DEPARTMENT OF TRANSPORTATION

Evaluation of Sustained Enforcement, Education, and Engineering Measures on Pedestrian Crossings

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Project Summary Report
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16. Abstract (Limit: 250 words)

Pedestrian fatalities and injuries represent a growing percentage of all traffic fatalities and injuries. This project used a multifaceted approach to improving compliance to the Minnesota crosswalk law in Saint Paul, Minnesota, including: (1) education, (2) measurement, (3) enforcement efforts, (4) social norming, and (5) engineering treatment. The multifaceted activities were planned and implemented in Saint Paul with city traffic engineers and enforcement officers. The study initially observed 32% yielding and frequent multiple threat passing at 16 unsignalized, marked crosswalks throughout Saint Paul, measured through staged pedestrian crossings by the research team. A program was implemented that used a phased treatment approach of disseminating educational materials, conducting four waves of high visibility enforcement (HVE), displaying yielding averages on feedback signs across the city, and introducing low-cost engineering solutions through in-street signs. The results demonstrated a significant impact from education, HVE, and engineering to increase yielding to as high as 78% at enforcement sites and 61% at untreated sites. Multiple threat passing was also reduced. Overall, the study demonstrated that the HVE program and combined low-cost engineering were effective at improving compliance to the crosswalk law.

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EVALUATION OF SUSTAINED ENFORCEMENT, EDUCATION, AND ENGINEERING MEASURES ON PEDESTRIAN CROSSINGS

FINAL REPORT

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LIST OF ABBREVIATIONS

HVE: High Visibility Enforcement

MnDOT: Minnesota Department of Transportation

PSA: Public Safety Announcement

SPPD: Saint Paul Police Department

SPPS: Saint Paul Public Schools

SRTS: Safe Routes to Schools

EXECUTIVE SUMMARY

Pedestrian safety has emerged as a growing problem in Minnesota and nationwide. In 2018, there was a national increase of 4% in pedestrian fatalities over the prior year, the most since 1990 (GHSA, 2019). This trend has been mirrored in both Saint Paul and Minnesota, with fatal pedestrian death rising to levels not seen in recent decades (MnDPS, 2017). The Stop For Me Campaign, conducted by the Saint Paul Police Department (SPPD) and its community partners, was designed to conduct high visibility enforcement of the Minnesota crosswalk law and engage community awareness. The campaign employed an integrated approach to combat this growing issue. The research team evaluated and expanded on this approach in 2018.

The University of Minnesota research team selected 16 marked, unsignalized crosswalks across the city of Saint Paul to measure existing driver compliance to the crosswalk law. The research team found that approximately 32% of drivers stopped for the researchers while they conducted staged pedestrian crossing protocols, which included natural pedestrians when present. In addition, they found that multiple threat passing was a persistent and dangerous behavior that was commonly practiced at many of the crosswalks, even on two-lane roadways, and was observed in approximately 1 out of 10 staged crossings.

The research team collaborated with the Saint Paul Police Department (SPPD) and Saint Paul Public Works (SPPW) to create a multidisciplinary program to engage the public about the issue of pedestrian safety through a phased approach over 18 months. The project used a multifaceted approach including: (1) education, (2) measurement, (3) enforcement efforts, (4) social norming, and (5) engineering treatment. The education strategy included extensive outreach efforts within Saint Paul through several different mediums to reach a wide variety of the population to establish a strong community partnership. The community partnership activities included creating and distributing physical and electronic educational materials, connecting with organizations, communicating with stakeholders, and interacting with local media. The research team continued data collection of yielding behaviors, yielding distances, multiple threat passing, and hard braking among others. SPPD conducted four two-week high visibility enforcement (HVE) waves at half of the 16 study sites in the months of May (warning only), June (start of ticketing), August (ticketing), and October (ticketing). Pedestrian safety expert project consultant Dr. Ron Van Houten, of Western Michigan University, trained the police team to enhance its operations. Social normalizing or social norming techniques were implemented in conjunction with the start of the June ticketing wave of enforcement to advertise weekly yielding and best yielding averages measured by the research team and displayed on large blue signs on eight major corridors across the city. Finally, low-cost engineering was implemented to coincide with the third and fourth wave of police enforcement. The first engineering treatment involved the installation of a single R1-6 in-street sign at the eight enforcement sites. The second engineering treatment involved installing multiple in-street signs at each of the enforcement sites in a split gateway configuration or a similar configuration based on the site characteristics.

The results of the study demonstrated a significant change in driver behavior over the course of the program. Consideration of police citation count and the driver behavior variables indicated a positive effect of HVE, outreach, and engineering on overall driver yielding percentages for both enforcement and generalization sites (i.e., those that received no enforcement or engineering treatment). The weekly average for enforcement sites in the baseline period was as low as 26% yielding but grew to as high as 78% during the final implementation of the gateway sign treatments. The weekly average of generalization sites in the baseline period was as low as 31% but grew to as high as 61% just prior to the gateway installation. An analysis of the distance of enforcement sites to generalization sites showed some diminishment of the HVE effect by distance; however, the observed improvement at generalization sites implied that the positive effect of HVE diffused throughout the city at least to the measured sites.

Furthermore, multiple threat passes were reduced for both site types and a positive impact of period/wave was observed for yielding more than 40 feet back. The decline in multiple threat passes may have also been attributed to an increase in penalty by the SPPD by checking the “endangering life or public property” box when the behavior was observed, a penalty requiring a court visit rather than simply paying a fine. However, continued HVE appeared to increase the rate of stopping less than 10 feet from the crosswalk at generalization sites, implying that drivers may have been particularly alert for pedestrians near enforcement site crosswalks (either due to in-street signage or recent police presence), and less so for pedestrians near generalization sites.

A survey distributed online prior to the installation of the feedback signs in June 2018 and after the final HVE wave in October 2018 indicate some opportunities for better education among community members about the crosswalk law. The greatest opportunity is to improve knowledge and awareness of what the law requires regarding pedestrians at a crosswalk. The results regarding unmarked crosswalks indicate that the vast majority of drivers are aware that the law requires the same stop behavior as it does for marked crosswalks. Finally, the survey results indicate that awareness of the Stop For Me campaign improved from Period 1 and Period 2 and that the blue feedback signs displaying yielding percentages were observed by a significant number of participants.

Overall, the low-cost engineering treatments, combined with education and enforcement, appear to maximize the effect of each of their contributions through a unified and concerted effort. Pedestrian deaths create an immeasurable toll on the well-being of a community and instill a great financial cost to society. The observed improvement in pedestrian safety, as evidenced by improved compliance to the Minnesota crosswalk law and reduced multiple threat passing observed because of this program suggests that this integrated approach is a cost-effective solution to help to change the driving culture into one that values and supports pedestrian safety.

CHAPTER 1: INTRODUCTION

Across the world, nearly a quarter (22%) of over a million traffic deaths per year are pedestrians (WHO, 2013). In 2016, there were 60 pedestrian fatalities in Minnesota, the highest number of pedestrian deaths in the state since 1991 (Roper, 2017). The need to reduce pedestrian fatalities in alignment with the statewide Toward Zero Deaths (TZD) program goal is a challenging one. Pedestrians interact with vehicles, and both pedestrian and vehicle behavior are influenced by infrastructure, a vast space of vehicle and pedestrian transit design possibilities, social rules and expectancies (e.g., not looking for pedestrians), and various human capabilities and limitations all contribute to this challenge. Any intervention to reduce the risk and rate of pedestrian crashes can utilize one or a combination of the aforementioned influences. The city of Saint Paul recently embarked on a safety evaluation and several citywide police enforcement waves to elevate awareness of pedestrian safety needs, particularly the requirement to yield to crossing pedestrians. The following review will (1) summarize the relevant literature on roadway design factors that influence motor vehicle yielding and pedestrian crash rates and describe the previous work in social engineering and educational interventions along with high-visibility enforcement approaches conducted by Van Houten and colleagues (2013; 2017) that will be implemented during this project, and (2) recount the efforts of Saint Paul and its police department to improve pedestrian safety.

In addition to the obvious importance of reducing pedestrian deaths, improving pedestrian safety could lead to an increased willingness to engage in walking rather than utilizing other forms of transport (Mead, Zegeer, & Bushell, 2014). In a broader analysis of community health factors, Gilderbloom, Riggs, and Meares (2015) found that areas with higher levels of “walkability”, as calculated by an algorithm integrating several geographic and mapping variables, were scored higher in measures reflecting value and well-being (e.g., real estate value, foreclosure rate, crime rate). Therefore, improving pedestrian safety could have extended effects in Saint Paul beyond reducing crash rates. For example, reducing the need to rely on motor vehicle travel could reduce environmental impacts including pollution and other consequences of carbon dioxide emission, which may have significant externality costs (Small & Kazimi, 1995).

1.1 PEDESTRIAN YIELDING, CRASH RATES, AND CONFLICT

Efforts to determine best practices for traffic safety have been ongoing since the 1980s (for a review, see Mead, Zegeer, & Bushell, 2014). In recent years, pedestrians have more sources of distractions, given smartphone technology and wearable music devices. One study found that texting, phone conversations, and listening to music contributed to unsafe behaviors and accidents involving pedestrians at a simulated crosswalk (Schwebel, Stavrions, Byington, Davis, O’Neal, & de Jong, 2012). Furthermore, children are at increased risk for pedestrian crashes, particularly younger, more impulsive children (Barton & Schwebel, 2007). Pedestrian risk is further complicated by continued sources of driver distraction including smartphones and other in-vehicle technologies (Horrey, Wickens, & Consaulus, 2006). The research efforts to investigate pedestrian safety can roughly be divided into two categories. First, there is substantive research on designs of traffic infrastructure and technological devices, and second, a significant but not as sizeable research literature exists to educate and shape the behavior of both drivers and pedestrians.

1.1.1 Roadway design and risk factors

Stoker and colleagues (2015) reviewed the high-level known risk factors for pedestrians from the literature relevant to pedestrian safety and found that visibility, pedestrian-traffic interaction, and traffic speed were key risks. Gårder (1989) measured counts of conflict or threat points for a number of crosswalks for pedestrians in relation to motor vehicles in Sweden. Using a count of traffic conflicts as the dependent variable, Gårder found high-speed (more than 30 km/h) intersections without signalization to be the riskiest of crosswalks. Low-speed intersections with signalization were notably less risky, as long as there was not a lot of turning at these intersections, which can lead to vehicles turning and hitting green-walking pedestrians. Gårder (2004) followed up with an evaluation of risk using pedestrian crash data as the dependent variable in Maine and found the most predictive variables were speed, with high speed leading to increased pedestrian crashes, and the wideness of roads, with wider roads being riskier. Boarnet, Day, Anderson, McMillan, and Alfonzo (2005) reviewed the benefits of various interventions in a Safe Routes to School (SR2S) program in California and found similar advantages in traffic signalization of an intersection; replacing stop signs with traffic signals had significant safety benefits. However, Boarnet and colleagues (2005) also found mixed results as it came to improvements to crosswalks and crosswalk signalizing. In-pavement crosswalk lighting led to improved yielding rates at one site but not at other sites where the use of either in-pavement flashing warning lights and crossing signs had no effect and sometimes led to an increase in risky behavior, such as motor vehicle speeding.

Zegeer, Stewart, Huang, & Lagerwey (2001) reviewed pedestrian crash rates over a five-year period on marked unsignalized and unmarked unsignalized crosswalks, as opposed to the signalized intersections reviewed by Gårder (1989; 2004). Zegeer and colleagues found that for two-lane roads, there was no difference between marked and unmarked crosswalks on crash rates per pedestrian, but for multi-lane roads with high traffic volumes, marked crosswalks were shown to have, on average, a significantly higher crash rate per pedestrian. The authors recommended not solely relying on crosswalk markings and static signing. Zegeer, Esse, Stewart, Huang, and Lagerwey (2004) replicated both findings, while also observing the somewhat obvious finding that higher pedestrian volume and a higher number of lanes were associated with increased pedestrian crashes. Zegeer and colleagues generally recommended not adding marked crosswalks for high-volume roads (>15,000 ADT), roads with high speeds (>35 mph), and roads with more than three lanes, although these factors interacted and other pedestrian enhancements could be considered in conjunction with the markings. One possible limitation of the Zegeer et al. (2004) results is the possibility of crash migration. Marked crosswalks may attract more vulnerable pedestrians to the marked crosswalk who might otherwise be struck near the crosswalk. Zegeer and colleagues did not test this possibility by examining whether crashes were lower at locations near marked crosswalks.

Van Houten (1988) tested whether advance stop lines and a regulatory sign (i.e., Stop Here for Pedestrians) would lead to safer driving behaviors at unmarked crossings. Using a multiple-baseline design in which the stop lines and signs were added and removed to verify any effects on driver behavior, the study found that there was a significant effect on stopping distance from the crosswalk and a reduction in conflict points between motorists and pedestrians but a minimal effect on actual yielding rates. Van Houten and Malenfant (1992) followed up the previous study and attempted to generalize the results to a signalized crosswalk. They found similar effects with a signalized crosswalk. For both studies, the beneficial effects lasted for some time after implementation, indicating sustainable improvements in pedestrian safety. Additional studies replicated the positive benefits of advance stop lines with larger samples (Van Houten, McCusker, Huybers, Malenfant, & Rice-Smith, 2002; Van Houten, McCuster, & Malenfant, 2001).

Pulugurtha, Desai, and Pulugurtha (2010) investigated whether pedestrian countdown timers had a beneficial effect on pedestrian crash rates. Pulugurtha and colleagues (2010) found no unique impact of countdown timers on pedestrian crashes but did find a positive impact for all crashes, although the research literature on the impact of countdown timers is mixed as Huitema, Van Houten, & Manal (2014) found a beneficial reduction in crash rates with countdown timers at signalized intersections. Pulugurtha, Vasudevan, Nambisan, and Dangeti (2012) also considered infrastructure countermeasures intended to improve pedestrian safety, including increasing the visibility of crosswalks (e.g., employing "ladder-style" crosswalk markings or continental style) and median refuges. They found that visibility improved yielding distance but not yielding rates (as measured by slowing or stopping for pedestrians crossing in the crosswalk) when pedestrians were attempting to cross, while median refuges improved yielding rates as well as distance.

Huang, Zeeger, and Nassi (2000) considered the effect of overhead crosswalk signs, in-road safety cones, and regulatory signs on unsignalized crosswalks in 9 cities and 11 locations. They found the most effective tools in terms of improving yielding rates were the overhead crosswalk signs, while the safety cones had mixed results, and the regulatory signs were ineffective. Huang and Cynecki (2000) also examined infrastructure measures intended to calm traffic and whether those would improve pedestrian safety via increased yielding rates. Testing both speed humps and traffic chokers, the authors found minimal effects.

Turner, Fitzpatrick, Brewer, and Park (2006) conducted a literature review on pedestrian crossing treatments and motorist yielding and found that half-signal, HAWK signal beacons, and in-street crossing signs have relatively high yielding rates from their respective studies (99%, 93%, and 77%, respectively). However, in-roadway warning lights, high visibility signs and markers, and flashing beacons were not quite as effective (66%, 52%, and 52%, respectively). A pre-post intervention study on 42 sites found that red signal/beacon devices performed the best (more than 90% yielding compliance), and in-street crossing signs did fairly well (87% yielding rates), while "active when present" and high visibility or enhanced devices such as overhead flashing beacons scored poorly (from 65% to 17% compliance). Fitzpatrick and colleagues (2014) conducted another extensive review of factors and crash rates in Texas and then performed a field study to test some potential interventions. Roadways with high posted speeds (particularly freeways) and dark lighting conditions contributed more to crashes with fatal injuries, while daylight conditions, intersections, and city streets were associated with a higher proportion of non-fatal incidents. Expectancy of pedestrians being present may contribute to the crash rate, as 21% of fatal crashes occurred on freeways. In the field study, researchers tested pedestrian hybrid beacons, rectangular rapid-flashing beacons (RRFB), and traffic control signal sites with staged pedestrian crossings to evaluate yielding rates. All sites had very high levels of yielding (86% to 98%), and a small pre-post intervention follow-up found significant improvements in yielding rates with pedestrian hybrid beacons and rectangular rapid-flashing beacons. These results are similar to those found by Shurbutt, Van Houten, Turner and Huitema (2009).

A substantive literature review was conducted by Mead, Zeeger, and Bushell (2014), focusing on studies using rigorous research methods. The relevant material includes information on marked crosswalks, high visibility crosswalks, and crosswalk enhancements. For marked versus unmarked crosswalks, numerous older studies show mixed results for marking crosswalks, and some even find worse rates for marked crosswalks. The authors suggested marked crosswalks might increase multiple threat crash risks, which leads to more risk of crashes at high traffic volumes. In addition, older pedestrians may be proportionally more likely to use marked crosswalks and older pedestrians may be more likely to exhibit limited walking speed, balance, and wayfinding, exacerbated with reductions in perceptual and cognitive abilities (Tournier, Dommes, & Cavallo, 2016). For high visibility crosswalks, five of the six studies reviewed found that raising crossings, bar pair markings, and other visibility enhancements improved safety measures such as crosswalk detection time, crash rates, and yielding across single and multi-lane roads (e.g., Chen, Chen, Ewing, McKnight, Srinivasan, & Roe, 2013, but see Turner, Fitzpatrick, Brewer, & Park, 2006 for evidence of a decline in beneficial effects of high visibility signalizing across multiple lanes). For other crosswalk enhancements, illumination and in-pavement lighting tended to show the best effects, while flashing beacons (not including RRFBs) had modest positive effects, likely because flashing beacons are used in other traffic operations, leading to confusion as to their meaning when used in the pedestrian context. However, rectangular rapid-flashing beacons had notably more positive effects on yielding rates, according to Mead, Zeeger, and Bushell's (2014) review of the literature. Finally, in the context of site selection and risk, the authors noted that lane counts were associated with pedestrian crashes, and road "diets" (reducing the number of lanes) led to a decline in pedestrian crash risk, although the pattern of results could vary when considering roadway segments versus intersections (see Chen, Chen, Ewing, McKnight, Srinivasan, & Roe, 2013).

1.1.2 Social and educational interventions

Boyce and Geller (2000) conducted a social norming study to improve pedestrian safety on a community college campus by asking members of the community to read guidelines on walking and driving through crosswalks. Members then signed a promise to indicate a "commitment" to adhere to the guidelines and received other materials indicating membership in the program and prizes. Using a baseline to intervention design, the researchers observed performance at preselected intersections. During interventions, crosswalk use increased from 58% to 68%, while yielding behavior increased from 23% to 41%. A year later, yielding rates were at 53%, suggesting that interventions with social norming of this kind have long-term efficacy for improving pedestrian safety and safe driving behavior around pedestrians, at least for smaller communities, such as a college or school. Harré and Wrapson (2004) evaluated a safety campaign intended to both minimize red light crossings by pedestrians and increase yielding by motorists, particularly when making left turns. The campaign had used visual media at five intersections and scheduled an interactive "footpath mime". Red light crossing rates declined significantly from before to after the campaign, but there was no improvement in driver behavior and no change in general attitudes as measured by pre and post surveys.

A substantial series of research studies, initially out of New Brunswick and Nova Scotia by Louis Malenfant and Ron Van Houten, employs the technique of combining community feedback with high visibility enforcement (Van Houten, Malenfant, Huitema, & Blomberg, 2013). Relying partly on general deterrence theory, which states that awareness of punishment for a particular behavior, will lead to reduction in that behavior (Thomas & Bishop, 1984), these multi-pronged interventions for changing driver behavior intends to increase the perception of threat to drivers for committing driving violations, while simultaneously changing community social norms for appropriate driving behavior. Community outreach and media coverage act to heighten the visibility of pedestrian safety and police enforcement to accomplish both increased risk perception and changing social norms.

One of the first studies employing this paradigm (Van Houten, Malenfant, Rolider, 1985) tested two heavily trafficked roads with crosswalks in Dartmouth, Nova Scotia. Community feedback was implemented via pedestrian prompting signs and feedback signs on recent yielding rates. Media coverage was accomplished via four local newspaper articles, one television interview, and two radio interviews. Enforcement was done by conducting staged crossings, in which police would pull over non-yielding vehicles and provide the driver with a flyer and a warning ticket. There was also a "reward" condition in which motorists who yielded to pedestrians were pulled over and received a small gift. There was little practical effect of the reward condition, but during enforcement, yielding rates increased more than 20%, which remained after a follow-up measurement. In a similar study in three Canadian cities in Newfoundland and New Brunswick, Malenfant and Van Houten (1990) used a public education program (feedback signs, flyers, media outreach) and roadway design elements such as advanced stop lines (see Van Houten, 1988), along with a police enforcement campaign using flyers and warnings for motorists who did not yield to pedestrians to attempt to increase yielding rates and reduce pedestrian crashes at selected unsignalized crosswalks. After implementation, measurements found a significant increase in yielding to pedestrians compared to a pre-implementation baseline. For two of the cities in which pre-implementation data on crashes and injuries were available, there was a notable decline after implementation of the program. A more recent study in Miami Beach, Florida, (Van Houten & Malenfant, 2004) considered whether enforcement efforts at an uncontrolled crosswalk would transfer to an untreated signalized crosswalk. Considering 8 treatment crosswalks and 12 untreated generalization crosswalks, with the latter having 7 with traffic signals, a similar measurement paradigm was used measuring yielding, and the numbers of conflicts between motorists and pedestrians (swerving or jumping back) were also measured. There was a significant improvement in yielding and reduction in conflicts for treatment sites during both the implementation and the post-implementation baseline follow-up measurements. There were mixed results for generalization sites, with some non-treatment sites showing improvements in yielding rates during and after implementation and other sites showing no effect.

The most recent published work in this line of research was conducted in Gainesville, Florida, (Van Houten, Malenfant, Blomberg, & Huitema, 2017; Van Houten, Malenfant, Blomberg, Huitema, & Casella, 2013; Van Houten, Malenfant, Huitema, & Blomberg, 2013). The high visibility enforcement (HVE) program in the study targeted locations with low yielding rates, implemented the program, and measured whether the program was successful at improving yielding rates for both treated and untreated unsignalized crosswalks. Over one year, the police in Gainesville conducted four waves of HVE, which was made high visibility by earned media, University news releases and website information, radio ads, outreach to communities and schools, signage, and feedback signs on the last nine weeks. Gainesville refreshed advanced crossing signs at six treatment and six control sites. During enforcement, warnings and flyers were issued on the first wave, and citations were issued for the next three waves. Measurements were conducted prior to implementation, during enforcement, and after enforcement using staged and unstaged crossings. Yielding rates increased during and after enforcement relative to baseline for both the treatment and to a lesser extent the generalized sites. However, the sample size of crashes was too small to draw any conclusions about the efficacy of the intervention on crash rates. A four-year follow up was conducted at the same location to determine whether there was a long-term effect of the high visibility enforcement protocol (Van Houten, Malenfant, Blomberg, Huitema, & Hochmuth, 2017). Observers measured yielding rates at the original sites, both treatment and generalization. The yielding rates for the last phase of the original study was 66% for treatment sites and 58.5% for generalization sites. The final phase of the follow-up measurements (4 years) found yielding rates of 75.7% for enforcement sites and 74.7% for generalization sites. Furthermore, there was now sufficient data to analyze the effects of the program on crash rates, with an initial crash rate of 101.2 pedestrian crashes per year and a yearly rate of 83 crashes for the years after the program ended, which is a statistically significant decrease. The authors argue that, outside of the observed improvement in behavior, the changes may have enacted a tipping point effect or positive feedback loop where higher levels of yielding observed by other drivers led to even more yielding (Van Houten & Nau, 1983).

1.2 SAINT PAUL EFFORTS AND EVALUATION

Recent roadway issues in Saint Paul, Minnesota, including pedestrian safety issues, were surveyed in a recent safety plan (CH2M, 2016). The report reviewed, over a five-year period (2009-2013), severe crash types (pedestrian and others) that could be targeted for reduction, best strategies for reduction of said crash types, and most at-risk locations for priority crash types. With respect to pedestrians, the top five road segments in Saint Paul with severe pedestrian and bike crashes were Rice Street – John Ireland Boulevard to University (8 crashes), Third Street East, Earl to McKnight (7 crashes), Grand Avenue – Cretin to Dale (37 crashes), Como Avenue – Eustis to Raymond (10 crashes), and Front Avenue – Dale to

Rice (10 crashes). The most common type of severe crashes involved pedestrians and bicycles (111 crashes). Identified strategies to deal with pedestrian crashes were media campaigns and public outreach, road diets, curb extensions, and median refuge islands, and for signalized intersections, countdown timers and leading pedestrian intervals. The identified streets the report recommended for interventions that overlap with the segments for severe pedestrian and bicycle crashes included Grand Avenue, Como Avenue, and Third Street East.

The Saint Paul Police Department engaged in several strategies to reduce the rate and severity of pedestrian crashes. One strategy was high visibility enforcement operations along with community outreach, with planning beginning in December 2014 and implementation of enforcement in August 2015. The initial weeklong enforcement used trained walkers and occurred on Grand Avenue, and in the Highland and the Macalester-Groveland neighborhoods. Results were thought successful by the police department, leading to grant funding in 2016 for a yearlong implementation phase, with a strategy to be equitable in terms of both education and enforcement and to concentrate efforts on high-risk areas throughout the city. The primary methodology was to use five police officers, with four for enforcement and one to lead volunteer spotters who reported violations triggered by staged walks. Spotters video-recorded violations and enforcement officers issued citations. Locations were attended for an hour and a half to two hours, between 2 pm and 8 pm, and eventually transitioned to a flagging operation from a chasing operation to pursue violators. Cones were placed at a specified distance from the crosswalks based on the speed limit to identify what counted as a violation. Furthermore, another test strategy implemented by Saint Paul was an experimental 4-3 conversion trial road diet implemented on Maryland Avenue in mid-2017, which had a high rate of crashes. The road diet did not drive down the overall crash rate but did reduce the number of severe crashes— although community acceptance of the road diet was mixed. Finally, a major reconstruction was scheduled for Rice Street (August 2018 to November 2018) and Como Avenue (May 2017 to November 2017) to include more facilities to improve pedestrian and bicycle safety.

