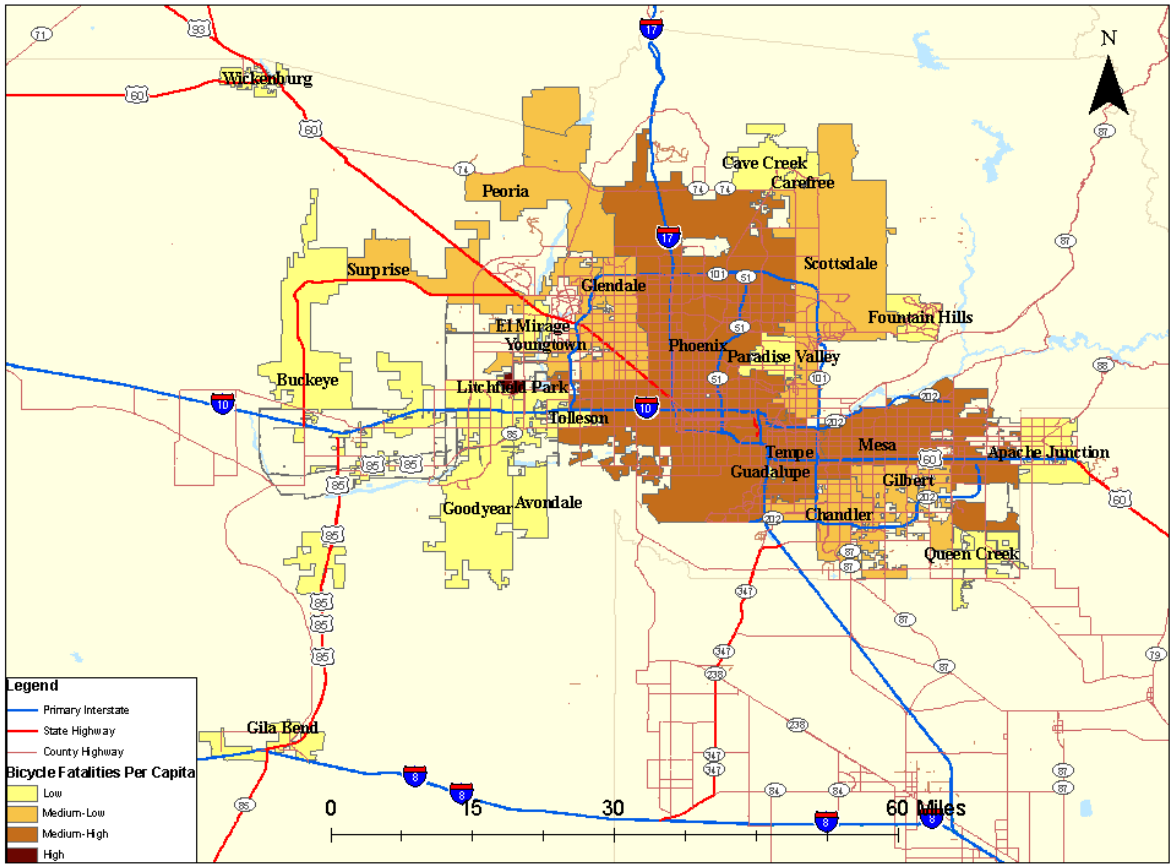
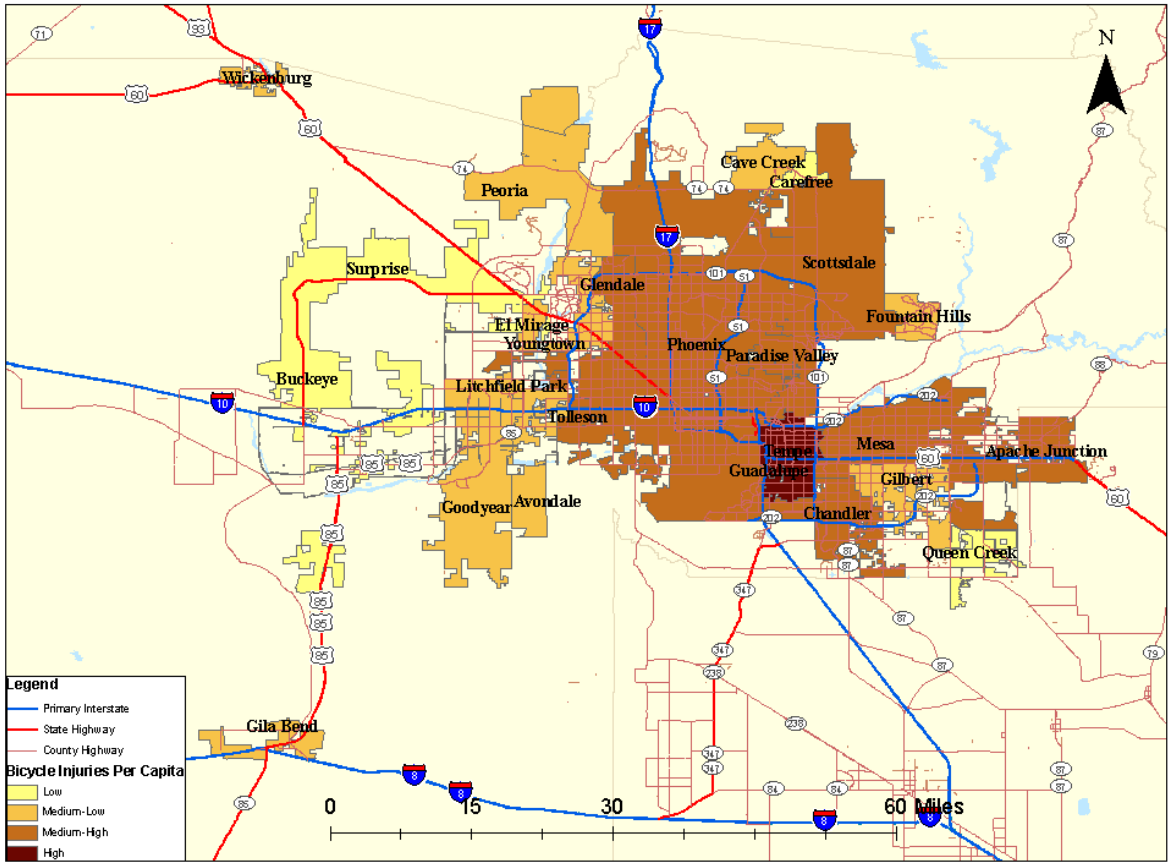