For results on the high visibility enforcement operations, researchers from HumanFIRST received citation and warning records provided by the Saint Paul Police Department (SPPD) and extracted data for the 2016 and 2017 high visibility enforcement periods. Data selected for analysis for each period, in both 2016 and 2017, started on March 17 because that date had similar daily citation rates for each location, which may be when flagging operations were initiated. Verbal communication with SPPD indicated that flagging operations managed to achieve three times the number of citations than chase-down operations. The extracted data for the second period ended on May 6, 2017. Data was also collected on May 10, 2016, but this data was not used because there were 15 location points recorded on May 10, whereas there was an average of 2-3 location data points for all other dates, leaving May 10 as a methodological outlier. This left a count of 33 times that officers staged a high-visibility enforcement operation. A similar count of enforcement operations (33) was then extracted for the first period, starting on May 17, 2016, and ending on September 14, 2016. This allowed for an equal comparison of the high-visibility enforcement operations for the data sample between years but added a time/season confound.

Given these periods, the first period of high visibility enforcement between March 17, 2016, and September 14, 2016, the 33 enforcement operations resulted in an average of 17.09 citations and 1.36 warnings per operation. The 33 enforcement operations during the second period between March 17, 2017, and May 6, 2017, resulted in an average of 12.42 citations and 1.30 warnings per operation. The locations used for the two periods were different, so these measures in the following analysis were treated as independent samples for the purpose of the statistical analysis. When compared using statistical t-tests with a significant effect requiring a *p*-value of less than .05, the average number of citations for drivers failing to yield tended to decline from the first to second year, but this did not reach statistical significance, $t\ (52.935) = 1.798$, $p = .078$. The number of warnings did not change from the first to second year, $t\ (64) = 0.135$, $p = .893$.

In addition, available pedestrian crash data was retrieved from SPPD (https://www.stpaul.gov/departments/police/pedestrian-and-bike-crash-data-city-st-paul) for the periods of January to October 9, 2016, and January to October 9, 2017. These dates were used to fairly contrast similar periods from 2016 to 2017. There were 133 pedestrian crashes and 3 fatalities during this period in 2016, and 153 crashes and 2 fatalities during this period in 2017, although there is not enough available data yet to determine whether these differences are statistically significant.

1.3 CONCLUSIONS

The data indicates that there has been some positive impact in terms of citation rates, but this has not yet translated into a change in crash rates as of yet. The use of expanded high visibility enforcement in conjunction with community partnerships and high levels of media broadcasting (earned media) the now well-practiced enforcement to the community are expected to yield greater safety gains going forward. An intensified effort, modeled after the work of Van Houten and colleagues (2013), is expected to build on the previous efforts by Saint Paul and the SPPD, should result in improved yielding rates, and hopefully will drive down pedestrian crash rates over the next few years, although the challenge in addressing possible increased multiple threat risks remains. The latter was planned to be addressed via a combination of community outreach, policy, and engineering interventions such as advance yield markings. Advance yield markings have been shown to partially mitigate multi-threat scenarios between vehicles and pedestrians (Fisher & Garay-Vega, 2012; Gómez, Samuel, Gerardino, Romoser, Collura, Knodler, & Fisher, 2011; Huybers, Houten & Malenfant, 2004; Van Houten et al., 2001; 2002). Policy changes through increased penalties are also recommended to reduce the instances of multiple threat passing.

CHAPTER 2: DEVELOPMENT OF COMMUNITY PARTNERSHIP

The success of this project depends on a multifaceted approach including: (1) education, (2) measurement, (3) enforcement efforts, (4) social norming, and (5) engineering treatment. The education strategy includes extensive outreach efforts within the city of Saint Paul through many different mediums to reach a wide variety of the population to establish a strong community partnership. The timing of the activities was set to occur just prior to the first wave of enforcement activities, occurring in the spring of 2018, to maximize the outreach efforts and public attention. The community partnership activities included creating and distributing physical and electronic educational materials, connecting with organizations, communicating with stakeholders, and interacting with local media. These activities are discussed in detail below.

2.1 EDUCATIONAL MATERIALS

The educational materials created for the study were designed to communicate:

- The importance of pedestrian safety in Saint Paul, highlighting how children are being affected;
- The law in Minnesota regarding stopping for pedestrians in crosswalks;
- That Saint Paul Police Department will begin enforcing the law more heavily;
- Safety information directed at drivers about safely stopping for pedestrians in crosswalks; and
- Safety information directed at pedestrians about safely crossing in crosswalks.

Several versions of the flyers were created to reach different audiences and communicate the messages in a format more tailored to each audience. Two main types of flyers were created, black and white, physical, paper flyers and colorful, electronic flyers. The targets of the paper flyers were the drivers pulled over by Saint Paul Police Department (SPPD) who violated the pedestrian stop law, families from Saint Paul Public Schools (SPPS), families from Saint Paul private schools, and community members. There were no identified targets of the electronic flyers, as their distribution is expected to be more widespread, but a specialized version was created to accommodate SPPS based on disclaimer requirements to share non-SPPS materials. All flyers received multiple design iterations based on feedback from TAP members from Minnesota Department of Transportation (MnDOT), City of Saint Paul, and SPPD, before receiving approval for distribution. The feedback on the fliers focused on these entities because the distribution of flyers were to be within the city of Saint Paul.

2.1.1 Saint Paul Police Department Flyers

The flyers (see Figure 2.1 and Appendix A) created for the SPPD were modified based on a previous flyer used by the Gainesville Police Department in a similar program (Van Houten, Malenfant, Blomberg, Huitema, & Casella, 2013) and used safety tips issued by the National Highway Traffic Safety Administration (NHTSA, 2013). The information was customized to include Saint Paul pedestrian crash statistics from 2013-2017 provided by SPPD and MnDOT. The flyers were created to convey a positive message to drivers who have been caught violating the pedestrian crosswalk law and encourage them to become a safety partner. Two thousand copies of the flyers on 80 lbs. 4.25” x 11” white matte cardstock were printed for SPPD for distribution during their enforcement operations. The first warning wave is expected to result in the greatest number of violations and is estimated to require up to 1,200 flyers. The following three enforcement waves are expected to result in fewer violations, thus requiring fewer flyers. Additional flyers were printed as required.

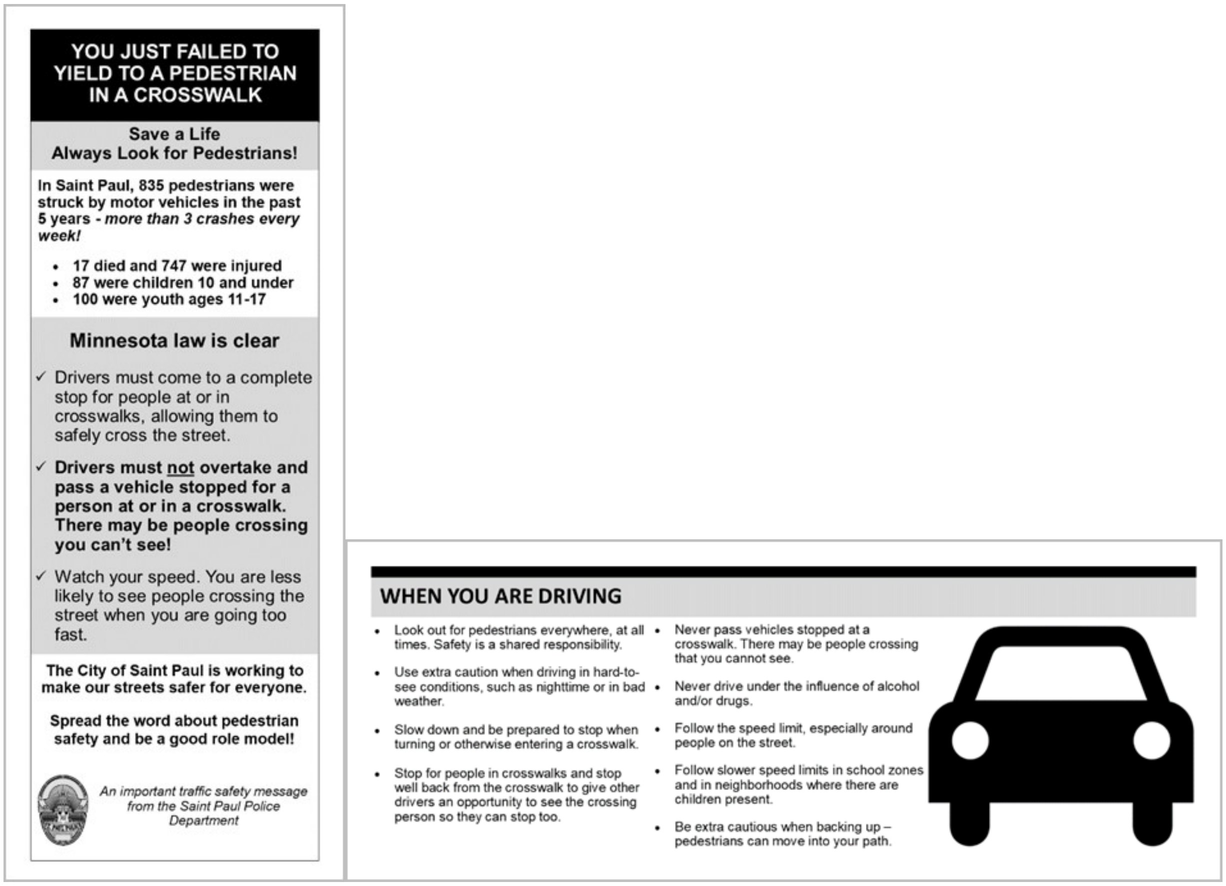

Figure 2.1 Vertical (side 1) and horizontal (side 2) images on SPPD enforcement flyer

2.1.2 School Distribution Flyers

Primary schools in Saint Paul were identified as an important target to reach Saint Paul residents and drivers from surrounding areas to communicate the importance of the pedestrian safety issue by highlighting its effect on children. The format of the flyer matched portions of the enforcement flyer (see Figure 2.2 and Appendix A). The vertical image was modified to serve as a notification of the upcoming enforcement operation by SPPD, contained the same pedestrian crash statistics, and included a required disclaimer from SPPS indicating that they are not officially sponsoring, endorsing, or recommending the activities announced in the flyer, as per their policy for all non-SPPS materials. The horizontal image of the flyer was also modified to focus attention to the multiple threat conflict issue.

Two sketches (see Appendix A for larger images) were created by the research team to convey the importance of stopping further back from the crosswalk to give appropriate sight distance to both crossing pedestrians and approaching vehicles in the next lane of travel. Additionally, the message was catered to address parents regarding the importance of talking to their children about checking every lane as they cross in crosswalks. This point was also conveyed in the first sketch showing a fast approaching oncoming car in the second lane in a four-lane roadway. A second iteration of this flyer was created for Saint Paul private schools which contained nearly identical information, but did not include the required SPPS disclaimer at the bottom of the vertical portion of the flyer (see Appendix A).

Figure 2.2 Vertical (side 1) and horizontal (side 2) images on SPPS Parent Flyer

The number of public schools in Saint Paul is significant, i.e., 56 schools and programs, with more than 37,000 students (SPPS, 2018). Reaching all students and families in the SPPS district presented a logistical and financial challenge. To prioritize efforts and budget, schools near the 16 study sites were identified as targets for distribution of the parent educational materials. The standard practice in SPPS schools is that paper flyers are distributed only to elementary students, not middle school or high school. In accommodating this practice, 19 elementary schools (see Table 2.1) were identified for paper flyer distribution. Three private schools near study sites were selected for distribution of paper communication materials to reach families beyond the SPPS system. Four additional schools (i.e., middle and high schools) from the SPPS system and three private schools near study sites (see Table 2.2) were identified for electronic distribution in order to broaden the reach of the communication materials beyond the limits of the paper flyer distribution. Overall, it is estimated that 17,328 students received information in paper and/or electronic format regarding the pedestrian safety information and upcoming enforcement activities.

Table 2.1 Saint Paul Elementary Schools Targeted for Paper Flyer Distribution

Saint Paul Public (and private) Elementary Schools	**Student Population**	**Study Site Approximate**
Como Park Elementary	550	Dale & Jessamine
Crossroads Elementary School	775	Dale & Jessamine
Jackson Elementary School	350	Marion & Charles; University & Kent
Maxfield Elementary	300	University & Kent
Saint Agnes School (Private)	700	University & Kent
Barack & Michelle Obama Elementary	500	Summit & Chatsworth
Expo for Excellence for Elementary	725	Randolph & Davern
Saint Paul Academy (Private)	900	Randolph & Davern
Randolph Heights Elementary	525	Hamline & Hartford
Holy Spirit School (Private)	300	Hamline & Hartford
Horace Mann School	375	Randolph & Prior
Groveland Park Elementary School	500	Cretin & Goodrich; Randolph & Prior
John A. Johnson Elementary	325	Arcade & Jessamine
Phalen Lake Elementary School	775	Arcade & Jessamine
Saint Paul Music Academy	625	Rice & Magnolia
Paul & Sheila Wellstone Elementary	625	Rice & Magnolia
Farnsworth PreK-4 Lower Campus	550	Maryland & Walsh
L'Etoile du Nord French Immersion, Lower Campus	250	Maryland & Duluth
The Heights Community School	525	White Bear & Nebraska
Frost Lake Elementary	575	White Bear & Nebraska
Hamline Elementary School	325	Snelling & Blair
Dayton's Bluff Elementary School	425	E 7th & Bates
Student Total	**11,500**	

Table 2.2 Saint Paul Schools Targeted for Electronic Flyer Distribution

Saint Paul Public (and private) Middle/High Schools	Student Population	Study Site Approximate
LEAP High School	500	Snelling & Blair
Como Park Senior High	1474	Dale & Jessamine
Saint Thomas More Catholic School (private)	254	Summit & Chatsworth
Ramsay Middle School	525	Snelling & Fairmount
Saint Paul City Primary School (private)	298	Marion & Charles
Cretin-Durham Hall (private)	1130	Randolph & Davern
Johnson Senior High School	1647	Maryland & Walsh
Student Total	**5,828**	

Similar to the SPPD enforcement flyers, the parent flyers were also printed on 80 lbs. 4.25" x 11" white matte cardstock. All materials were submitted to the SPPS school district administration for official approval prior to distribution in the schools. As per policy and to accommodate greater ease of distribution, the research team separated and bundled the flyers into stacks of 25, 30, or 35 (depending on individual requests from each school) to distribute flyers into appropriate classroom sizes. In total, 9,600 flyers (approx. 377 bundles) were hand delivered by the research team to each of the targeted elementary schools on April 24, 2018. Additionally, 1,900 flyers were hand delivered to private schools in Saint Paul on April 25, 2018. Each school was contacted the week prior with both a phone call and email to alert them to the program and upcoming flyers. The public schools were provided with a paper and/or a digital version of the official approval from SPPS district administration to distribute the materials. Additionally, each school received a follow up email thanking them for their distribution of the flyers and for their support in the study. Middle and high schools received a single email alerting them to the study and communication materials. The emails contained digital versions of the two infographics (see Figure 2.3 and Appendix A) for electronic distribution. The infographics were created using Canva, an online software tool (Canva, 2018). The safety information from the paper flyers was divided and enhanced into two separate images. One infographic made to address drivers regarding safe stopping behavior around crosswalks and one to address pedestrians regarding safe crossing behavior in crosswalks. The infographics included less directed information (i.e., did not address parents) and did not include any time reference for SPPS enforcement activities. This allows the electronic information to maintain relevance beyond the study and upcoming enforcement activities.

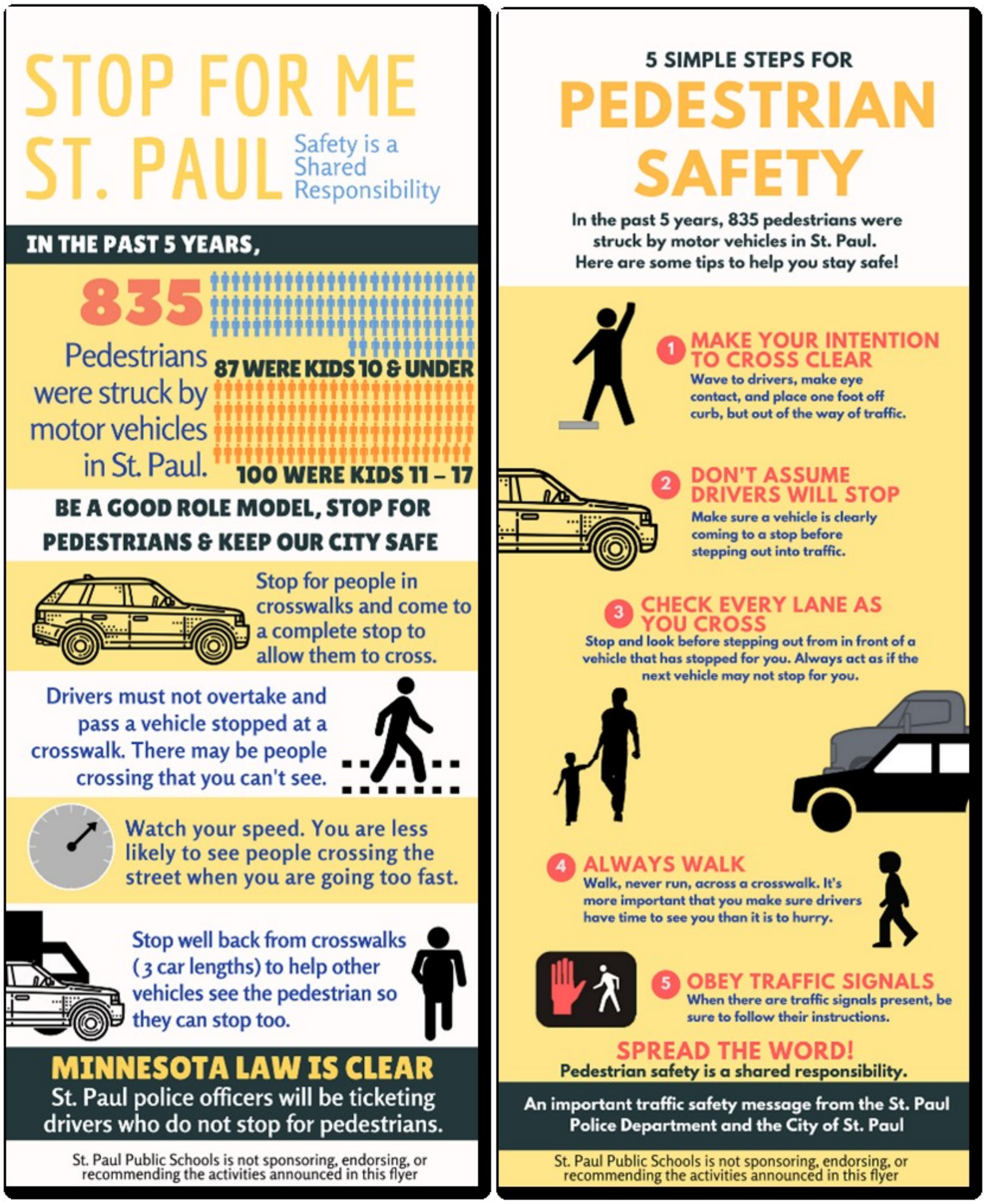

Figure 2.3 Two infographics addressing driver safety tips and pedestrian safety tips with SPPS disclaimer.

2.1.3 Community Distribution Flyers

The communication materials were distributed more widely throughout Saint Paul, targeting institutions or groups that were near study sites or capable of distributing the information to a large population. The first institutions identified were any universities and colleges near study sites in Saint Paul. Six universities were selected for distribution of materials (see Table 2.3).

Table 2.3 Saint Paul Universities Targeted for Electronic Flyer Distribution

Saint Paul Universities	Student Population	Study Site Approximate
Metropolitan State University	11,506	E 7th & Bates
St. Thomas University	9,878	Cretin & Goodrich
St. Catherine's University	5,055	Randolph & Prior
Macalester College	2,146	Snelling & Fairmount
Mitchell Hamline School of Law	930	Summit & Chatsworth
Hamline University	2,117	Snelling & Blair
Student Total	**30,702**	

The format of the community flyer largely matched that of the parent flyer; however, the horizontal portion was modified to not address parents regarding their children and addressed pedestrians more directly (see Figure 2.4 and Appendix A).

Figure 2.4 Vertical (side 1) and horizontal (side 2) images on Community Flyer

Saint Paul universities were contacted via phone call and/or email. Typically, the Director of Public Safety was contacted directly, informed of the study and upcoming enforcement activities, and provided the digital versions of the community flyer and two infographics for distribution (see Appendix A). Not all communications received a response, but generally the response rate was positive and the directors indicated they would distribute the information. For example, the Associate Director of Campus Security at St. Catherine's University stated plans to post the information on entry doors to every building on campus.

Other organizations or groups were identified as community partners who could distribute the information to community members. These included churches, community centers, and business associations, among other (see Table 2.4). Organizations were contacted via phone call, email, and Facebook to make multiple attempts based on available information to reach the groups. Electronic versions of the community flyer and infographics were sent to each group. Response rates were generally low; however, some organizations did respond and indicated they would distribute the information electronically.

Table 2.4 Saint Paul Community Partners for Electronic Flyer Distribution

Saint Paul Community Partners	Study Site Approximate
American Legion 577	Arcade & Jessamine
Hmong American Partnership	Arcade & Jessamine
Shiloh Missionary Baptist Church	Dale & Jessamine
St. Adalbert's Church	Marion & Charles
East Side Pride Community Group	Maryland & Duluth
Arlington Hills Community Center	Maryland & Walsh
Rice Recreation Center	Rice & Magnolia
Junior League of Saint Paul	Snelling & Blair
Fairmount Avenue United Methodist Church	Snelling & Fairmount
University Ave. Business Association	University & Kent
Asian Economic Development Association	University & Kent
Neighborhood Development Center	University & Kent
White Bear Ave. Business Association	White Bear & Nebraska
Hayden Heights Library	White Bear & Nebraska
Saint Paul Bike Coalition	City wide
Metro Transit	City wide

2.2 OUTREACH ACTIVITIES

The two main outreach activities were conducted prior to the first wave of enforcement. They included presenting study and program information to stakeholders and interacting with the media. The research team presented to the Saint Paul Transportation Committee, Saint Paul City Council, and the Saint Paul

Safe Routes to Schools (SRTS) Steering Committee (see Table 2.5). Additionally, one-on-one meetings took place with community leaders regarding the project. In general, the presentations and meetings focused on bringing attention to the project and safety culture needs for Saint Paul and created opportunities to gain buy-in and further dissemination of the safety information through the stakeholders. Outreach activities, including presentations and education material distribution continued throughout the study to continually engage the public, especially in preparation of each of the four waves of police enforcement.

Table 2.5 Saint Paul Community Partners for Electronic Flyer Distribution

Saint Paul Stakeholders	Distribution Date
Kevin Gallatin, Highland District Council	January 8th, 2018
Saint Paul Transportation Committee	March 12th, 2018
Julie Rieter, Union Park District Council	March 16th, 2018
Saint Paul City Council	March 21st, 2018
Saint Paul SRTS Steering Committee	April 17th, 2018

Media interaction was purposefully limited in the fall of 2017 to reduce an undue influence on any baseline data collection and to condense and enhance media interest for the scheduled media engagement wave at the start of the first enforcement wave. Outreach continued throughout the study under a communication plan with the city of Saint Paul, MnDOT, and SPPD. Media interaction was intensified leading up to and coinciding with each wave of SPPD enforcement, see Appendix K for a complete list of media interviews and cover stories. Enforcement site locations and feedback sign locations were distributed via SPPD press releases and were advertised on the city of Saint Paul's website, Walking Saint Paul (see https://www.stpaul.gov/departments/public-works/transportation/walking-saint-paul).

A special outreach activity was conducted to spread awareness of pedestrian safety issues in Saint Paul and to educate drivers about multiple threat passes. The research team worked with the city of Saint Paul, SPPS, and Saint Paul Mayor Melvin Carter's office to create a public safety awareness (PSA) video in May 2018. The video was filmed at a study site, University and Kent, which would create an identifiable location near the light rail tracks and allowed for access to two lanes of travel in one direction (i.e., four-lane roadway divided by the light rail tracks) for easier police restriction of the roadway and clear demonstration of a multiple threat pass event. The video demonstrated the sight distance gains for drivers when drivers stop further back from the crosswalk (see Figure 2.5 and Figure 2.6), urged drivers to never pass a vehicle stopped at a crosswalk, and highlighted the increased police enforcement for violating Minnesota crosswalk laws. The video was shared on social media sites (i.e., YouTube, Facebook, and Twitter) and is permanently linked on the Walking Saint Paul website. See the entire video at https://www.youtube.com/watch?v=QOahnV7DJ2s&feature=youtu.be.

Figure 2.5 Still frame from Saint Paul PSA demonstrating short sight distances when driver stops near crosswalk

Figure 2.6 Still frame from Saint Paul PSA demonstrating long sight distances when driver stops far back from crosswalk

CHAPTER 3: PLANNING IMPLEMENTATION OF THE PROGRAM

The following describes the main components of the program planning and implementation. These include site selection for systematic treatment and measurement, data coder training and data collection, police training and enforcement activities, social norming feedback signs, and engineering treatments. These activities were phased over a 14-month schedule and are discussed below to demonstrate their sequencing, see Table 3.1.

Table 3.1 General overview of program activities by date

Program Planning and Implementation	Dates
Site Selection and Assignment	Sept 2017 – Oct 2017
Data Coder Training	Sept 2017 (and ongoing through 2018)
Data Collection	Sept 2017 – Oct 2017 and Apr 2018 – Oct 2018
Officer Training and Workshop	April 30, 2018
High Visibility Enforcement	1: Apr 30, 2018 – May 4, 2018 2: Jun 18, 2018 – June 29, 2018 3: Aug 6, 2018 – Aug 17, 2018 4: Oct 1, 2018 – Oct 12, 2018
Social Norming Feedback Signs	Jun 18, 2018 – Oct 31, 2018
In-street Signs	Single: Aug 6 – Sept 31, 2018 Gateway: Oct 1, 2018 – Oct 31, 2018

3.1 SITE SELECTION AND ASSIGNMENT

Sixteen sites spread throughout Saint Paul were selected with a variety of traits, including proximity to public spaces such as parks and schools, two lane and multi-lane roads, and varying proximities to public transportation including metro bus and light rail. Sites were all marked crosswalks, with no signalization or stop signs on the crossed direction of travel (see Figure 3.1 and Table 3.2) and had speed limits of 30 mph. Please see Figure 3.2 through Figure 3.6 for pictures of a sample of the selected sites and the lane types. Sites were assigned as enforcement sites (i.e., receiving both high-visibility enforcement and engineering treatment) or generalization sites (i.e., receiving no enforcement or treatment). The research team used the criterion for spread of treatment, equitable enforcement across wards of the city, and adequate space for flagging operations to assign sites to enforcement or generalization groups. Slightly more of the enforcement sites selected were multi-lane as the generalization sites are evenly divided with two-lane and multi-lane; however, balance of other selection criterion could not be met, particularly spread of treatment across the city, while ensuring equal balance of lane numbers across the two groups.

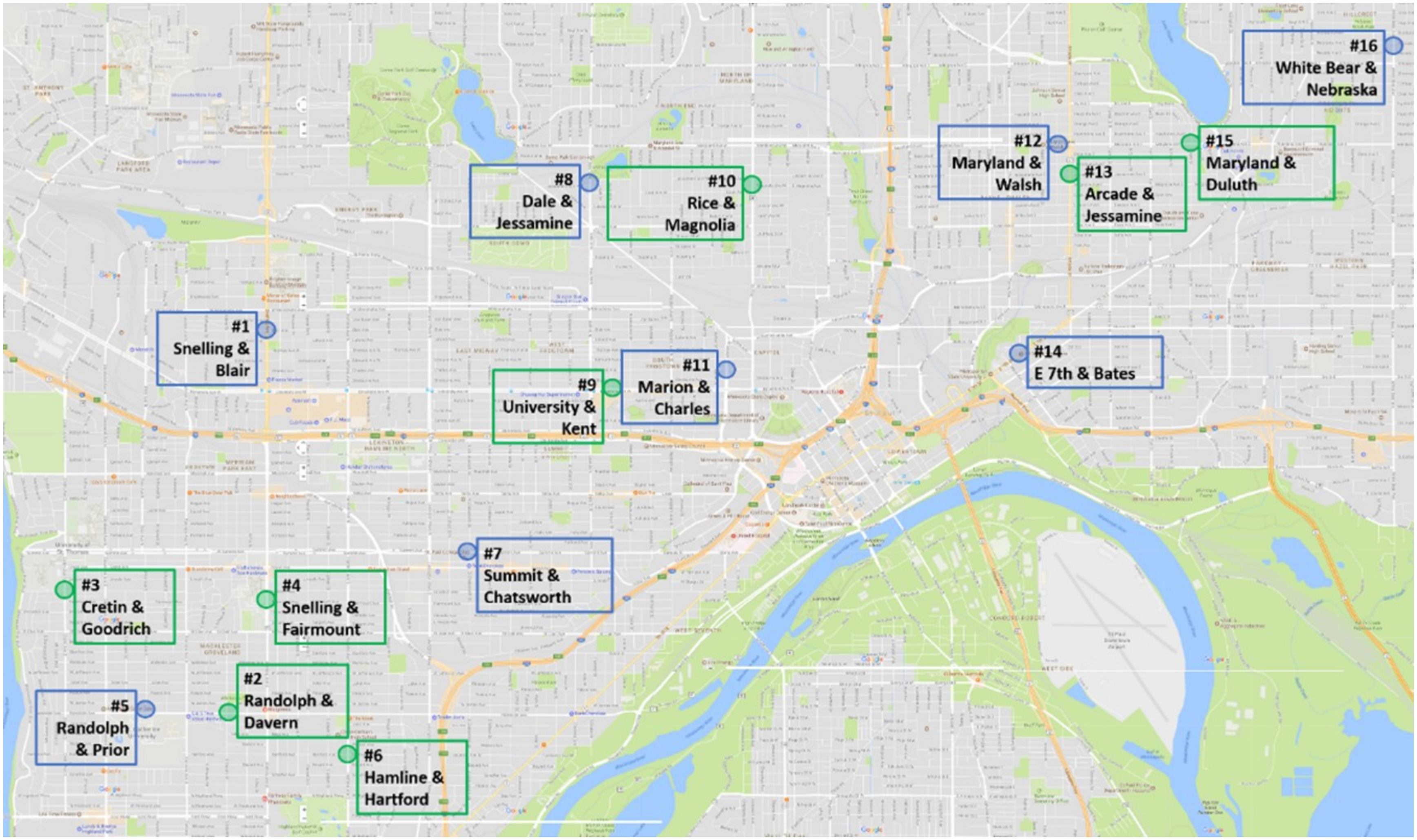

Figure 3.1 Sites selected in Saint Paul, with colors representing site assignment to generalization (green) or enforcement (blue) groups.

Table 3.2 Selected sites and their characteristics

	Lanes	Transit Proximity	Marking Type	Enhancements	Study Assignment
7th & Bates	4	Y	T	2 Bump Outs	Enforcement
Arcade & Jessamine	3	N	T	None	Generalization
Cretin & Goodrich	2	N	T	2 Crosswalk Signs	Generalization
Dale & Jessamine	4	Y	T	2 Crosswalk Signs	Enforcement
Hamline & Hartford	2	N	T	None	Generalization
Marion & Charles	4	N	C	Adv. Stop Line; Ped Refuge 2 Crosswalk Signs	Enforcement
Maryland & Duluth	2	Y	T	Ped Refuge; 2 Crosswalk Signs	Generalization
Maryland & Walsh	2+1T	Y	T	None	Enforcement
Randolph & Davern	2	Y	T	4 Crosswalk Signs	Generalization
Randolph & Prior	2	Y	T	None	Enforcement
Rice & Magnolia	3	Y	T	In-street Sign	Generalization
Snelling & Blair	4+1T	Y	C	None	Enforcement
Snelling & Fairmount	4	N	C	Ped Refuge	Generalization
Summit & Chatsworth	2	N	T	None	Enforcement
University & Kent	4	Y	L	Adv. Stop Line (one side); 2 Crosswalk Signs; 2 State Law Signs	Generalization
White Bear & Nebraska	4	Y	C	None	Enforcement

Note. For Transit Proximity: the presence of metro transit bus or light rail stop within a half block of the crossing is indicated with Y for Yes and N for No. For Marking Type: T indicates transverse crosswalk markings (thin vertical stripes), C indicates Continental crosswalk markings (thick horizontal bars), and L indicates Ladder crosswalk markings. For Lanes: Straight through lanes are indicated in numbers and any present turn lanes are indicated with a T (e.g., 1T).

Figure 3.2 The transverse crosswalk at Cretin & Goodrich, a two-lane road. Image taken from Google Maps.

Figure 3.3 The crosswalk at Rice & Magnolia, a three-lane road. Image taken from Google Maps.

Figure 3.4 The crosswalk at Dale & Jessamine, a four-lane road. Image taken from Google Maps.

Figure 3.5 The crosswalk at Snelling & Blair, a five-lane road divided by raised median. Image taken from Google Maps.

Figure 3.6 The crosswalk at University & Kent, a four-lane road divided by the light rail transit. Image taken from Google Maps.

3.2 DATA CODER TRAINING

3.2.1 UMN Data Coder Training

Data coders completed a detailed safety and protocol training to ensure highly valid and reliable data collection through the treatment phase, but most importantly, to ensure their own personal safety was protected during the data collection activities.

Coders were trained by senior research staff for approximately 4 hours on selected sites to introduce simple, two-lane roadways and then graduate to complex 4-lane roadways. Ten coders were initially trained from April 23, 2018 to May 3, 2018. Training was only conducted under conditions of dry pavement, free of snow or ice for crossings. Additional training occurred as needed as coders graduated and new coders were hired. The majority of the coders were paid undergraduate students at the University of Minnesota. One of the coders was a human factors Ph.D. graduate student volunteering in exchange for research experience. Four coders were full-time research staff at the HumanFIRST Laboratory at the University of Minnesota. The project leads were also involved in coding and additionally conducted secondary coding at several different locations to determine coder reliability. Training was focused on the safe crossing protocol and coding protocol (Appendix B) using the data coding sheet (Appendix C). The safe crossing protocol was refined and approved in collaboration with the University of Minnesota's Assistant Vice President for University Health and Safety due to the heightened safety concerns of the coding team's exposure to risk and injury. For problematic sites that both coders and the main research team felt had high traffic volume, higher lane count, and low yielding rates or high multiple pass events, the project leads assumed safe crossing responsibilities (i.e., undergraduate coders did not cross at those sites). These sites included Dale and Jessamine, Snelling and Blair, and E 7th and Bates.

Coders were also trained on how to interact with the public for instances in which community members, assuming either positive or negative feedback, may approach them. For occasions when community members would ask coders about their activities while the coders were attempting to perform the protocol on site, the coders would provide a brief explanation and a handout (Appendix D). Coders were instructed to be friendly and respectful to community members and record any comments or feedback they received. While a majority of interactions were positive or informative, coders were instructed to leave the area if they were experiencing persistent harassment that made them feel unsafe or otherwise prevented them from continuing their duties or call 911 if anyone made threats against them.

3.2.2 Community Data Coder Training

The research team offered coder training to support and encourage community groups, SPPW, and SPPD to engage in standardized data measurement on community and city infrastructure improvement projects. One community member from the Macalester-Groveland Community Council participated in a single training session on May 4, 2018 to utilize the research team's data collection methods in a community study of a temporary bumpout at a crosswalk at Grand Ave and Cambridge St.

Additionally, the HumanFIRST research team offered a community training, advertised to the public through social media and email listservs from MnDOT and SPPW, on Oct 29, 2018. Attendees included SPPD cadets, SPPW staff, district council community members, and pedestrian advocacy representatives. Attendees received a demonstration and tutorial on the safe crossing protocol, observed crossing and data collection at both enforcement and generalization sites, and received a packet of safe crossing protocol materials for future uses.

3.3 DATA COLLECTION METHODS

By design, each site was visited twice a week, between the hours of 8:00 AM and 4:30 PM, to avoid rush hour traffic and maintain adequate daylight. For personal safety, coders were also instructed not to code during days with precipitation (rain/snow), wet roads, or if they felt the traffic was becoming too dangerous to safely cross and code at the crosswalk site. Coding took place in teams of two, with one person crossing the crosswalk and focusing on following the safe crossing protocol, and the other responsible for observing vehicle maneuvers and coding. Within 2 hour assigned blocks, teams crossed sites 20 times per visit, 10 times per coder, with any observed natural pedestrian crossing replacing a planned staged crossing.

Staged crossings, following the safe crossing protocol (see Appendix B for further detailed explanation), involved the staged crosser approaching and reaching the crosswalk as vehicles were just beyond the "dilemma zone" (i.e., 141 feet from the crosswalk) to allow adequate time for vehicles to see and respond to pedestrians, see section 3.4.2 for dilemma zone calculations. The staged crosser initiated the yield request by always planting one foot out of the street and one foot into the street, with no further movement. The staged crosser looked at oncoming vehicles. Once a vehicle in the first lane of traffic yielded or significantly slowed, the staged crosser waved thanks to the motorist and fully entered the first lane of the roadway, but did not proceed into further lanes until other motorists yielded or large gaps were available to where they could safely cross at a normal walking pace. Notably, Minnesota law requires drivers to stop for pedestrians at crosswalks, rather than simply yield. However, for the purposes of this study, the research team measured yielding instead of stopping since in many instances drivers may slow significantly and at a far enough distance for a pedestrian to safely and comfortably cross in front of them. The protocol of stopping to check subsequent lanes for approaching vehicles before proceeding was particularly important on multi-lane roads where multiple threat conflicts were likely to occur. In a multiple threat conflict, the staged crosser could be at risk of being struck by the "passing" vehicle in the next lane of travel after receiving a yield from a vehicle in one, typically the first, lane of travel.

Coders observed the staged crosser and oncoming vehicles to denote when and where yielding occurred (see Appendix B for a more detailed explanation). Each side of the street and/or curb was marked with neon orange spray paint at 140 ft. from the marked crosswalk to denote the "dilemma zone". Other physical structures were noted at the 140 ft. mark to aid decision making when vehicles occluded painted markings. Vehicles beyond the "dilemma zone" were coded if they failed to yield or where they yielded by distance from the crosswalk (i.e., less than 10 ft., 10-40 ft., or greater than 40 ft.) based on final stopping locations near spray painted neon orange dots placed by the research team in the middle of each lane of travel, see Figure 3.7. Vehicles on the inside of the "dilemma zone" when the staged crosser stepped into the crosswalk were not coded for failing to yield but their yielding distances were coded if they did stop. Other behaviors, such as hard braking, trapped, and evasive actions, were coded as they occurred. Multiple vehicle threats were coded as a "pass" where one vehicle would yield and another vehicle would continue past the stopped vehicle in a separate lane of travel. Multiple vehicle threats or “passing” is most likely to occur on multi-lane (e.g., 4 or more lanes) roadways, but is also possible on 2-lane roads with wide lanes or parking lanes with sufficient space for passing on the right.

Location: ______________________________

Describe condition: ____________________ Coder #1__________ Coder #2__________

Date: ______________ Start Time:__________ Stop Time:__________

	Staged Crossings	Cars Not Yielding	Distance Cars yielded from crosswalk			Multiple Threat Conflict		Evasive Action		Trap	Failure in Protocol
			Less than 10 ft	Between 10 ft - 40	More than 40 ft	Pass	Hard Brake	Ped	Veh		
n #1	1										
	2										
	3										

Figure 3.7 Sample top image of data coder data collection sheet

Natural pedestrians were observed and any crossing attempts by natural pedestrians at the crosswalk in the presence of the research team was coded. The staged pedestrian stepped back to allow the natural pedestrian to stand alone at the intersection. Yielding rates and distances, among other metrics, were coded once the pedestrian stood near the curb edge or into the street (a less stringent criterion). Once the natural pedestrian crossing was complete, the team would resume staged crossing and coding activities.

3.4 OFFICER TRAINING AND WORKSHOP

The implementation of the HVE program depended on proper training of Saint Paul Police Department (SPPD) enforcement team. This works to maximize the impact of the enforcement operations to encourage community support as well as match the methodology of the research coding team. The training activities occurred in two main phases: 1) Staged pedestrian and data coder protocol training and 2) High visibility enforcement of pedestrian’s right-of-way at crosswalks (HVE). The first training was directed at new coding members or retraining existing coding members and was carried out by HumanFIRST senior research staff. The latter training was directed at SPPD and was carried out by Dr. Ron Van Houten, in partnership with Commander Jeremy Ellison.

3.4.1 High Visibility Enforcement of Pedestrian’s Right-Of-Way at Crosswalks (HVE)

Dr. Ron Van Houten conducted a training with 10 officers from SPPD on April 30, 2018 at the Saint Paul Western District building from 9:00am-10:00am for classroom instruction and was followed by field training from 10:00am-3:00pm at three study sites: Summit and Chatsworth, Maryland and Walsh, and Dale and Jessamine. The content of the classroom instruction is summarized below and additional information can be found in Appendix E.

The success of the HVE is contingent upon community support and requires the cooperation of the jurisdiction's public information service and its engineering department. Although pedestrians are often at fault, the primary focus of the enforcement program is to target drivers who fail to yield the right of way to pedestrians at crosswalks. Pedestrians that disregard crosswalk regulations are, however, not exempt from being warned or cited.

Reasons for focusing on drivers:

a) Pedestrians include children, youth, persons with disabilities, and seniors who can no longer drive
b) Drivers are licensed and expected to meet a higher standard
c) Pedestrians are the vulnerable road user, they are most at risk
d) Pedestrians cannot be expected to go out of their way to use crosswalks if drivers do not yield to them in crosswalks.

STEP #1 - Support from command staff and the community

Enforcement programs designed to alter the driving culture are not likely to succeed without support from the public, police command staff, and civic leaders. For example, without proper briefing, a police chief who first hears about the program after because he received a number of complaints from irate citizens that have been cited for failing to yield to pedestrians may be inclined to terminate the program. Much of this work was completed in Saint Paul before the workshop and is part of an ongoing effort to improve yielding in the city of Saint Paul.

STEP #2 - A crosswalk audit

Prior to the introduction of enforcement operations, it is essential that appropriate sites for enforcement operations be pre-selected. The outcome of the hands-on enforcement operations is highly dependent on selecting sites that will work well. Pedestrian right-of-way enforcement cannot be conducted at all crosswalk locations. Eight treatment and eight generalization sites were selected in the city of Saint Paul. All eight treatment sites were evaluated on April 29, 2018 by Dr. Van Houten, Nichole Morris, and Commander Jeremy Ellison and three sites were selected as training sites. These sites were: Summit and Chatsworth (a two lane site); Maryland and Walsh (a three lane site); and Dale at Jessamine (a four lane site). Safe flagging locations for these sites and for all of the remaining enforcement sites were re-examined to ensure the safety and efficacy of the locations.

The following criteria were used when selecting appropriate enforcement locations to flag violators:

a) Flaggers should be clearly visible to violators. This is critical if the officer is to safely pull over violators.
b) Storage capacity should be adequate to pull over at least four violators.
c) It should be easy for drivers to safely pull over and re-enter the roadway when stopped by police.

d) If it is a multilane road the officers should be able to safely stop both travel lanes. It is unwise to conduct enforcement on roads with more than two travel lanes in each direction. Typically, crosswalks at intersections on six lane roadways are marked and controlled.
e) It should be possible for the officers to talk with the driver while the vehicle is stopped without danger from passing vehicles.
f) It is preferable, but not always possible, that flaggers should be able to see the violation and determine whether the driver was beyond the dilemma zone when the pedestrian entered the crosswalk. In heavy traffic, the spotter, responsible for identifying the violators and calling the flaggers on their radio, may miss violations.

STEP #3 - Preparation for the launch of a High Visibility Enforcement Campaign

Materials Required. The following materials were required to conduct pedestrian right-of-way training operations:

a) Four cones to mark dilemma zones (Required at uncontrolled sites) and orange spray paint to mark the zone.
b) Measuring wheel or laser radar to measure the locations of the paint marks or cone placement at the dilemma zone.
c) Adequate supply of enforcement flyers for non-yielding drivers.
d) Radios and a predetermined frequency selected that can be used by members of the enforcement team. Although an operation can be conducted with as few as three radios it is preferable to have 5 radios.
e) Reflective vests to ensure the visibility of flaggers.
f) Clipboards, data collection sheets to record the number of stops, warnings and citations per operation.
g) Large signs to be installed at flagging locations to alert passing drivers that a pedestrian enforcement operation is in effect.

STEP #4 - Police Officer Training Workshop

The training workshop should provide information on:

a) The severity of the problem as it relates to the jurisdiction.
b) The state laws on pedestrian safety at uncontrolled and signalized crosswalks. Pedestrian laws at uncontrolled crosswalks.

The training workshop should also provide information on recommended Engineering interventions; educational interventions; and feedback strategies. A description of many of these elements can be found in two published papers (see Van Houten, Malenfant, Blomberg, Huitema, & Hochmuth, 2017 and Van Houten, Malenfant, Huitema, & Blomberg, 2013).

Engineering interventions covered in the workshop include;
Uncontrolled crosswalks associated with reductions in pedestrian-vehicular crashes including:

a) A solid centerline from the dilemma zone to the nearest crosswalk stop line or to the advance stop markings if the crosswalk is on a multilane road. This line when present enables officers to set up without placing cones since the start of the solid line marks the location of the dilemma zone.

b) Advance stop markings on multilane roads. The purpose of advance yield markings is to encourage motorists that yield to pedestrians to yield far enough back from the crosswalk to allow the pedestrians and other motorists approaching the crosswalk an un-obscured view of each other.
c) The use of In-Street signs that warn drivers that State Law requires drivers to yield or stop (depending on State Law) for pedestrians in crosswalks.
d) Use of the Rectangular Rapid Flashing Beacon (RRFB) at sites multilane crosswalk locations with vulnerable road users or a very high risk of a pedestrian crash. These engineering treatments works best when associated with enforcement.
e) Pedestrian refuge islands. These small islands are much less expensive than a full median and allow pedestrians to cross a road in two stages.

3.4.2 The High Visibility Enforcement of Pedestrian Right-of-Way Training

Once the police officers have received the required information on the nature of the campaign, they were trained to carry out successful High Visibility Pedestrian Safety Enforcement Operations. Critical elements that were included were why:

a) Crosswalk enforcement operations should only last 1.5 hours at each site. It takes about 10 minutes to set up an operation and another 10 minutes to debrief before moving on to the next enforcement site. This leaves approximately 1 hour and 10 minutes of enforcement. During this period of time police officers typically make approximately 50 stops and depending on traffic counts, five to ten times more drivers who drive by become aware that a crosswalk operation is in progress when they see the sign placed at the flagging areas.
b) Operations should be conducted at different times of the day. We recommended that enforcement operations be carried out during daylight hours. We also recommended that drivers not be alerted ahead of time where and when enforcement will occur.
c) Enforcement times should match data collection times, if the jurisdiction is interested in evaluating the impact of the enforcement campaign. When data on driver yielding are collected, it should match enforcement to better assess its impact.
d) Enforcement should be carried out for intensive two-week enforcement steps followed by a pause of one or two months before resuming. This permits police agencies to spread out the enforcement operations over a longer period. This pause gives drivers time to adapt their driving behavior to the enforced rules.

High Visibility Enforcement operations at uncontrolled crosswalks:

a) **Site selection.** The site selection criteria have been described in detail in a previous section.
b) **Calculation of the dilemma zone.** Driver yielding must be operationally defined. It is important that officers understand the importance of the dilemma zone cone placement or no pass solid line that are painted from the crosswalk to the dilemma zone to ensure that drivers could have yielded if they had chosen to yield. Officers were made familiar with the traffic engineering signal timing formula used to determine the dilemma zone. The dilemma zone is the distance beyond which a motorist can safely stop for a pedestrian in an uncontrolled crosswalk. It is measured from the nearest crosswalk edge to the dilemma zones prior to the crosswalks. We

used the formula used by traffic engineers to determine whether a driver could have safely stopped at a traffic signal to determine whether the driver could have stopped for a standing with one foot in the crosswalk. Calculating the distance beyond which a motorist can safely stop for a pedestrian is assumed to be the same as calculating the distance in advance of a traffic signal that a motorist driving the speed limit can stop if the traffic signal changes to yellow. Traffic engineers use the signal-timing formula (Institute of Transportation Engineers, 1985), which takes into account driver reaction time, safe deceleration rate, the posted speed, and the grade of the road to calculate this interval for the amber indication. This formula ($y = t + v/(2a+2Gg)_1$ was used to determine the distance to the dilemma zone by multiplying the time by the speed limit in feet per second. Motorists who pass this cone or marker when a pedestrian has entered the crosswalk cannot be scored as failing to yield, because they passed the point in which there was sufficient time to safely yield right-of-way to pedestrians. Motorists beyond the dilemma zone cone or marker when the pedestrian entered the crosswalk can be cited as not yielding because they had sufficient distance to safely stop. When the pedestrian first started to cross, only drivers in the first half of the roadway are noted as failing to yield the right of way, despite the fact that Minnesota law states that drivers in all lanes and directions of travel must stop for pedestrians who have entered the roadway (with the exception of divided roadways or those with raised medians). Focusing attention on the first half of the roadway is necessary because visual and cognitive attention of the staged pedestrian or observer cannot be accurately split to both dilemma zone markings. Once the pedestrian approached within a half lane of the center of the road, the yielding behaviors of motorists in the remaining lanes behind the dilemma zone are observed and enforced.

Assuming a street with no grade, the dilemma zone for a 25 mph speed limit, the dilemma zone should be marked at 104 feet from the crosswalk; for a 30 mph speed zone, the dilemma should be marked at 141 feet from the crosswalk and at 35mph, it should be marked at 183 feet.

c) **Use of decoy pedestrians**. This feature of the program ensures that officers can maximize the number of stops during an operation. Officers must also cross in compliance with the crosswalk statutes to ensure that citations, when they are given, stand up in court. It is also necessary to use decoy pedestrians at crosswalks because pedestrian traffic at busy crosswalks is typically insufficient to generate optimum rates of non-yielding drivers to justify the presence of 6 police officers at a crosswalk and the accompanying down time for the enforcement team. Furthermore, pedestrians at crosswalks cross in a variety of ways. Some stand on the sidewalk without placing at least one foot in the crosswalk. Some dart out in front moving vehicles well within the dilemma zone. Some cross outside the crosswalk markings. In these cases, drivers cannot be cited for failing to yield.

d) **The importance of the standard crossing protocol.** The use of the standard crossing protocol helps ensure that citations will be upheld in court and most important ensures the safety of officers serving as decoy pedestrians. It is important that decoy pedestrians be trained to follow a standard safe crossing protocol.

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[1] Where **t** stands for a reaction time of 1 second, **v** stands for the speed limit, **a** stands for a safe deceleration constant, **a** stands for the deceleration rate (3.05 m/sec^2), **G** stands for acceleration due to gravity (9.8 m/sec^2) and **g** stands for grade of the approach road in percent divided by 100

The Standard Safe Crossing Protocol. The following directions should be adhered to assure proper crossing by the decoy pedestrian;

a) Step with one foot into the crosswalk when an approaching vehicle is just beyond the cone placement distance (beyond the dilemma zone described above). This is the measured distance for the posted vehicle speed, which ensures a safe stopping distance for vehicles approaching the crosswalk.
b) If the vehicle does not attempt to stop, do not proceed to cross and score the vehicle as not yielding. Also, score subsequent vehicles that do not stop as not yielding.
c) If the vehicle clearly begins to yield and the next lane is free, begin crossing. Always stop at the lane line and make sure the next lane is clear. Score the vehicle that slowed or stopped as yielding.
d) If a vehicle in the second lane does not attempt to slow and stop, let it pass and score it as not yielding.
e) If the vehicle yields, proceed to the centerline or median.
f) If a vehicle that is inside the cone yields, score the driver as yielding, but if they do not yield, do not score them at all.
g) If a large gap appears, the officer should finish crossing.
h) For four-lane roads, follow the same procedure for the second half of the crossing.

Enforcement flyers and asking for driver's cooperation: a winning combination. The use of enforcement offers several advantages because they can be used for warnings and citations. First, it serves as on-site education for all stopped drivers; second, the enforcement flyer conveys a clear message that police officers do not have to repeat every time they stop a driver. Mentioning crashes helps motivate drivers to want to change their behavior and asking them to help shows respect for them and makes it more likely they will share the information with others. The sample enforcement flyer presented in Appendix 1 is the result of many revisions resulting from feedback from police agencies, interested community groups and civic officials.