Figure 3.10 Bicycle Injuries Per Capita, 2005-2009



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. 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 conspicuity may be an area for improvement.

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 3.1 was proven, and one provided a crash reduction factor. Table 3.2 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 3.1 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
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	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*	All bicycle crashes

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue addressed
		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).			*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.	

Table 3.2 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 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.		Bicycle crashes at intersections
Improve enforcement of bicycle-related laws	This strategy directly targets activities of law enforcement officers as they relate to bicycling and indirectly targets	Many crashes can be avoided if both bicyclists and motorists follow the rules of the road. Heightened awareness	Process Measure: • Number of citations issued for violations of bicycle-related laws	NCHRP Report 500 Volume 18: A Guide for Reducing Collisions	Information on training of law enforcement personnel to	Crashes involving driver and bicyclist violations

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
	behavior of bicyclists and motorists.	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.'	Performance Measure: • Number and severity of crashes involving bicycles	Involving Bicycles, Countermeasures That Work, 2011	improve bicyclist safety NHTSA's *Enhancing Bicycle Safety: Law Enforcement's Role*: www.nhtsa.gov/Driving+Safety/Bicycles/Enhancing+Bicycle+Safety:+Law+Enforcemen t's+Role Safe Routes to School's *Enforcement: Role for Law Enforcement in SRTS*: www.saferoutesinfo.org/resources/enforcement_role-for-law-enforcement.cfm	
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	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	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.	http://www.bicyclingambassadors.org/about.html Bicycle and *Pedestrian Safety Resource Guide*, NHTSA, 2006. Available at: http://www.nhtsa.dot.	All bicycle crashes