The importance of a warning phase. As mentioned above, police agencies generally do not have a history of enforcing crosswalk laws. A warning phase for non-yielding drivers to launch a crosswalk enforcement campaign is a very effective way to not only alert drivers that non-yielding will no longer be ignored, it is also a powerful means of generating good will and fair warning to drivers. A warning phase allows a larger number of violators to be stopped because warnings take less time to give then citations. It goes without saying that flagrant non-yielding drivers that endanger road users can and perhaps should be charged even during the warning phase.

When used with an enforcement flyer, a warning phase allows officers to use the short standardized script to point out how serious the problem is and asks them to help make their community a safer place by sharing the information they have received with friends and neighbors Most of all it makes it easier for police officers to invite drivers to help by serving as a model by yielding the next time they see a pedestrians in a crosswalk. Anecdotal data collected by Malenfant and Van Houten, indicate that warned drivers share the information an average of 4 to 5 persons.

Following the classroom presentation of the components of an enforcement operation and explanation of how to set up the operation, three 75-minute, in-vivo, hands-on enforcement operations were conducted. The in-vivo, hands-on enforcement operations provided officers with practical experience. It also generated positive reactions from the workshop participants. A short debrief was conducted at the end of the training.

3.5 SOCIAL NORMING FEEDBACK SIGNS

An important component of the program is consistently reminding the community about the issue of pedestrian safety and inviting them to be a part of the solution. A method employed by Van Houten, Malenfant, Huitema, and Blomberg (2013) is to use large feedback signs to display community stopping rates for pedestrians, drawn from weekly averages, to encourage drivers to behave like their peers. This strategy is drawn from the theoretical understanding that drivers are responsive to the "culture of driving" and wish to drive like their peers and changing the behavior of drivers could be magnified across the entire community through culture change (Zaidel, 1992). Additionally, using descriptive norms is also believed to de-bias individuals who may believe an undesirable behavior (e.g., binge drinking or not stopping for pedestrians) is more common among their peers than it really is (Prentice & Miller, 1993). Using this understanding, leveraging signs that show that most drivers do stop for pedestrians (i.e., best if over 50%) and that the percentage is improving week to week is likely to capture the attention of drivers and encourage them to stop for pedestrians along with the rest of the changing driver community.

This approach does present some risk if the average observed stopping percent is below 50%, as it did when the signs were first deployed in June 2018. This is because using descriptive norms to communicate low compliance by one's peers can result in destructive performance or a "boomerang effect" where undesirable behaviors are increased rather than improved or even maintained (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). The weekly updating of the feedback signs, however, adds an additional element beyond descriptive norm sharing and implies ongoing surveillance of drivers (i.e., suggests some entity is measuring driver stopping performance in Saint Paul), a tactic which has been demonstrated to reduce undesirable behaviors, such as driver speeding (Van Houten & Nau, 1983; Wrapson, Harré, & Murrell, 2006). The combined effects of normative messaging, implied surveillance, and phased engineering treatments were hypothesized to drive up performance in the following weeks well beyond 50% stopping averages to encourage a "culture of driving" that stops for pedestrians.

3.5.1 Feedback Sign Site Selection

Sites were selected across the city to place one of eight feedback signs in locations that would maximize driver exposure. Locations were selected prioritized based on average daily traffic, entry points into the city, adequate space for placement, and spread across the city; see Table 3.3 and Figure 3.8

Table 3.3 Selected feedback sign sites

Location	Placement
Snelling Ave & Lafond Ave	Concrete Median, South Facing
Snelling Ave, Between (b/n) Carroll Ave & Iglehart Ave	Grassy section on southbound side in front of Holiday Building, North Facing
Lexington Pkwy N, b/n Concordia Ave & Marshall Ave	Grassy median in between Central High School and Oxford Community Center, North Facing
Maryland Ave E, b/n Edgerton St and Payne Ave	Grassy Section on eastbound side between two alley entrances, West facing
Maryland Ave E, b/n Clark and Arkwright St N	Grass second on the westbound side, East Facing
University Ave W, b/n Hampden Ave and Vandalia	Break section between bushes on eastbound side, across from McDonalds, West facing
Marshall Ave, b/n Mississippi River Blvd and Otis Ave	Grassy median before trees, West facing
W 7th, b/n Springfield St. and S Homer street	Grassy section on NE Bound side in front of Pearsons, SW facing

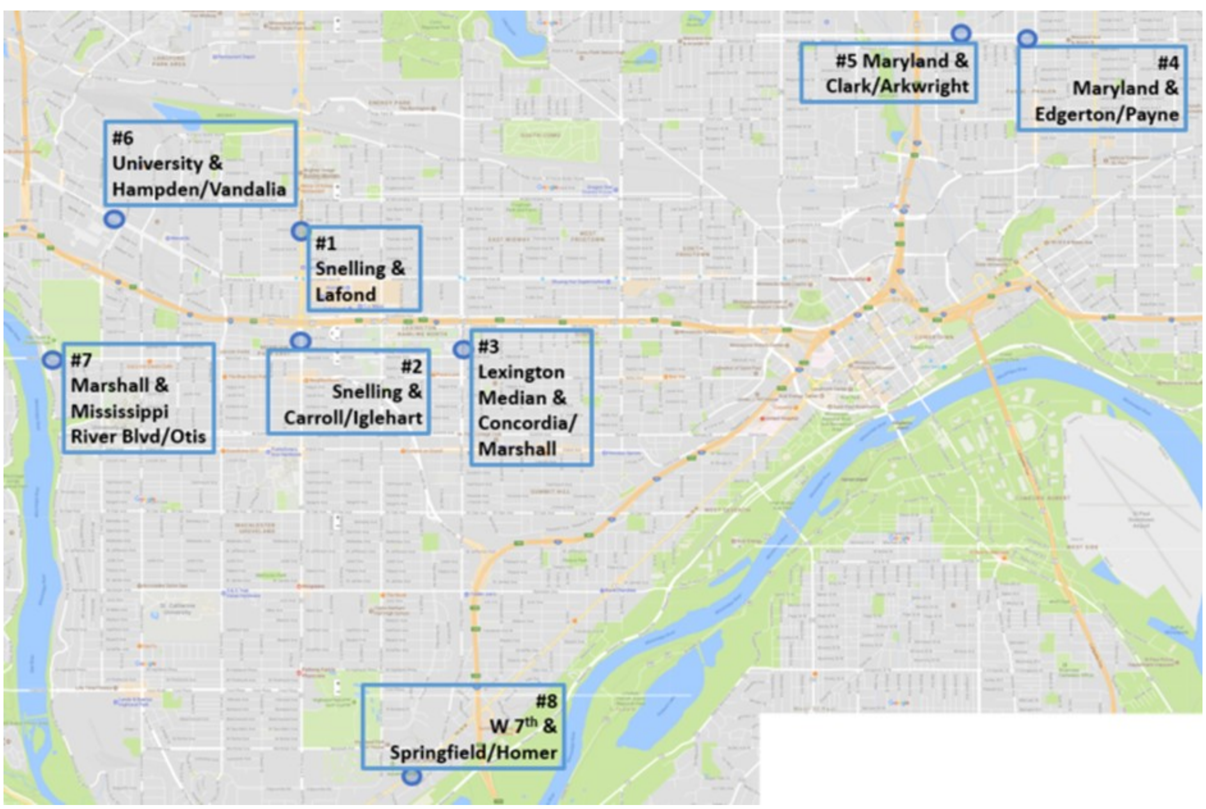

Figure 3.8 Map of Saint Paul and placement of eight feedback signs to their nearest intersection.

3.5.2 Feedback Sign Dimensions

The research team worked with the city of Saint Paul and MnDOT engineers to design the signs to maximize readability and safety while working within design guidance constraints. The temporary signs were 48 inches wide by 48 inches tall, see Figure 3.9, and mounted on posts approximately 7 feet off of the ground and 2 feet from the right of way. Signs were occasionally mounted on existing posts, see Figure 3.10. The white lettering was 3.5 inches in height and placed on a blue background. The percentages were displayed on two small, blue, removable placards with white numbers that were affixed to the sign with a ½ inch bolt. However, the placards were changed to white background with blue numbers after the first week for easier number removal and placard reuse. The “LAST WEEK” percentage displayed the average stopping percentage for the enforcement/treatment sites for the week prior and the “RECORD” displayed the highest observed stopping percentage.

Figure 3.9 Feedback Sign Dimensions (credit HunWen Westman, P.E., Saint Paul Public Works)

3.5.3 Feedback Sign Methods

The research team calculated the weekly averages for the signs based on observed driver stopping percentages measured from the study sites. The posted average was typically drawn from the average calculated from the eight enforcement sites. However, if the overall yielding percent (i.e., average of 8 enforcement and 8 generalization sites) was larger than the enforcement percent, then the overall yielding percent was used. Under conditions of perfect data collection, the number would be an average of two data collection sessions for each of the study sites. However, due to inclement weather conditions or nearby road construction or maintenance, the research team may have been unable to conduct two sessions at every site for the week. In circumstances in which a site was missing a data collection session, the research team would replace the missing data point with an average of the last two data collection sessions for that site. If both sessions were missing for a site, only one of the missing data points was replaced and the other was left as missing for the week. This process of replacing missing data with rolling averages from the past two data collection sites helped to remove unnecessary noise in the overall averages that would be present in weeks with fewer sessions. When a new weekly percentage matched the last posted percentage, the new percentage was rounded up or down by no more than one percentage point to ensure the weekly average was always changing and engaging the public's attention. Weekly averages were calculated on Fridays by the research team and sent to Saint Paul Public Works to create new placards for the signs. On Mondays, the research team collected the new placards from Saint Paul Public Works, traveled to each of the eight sign locations to replace the existing placards (i.e., using a folding ladder to reach the signs), and then returned the old placards to Saint Paul Public Works to be reused for the next week. Pictures were taken of the signs and increases in the percentages were shared on social media (i.e., Twitter and Facebook) to increase exposure of the signs beyond those who drove by them.

The initial feedback sign installations were scheduled to coincide with the second wave of police enforcement, June 18, 2018. The combined attention of the first high visibility enforcement activity (i.e., warning phase) and media attention leading up to the second enforcement (i.e., ticketing) phase was expected to have raised driver stopping rates at treatment sites to near or over 50% compliance; however, the initial weekly average posted was 43% with a record high of 45% which was observed three weeks prior, see Figure 3.10. Notably, the feedback signs captured limited local media attention during their first two weeks, however, an increase of media attention occurred in July once yielding percentages began to climb over 50%, see Figure 3.11. See Appendix L for additional sign images.

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Figure 3.10 Feedback sign at Snelling and Carroll, first week posted (June 18, 2018).

Figure 3.11 Feedback sign at Maryland and Clark, following second wave of SPPD enforcement (July 17, 2018).

3.6 ENGINEERING TREATMENT

The final phases of treatments in the HVE program included low-cost, engineering enhancements to the crosswalks. The low-cost enhancements used in-street R1-6 signs in a single in-street or gateway configuration. The addition of the signs to the enforcement crosswalks corresponded with the final two waves of SPPD enforcement.

3.6.1 Single Sign Treatment

The first implementation occurred to coincide with the third wave of SPPD enforcement, starting on Aug 6, 2018. A single R1-6 sign was installed by Saint Paul Public Works (SPPW) on the centerline on one (see Figure 3.12) or both sides of the crosswalk based on the number of lanes, divided roadway status (see Figure 3.13), or specific site needs. Specific distance guidance was not provided and SPPW was instructed to place the signs according to their normal judgment and practices. An additional recommendation was made to remove a tree from Dale and Jessamine that was too close to the crosswalk and obstructed the view of the pedestrian from southbound traffic, see Figure 3.14. An additional recommendation was made to the city to remove the Metro Transit bus stop sign from the W11-2 signpost that was also obstructing the vehicle-to-pedestrian view on the west side of the crosswalk entry. That recommendation was not implemented during the study. The single R1-6 signs placed on centerlines at enforcement sites were maintained and replaced as needed since signs were frequently struck by vehicles.

Figure 3.12 Single in-street sign (R1-6) on yellow centerline at Summit and Chatsworth

Figure 3.13 One of two in-street signs (R1-6) on white centerline at Marion and Charles (divided 4-lane roadway)

Figure 3.14 Dale and Jessamine after tree removal.

3.6.2 Gateway Sign Treatment

The second engineering implementation occurred to coincide with the fourth and final wave of SPPD enforcement, starting on Oct 1, 2018. Multiple R1-6 signs were installed by Saint Paul Public Works in split gateway configurations, depending on specific site needs and layout, Table 3.4. The research team used extra R1-6 signs on movable rubber bottoms to test different configurations (i.e., varying the number, placement, and distance from the crosswalk) at all enforcement sites to determine the recommended enhancement. Based on the test session's yielding rate, as observed using 20 staged crossings, the team determined the optimal number and placement of additional signs (if any) that were needed to increase the yielding percentage from the single sign configuration. Additional considerations, such as driveways, turning movements, and curb infrastructure were considered in determining the placement and distance of the signs from the crosswalks.

The split gateway configuration was deemed unnecessary at three sites. Specifically, the temporary split gateway configuration at E 7th and Bates did not see an improvement in yielding (i.e., yielding actually decreased from 76% to 60%, but lunch hour traffic patterns may have been a factor), so only an additional single centerline to the north of the crosswalk was recommended. The wide lanes and parking lanes on the two-lane crosswalk at Randolph and Prior made a gateway configuration difficult to implement; however, the testing did reveal sub-optimal stopping distances with the 10 ft. single sign placement, so a recommendation was made to move the west edge sign back to 40 ft. along with an additional sign on the west edge of the crosswalk. Finally, the single R1-6 sign at Summit and Chatsworth resulted in yielding rates ranging from 80%-90%, so no additional signs were requested.

Table 3.4 Enforcement sites in-street sign recommendations

Enforcement Site	Phase 1	Phase 2
E 7th and Bates	Single R1-6 on yellow line, 40 ft. from south edge of crosswalk	Single R1-6 on yellow line, 40 ft. from south edge of crosswalk. Single R1-6 on yellow line, 75 ft. from north edge of crosswalk
Dale and Jessamine	Single R1-6 on yellow line, 10 ft. from north edge of crosswalk	Two R1-6, on yellow line and outside curb 40 ft. on north edge of crosswalk. Two R1-6, on yellow line and outside curb 65 ft. from south edge of crosswalk
Marion and Charles	Single R1-6 on white centerline, 50 ft. from south edge of crosswalk and 40 ft. from north edge of crosswalk on north side of intersection (non-study crosswalk)	Two R1-6, on white centerline and inside median curb 50 ft. from south edge of crosswalk. Two R1-6, on white centerline and inside median curb 40 ft. from north edge of crosswalk of north side of intersection (non-study crosswalk).

Maryland and Walsh*	Single R1-6 on yellow line, 40 ft. from east edge of crosswalk	**Study Site removed after crosswalk marking removed*
Randolph and Prior	Single R1-6 on yellow line, 10 ft. from west edge of crosswalk	Single R1-6 on yellow line, 40 ft. from west edge of crosswalk Single R1-6 on yellow line, 40 ft. from west edge of crosswalk
Snelling and Blair	Single R1-6 on white centerline, 10 ft. from south edge of crosswalk and 10 ft. from north edge of crosswalk on north side of intersection (non-study crosswalk)	Two R1-6, on white centerline and inside median curb 40 ft. from south edge of crosswalk. Two R1-6, on white centerline and inside median curb 40 ft. from north edge of crosswalk of north side of intersection (non-study crosswalk), see Figure 3.15.
Summit and Chatsworth	Single R1-6 on yellow line, 40 ft. from east edge of crosswalk	Single R1-6 on yellow line, 40 ft. from east edge of crosswalk
White Bear and Nebraska	Single R1-6 on yellow line, 40 ft. from north edge of crosswalk	Two R1-6, on yellow centerline and outside curb 74 ft. from north edge of crosswalk. Two R1-6, on yellow centerline and outside curb 74 ft. from south edge of crosswalk.

The sign recommendations for phase 2 were provided to Saint Paul Public Works with images, specific distance, and placement information for each of the sites. Recommendations were carried out to the greatest extent possible; however, engineering judgment was made regarding slight modifications of the configurations due to repeated vehicle strikes of signs at various sites.

Figure 3.15 Snelling and Blair split gateway configuration, north side of crosswalk

CHAPTER 4: BASELINE DATA COLLECTION RESULTS

The HumanFIRST Laboratory research team collected baseline data from the 16 selected study sites from September 22, 2017 until October 29, 2017. Winter weather, including snow and freezing temperatures, prohibited the team from safely collecting any data beyond October 30, 2017. Additional baseline data was collected from April 25, 2018 to April 27, 2018, just prior to the start of the first enforcement activities.

The observational metrics collected at the 16 intersections included a number of driver and staged pedestrian behaviors. There were insufficient numbers of natural pedestrian crossings (i.e., most crossings involved no natural pedestrians) to allow analysis or examination of trends. The data metrics collected and analyzed by the research team and listed in described in Table 4.1 below. The April 2018 data was excluded from the initial baseline analysis (which correspond to the averages listed in Appendix F) due to the off-seasonal effects and small sample size resulting from late spring weather; however, this data is included in the overall analysis in Chapter 5.

Table 4.1 Data coding metrics and definitions

Metric	Definition
Yielding counts	Number of vehicles stopped for staged pedestrians
Total Vehicle Count	Number of vehicles counted while staged pedestrian stood in crosswalk during a single coding session
%Yielding	Percent of yielding vehicles out of total vehicles encountered while staged pedestrian stood in crosswalk during single coding session
Cars Yielding < 10 ft. Count	Number of vehicles that yielded less than 10 ft. from crosswalk
% Cars Yielding < 10 ft.	Percent of vehicles less than 10 ft. out of all yielding vehicles
Cars Yielding between 10 to 40 ft. Count	Number of vehicles that yielded between 10 and 40 ft. from crosswalk
% Cars Yielding between 10 to 40 ft.	Percent of vehicles between 10 ft. and 40 ft. out of all yielding vehicles
Cars Yielding > 40 ft. Count	Number of vehicles that yielded greater than 40 ft. from crosswalk
% Cars Yielding > 40 ft.	Percent of vehicles greater than 40 ft. out of all yielding vehicles
MT Pass Count	Number of vehicles that passed a stopped vehicle in the same direction of travel at the crosswalk. Typically this happened in the next lane on a multi-lane road, but could be illegally passing to the right or left on a two-lane road
%Pass	Percent of multiple threat passes experienced in a session out of the number of staged crossings (typically 20) of each session
MT Hard Brake Count	Number of vehicles that stopped late or excessively braked behind another yielding vehicle making an audible tire screeching sound or visibly tipping the nose of the vehicle down in the stop

%Hard Brake (MT)	Percent of multiple threat hard brake events in a session out of the number of staged crossings (typically 20) of each session
Pedestrian Evasion Count	Number of instances when a pedestrian (either staged crosser or natural pedestrian) was forced to move out of the way of a vehicle
%Ped Evasion	Percent of pedestrian evasions in a session out of the number of staged crossings (typically 20) of each session
Vehicle Evasion Count	Number of instances when a vehicle was forced to swerve out of the way of a pedestrian (either staged crosser or natural pedestrians)
%Veh Evasion	Percent of vehicle evasions in a session out of the number of staged crossings (typically 20) of each session
Traps	Number of instances when pedestrians received yielding to allow them to proceed into the middle of the road, but then were trapped between two lanes of opposing traffic without the presence of a pedestrian refuge
%Trap	Percent of pedestrian trapped instances within a session out of the number of staged crossings (typically 20) of each session

The consistency among data points for each count variable was analyzed with inter-item correlations for the site visits when a secondary coder was present with the primary coder (see Table 4.2). Estimates are not included for failure to yield rates because those represent the inverse of yielding rates, which are presented. Yields were counted when vehicles stopped for pedestrians who were waiting to cross with one foot on the crosswalk for cars beyond a distance marked (with spray paint) “dilemma zone”. The final stopping place of yielding vehicles were binned into three distances from the edge of the crosswalk (as marked with spray paint). Multiple Threat (MT) Pass counts were denoted when a vehicle yielded for the pedestrian and another vehicle in the same direction of travel passed the stopped vehicle (i.e., either in the next lane or illegally passing to the right or left). Multiple Threat (MT) Hard Brakes were counted when one vehicle yielded and another vehicle braked late behind the vehicle making an audible tire screeching sound or visibly tipping the nose of the vehicle down in the stop.

Evasion counts, when pedestrians had move out of the roadway to evade vehicles, and traps, when pedestrians were trapped between two lanes of opposing traffic, were not analyzed in the interrater assessment because those events were not observed during any site visits when a secondary coder was present. Exact scoring metrics are provided in Appendix F.

Table 4.2 Interrater assessment.

	Average Inter-item Correlation
Yielding Count	0.985
Cars Yielding < 10 ft. Count	0.934
Cars Yielding between 10 to 40 ft. Count	0.975
Cars Yielding > 40 ft. Count	0.903
MT Pass Count	0.989
MT Hard Brake Count	0.941

For deriving the percentages of the data, the scores in overall yielding and not yielding categories were calculated by dividing by total number of counted cars, while yielding distance percentages were calculated by dividing by total number of yielding cars. Please note that yielding distance percentages will not add up to 100% because the first week of coding only included yielding counts, and not their distance (i.e., 9.89% of yielding distances are unknown). The vehicle and pedestrian behavior percentage variables (e.g., pass, hard brake, pedestrian evade, etc.) were calculated by dividing by the number of crossings at that site on that visit (overall crossings: M = 19.41, SD = 2.83). See Table 4.3 and Table 4.4.

Table 4.3 Descriptive statistics for yielding and vehicle count.

	Total Vehicle Count	%Yielding	% Cars Yielding < 10 ft.	% Cars Yielding between 10 to 40 ft.	% Cars Yielding > 40 ft.	%Yielding Distance Unknown
Mean	67.68	31.53%	3.64%	34.82%	51.65%	9.89%
Std. Deviation	*(23.35)*	*(14.04%)*	*(4.82%)*	*(18.65%)*	*(24.29%)*	-

Table 4.4 Descriptive statistics for vehicle and pedestrian behaviors.

	% Pass	% Hard Brake (MT)	% Ped Evade	% Veh Evade	% Trap
Mean	11.54%	3.54%	0.2138%	0.16%	0.43%
Std. Deviation	*(15.78%)*	*(4.42%)*	*(1.02%)*	*(0.89%)*	*(2.04%)*

The average score breakdown for the collected variables (not yielding, distance yielding, pass, pedestrian and vehicle evasion, etc.) on **each site** are presented separately in Appendix F for closer review and evaluation.

For further breakdown of interesting potential effects of road characteristics in the data, two lane and multilane roads were contrasted on yielding percentages and multiple threat pass and hard brake percentages, via an independent samples t-test, with a p-value of .05 as the criterion value for statistical significance. As observed in Figure 4.1, there **was** a significant difference between two lane (M = 63.31, SD = 14.60) and multi-lane (M = 71.58, SD = 12.84) roads for not yielding behavior, t (91) = 2.86, p = .005, d = .61. There **was** a significant difference between two lane (M = 5.58, SD = 10.45) and multi-lane (M = 15.14, SD = 17.38) roads for multiple threat passing percentages, t (91) = 2.91, p = .004, d = .63. There was **not** a significant difference between two lane (M = 2.72, SD = 4.31) and multi-lane (M = 4.03, SD = 4.46) roads for multiple threat hard braking percentages, t (91) = 1.40, p = .165, d = .30. All analyses were conducted with JASP 0.8.3.1 (JASP Team, 2017). The proceeding analyses suggest that an approach may be needed to mitigate changes in multiple threat variables, particularly on multi-lane roads.

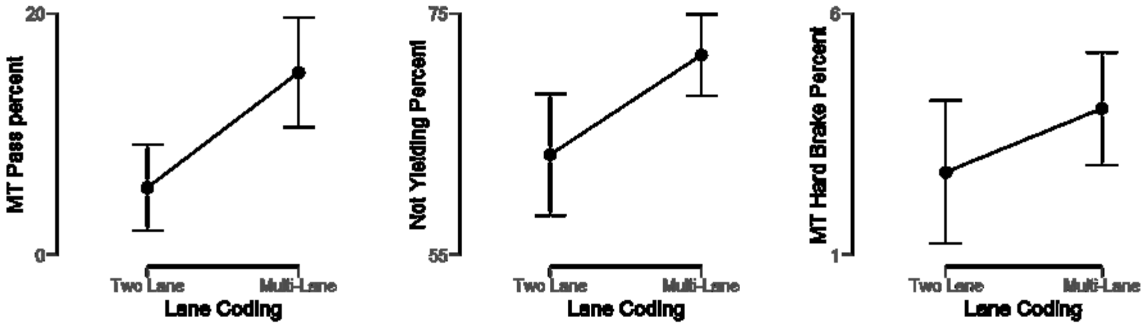

Figure 4.1 Descriptive plots of driver behavior percentages for two lane and multi-lane roads.

4.1 SUBJECTIVE CODING OBSERVATIONS

Following the conclusion of the baseline data collection period, a focus group of coders was conducted to discuss the data coding process and anecdotal observations made by the coding team throughout the data collection process. Additionally, any observations about the coding procedure were solicited from the team to determine if any improvements in safety or data quality could be achieved.

Initially, the team recounted multiple instances of being approached by community members interested in the coders' activities. In most cases, community members expressed gratitude to the team for taking interest in improving the safety of the crossing and expressed frustration with their own safety and ability to cross the nearby intersection. One woman, at Randolph and Prior, stated that the yielding rates were "ridiculous" at this crossing, especially given the number of students crossing to St. Catherine's University and thanked the team for "risking their lives to collect the data." Another man expressed interest in the activities at Marion and Charles but suggested that Rice and Charles (a site that was considered, but ultimately not selected for the study due to constraints) experienced far worse yielding. Notably, one woman approached the team at University and Kent and was agitated because she noticed the coder write something about her vehicle and believed the team was writing down license plates. Upon inspection of the coding sheets, she was satisfied with the explanation of the activities of the team. Generally, most community members were positive about the presence of the research team and validated the need for the work based on their own feelings of crossing risk.