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
	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, DC: Federal Highway Administration.)	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) non-motorist 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).			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	
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		Bicycle crashes involving children

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 that many of the safety benefits associated with SRTS countermeasures are assumed rather than known.	Process Measure • Pedestrian Crashes involving School Age Children Performance Measure • Number of sites having implemented SRTS improvements	Countermeasures that Work, 2011	Safe Routes to School website: 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 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.		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	Pedestrian and Bicycle Information Center http://www.bicyclinginfo.org/education/motorists.cfm	All bicycle crashes
Driver Training	The purpose of addressing bicycle safety as part of driver education is to increase the sensitivity of drivers	Driver education has not been shown to reduce overall crash rates. The objective for adding more bicycle information would	Process Measure • Inclusion of improved content on bicycle safety in driver education materials	Countermeasures That Work, 2011	Pedestrian and Bicycle Information Center http://www.bicyclinginfo.org/education/mo	All bicycle crashes

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
	to the presence and characteristics of bicyclists and how to safely share the road with them. Although driver education and most State driver manuals address sharing the road with bicyclists, many spend relatively little time on the topic	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.	Performance Measure • Number of fatal and injury bicycle crashes		torists.cfm	

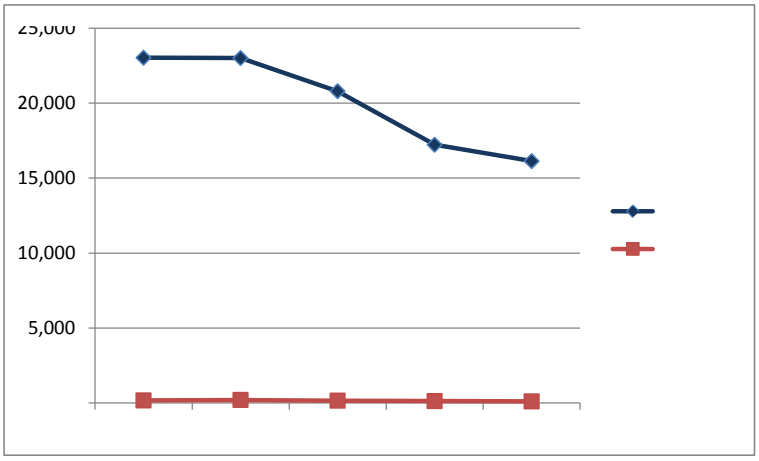
4.0 Intersections

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

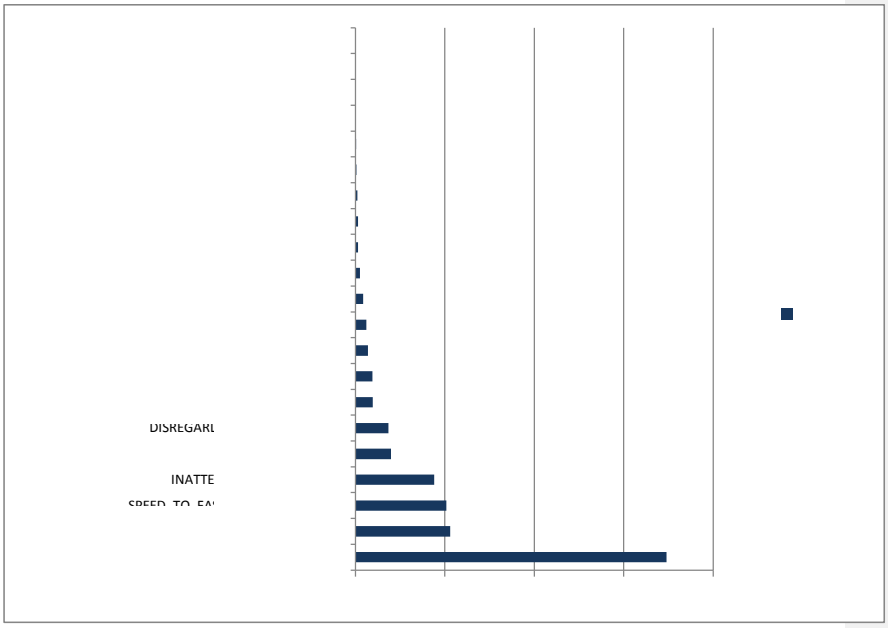
Intersection injuries and fatalities have declined significantly from 2005 to 2009, as shown in Figure 4.1. However these types of crashes still represent a large proportion of the roadway safety problem.