Anecdotal observations of trends among driver and vehicle types were discussed. The coding team reported that women drivers were more patient as the pedestrian crossed the street, and men drivers were more impatient in gesturing pedestrians to cross more quickly as they were crossing, often urging pedestrians to move into the next lane of traffic, which was not clear or had not yet been met with a yielding vehicle. Higher-end, luxury cars were perceived to be less likely to yield than mid-tier or low-tier vehicles. Metro Mobility buses were observed to almost never yield to pedestrians, while regular Metro Transit buses had better yielding rates and school buses had poor yielding rates. The vehicle type most predictably to yield were large, commercial trucks. These rates surprised the coding teams given the increased difficulty in stopping for large trucks in comparison to smaller passenger vehicles, which could more easily yield, but often do not. Increased yielding by commercial truck may have been because professional drivers may be more concerned about violations.

Individual sites were discussed, to highlight differing perceived risks or potentials for engineering interventions. The site perceived as the most dangerous to cross and the coders' most dreaded location was Dale and Jessamine. The reasons stemmed from the high speeds of vehicles traveling through the intersection and extremely low yield rates (i.e., only 16.5% of drivers yielded). Other problems at that site related to blind spots created by Metro Transit bus stop signage and row of trees. Another high-risk location identified was W 7th and Bates (see Figure 4.2). Notably, traffic headed downhill in the SW bound lane were more likely to yield but drivers headed in the NE bound lane of traffic were highly unlikely to yield, often causing the staged pedestrian (who was waiting with one foot in the crosswalk) to abandon the crossing and try again on a new stream of traffic.

Figure 4.2 The crosswalk at W 7th & Bates, a four-lane road with a downhill slope in the SW bound lanes.

Three sites were cited as most likely to cause the pedestrian to become "trapped" (see Appendix F) in the center of the road: Maryland and Walsh (see Figure 4.3), Arcade and Jessamine, and Snelling and Blair. The perceived risk was mitigated by some infrastructural elements. Snelling features a concrete median, which while not a true pedestrian refuge, provides some level of protection for the pedestrian once trapped. The middle turn lane of the road diet at Maryland and Walsh created some spatial separation between the pedestrian and vehicles once trapped at that site. However, the Arcade and Jessamine location featured no infrastructural elements to protect or separate pedestrians from vehicles, making the trapped experience more stressful (Figure 4.4).

Figure 4.3 The crosswalk at Maryland and Walsh, a two-lane road separated by a turn lane / road diet.

Figure 4.4 The crosswalk at Arcade and Jessamine, a three-lane road with no enhancements or pedestrian refuge.

Other infrastructure was discussed as problematic. The bike lane, combined with a parking lane, on each side of the crossing at Summit and Chatsworth appeared to encourage passing behaviors on the right due to the added road width, even though the two-lane road should limit multiple threat (i.e., “passing”) frequency (Figure 4.5). Notably, the two-lane Cretin and Goodrich crossing had no bike or parking lanes, which would create space for passing on the right; however, impatient motorists were observed to pass stopped vehicles on the left instead.

Figure 4.5 The crosswalk at Summit & Chatsworth, a two-lane with bike lane and parking lane on both sides of the roadway.

Finally, the sites deemed “easy to cross” were Snelling and Fairmount as well as Maryland and Duluth (Figure 4.6), both due to the pedestrian refuges creating a physical separation between staged crossers and vehicles and notably the higher yield rates at Snelling and Fairmount (i.e., 51% of drivers yielded).

Figure 4.6 The crosswalk at Maryland and Duluth, a two-lane road separated by a pedestrian refuge/road diet.

The focus group included a brief discussion regarding engineering opportunities at some of the locations. While identifying engineering recommendations was not the responsibility of the coders, the discussion did provide some meaningful potential solutions. The advance stop line at Maryland and Charles appeared to be effective in achieving greater than 40 ft. yielding when drivers did yield and similar stop lines are desired at all locations. Moving the crosswalk to the south edge of the intersection at Dale and Jessamine was suggested, as it would increase sight distance and give greater visibility to pedestrians trying to cross due to the presence of the bus signs and tree line occlusion. Moreover, a road diet at Dale would reduce the high speeds and passing opportunities at this location. The team also suggested adding a true pedestrian refuge at Snelling and Blair, as this would add greater safety for pedestrians when trapped at that crosswalk. In addition, adding a bike-passable pedestrian bump-out at Summit and Chatsworth would be valuable to discourage motor vehicle drivers from passing through the parking/bike lane. Finally, although no coders raised this issue, some crosswalk markings could potentially be removed altogether, although this option would require further discussion and is likely beyond the scope of this study.

The final discussion point regarded the safe crossing and data collection protocols. Ensuring that spray paint markings are frequently reapplied was suggested to improve decision making of both staged pedestrian and coder, as these spray markings were used to help identify coders when to score cars for yielding, and how far the cars yielded from the crosswalk. Additionally, identifying a set coding location at each site would add more consistency for each coding session. Finally, frequently reinforcing coders to abandon coding sessions when they feel their safety is at risk was thought to be critical to maintaining a safe study for the research team.

4.2 INITIAL PROGRAM IMPLEMENTATION RECOMMENDATIONS

The research team and coding teams selected and collected data at multiple marked unsignalized crosswalks across the city of Saint Paul. Initial baseline data on the percentage of drivers yielding-to-pedestrian and other variables were derived from this data, with a low overall observed average yielding rate of 31.5%. Furthermore, multiple threat passing rates per site visit was high (11.5%). However, when vehicles did yield, they tended to yield relatively far back from the crosswalk (51.7% yielding more than 40 feet from crosswalk markings).

The preliminary data led to the greatest focus and attention being on passing behaviors (i.e., multiple threat events), due to the frequency at which the behavior occurs (i.e., 11.5% of crossings on all roads and 15% of crossings on multi-lane roads) and the severity of crash outcomes which they can impose. Also, as primary yielding rates increase, there was a risk for passing rates to increase simply because more vehicles are stopped in one lane, giving an opportunity for vehicles to pass in another lane. This by no means should dissuade or stymie efforts to increase yielding rates, rather it should intensify efforts to educate and prevent drivers from passing vehicles stopped in the roadway without significantly slowing to ensure they are not stopped for a pedestrian.

One approach proposed was to work with city of Saint Paul officials to change the violation for passing behaviors to be more severe than simply failing to yield. Under current state statute and city ordinance, the citation penalty is equal for both violations. Upon consultation with Commander Jeremy Ellison of SPPD and the Saint Paul City Council, including Council President Russ Stark, an intermediary step by SPPD was proposed to change the passing citation protocol to check the “endangerment” check box so that violators must appear in court. The planned procedural change was paired with media engagement to raise the visibility of the issue and awareness of the risk of the behavior to motorists. It is recommended, however, that local and state officials provide input into the Judicial Council and State Court Administration’s review and comment period of the Statewide Payables List to formally raise the payable amount of the passing violation at the state level.

Finally, media outreach was a critical component of the success of the safety culture emphasis of this project. The research team leveraged earned media to communicate to the greater Saint Paul community the scope of the pedestrian safety problem, an education message about how pedestrians can cross safely, and a clear and advanced notification of the upcoming SPPD high visibility enforcement activities. This media outreach was done in partnership with the city of Saint Paul and their communications team. The timing of the media engagement coincided with the first wave of enforcement activities (i.e., the warning, not ticket, phase of high visibility enforcement). An additional media outreach coincided with the deployment of the stopping feedback signs installed around the entry points into the city and media entities were engaged and encouraged to report on these signs.

CHAPTER 5: HVE PROGRAM IMPLEMENTATION AND RESULTS

5.1 HVE PROGRAM OVERVIEW

The implementation of the HVE program began on March of 2018 with the initiation of community outreach activities. The targeted educational materials distribution to schools and community partners was closely followed by the first wave of warning SPPD enforcement activities on April 30, 2018. As detailed in Chapter 3, the research team collected data from all study sites as the program progressed with additional waves of enforcement, feedback signs, and low-cost engineering treatment and concluded on Oct 31, 2018, see Table 5.1. Additional data collection occurred through an online survey distributed in two periods (i.e., June 8, 2018-June 19, 208 and October 19, 2018-November 1, 2018) to measure community awareness of the overall program and its individual components (e.g., feedback signs). The following summarized the data collection and enforcement activities and details the descriptive and inferential statistics conducted.

Table 5.1 Abbreviated Schedule of Study Activities: Data Collection and Enforcement

	2017		2018						
	Sept	Oct	April	May	June	July	Aug	Sept	Oct
Data Collection									
SPPD HVE Waves				Warning	Ticketing		Ticketing		Ticketing
Other Signage Treatment					Feedback Signs		In-street signs		Gateway signs

5.2 SAINT PAUL POLICE DEPARTMENT ENFORCEMENT SUMMARY

The Saint Paul Police Department (SPPD) conducted four high-visibility enforcement (HVE) waves at the eight enforcement study sites from May to October 2018. Each wave lasted two two-weeks. The first wave only involved warnings and the second through fourth waves involved ticketing drivers (see Table 5.1). Ten police officers from the Saint Paul Police Department (SPPD) received classroom and field instructions on April 30, 2018 on how to optimize high-visibility enforcement of pedestrians' right-of-way at crosswalks. Each location was enforced for approximately 90 minutes two to three times per week, prioritizing frequency of operations to poorer performing sites. The police teams used the same dilemma zone distances and staged pedestrian protocols as used by the research coding teams. Drivers in violation received educational materials containing much of the same information that was included in the community outreach flyer but addressed to the driver as a violator.

The number of warnings and citations issued by SPPD during the four HVE waves were shared with the research team and are summarized in Table 5.2 below. One officer was struck by a car attempting to flee after being flagged over for failing to yield to the officer acting as a staged pedestrian at Maryland and Walsh during the August enforcement wave. The officer sustained minor injuries and the driver was caught and arrested. The number of citations issued declined over the course of the study because improved yielding decreased the opportunity to make traffic stops for failure to yield right-of-way to a pedestrian, see Table 5.2.

Table 5.2. Summary of SPPD Enforcement Activities

HVE Wave	Dates	Study Weeks	HVE Type	Number Issued
Wave #1	April 30-May 4, 2018	Weeks 1 & 2	Warning	1,112 warnings; 0 citations
Wave #2	June 18-29, 2018	Weeks 8 & 9	Citation	34 warnings; 633 citations
Wave #3	August 6-17, 2018	Weeks 15 & 16	Citation	74 warnings; 386 citations
Wave #4	October 1-12, 2018	Weeks 23 & 24	Citation	34 warnings; 248 citations

5.3 DATA COLLECTION METHODS SUMMARY

Baseline data collection was suspended from October 31, 2017 and resumed April 25, 2018 when weather conditions improved sufficiently to allow safe data collection again (see Table 5.1). Baseline data collection continued until April 30, 2018, when SPPD's first wave of enforcement began. Data collection continued to measure the treatment effects of the HVE program until Oct 30, 2018. Safe crossing protocols and data collection protocols detailed in Chapter 3 were continued in this phase of data collection. As before, for personal safety, coders were also instructed not to code during days with precipitation (rain/snow), wet roads, or if they felt the traffic conditions were too dangerous to safely cross and code at the crosswalk site. For additional safety and data quality issues, coders were instructed not to cross or collect data from sites where road work was being conducted at locations immediately upstream or downstream from the crosswalk location that could influence traffic flow.

If scheduling permitted, the team rescheduled data collection sessions to accommodate data collection sessions lost because of inclement weather. During weeks that experienced heavier rains or more frequent road work that affected a significant number of the sessions, priority was given to scheduling make up sessions at sites that had not received data collection for the proceeding week. Major road construction on Maryland Ave resulted in little data collection at two sites, Maryland & Duluth and Maryland & Walsh, during the months of April, June, and July 2018. Following the road construction, the crosswalk marking was no longer present at Maryland & Walsh, impeding safe and controlled data collection; however, some data were still collected at these sites throughout the study, but was not included in any analyses due to the confounding factor of the crosswalk marking removal.

The following summary data are presented by site: The number of times data were collected by site, average weekly yielding by site, average weekly yielding distance by site, and average weekly passing and hard braking by site. Additional data along with inferential statistics are described along with a description of the statistical analysis applied and the level of statistical significance of the visible trends shown below.

5.3.1 Data Collection by Site

Table 5.3 outlines the frequency of data collection sessions over the measurement period and the total number of crossings (i.e., both staged and natural crossings) measured at each study site. A total of 636 data collection sessions were conducted over the study period. Additionally, a total of 12,246 crossings (i.e., including both staged crossings and natural pedestrian crossings) were conducted over the study period. Due to marked crosswalk markings being removed following road diet repavement project, Maryland & Walsh had the fewest number of data collection sessions and total crossings of all the sites. Given the early study performance of yielding, passing, and higher speeds at 7th & Bates, it was the site most likely to have data collection halted due to increased traffic volumes nearing afternoon rush hour and thus had a lower number of total crossings relative to its data collection sessions.

Table 5.3 Data collection count by session and crossing by site

Site	Type	Total Data Collection Sessions	Total Crossings (Staged and Natural)
7th & Bates	Enforcement	36	600
Arcade & Jessamine	Generalization	46	914
Cretin & Goodrich	Generalization	38	752
Dale & Jessamine	Enforcement	44	754
Hamline & Hartford	Generalization	42	794
Marion & Charles	Enforcement	42	826
Maryland & Duluth	Generalization	35	713
Maryland & Walsh	Enforcement	27	542
Randolph & Davern	Generalization	35	680
Randolph & Prior	Enforcement	39	769
Rice & Magnolia	Generalization	36	705
Snelling & Blair	Enforcement	46	771
Snelling & Fairmount	Generalization	45	892
Summit & Chatsworth	Enforcement	45	873
University & Kent	Generalization	37	792
White Bear & Nebraska	Enforcement	43	869
Total		**636**	**12,246**

5.4 DATA ANALYSIS SUMMARY

A series of data analyses were conducted to determine the efficacy of high visibility enforcement, media and community outreach, and engineering methods on improving stopping for pedestrians and reducing passing rates in Saint Paul, Minnesota. Additionally, results of the online survey measuring public awareness to the Minnesota crosswalk law and the Stop For Me campaign are summarized and discussed.

5.4.1 Driver yielding

Weekly yielding averages by site is displayed in Figure 5.1 to visualize trends over the data collection period. Baseline data indicates weekly average yielding measured from Sept. 22, 2017 to Oct. 29, 2017 and Apr. 25-27, 2018 (i.e., just prior to the first wave of HVE). Baseline data is noted as the weeks collected prior to the start of treatment with the first week of data collection noted at Week -6 (i.e., Sept. 22-29, 2018) and progresses to Week -1 (i.e., Apr. 25-27, 2018). However, some early sites were replaced and some did not enter the study until Week -4. Any data collection at individual sites in baseline Weeks -5 and -6 are noted in individual site graphs (see Appendix G). Given the data sparseness in Weeks -5 and -6 weeks, any collected data is averaged into Week -4 for overall study averages to avoid the appearance of trends within the small data sets (i.e., approximately three sessions each week).

Data collected beginning on May 3, 2019 was averaged by week and was numbered after the start of treatment (i.e., Week 1). Week 26 includes a full and partial week (i.e., Oct 22-29, 2018). Figure 5.1 displays the increasing yielding rates throughout the study for both enforcement and generalization sites. Due to changes in crosswalk markings after the Maryland Ave. road diet resurfacing, Maryland & Walsh data is excluded from the averages shown in Figure 5.1, but can be seen in Appendix G.

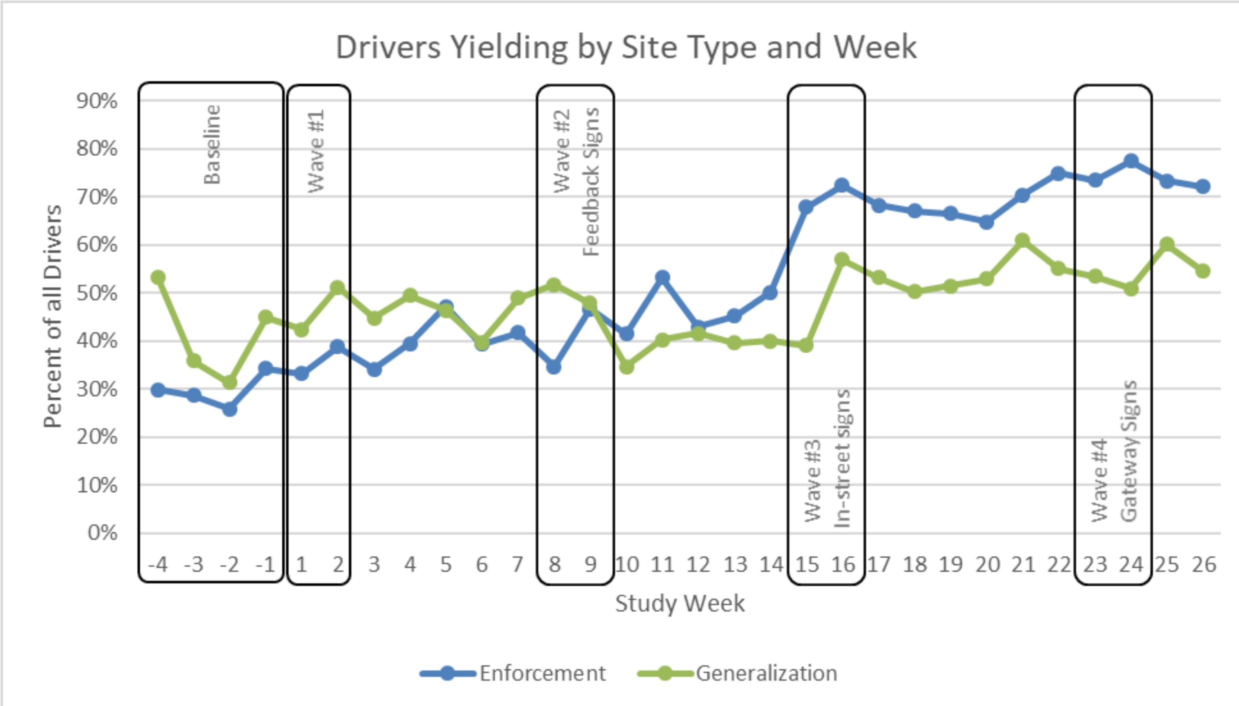

Figure 5.1 Average weekly driver yielding by site type (i.e., enforcement and generalization) and by week (excluding Maryland & Walsh). Black boxes note baseline and each of the four HVE waves.

5.4.2 Driver yielding distances

Driver yielding distances were noted in all data collection sessions and averaged by study week with baseline weeks ranging from -6 to -1 and treatment weeks beginning with Week 1 and spanning until Week 26. Overall averages have included Weeks -5 and -6 in the Week -4 baseline averages due to sparse data collection across sites at the beginning of the study. The average yielding distance was binned into three categories: less than 10 ft., between 10 and 40 ft., and greater than 10 ft., and showed little change over the study period (see Figure 5.2). Average yielding distances at individual sites are shown in Appendix H. Small differences are noticeable between the enforcement and generalization sites, with enforcement sites generally having fewer instances of yielding less than 10 ft. and between 10 and 40 ft. compared to generalization sites (see Figure 5.3 and Figure 5.4). Additionally, enforcement sites tended to have a greater percentage of drivers yielding greater than 40 ft. compared to generalization sites (see Figure 5.5).

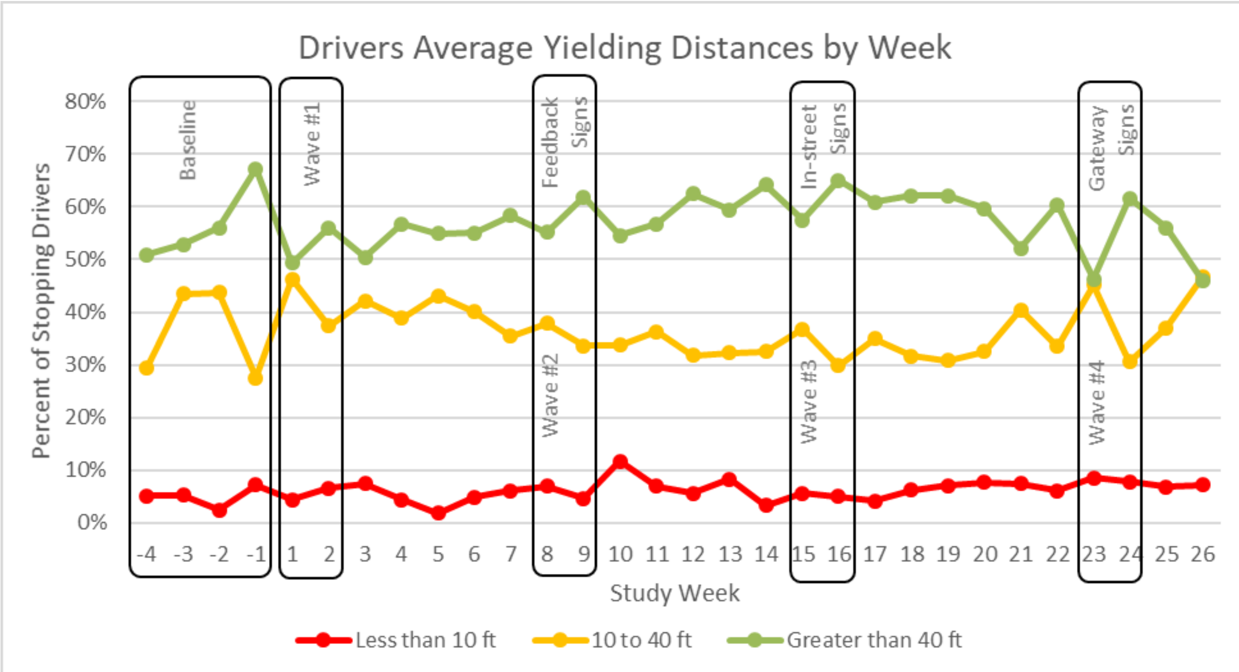

Figure 5.2 Average driver yielding by distance (i.e., less than 10 ft., between 10 and 40 ft., and greater than 10 ft.) averaged across all sites (i.e., enforcement and generalization) and by week (excluding Maryland & Walsh)

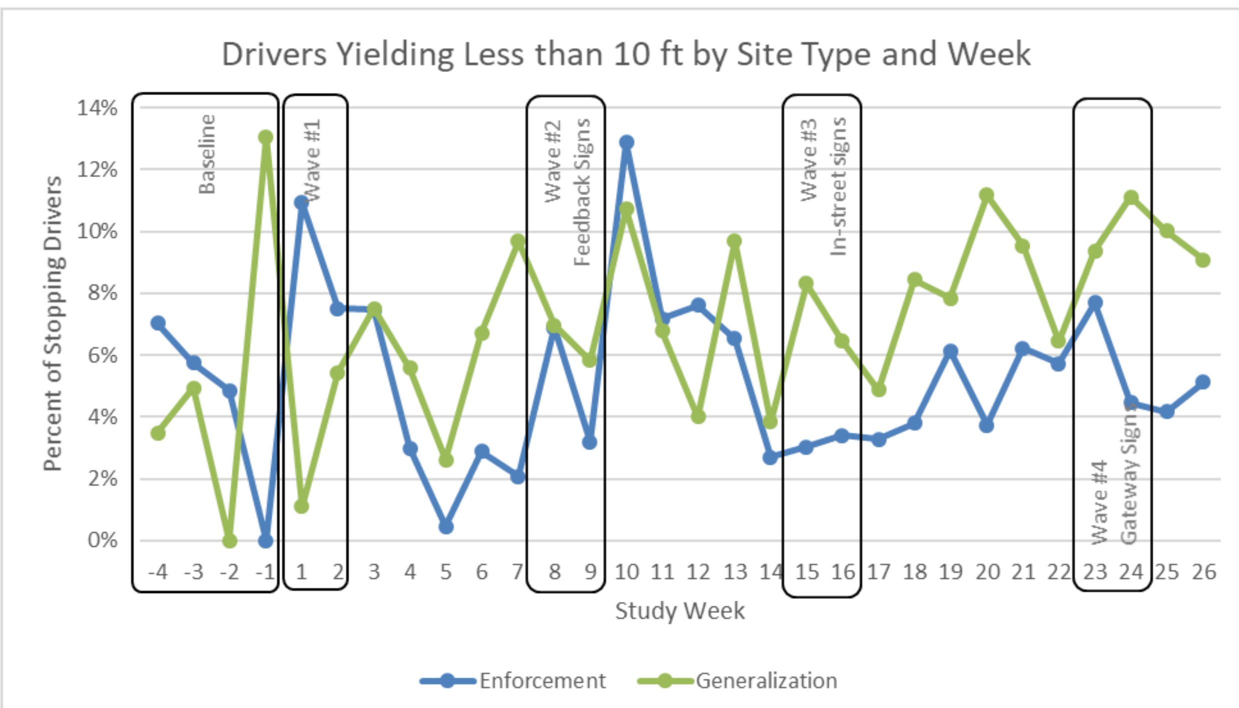

Figure 5.3 Average driver yielding less than 10 ft. by site type (i.e., enforcement and generalization) and by week (excluding Maryland & Walsh)

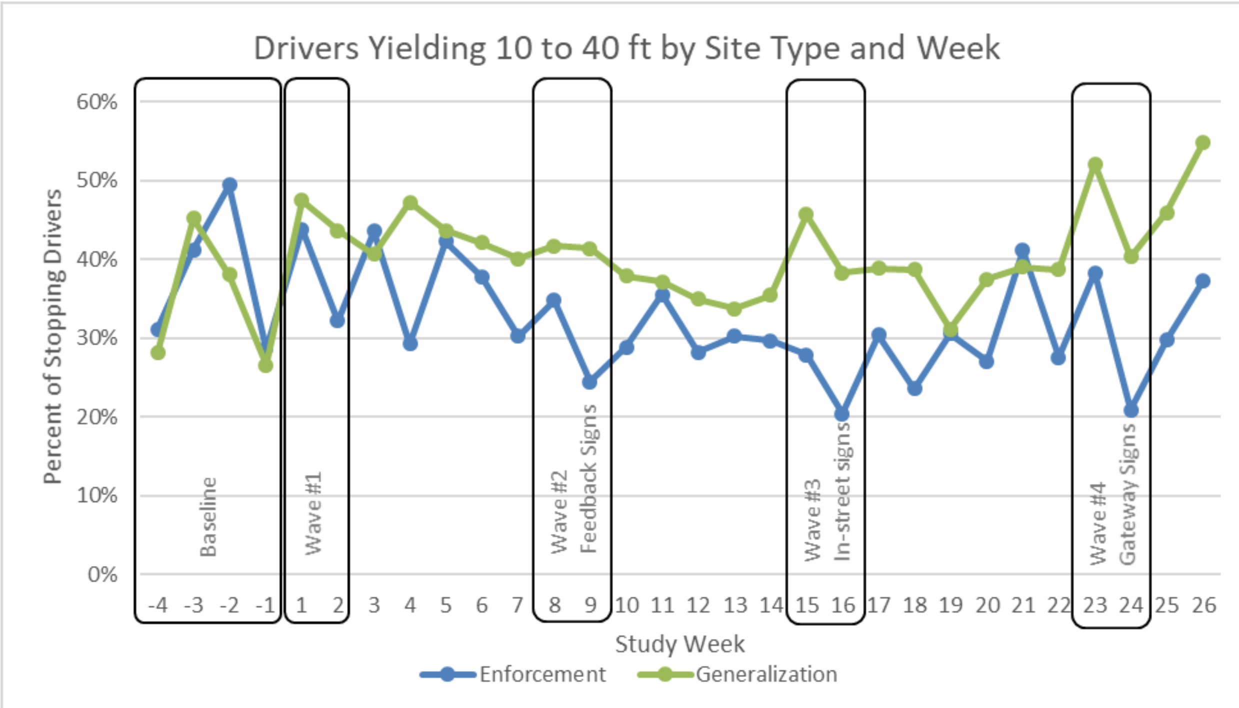

Figure 5.4 Average driver yielding 10 to 40 ft. by site type (i.e., enforcement and generalization) and by week (excluding Maryland & Walsh)

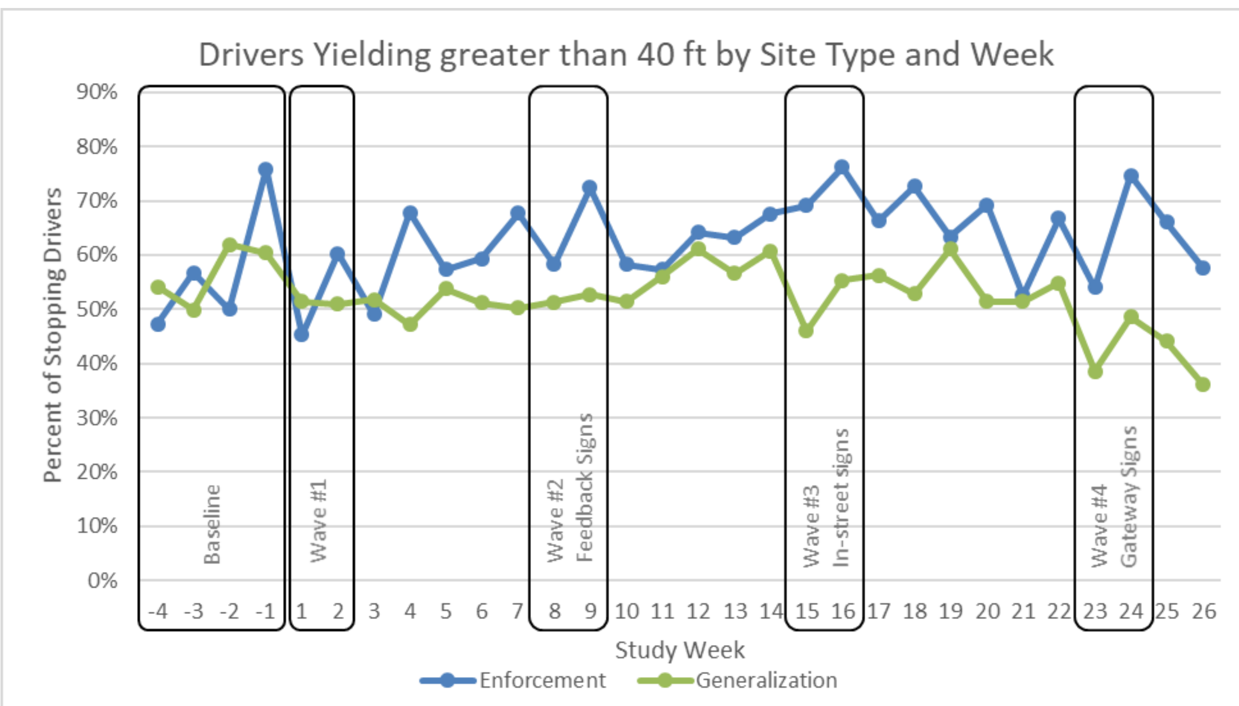

Figure 5.5 Average driver yielding greater than 40 ft. by site type (i.e., enforcement and generalization) and by week (excluding Maryland & Walsh)

5.4.3 Driver passing and hard braking

The final key data collection activity was monitoring the frequency of drivers passing or hard braking during a crossing. Passing and hard braking events were collected as a percent of total crossings and averaged by study week (i.e., negative weeks for baseline and positive for treatment) and the averages are displayed in Figure 5.6 and Figure 5.7. Passing events showed a pronounced decline throughout the study for the enforcement sites and were generally uncommon at generalization sites throughout (see Figure 5.6). Hard braking events were more variable in their frequency throughout the study but did appear to trend downward throughout the study period (see Figure 5.7). Individual site passing and hard braking averages over time are shown in Appendix I.

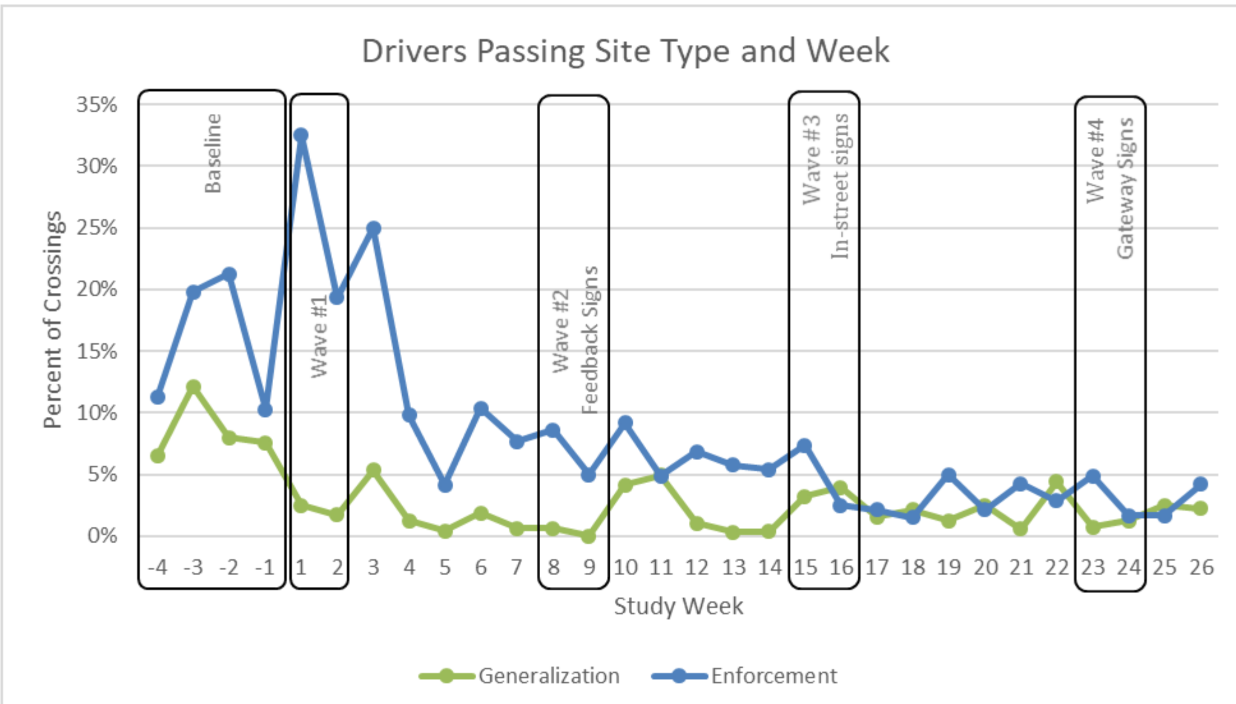

Figure 5.6 Average driver passing by site type (i.e., enforcement and generalization) and by week (excluding Maryland & Walsh)

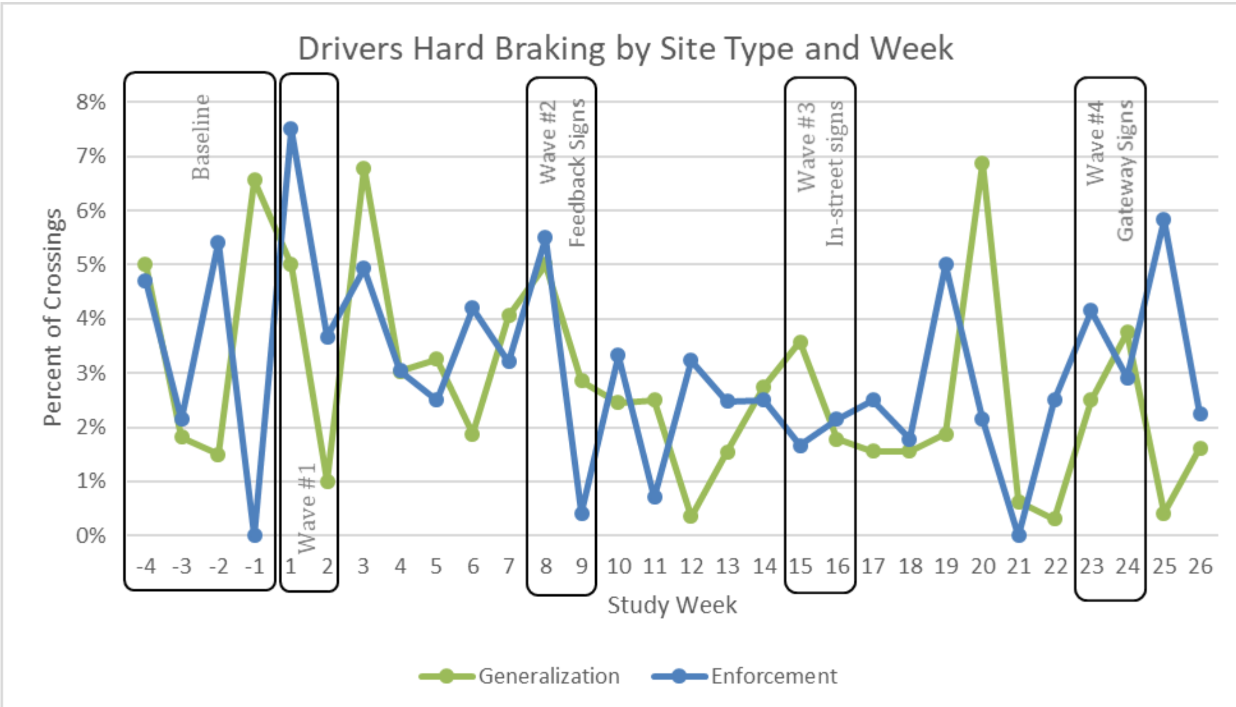

Figure 5.7 Average driver hard braking by site type (i.e., enforcement and generalization) and by week (excluding Maryland & Walsh)

5.5 STATISTICAL ANALYSES

5.5.1 Descriptive Statistics

While some descriptive statistics are detailed above, the following tables provide some alternative summaries of the descriptive statistics. In Table 5.4, the site-related variables of ADT and 85% speed (averaged from both directions) were taken from data provided by the Saint Paul Public Works Department. Initial enhancement reflects whether crosswalk enhancements were present at the site at the beginning of the study, with scores reflecting either no enhancements outside of markings, at least one enhancement (e.g., crosswalk sign, advance stop lines), or more than one enhancement.

Table 5.4 Site-related Variables

Site	ADT	Avg. 85% Speed	Initial Enhancement	Site Assignment
Snelling & Blair	24550	35	0	Enforcement
Randolph & Davern	11477	35	1	Generalization
Cretin & Goodrich	13415	35.5	1	Generalization
Snelling & Fairmount	23200	38.5	1	Generalization
Randolph & Prior	9260	36	0	Enforcement
Hamline & Hartford	4325	34	0	Generalization
Summit & Chatsworth	11025	36	0	Enforcement

Dale & Jessamine	16925	39.5	1	Enforcement
University & Kent	13000	35.5	2	Generalization
Rice & Magnolia	13350	34	0	Generalization
Marion & Charles	11500	34.5	2	Enforcement
Arcade & Jessamine	14400	31	0	Generalization
7th & Bates	29375	36.5	1	Enforcement
Maryland & Duluth	15110	34.5	2	Generalization
White Bear & Nebraska	20080	36.5	0	Enforcement

In Table 5.5, the major driver behavior variables of interest are collapsed across enforcement and generalization sites. Waves are defined as the overall measurement period between certain start and end points, examples including baseline or Wave 0 (start of data collection to the start of the first police enforcement wave), and Wave 1 (start of the first police enforcement wave to the start of the second police enforcement wave).

Table 5.5 Driver-behavior Variables over Wave Periods

	Mean (St. Dev)	
	Driver Stopping Percent	
Wave	Enforcement	Generalization
0	28.67 (12.48)	38.84 (16.59)
1	39.37 (16.66)	47.02 (19.52)
2	45.85 (16.42)	41.75 (17.24)
3	69.47 (13.62)	54.14 (18.01)
4	72.46 (12.92)	53.43 (20.33)
	Driver Stopping < 10 ft. Percent	
Wave	Enforcement	Generalization
0	3.952 (4.597)	4.371 (6.95)
1	4.013 (5.165)	5.961 (6.306)
2	6.458 (7.696)	6.919 (7.016)
3	4.371 (6.742)	7.241 (9.573)
4	5.828 (5.453)	9.12 (9.115)
	Driver Stopping > 40 ft. Percent	
Wave	Enforcement	Generalization
0	56 (22.97)	53.95 (21.57)
1	61.11 (14.51)	51.38 (17.97)
2	64.27 (18.39)	55.85 (16.09)
3	67.01 (15.59)	54.66 (15.76)
4	60.9 (20.42)	43.86 (20.65)
	MT Pass Percent	
Wave	Enforcement	Generalization
0	15.35 (18.18)	8.389 (12.14)
1	12.99 (16.47)	1.996 (4.219)

2	6.844 (10.21)	1.521 (4.928)
3	3.482 (5.864)	2.527 (5.996)
4	3.004 (5.659)	1.657 (3.734)
	MT Hard Brake Percent	
Wave	Enforcement	Generalization
0	3.625 (4.318)	3.577 (4.543)
1	3.924 (4.58)	3.584 (4.817)
2	2.41 (3.928)	2.345 (3.518)
3	1.989 (3.831)	2.022 (3.823)
4	3.548 (5.242)	2.371 (4.23)
Note. Wave 0 is the baseline.		

As described in Chapter 4, the consistency among data points for each count variable was again analyzed with inter-item correlations for the site visits when a secondary coder was present with the primary coder. A secondary coder was on site approximately once a month and provided a separate set of scores to verify coding reliability. As of mid-October 2018, the interrater agreement on the coded items was 84.1%. The consistency among data points for each count variable was also analyzed with inter-item correlations between the secondary coder and the primary coder (see Table 4.2). Exact scoring metrics are provided in Appendix F and additional details regarding the interrater assessment process are included in Chapter 4.

Table 5.6 Interrater assessment.

	Average Inter-item Correlation
Yielding Count	0.985
Cars Yielding < 10 ft. Count	0.934
Cars Yielding between 10 to 40 ft. Count	0.975
Cars Yielding > 40 ft. Count	0.903
MT Pass Count	0.989
MT Hard Brake Count	0.941

5.5.2 Inferential Statistics

The following are inferential statistics analysis of the effects of mixed methods HVE on both enforcement sites and generalization sites. All subsequent analyses exclude Maryland & Walsh.

5.5.2.1 Citation count

The impact of High Visibility Enforcement (HVE) waves on number of citations by SPPD is analyzed, comparing Wave #2 to Wave #3 and Wave #4. Wave #1 is excluded, as it was explicitly a warning wave and not a citation wave. Using a multinomial test to verify whether there was an equal distribution of citations by wave, it was observed that the distributions were not equal or proportional. χ^2 (2) = 180.2, *p*

< .001. The inference is that the number of citations significantly declined by wave (see Table 1), suggesting an effect of HVE on driver yielding over time.

5.5.2.2 Driver behavior analyses as a function of enforcement period or wave

The subsequent analyses of driver behavior and factors influencing those behaviors are replicated from preliminary analyses by Craig, Morris, Van Houten, and Mayou (2019).

Stepwise linear regressions were used to determine how HVE waves, ADT, average driver speed for both directions, lane count, season, and initial crosswalk enhancement presence affect the outcome variables. Model inclusion criteria was a p-value of .05, and model removal criteria was a p-value of .10. Separate regression analyses were conducted on enforcement sites and generalization sites, see Table 5.7 through Table 5.11. Waves or periods in this context reflect both the period of police enforcement and the data collection period following the time of enforcement until the next police enforcement wave. The final wave or period (#4) starts at the last or fourth police enforcement wave until the cessation of data collection at the end of October 2018.

Table 5.7 Stepwise Regression for Driver Stopping Percent

Driver Stopping Percent	**Enforcement**				**Generalization**			
Final Model Number	3				5			
Model Statistics	*F* (3,300) = 183.4, *p* < .001				*F* (5,313) = 57.72, *p* < .001			
R^2 (RSME)	0.649 (13.04)				0.484 (13.81)			
Significant Factors		Standardized *b*	*t*-value	*p*-value		Standardized *b*	*t*-value	*p*-value
	Wave/Period	0.711	20.66	<.001	**Wave/Period**	0.23	5.614	<.001
	85% Speed	-0.115	-3.354	<.001	**85% Speed**	0.847	15.28	<.001
	Lane Number	-0.35	-10.18	<.001	**Lane Number**	-0.307	-5.287	<.001
					ADT	-0.369	-7.145	<.001
					Season	-0.085	-2.073	0.039

Table 5.8 Stepwise Regression for Driver Stopping < 10 ft. Percent

Driver Stopping < 10 ft. Percent	**Enforcement**				**Generalization**			
Final Model Number	-				2			
Model Statistics	*F* < 1				*F* (2,312) = 11.18, *p* < .001			
R^2 (RSME)	-				0.067 (7.707)			
Significant Factors		Standardized *b*	*t*-value	*p*-value		Standardized b	*t*-value	*p*-value
	-	-	-	-	**Wave/Period**	0.157	2.865	0.004
	-	-	-	-	**ADT**	0.208	3.786	<.001

Table 5.9 Stepwise Regression for Driver Stopping > 40 ft. Percent

Driver Stopping > 40 ft. Percent	**Enforcement**				**Generalization**			
Final Model Number	5				3			
Model Statistics	*F* (5,299) = 8.516, *p* < .001				F (2,312) = 14.66, *p* < .001			
R^2 (RSME)	0.127 (17.11)				0.125 (17.00)			
Significant Factors		Standardized *b*	*t*-value	*p*-value		Standardized *b*	*t*-value	*p*-value
	Wave/Period	0.156	2.847	0.005	**Lane Number**	-0.358	-6.321	<.001
	Lane Number	0.157	2.751	0.006	**Initial Enhancement**	0.185	3.255	0.001
	85% Speed	-0.169	-3.09	0.002	**Season**	0.107	1.996	0.047
	Initial Enhancement	0.145	2.543	0.011				
	Season	0.142	2.598	0.1				

Table 5.10 Stepwise Regression for Multiple Threat Pass Percent

MT Pass Percent	**Enforcement**				**Generalization**			
Final Model Number	3				3			
Model Statistics	*F* (3,300) = 36.92, *p* < .001				*F* (3,313) = 24.50, *p* < .001			
R^2 (RSME)	0.272 (11.08)				0.192 (6.334)			
Significant Factors		Standardized b	t-value	p-value		Standardized *b*	*t*-value	*p*-value
	Wave/Period	-0.349	-7.047	<.001	**Wave/Period**	-0.202	-0.396	<.001
	Lane Number	0.237	3.299	0.001	**Lane Number**	0.36	7.055	<.001
	ADT	0.17	2.377	0.018	**Season**	-0.136	-2.657	0.008

Table 5.11 Stepwise Regression for Multiple Threat Hard Brake Percent

MT Hard Brake Percent	**Enforcement**				**Generalization**			
Final Model Number	-				2			
Model Statistics	$F < 1$				F (2,313) = 13.78, $p < .001$			
R^2 (RSME)	-				0.081 (4.032)			
Significant Factors		Standardized b	*t*-value	*p*-value		Standardized *b*	*t*-value	*p*-value
	-	-	-	-	**Wave/Period**	-0.0137	-2.513	0.012
					Lane Number	0.248	4.563	<.001

5.5.2.3 Diffusion effect

The diffusion effect (Van Houten, Malenfant, Huitema, & Blomberg, 2013) occurs when the positive impact of high visibility enforcement on drivers stopping to pedestrians is diffuse or spread out (i.e., not localized to only the enforcement sites), and is also reduced with increasing distance from the enforcement sites. An initial comparison of the effect size between the impact of HVE waves on enforcement sites (b = .711) and on generalization sites (b = .23), suggest a larger impact of HVE waves on enforcement, although the effect is still present and significant for generalization sites. This implies that the positive effect of HVE has diffused throughout the city of Saint Paul, at least to the measured sites.

5.6 ONLINE SURVEY RESULTS

5.6.1 Survey Purpose

The purpose of this survey was to measure the knowledge of the Minnesota crosswalk law by drivers in and around the city of Saint Paul and to measure the awareness of the Stop For Me campaign, including study treatments such as the feedback signs.

5.6.2 Methods

The survey was disseminated through multiple methods including Twitter, Facebook, and email. Different social media platforms and email lists were used including the University of Minnesota HumanFIRST Lab, the city of Saint Paul, and MnDOT. The survey was advertised during two separate data collection periods: period 1 (June 8, 2018-June 19, 208) and period 2 (October 19, 2018-November 1, 2018). Survey respondents were provided an internet link that routed them to the University of Minnesota online survey tool, Qualtrics. Participants were provided a brief description of the purpose of the survey and were notified that their participation was voluntary. The survey was determined to be "Not human subjects research" by the University of Minnesota Institutional Review Board, so a formal informed consent form was not provided. Those who wished to proceed with the survey then answered the 23 questions (see Appendix J for complete list).

5.6.3 Participants

Overall, 1,313 (793 in period 1 and 520 in period 2) people initiated the online survey and answered at least 30% of the questions and 1,227 answered at least 60% of the questions. The average age of respondents was 45.46 (*SD* = 13.5, Min = 19, Max = 88). The majority of respondents (98%) were licensed drivers and had received their license an average of 28.7 years ago (*SD* = 13.9, Min = 1, Max = 73). Over half (66%) reported to drive in Saint Paul every day and 86% reported to drive in Saint Paul at least once a week. The majority of respondents identified as female/woman (720), fewer identified as male/man (374) or non-binary/other (27), and 192 provided no answer or provided other commentary.

Thirty-three respondents reported to have taken the survey during Period 1 and 2, 29 indicated they were unsure if they had also taken the survey in Period 1.

The majority (924, 74.2%) reported that they lived in Saint Paul, MN and 14.2 miles (SD = 26, Min = .25, Max = 250) was the average distance from Saint Paul that the non-residents reported living from the city. The distribution of neighborhoods that the Saint Paul resident participants reported living in are shown in Table 5.12. Responses from every district were received; however, some districts were oversampled compared to others. The greatest responses came from residents of Districts 15 (Highland Park), District 10 (Como Park), and District 14 (Macalester-Groveland) and fewest came from District 1 (Eastview, Conway, Battle Creek, Highwood Hills), District 4 (Dayton's Bluff), and District 16 (Summit Hill). There were observed differences between the two survey periods with District 15 (Highland Park) representing the greatest number (20%) of respondents in Period 1, but District 12 (Saint Anthony Park) representing the greatest number (30%) of responses in Period 2.

Table 5.12 Distribution of Saint Paul Neighborhood Participation in the Online Survey

Saint Paul Neighborhoods/Districts	**Count (*N*)**
District 1 - Eastview, Conway, Battle Creek, Highwood Hills	7
District 2 - Greater East Side	39
District 3 - West Side	15
District 4 - Dayton's Bluff	8
District 5 - Payne-Phalen	19
District 6 - North End	17
District 7 - Frogtown (Thomas-Dale)	13
District 8 - Summit-University	19
District 9 - West Seventh/Fort Road	44
District 10 - Como Park	125
District 11 - Hamline Midway	69
District 12 - Saint Anthony Park	107
District 13 - Union Park	76
District 14 - Macalester-Groveland	128
District 15 - Highland Park	137
District 16 - Summit Hill	27
District 17 - Downtown	36

5.6.4 Survey Responses

5.6.4.1 Crosswalk law knowledge

The survey asked a series of basic questions to determine the level of knowledge respondents had regarding the Minnesota Crosswalk Law (Minnesota Statutes 1999, Chapter 169.21 - Pedestrian Law).

Q4: Do you know what Minnesota law requires drivers to do when they approach a pedestrian in a crosswalk?

Most respondents said they did know what the law requires of drivers and little differences in responses were observed between the two periods (see Table 5.13).

Table 5.13 Frequency of responses to the question about the crosswalk law for driver requirements

	Answer		
	Yes	**No**	**Unsure**
Period 1	93% (741)	1% (5)	6% (49)
Period 2	95% (496)	1% (2)	4% (22)
Overall	94.1% (1237)	.5% (7)	5.4% (71)

Q5: What does Minnesota law require drivers to do when they approach a pedestrian in a crosswalk?