Figure 4.1 Intersection Injuries and Fatalities, 2005-2009



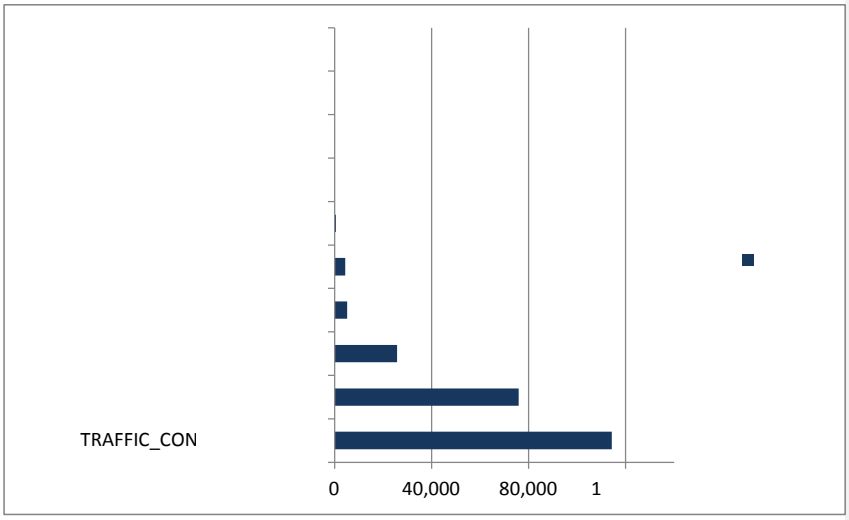
As shown in Figure 4.2, the top three driver violations are failure to yield right of way, speeding, and inattention/distraction. Distraction was a top factor in pedestrian and bicycle crashes as well; therefore, this is an area of opportunity for improving safety among all three modes of travel.

Figure 4.2 Driver Violations – Intersection Crashes, 2005-2009



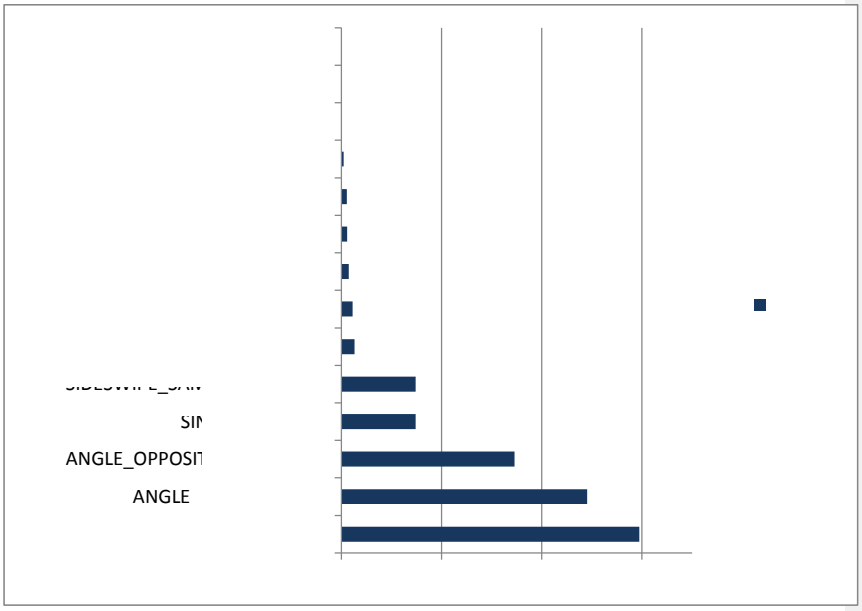
The majority of crashes occur at signalized intersections; however a significant number of crashes do occur at intersections with stop signs, as shown in Figure 4.3. This breakdown of intersection crash types may be proportional to the number of these types of intersections in the region.