Survey participants were asked to report what the requirements were if they had indicated "Yes" to Question 4 or were asked to give their best guess if they indicated "Unsure" or "No" to Question 4. The field was open entry and was recoded for analysis. Some respondents provided more lengthy and detailed answers (e.g., The law requires cars to stop for pedestrians who have entered the crosswalk as long as the car is within a safe stopping distance), but the majority of responses in both Period 1 and Period 2 surveys were simple (e.g., Stop), 88% and 90%, respectively. While a 94.1% had indicated "Yes" to their knowledge of the law, fewer could accurately indicate that the requirement was to "Stop". Slightly more indicated "Stop" as the correct answer in Period 2; however, this difference is not significant ($p < .05$), see Table 5.14.

Table 5.14 Frequency of responses to question about details of crosswalk law driver requirements

	Period 1	**Period 2**
Answer	**Percentage (Count)**	**Percentage (Count)**
Stop	80% (193)	85% (420)
Yield	12% (91)	9% (47)
Both	~2% (13)	3% (13)
Other	3% (23)	3% (16)

Q6: Is there a difference in what drivers must do if the pedestrian is crossing at an intersection but there is no painted crosswalk?

The sixth question asked drivers about their knowledge of how the law applies to intersections with no painted crosswalk. Most respondents (79%) reported accurately that there is no difference for what drivers must do if a pedestrian is at an intersection with no painted crosswalk (see Table 5.15). Nearly 20% were either unsure if there is a difference or believed there was a difference for driver requirements at unmarked crosswalks. The distribution of correct and incorrect answers from Period 1 to Period 2 is significantly different from one another X^2 (1, N = 1310) = 3.96, p = .047.

Table 5.15 Frequency of responses to question about crosswalk law for unmarked crosswalks

	Answer		
	Yes	**No**	**Unsure**
Period 1	5.3% (42)	80.4% (635)	14.3% (113)
Period 2	9.8% (51)	75.8% (394)	14.4% (75)
Overall	6.9% (93)	79.0% (1,059)	14.0% (188)

Q7: Please provide your best guess for what the difference is for what drivers must do if the pedestrian is crossing at an intersection but there is no painted crosswalk? (write "Do not know" if you cannot provide a guess)

Survey participants were asked to report their best guess for the difference in requirements were if they had indicated "Yes" or "Unsure" to Question 6. The field was open entry and was recoded for analysis. While approximately 20% of participants had indicated in Question 6 that they believed or were unsure about a difference for unmarked crosswalks, approximately 40% of those still indicated that they believed drivers were required to stop for pedestrians at unmarked crosswalks. The remaining believed drivers were not required to stop, were only required if there was adequate time to do so, provided another answer (often including mention of "right of way", or were unsure (see Table 5.16).

Table 5.16 Frequency of responses to question about details of crosswalk law driver requirements at unmarked crosswalks

	Period 1	Period 2
ANSWER	**Percentage (Count)**	**Percentage (Count)**
Required to stop	45% (68)	40% (46)
Not required to stop	19% (28)	16% (18)
Stop only if time to do so	8% (12)	8% (9)
Other	10% (16)	19% (22)
I don't know	18% (27)	17% (20)

Q8: Do you know what Minnesota law requires pedestrians to do when they cross the road in a crosswalk?

Fewer participants reported that they knew what the law required of pedestrians compared to their knowledge of its requirements for drivers. Participants stated "Yes" approximately 55% of the time but were similarly likely (31.8%) to say they were "Unsure" about the law's requirements for pedestrians, see Table 5.17. Only slight differences were observed between Period 1 and Period 2.

Table 5.17 Frequency of responses to knowledge question about crosswalk law for pedestrian requirements

	Answer		
	Yes	**No**	**Unsure**
Period 1	53.9% (422)	13.0% (102)	33.1% (259)
Period 2	57.1% (290)	13.0% (66)	29.8% (151)
Overall	55.2% (712)	13.0% (168)	31.8% (410)

Q9: What does Minnesota law require pedestrians to do when they cross the road in a crosswalk?

Survey participants were asked to report what the requirements of pedestrians were if they had indicated “Yes” to Question 8 or were asked to give their best guess if they indicated “Unsure” or “No” to Question 8. The field was open entry and was recoded for analysis. The responses were far more variable for this question and more difficult to categorize. The clearest and common response included some mention of the pedestrian being required to “look” or “wait”, followed by “stepping into the road”, and less often “make eye contact with the driver”, see Table 5.18. However, other answers included mentions of being “alert”, “obeying lights”, using “red flags”, and “making intention to cross clear”. Figure 5.8 displays a word cloud generated using the responses from Question 9.

Table 5.18 Frequency of responses to question about details of crosswalk law pedestrian requirements

	Period 1	**Period 2**
ANSWER	**Percentage (Count)**	**Percentage (Count)**
Look	21.3% (193)	39.1% (141)
Wait for traffic/light/clear	11.3% (102)	12.5% (45)
Step into road	5.0% (45)	8.3% (30)
Make eye contact with driver	4.9% (44)	3.0% (11)
Other	57.5% (521)	37.1%(134)

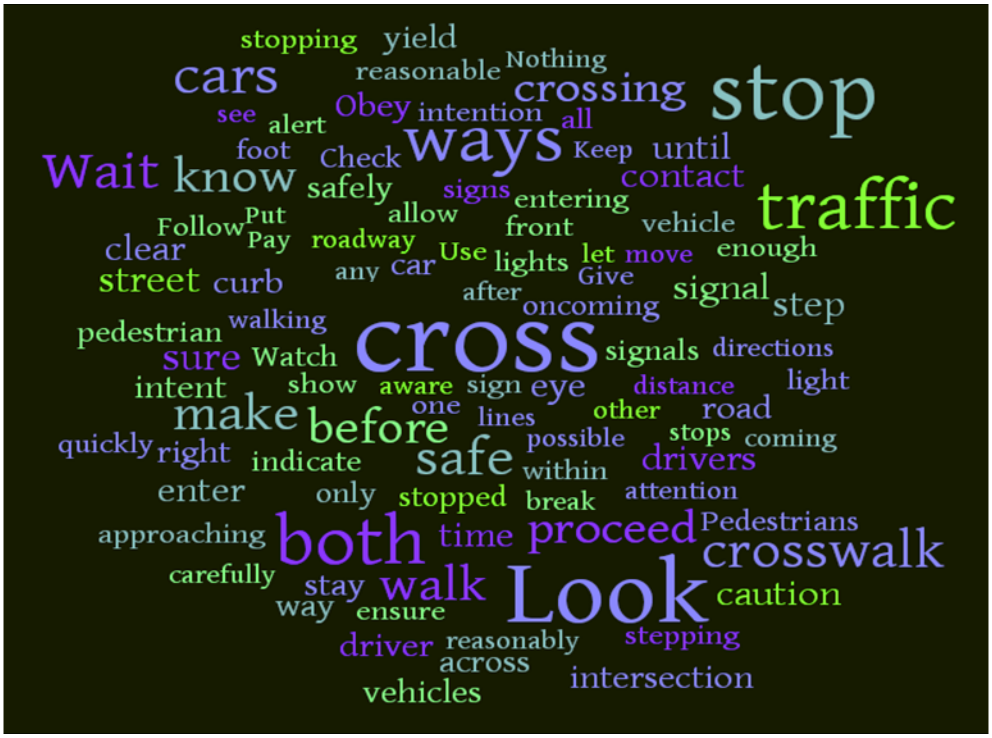

Figure 5.8 Word cloud generated using answers from participants understanding of pedestrian requirements at crosswalks

5.6.4.2 Stop For Me Campaign Knowledge

A series of questions were asked to assess participants' knowledge, perception, and awareness of the Stop For Me campaign, along with other treatments used in this study.

Q10: How strictly do you think the police enforce the Minnesota law requiring drivers to stop for pedestrians in a crosswalk?

The first question relating to high visibility enforcement of the crosswalk law asked participants how strictly they felt police enforced the law. Responses were made on a 5 point (0-4) Likert scale with 0 being "not at all" and 4 being "very strictly". Participants in Period 1 were less likely (mean score = 1.53, SD = 1.07) to report that the law was being strictly enforced that were participants in Period 2 (mean score = 1.84, SD = 1.10). The difference in the perception of the enforcement of the law from June 2018 to October 2018 was statistically significant, $t(1262) = 4.95$, $p < 0.0001$, see Figure 5.9. These results indicate that the activities of the HVE program raised the awareness and perception of law enforcement of the crosswalk law from the time that the first survey period was collected in June 2018 to the second period in October 2018.

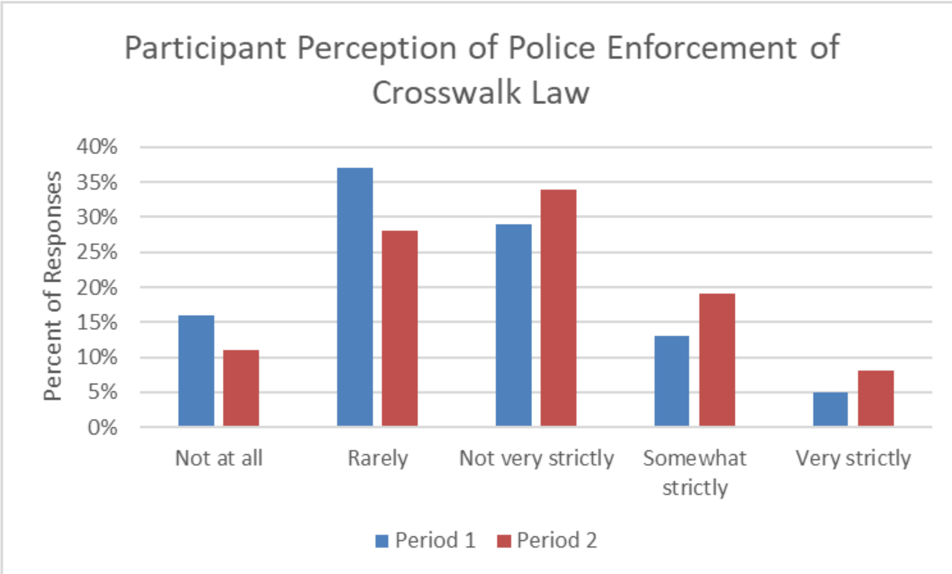

Figure 5.9 Distribution of responses for perception of enforcement for crosswalk law in Period 1 (June 8, 2018-June 19, 208) and Period 2 (October 19, 2018-November 1, 2018)

Q11: Have you recently seen any special police enforcement at crosswalks near where you live or typically drive?

Interestingly, participants did not report an increase in reporting seeing enforcement near where they typically live or drive from Period 1 to Period 2. In Period 1, 24% of participants stated that they had seen special enforcement near where they live or typically drive, but 21% reported the same in Period 2. However, it is noteworthy that Saint Anthony Park was the most frequent neighborhood of participants in Period 2, but this neighborhood did not have any HVE activities related to this study occur within it. Highland Park, the neighborhood most common among Period 1 participants did have HVE activities related to the study within it.

Q12: Where did you see special police enforcement at crosswalks? (approximate cross streets or neighborhood)

Participants were asked to report the location of where they had seen special police enforcement at crosswalks in an open entry field. The locations observed to have had special police enforcement by participants were variable and ranged to specific cross streets to neighborhoods. The most common location listed in Period 1 was a location on Snelling Ave, see Table 5.19. The most common location listed in Period 2 was a location on White Bear Ave. Some participants were able to list multiple locations in which they had observed special enforcement while others were unable to recall a specific location. Many participants could not remember a location but were able to recall it was in relation to a Stop For Me event and some reported to have participated in an event.

Table 5.19 Frequency of locations listed for enforcement locations observed by participants

	Period 1	Period 2
Snelling Ave	28	9
Highland Park	16	4
White Bear Ave	1	14
Grand Ave	13	8
Fairview Ave	11	0
Lexington Ave	10	8
Hamline Midway	10	4
Dale Street	9	2
Rice Street	8	3
Kellogg Ave	2	8
East Side	2	7
Como Ave	6	7
Macalester Groveland	8	5
Downtown	8	3
Summit Ave	6	3
Randolph Ave	5	2
E 7th	5	1
Maryland Ave	4	5
Other Saint Paul/Stop for me	45	37
Cannot Recall	11	5

Q13: In the past month, have you seen or heard any publicity about drivers stopping for pedestrians in crosswalks?

Participants were more likely (59%) to say they had seen recent publicity in the Period 1 survey than they were in the Period 2 survey (50%), see Table 5.20. This result is consistent with the amount of media coverage of pedestrian safety and the Stop For Me campaign/research study leading up to Period 1, but fewer stories in Period 2, see Appendix K for a complete list of relevant media coverage.

Table 5.20 Frequency of responses to publicity about pedestrians at crosswalks

	Period 1	**Period 2**
Yes	59% (452)	50% (244)
No	41% (312)	50% (247)

Q14: Where did you see or hear the publicity about drivers stopping for pedestrians in crosswalks?

Participants were asked to indicate where they saw or heard publicity about drivers stopping for pedestrians in crosswalks. The most common response in both survey periods as social media (e.g., Facebook or Twitter), see Table 5.21. Newspaper and TV media were the next most frequent responses. “Other” responses were most often listed as seeing signs in or near the street, district council communications, and email list servers. The follow-up question 15 indicated that the content of the media or publicity was most often remembered as “education” or “enforcement” in nature; however, “statistics” was the most frequent (i.e., 32%) response in Period 2.

Table 5.21 Frequency of responses to publicity about pedestrians at crosswalks

	Period 1	**Period 2**
Social Media	73% (329)	67% (158)
Newspaper	34% (151)	29% (68)
TV	18% (83)	25% (58)
Radio	14% (61)	11% (27)
Brochure/Flyer	2% (8)	1% (3)
Poster	2% (10)	2% (4)
Website	10% (47)	13% (30)
Newsletter	4% (20)	3% (8)
Banner	4% (17)	4% (9)
Information Booth	1% (4)	1% (3)
Other	8% (35)	21% (50)

Q16: Have you recently seen a road sign about the percent of Saint Paul drivers stopping for pedestrians?

The final set of questions aimed to assess the exposure of the feedback signs among drivers in Saint Paul. While the signs were not in place in Period 1, it was important to assess the likelihood that participants might indicate “Yes” to the question even if they had not seen the signs. This could be due to confusion about which signs are in question, error, or default bias. Indeed 4% of participants responded “Yes” in Period 1, but most often (85% of the time) they said they could not remember the location of the signs upon follow-up, see Figure 5.10. In Period 2, 37% of participants (177) indicated they had seen the feedback signs.

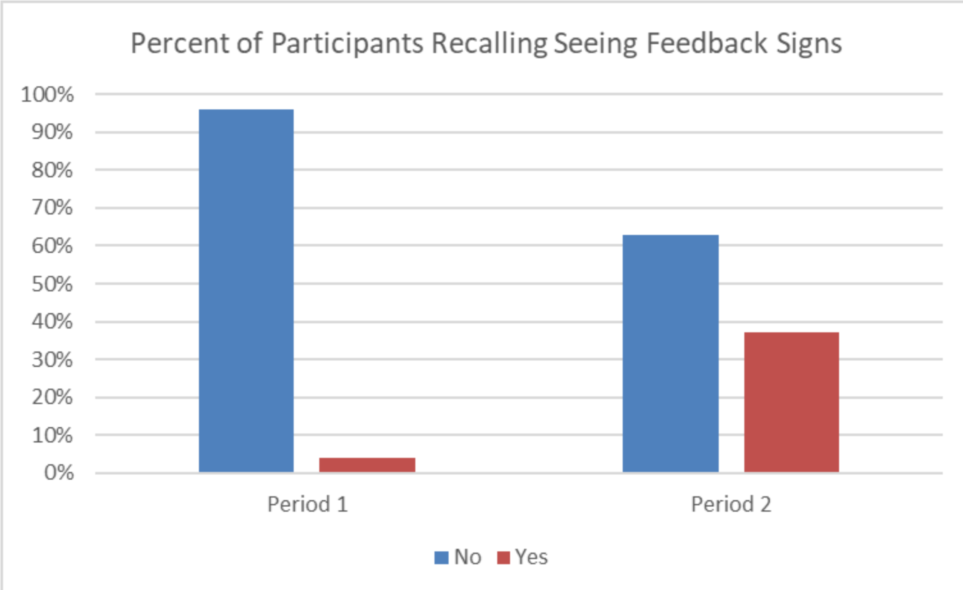

Figure 5.10 Distribution of responses for indicating to have seen the feedback signs

The follow-up, Question 17, in Period 2 yielded better-informed responses about where participants had seen the feedback signs. The most common location listed was on Snelling Ave, with specific mentions of the locations of both the sign near Lafond and near Iglehart, see Table 5.22. Notably, participants in Period 2 listed all of the eight feedback signs and a sizable percentage of participants (12%) had only seen them through social media.

Table 5.22 Frequency and percentage of locations listed for feedback signs

Answer	Percentage (Count)
Lexington Ave	14% (24)
Marshall/East River Road	3% (6)
Maryland Ave*	7% (13)
Snelling Ave**	18% (32)
Social Media	12% (21)
University Ave	10% (17)
W 7th St and Springfield/Homer	6% (10)
Other i.e. "I don't know", "on the street", etc.	30% (53)

*Maryland (general) 6, Maryland (Edgerton/Payne) 6, Maryland (Clark/Arkwright) 1
**Snelling (general) 18, Snelling (Lafond) 4, Snelling (Carroll/Iglehart) 10

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

The issue of pedestrian safety continues to rise to more alarming levels with 2018 resulting in a four percent increase in pedestrian fatalities over the prior year, the most since 1990 (GHSA, 2019). While 2018 pedestrian fatalities in Saint Paul and Minnesota overall appeared to stagnate, there were 14 pedestrian deaths in Minnesota in the first three months of 2019 alone (MnDPS, 2019). The importance of integrating multidisciplinary approaches to maximize their efficacy to address this growing problem is more pressing than ever.

The Stop For Me Campaign by Saint Paul Police Department and its community partners that was already underway is believed to have created a strong framework of community advocacy and interest in pedestrian safety that allowed this program to have a greater chance of success. The initial analysis of the data collected from past Stop For Me events indicates that there has been some positive impact in terms of citation rates, but this had not yet translated to a change in crash rates. The initial survey responses do indicate that previous activities have helped to create widespread knowledge about the Minnesota crosswalk law and increase awareness about pedestrian safety issues. Baseline data collection, however, suggested that drivers in Saint Paul had not yet translated the knowledge and awareness into widespread compliance as evidenced by the 32% yielding rate measured by the research team.

The educational and outreach activities conducted in this study included paper materials distribution, electronic educational distribution, stakeholder engagement, social media engagement, feedback signs and earned media engagement. While each of these activities is expected to have reach audiences to different levels, their combined efforts created the greatest opportunity to reach a diverse audience and continually remind them of the issue of pedestrian safety. Changing driver behavior, and ultimately culture, hinges on a critical component, which is convincing people that a problem exists. Using each of these education and outreach activities in concert helps to educate about the growing problem of pedestrians being struck and killed in messaging formats that are easily understandable. The infographic shown in Figure 2.3 used a visual representation to show the number of children struck in the last five years and their breakdown by small and older children that is expected to aid individuals who may be low in numeracy or those who struggle to understand risks (Garcia-Retamero & Galesic, 2010). The issue of “car culture” remains a persistent issue that should be examined in the future for countermeasures to reduce driver attitudes of “owning the road” or diminished feelings of pedestrians and bicyclists’ right to share the road with motor vehicle drivers.

The educational and community outreach activities done in preparation of the partnership and implementation plan involved considerable time in the creation and distribution of the educational materials. The impact of the materials, however, was substantial with tens of thousands of Saint Paul and surrounding residents reached. Raising the awareness of the issue of pedestrian safety, particularly highlighting the impacts on children and multiple threat passing, was a critical step in creating a culture that is more accepting of the engineering and enforcement activities of the program and ultimately changing behavior. Additionally, ensuring that community awareness is broad and captures all socioeconomic, regional, racial, and other demographic groups is paramount in ensuring equitable safety and policing practices across all areas of the city.

The results of the study demonstrated significant change in driver behavior over the course of the program. Consideration of police citation count and the driver behavior variables indicates a positive effect of HVE, outreach, and engineering on overall driver yielding percentages for both enforcement and generalization sites. The weekly average for enforcement sites in the baseline period was as low as 26% yielding, but grew to as high as 78% during the final implementation of the gateway sign treatments. The weekly average of generalization sites in the baseline period was as low as 31%, but grew to as high as 61% just prior to the gateway installation.

Furthermore, multiple threat passes were reduced for both site types, and a positive impact of period/wave was observed for yielding more than 40 feet back. The decline in multiple threat passes may have also been attributed to an increase in penalty by SPPD by checking the "endangering life or public property" box when the behavior was observed, a penalty that requires a court visit rather than simply paying the fine. However, continued HVE appeared to increase the rate of stopping less than 10 feet from the crosswalk at generalization sites, implying that drivers may have been particularly alert for pedestrians near enforcement site crosswalks (either due to in-street signage or recent police presence), and less so for pedestrians near generalization sites. Finally, although the initial positive impact of HVE on drivers stopping for pedestrians was found prior to implementation of engineering as described in Craig, Morris, Van Houten, and Mayou (2019), the effect was significantly larger after engineering was implemented (see Table 5.7 and Figure 5.1).

The survey results indicated some opportunities for better education among community members about the crosswalk law. The greatest opportunity is to improve knowledge and awareness is regarding what the law requires pedestrians to do at a crosswalk. The results regarding unmarked crosswalks surprisingly indicated that the vast majority of drivers are aware that the law requires the same stop behavior as it does for marked crosswalks. Poorer compliance with the law at unmarked crosswalks in Saint Paul is examined in Craig, Morris, and Hong (2019). Finally, the survey results indicated that awareness of the Stop For Me campaign improved from Period 1 and Period 2 and that the feedback signs were observed by a significant number of participants. It is worth mentioning that there is a possibility of selection bias when one gets a voluntary sample from social media. People who do not respond to this type of approach may be significantly different from those who do regarding their interest in pedestrian safety issues.

6.1 RESEARCH BENEFITS AND IMPLEMENTATION STEPS

6.1.1 Anticipated benefits

The research team initially identified three areas that were expected to have measurable outcomes regarding key benefits. The details of the expected outcomes have been listed below.

6.1.1.1 Material and labor cost savings

The cost, according to Bushel, Poole, Rodrigues, and Zegeer (2013), of a rectangular rapid flashing beacon (RRFB), along with powering units and signage, is an average of $22,250 (up to $52,310 with labor included) for the purchase of installation of two units on a single crosswalk section (one for each side of the street). While this approach may be a solid solution to heighten driver awareness of crossing pedestrians and achieve high yielding rates, they are not affordable nor practical on a wide scale. This project highlighted another signage approach that can be done at a lower cost and deployed more widely. The main enhancement employed in the intervention was in-street crossing signs (i.e., R1-6 signs). The in-street signs are estimated to cost $360 (up to $1,240 with labor of installation and maintenance over three months from August 2018 through October 2018 included) each.

6.1.1.2 Improved safety

Increasing crosswalk law compliance across serves to improve safety and walkability for communities. The expected outcome of increased driver yielding to pedestrians across all lanes of travel would not only be of great importance in protecting community members but also result in more livable, healthy communities. Greater community awareness of media campaigns and enforcement strategies surrounding pedestrian safety will serve to improve recognition of pedestrian/yielding laws and ultimately improve compliance.

6.1.1.3 Reduced risk

The ultimate outcome of this work is increasing driver yielding to pedestrians at crosswalks. Also, yielding distance from the crosswalk is an important component of risk reduction. Not only does the vehicle distance serve as a buffer for the pedestrian in the event of rear-end collisions, but yielding distance also improves sight distance for vehicles in the other lanes of travel, along with sight distance for the pedestrian. The increased awareness through education and enforcement efforts regarding the importance of 40 ft. yielding in Saint Paul should influence drivers by increasing the distance in which they yield from cross walks.

6.1.2 Final Benefits

6.1.2.1 Materials and labor cost savings

Forty total in-street signs were used at the eight enforcement sites over the course of the study, with 22 signs initially installed and 18 replacement signs put into place. At a cost of an estimated $360 per sign, this leads to an estimated $14,400 dollars for materials. There was an estimated $30,000 for labor cost, and approximately half of that number was for installation and maintenance in-street signs from June 2018 through October 2018. Some locations had a greater number of vehicle strikes to the signs (i.e., often simply dislodging the sign, but occasionally breaking it beyond repair) that required a greater number of reinstallations than others. These vehicle strikes were most common at 4-lane roadway locations where signs were placed on white centerline stripes. An extreme example was at Snelling and Blair that required 32 reinstallations of the signs (the tendency was similar, but smaller at Marion & Charles). The other half of the labor costs was for other components of the project, such as installing feedback signs and updating placards. The total cost for the signs materials and labor of the eight sites is estimated at $44,400 or $5,550 per location.

An equivalent set of RRFBs at each of the eight enforcement sites would have cost $178,000 in materials ($22,250 * 8) and $240,480 in labor ($30,060 * 8), for a total cost of $418,480, over nine times the cost of the low-cost treatment solution. However, this approach may have lower maintenance costs than in-street signs.

The additional cost to be considered for this program should be the labor of the Saint Paul Police Department (SPPD). Between April 30, 2018, and October 12, 2018, SPPD conducted the following pedestrian related enforcement: 1,993.5 hours of on-duty enforcement (approximate cost of $74,134.35), 828 hours of overtime enforcement (approximate cost of $34,096.07), and 200 hours of administrative time (approximate cost of $14,000). The total costs are estimated at $122,230. Notably, these costs include additional SPPD high visibility enforcement activities outside of the eight study locations, however, the allocation of costs for study and non-study enforcement during this time is not known.

6.1.2.2 Improved safety

There were four pedestrian fatalities in Saint Paul in 2018. However, two of those four involved the light rail (i.e., not a motor vehicle involved crash) and one was an apparent suicide. By comparison, there were three pedestrian fatalities in 2017 and four in 2016, none from the light rail or a clear suicide. From 2008-2018, there has been an average of 37.9 pedestrian fatalities per year in the state of Minnesota; however, 2016, 2017, and 2018 were all above average years, with 59, 42, and 42 fatalities, respectively. Fatalities are estimated to cost $4,538,000 per death to society (Xie, Ozbay, Kurkcu, & Yang, 2017).