Figure 4.3 Intersection Traffic Control Type, 2005-2009



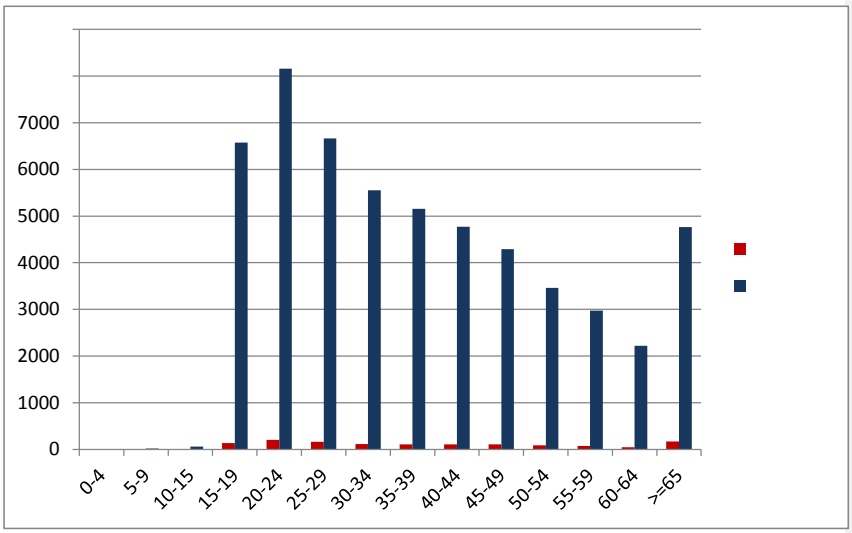
As shown in Figure 4.4 the most prevalent crash type is rear-end crashes, which is often related to high approach speeds and inattention by the driver. The next two most common crash types are angle crashes, which occur with turning movements.

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 20-24, with the next highest age groups being age 15 to 19, 25 to 29, and 65-plus. 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[4].

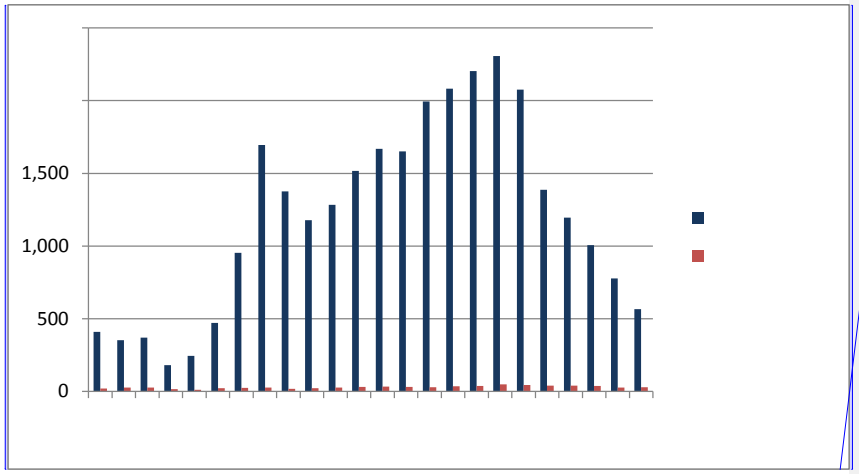
Figure 4.5 Intersection Related Fatalities and Injuries by Age, 2005-2009



[4] 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.

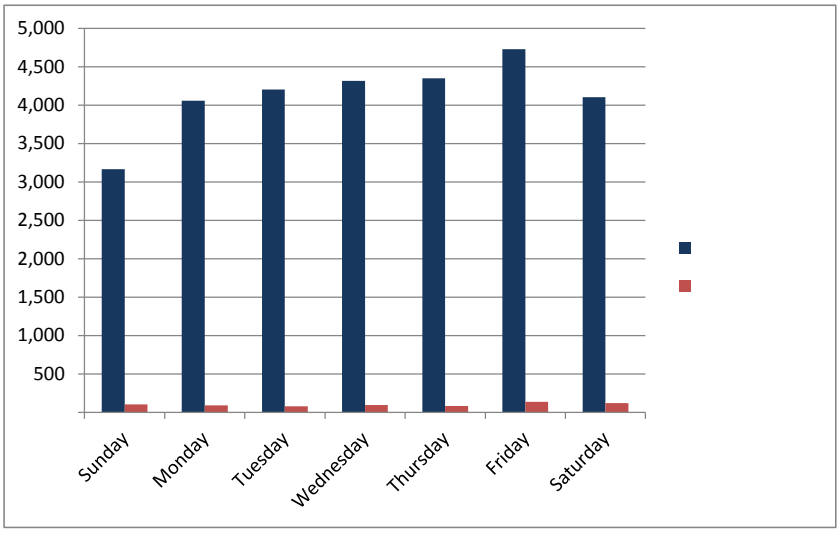
Figure 4.6 Intersection Fatal and Injury Crashes by Time of Day



Comment [sj2]: This figure needs to be cleaned up. Showing the numbers in the middle of the chart makes it messy.

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 municipality in the MAG region. 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

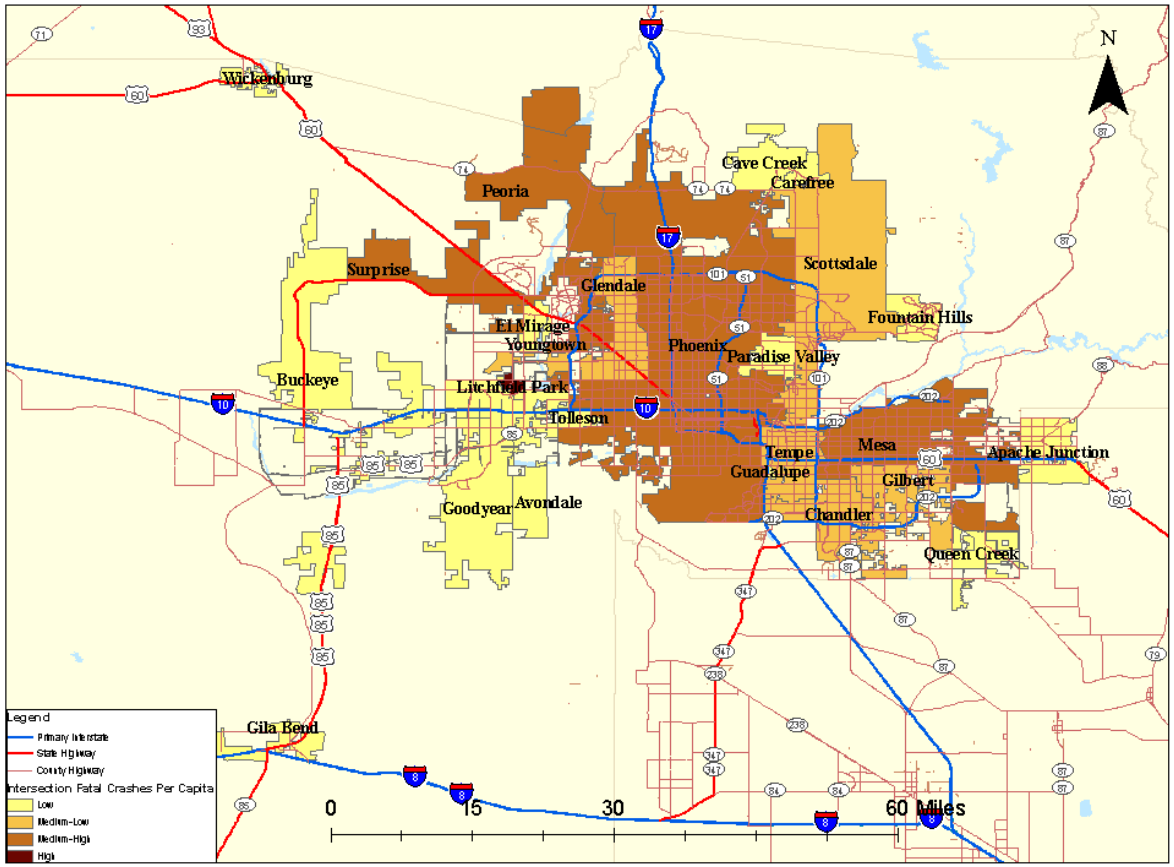
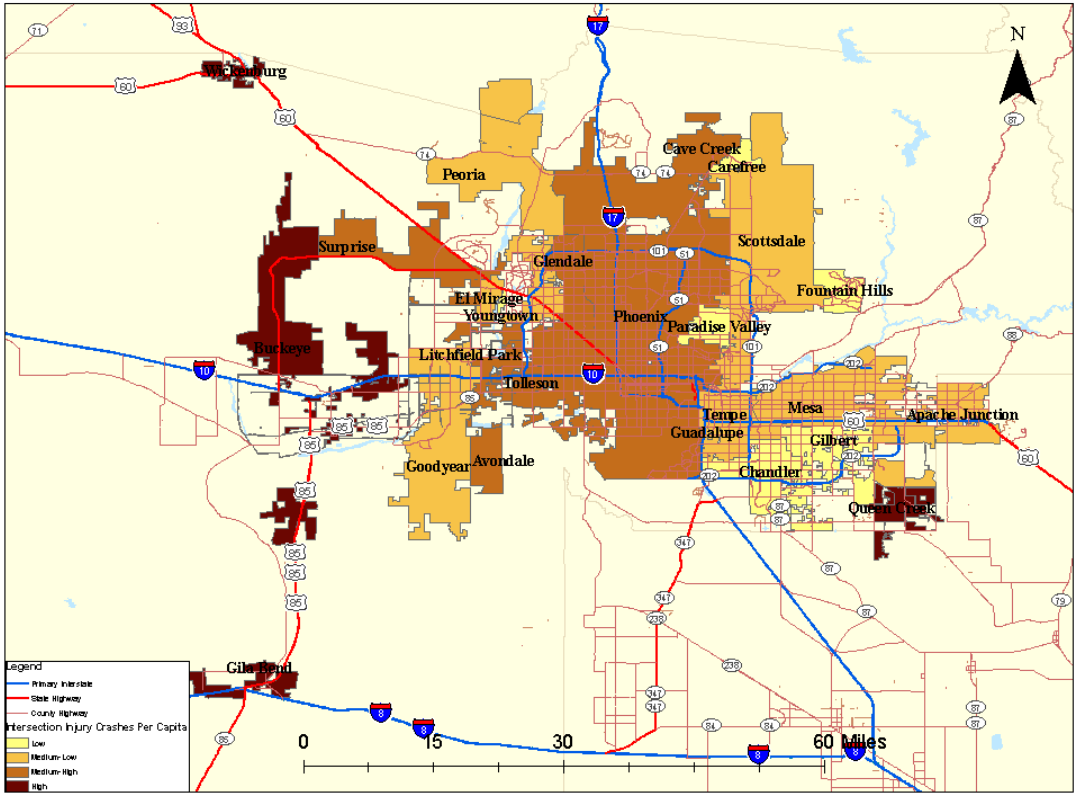


Figure 4.9 Intersection Injury Crashes Per Capita



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						
Eliminate parking that restricts sight distances near intersections	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 extensions can be constructed where pedestrians cross streets, and parking should not be permitted on approaches to crosswalks.	For unsignalized intersections – Based on existing literature, it has been estimated that if the available sight distance in any quadrant of an intersection is less than or equal to the design sight distance for a speed of 12 mph less than the actual 85th-percentile speed of the approach, then the frequency of related crashes at the intersection would be increased by approximately 5%. Each additional quadrant accounts for an approximate 4% decrease in crashes. Thus, a project may be 5 to 17% effective in reducing related crashes, depending upon the severity of the existing sight restriction and the number of intersection quadrants affected. Desktop Reference for Crash Reduction Factors CRF = 49 for all crash types	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. Performance Measures • Number and severity of intersection crashes	NCHRP Report 500 Volumes 5 and 12.	FHWA Office of Safety Design guidance for unsignalized intersections http://safety.fhwa.dot.gov/intersection/resources/intsafestratbro/uc4_eliminate_park_restricts.pdf Desktop Reference for Crash Reduction Factors, USDOT, 2007: http://www.transportation.org/sites/scohts/docs/Crash%20Reduction%20Factors%20Desktop%20Reference%2012-19-07.pdf	All intersection crashes
Provide public information and	The target for this strategy is crashes related to drivers	The estimated impact of mass media road safety campaigns is	Process Measures: • Number and frequency	NCHRP Report 500 Volumes 5 and 12.		Crashes involving driver violations

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
education	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.	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)	of different media used (radio ads, brochures, etc.) • Population exposed to the message. • Level of expenditure Performance Measures: Frequency and severity by crash type.	A Review of Mass Media Campaigns in Road Safety, Delaney et al, 2004. http://www.monash.edu.au/muarc/reports/muarc220.pdf		
Intersections – Signalized						
Prohibit Right Turn on Red	The target for this strategy is reduction of run-off-road, rear-end, right-angle and sideswipe crashes at signalized intersections.	-CRF = 30 for run-off-road crashes -CRF= 20 for rear-end crashes -CRF = 30 for right-angle crashes -CRF = 20 for sideswipe crashes	Process Measure • Number of locations at which strategy is implemented Performance Measure • Number and severity of signalized intersection crashes	Crash Reduction Factors Desktop Reference http://www.transportation.org/sites/scohts/docs/Crash%20Reduction%20Factors%20Desktop%20Reference%2012-19-07.pdf		All signalized intersection crashes
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)	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)	Process Measure • Number of cameras installed • Number of citations issued	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,	Signalized intersection crashes involving red-light running

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
	are generally not well-accepted.	-CRF=45 for left turn -CRF =20 for right angle -CRF=-45 for rear end	Performance Measure • Number, type and severity of crashes at targeted intersections		Insurance Institute for Highway Safety, Feb. 2011. NCHRP 622: Effectiveness of Behavioral Countermeasures	
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)	Speed cameras: on average result in 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.) 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
	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.					
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,	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
	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.					
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. 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

Strategy	Description	Effectiveness	Process/Performance Measures	Source	Resources	Safety Issue Addressed
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. Implementation of a new policy to prohibit parking near intersections in Mesa, AZ.
    - Mesa experienced 19,745 intersection crashes from 2005-2009, for an average of 3,949 intersection crashes per year.
    - It is estimated that by eliminating on-street parking near intersections, which reduces intersection visibility, intersection crashes will be reduced by 49 percent (the Crash Reduction Factor is 49).

- Therefore, the number of intersection crashes would be estimated to be reduced by 1,935 crashes per year if this policy were implemented community-wide.

3. Installation of red-light running cameras.
    - The assumption 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.
    - 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.