6.1.2.3 Reduced risk

The initial or baseline overall yielding rate was 31.53%, with 51.65% of those yields occurring at greater than 40 feet. There was also an 11.54% % multiple threat pass rate per 20 crossings and 3.54% hard brake rate per 20 crossings. At the final (fourth) wave of enforcement, the overall yielding rate was 62.95% (72.46% at enforcement sites), with 52.38% occurring at greater than 40 feet (60.9% at enforcement sites). There was a 2.33% multiple threat pass rate per 20 crossings and a 2.96% hard braking rate per 20 crossings. This generally reflects an improvement in overall yielding rates and multiple threat pass rates at the measured sites in Saint Paul during the course of the study.

6.1.2.4 Conclusions for benefits

The implementation of the three E’s (i.e., education, engineering, and enforcement) found several positive outcomes in terms of safety and financial benefits. While the costs of education and enforcement were not itemized, the engineering intervention was significantly less expensive than its proven counterparts (e.g., rapid rectangular flashing beacons) in terms of materials and labor costs. Narrower in-street signs (e.g., QWICK KURB™ Slender Bender) that are designed to have improved survivability at crosswalks with high ADT could further reduce these costs in both materials and labor.

Also, benefits were observed in terms of improved safety metrics (e.g., fatalities) and reduced risk to pedestrians. For future attempts in utilizing this implementation, in order to maximize the investment made, the three E’s of education, engineering, and enforcement must be effectively combined. The improvement in stopping percentage and passing percentage was observed not just at the enforcement sites but also through overall metrics (i.e., including generalization sites). Therefore, behavioral change relies on engineering to highlight the presence of the crosswalk and the required stopping behavior, enforcement to highlight the costs of not stopping, and education to broadcast appropriate behaviors throughout the region to the local population via community and media outreach. This systematic integration of activities creates a systematic influence across the community, beyond targeted engineering interventions, to change the culture of driving.

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APPENDIX A: EDUCATIONAL MATERIALS

Flyers distributed to violating drivers

YOU JUST FAILED TO YIELD TO A PEDESTRIAN IN A CROSSWALK

Save a Life
Always Look for Pedestrians!

In Saint Paul, 835 pedestrians were struck by motor vehicles in the past 5 years - *more than 3 crashes every week!*

- **17 died and 747 were injured**
- **87 were children 10 and under**
- **100 were youth ages 11-17**

Minnesota law is clear

✓ Drivers must come to a complete stop for people at or in crosswalks, allowing them to safely cross the street.

✓ **Drivers must <u>not</u> overtake and pass a vehicle stopped for a person at or in a crosswalk. There may be people crossing you can't see!**

✓ Watch your speed. You are less likely to see people crossing the street when you are going too fast.

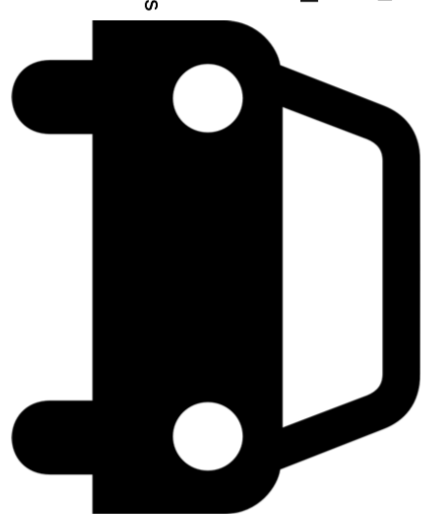
The City of Saint Paul is working to make our streets safer for everyone.

Spread the word about pedestrian safety and be a good role model!

An important traffic safety message from the Saint Paul Police Department

WHEN YOU ARE DRIVING

- Look out for pedestrians everywhere, at all times. Safety is a shared responsibility.
- Use extra caution when driving in hard-to-see conditions, such as nighttime or in bad weather.
- Slow down and be prepared to stop when turning or otherwise entering a crosswalk.
- Stop for people in crosswalks and stop well back from the crosswalk to give other drivers an opportunity to see the crossing person so they can stop too.
- Never pass vehicles stopped at a crosswalk. There may be people crossing that you cannot see.
- Never drive under the influence of alcohol and/or drugs.
- Follow the speed limit, especially around people on the street.
- Follow slower speed limits in school zones and in neighborhoods where there are children present.
- Be extra cautious when backing up – pedestrians can move into your path.



Flyers distributed to Saint Paul Public Schools

NOTICE

Saint Paul Police Department will begin ticketing drivers who do not stop for people in crosswalks starting this coming week.

In Saint Paul, 835 pedestrians were struck by motor vehicles in the past 5 years – *more than 3 crashes every week*!

- **17 died and 747 were injured**
- **87 were children 10 and under**
- **100 were youth ages 11-17**

Minnesota law is clear

✓ Drivers must stop for people crossing in crosswalks. This means coming to a complete stop to allow them to cross.

✓ **Drivers must <u>not</u> overtake and pass a vehicle stopped at a crosswalk. There may be people crossing you can't see!**

✓ Watch your speed. You are less likely to see people crossing the street when you are going too fast.

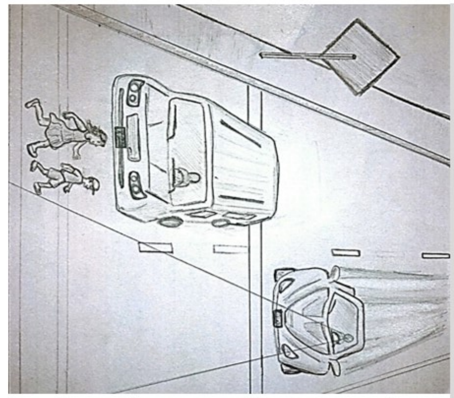
The City of Saint Paul is working to make our streets safer for everyone.

Be a good model, stop for pedestrians, avoid a ticket, and help keep our pedestrians safe!

An important traffic safety message from the Saint Paul Police Department and the City of Saint Paul

Saint Paul Public Schools is not sponsoring, endorsing, or recommending the activities announced in this flyer.

LOOK OUT FOR PEDESTRIANS EVERYWHERE. SAFETY IS A SHARED RESPONSIBILITY.



Pedestrians:

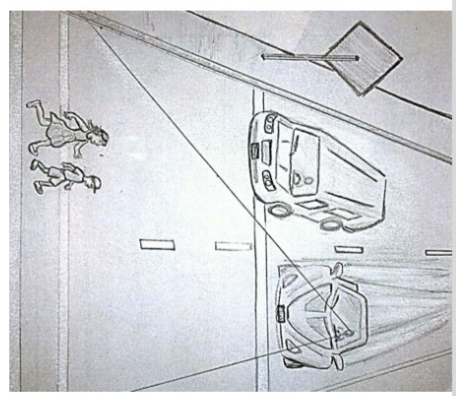
- Be sure to stop and look before stepping out from in front of a vehicle that has stopped for you close to the crosswalk.

Parents:

- Teach your kids to check **every lane** and <u>walk</u>, *never run*, across crosswalks.

Drivers:

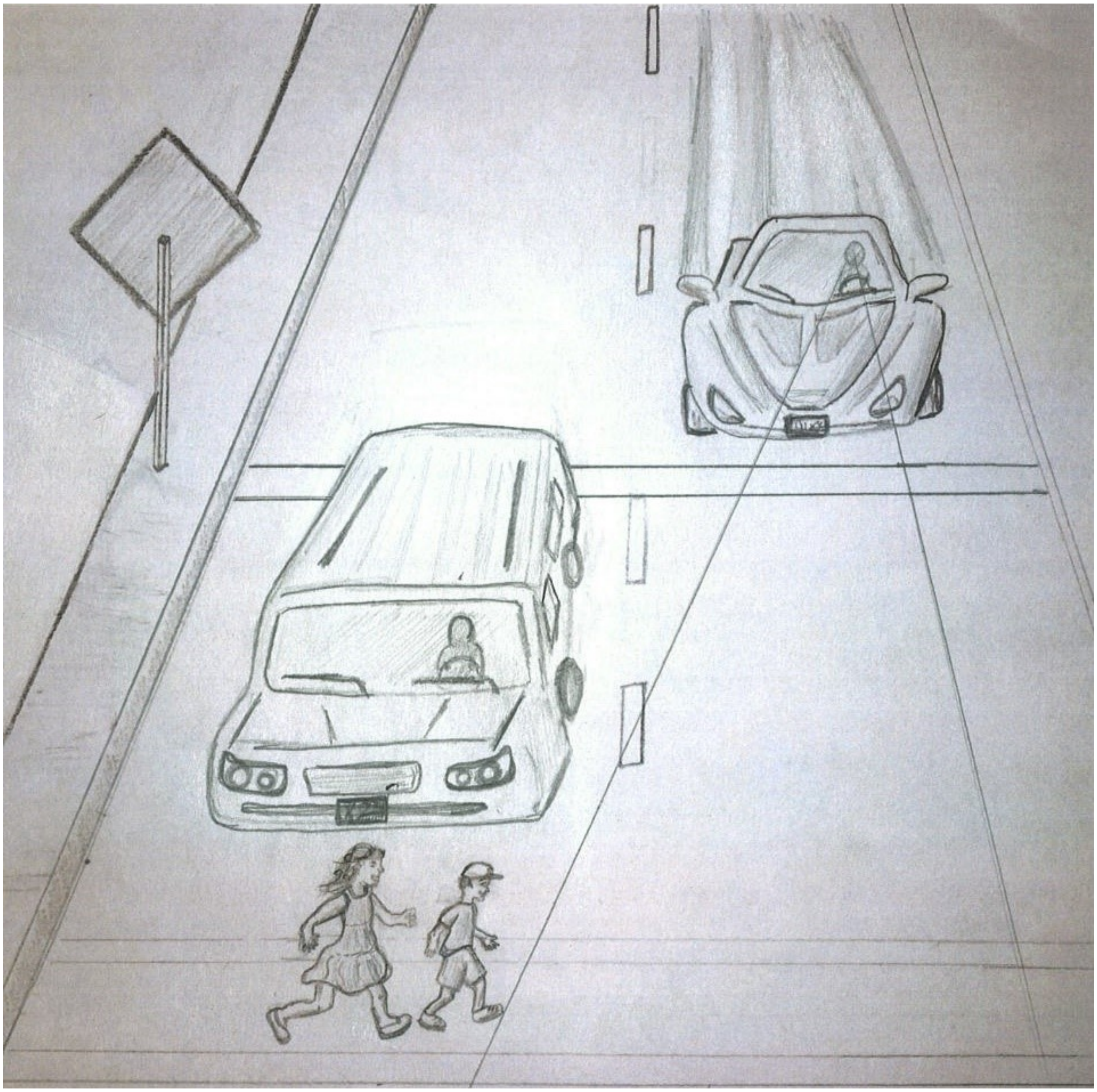
- **Never pass vehicles stopped at a crosswalk. There may be people crossing you can't see.**

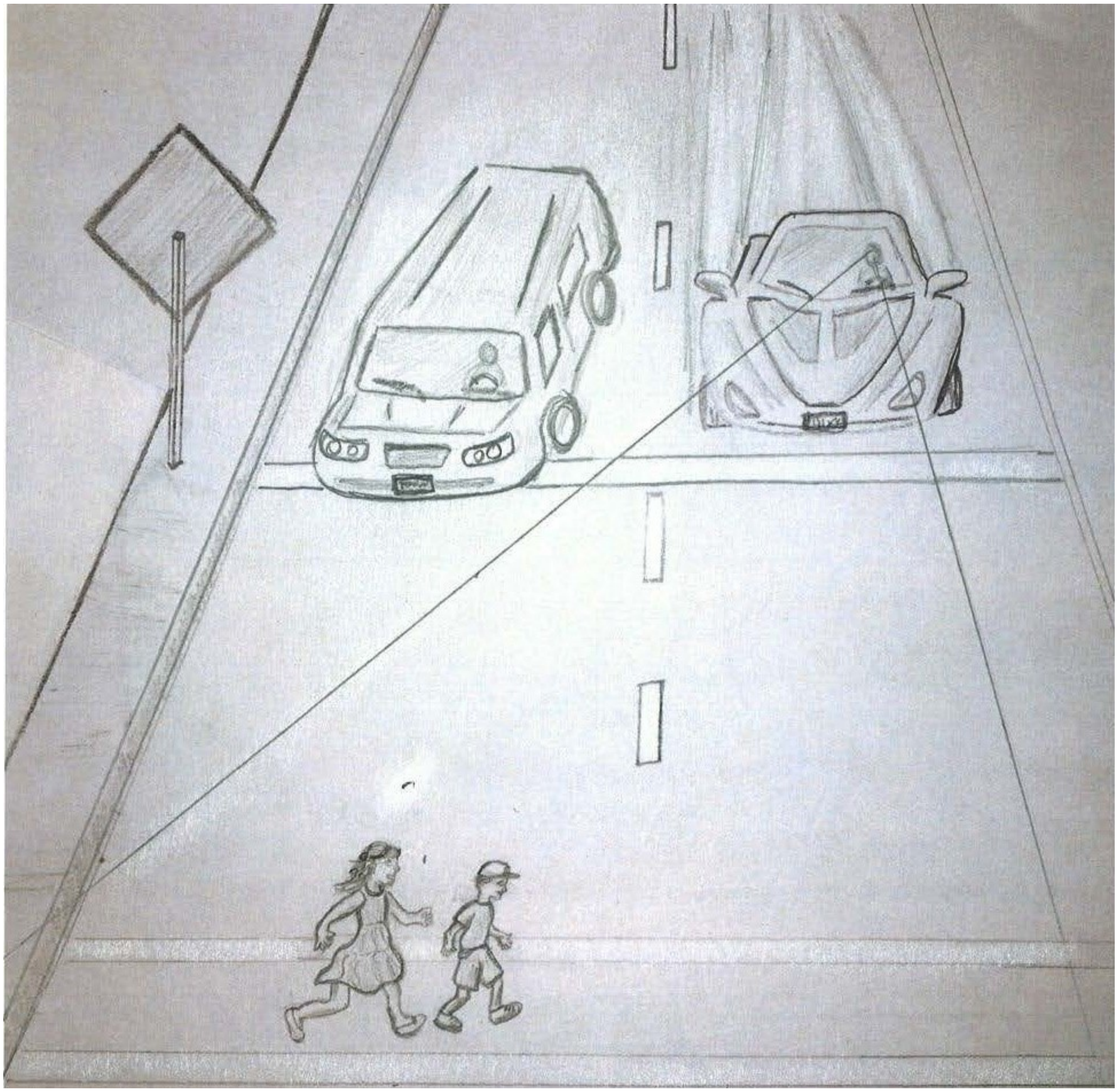


Drivers:

- Stop for people in crosswalks and stop well back to help other vehicles see the crossing person so they can stop too.
- You are more likely to see people crossing the street if you follow the speed limit.
- Slow down and be prepared to stop when turning or otherwise entering a crosswalk.

Flyers stopping distance sketches





Flyers distributed to Saint Paul Private Schools

NOTICE

Saint Paul Police Department will begin ticketing drivers who do not stop for people in crosswalks starting this coming week.

In Saint Paul, 835 pedestrians were struck by motor vehicles in the past 5 years – *more than 3 crashes every week*!

- **17 died and 747 were injured**
- **87 were children 10 and under**
- **100 were youth ages 11-17**

Minnesota law is clear

✓ Drivers must stop for people crossing in crosswalks. This means coming to a complete stop to allow them to cross.

✓ **Drivers must not overtake and pass a vehicle stopped at a crosswalk. There may be people crossing you can't see!**

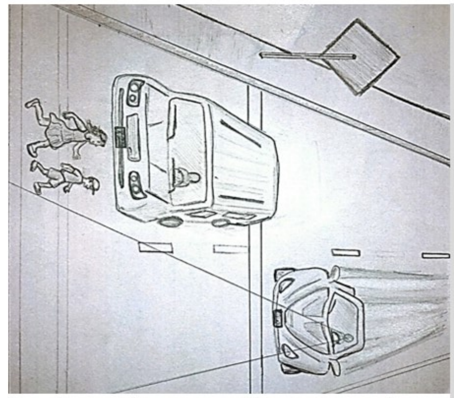
✓ Watch your speed. You are less likely to see people crossing the street when you are going too fast.

The City of Saint Paul is working to make our streets safer for everyone.

Be a good model, stop for pedestrians, avoid a ticket, and help keep our pedestrians safe!

An important traffic safety message from the Saint Paul Police Department and the City of Saint Paul

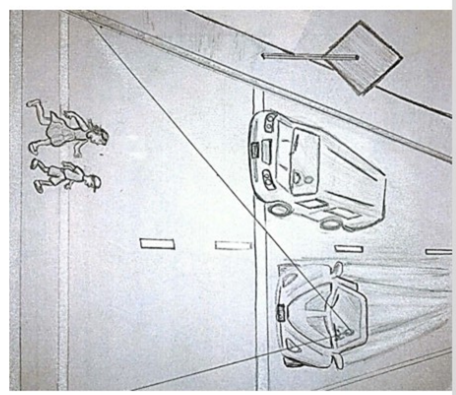
LOOK OUT FOR PEDESTRIANS EVERYWHERE. SAFETY IS A SHARED RESPONSIBILITY.



Pedestrians:
- Be sure to stop and look before stepping out from in front of a vehicle that has stopped for you close to the crosswalk.

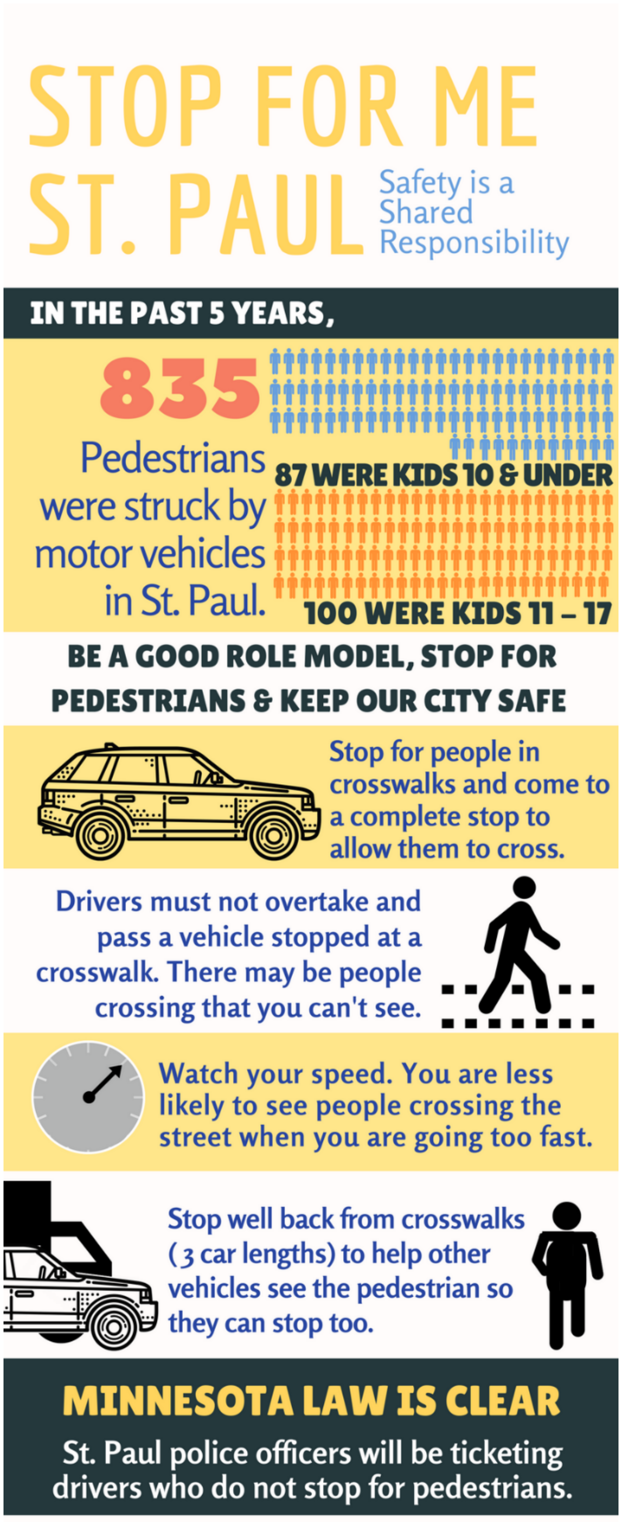
Parents:
- Teach your kids to check **every lane** and walk, *never run*, across crosswalks.

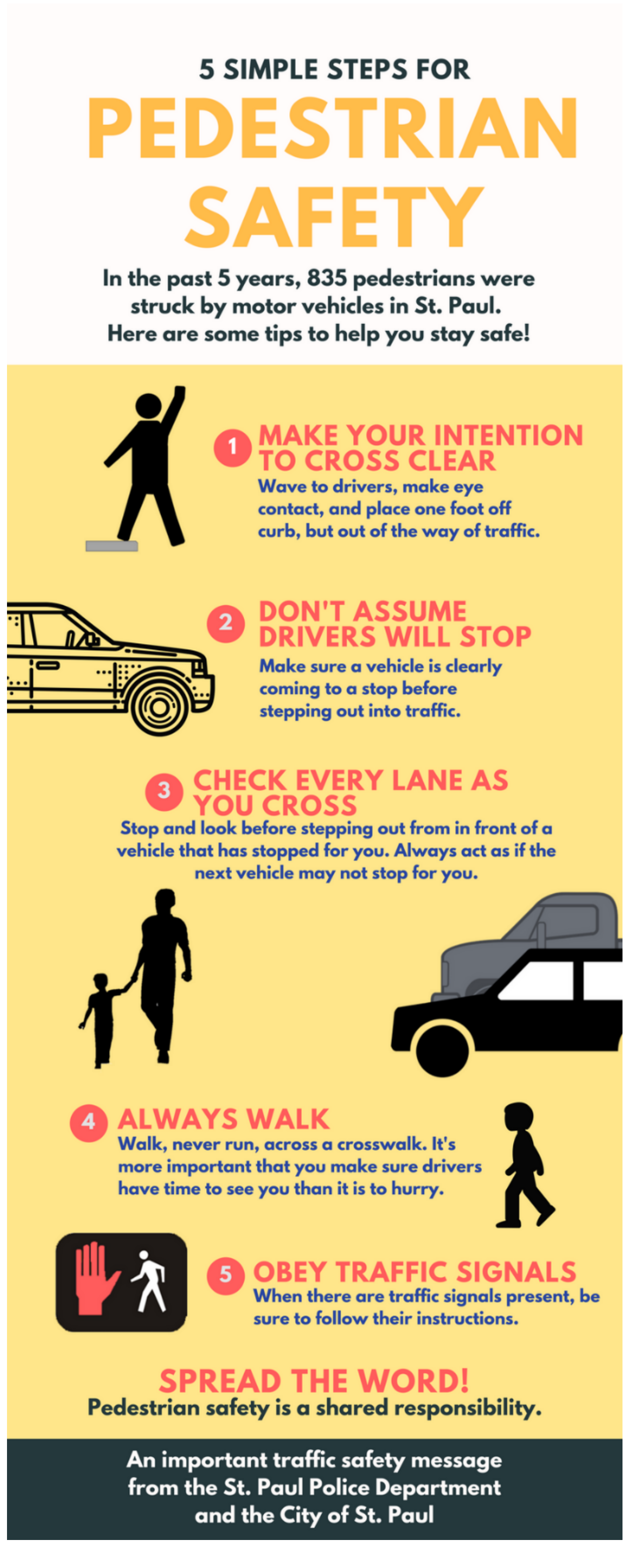
Drivers:
- **Never pass vehicles stopped at a crosswalk. There may be people crossing you can't see.**



Drivers:
- Stop for people in crosswalks and stop well back to help other vehicles see the crossing person so they can stop too.
- You are more likely to see people crossing the street if you follow the speed limit.
- Slow down and be prepared to stop when turning or otherwise entering a crosswalk.

Electronic Infographics (without SPPS disclaimer)





Flyers distributed to community partners

NOTICE

Saint Paul Police Department will begin ticketing drivers who do not stop for people in crosswalks starting this coming week.

In Saint Paul, 835 pedestrians were struck by motor vehicles in the past 5 years – *more than 3 crashes every week*!

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Minnesota law is clear

✓ Drivers must stop for people crossing in crosswalks. This means coming to a complete stop to allow them to cross.

✓ **Drivers must <u>not</u> overtake and pass a vehicle stopped at a crosswalk. There may be people crossing you can't see!**

✓ Watch your speed. You are less likely to see people crossing the street when you are going too fast.

The City of Saint Paul is working to make our streets safer for everyone.

Be a good model, stop for pedestrians, avoid a ticket, and help keep our pedestrians safe!

An important traffic safety message from the Saint Paul Police Department and the City of Saint Paul

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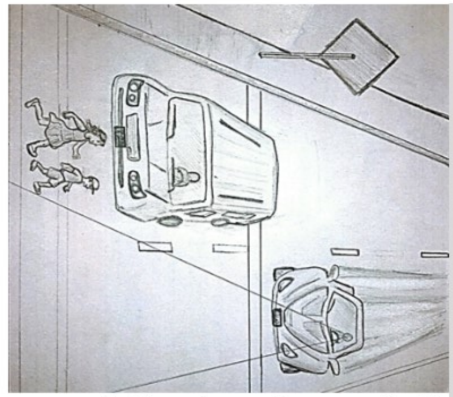
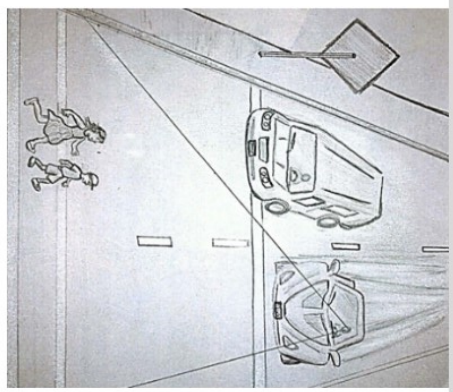


Pedestrians:

- Be sure to stop and look before stepping out from in front of a vehicle that has stopped for you close to the crosswalk.
- Wave to drivers to make yourself visible and make your intent to cross clear.
- Always <u>walk</u>, *never run*, across crosswalks.

Drivers:

- **Never pass vehicles stopped at a crosswalk. There may be people crossing you can't see.**



Drivers:

- Stop for people in crosswalks and stop well back to help other vehicles see the crossing person so they can stop too.
- You are more likely to see people crossing the street if you follow the speed limit.
- Slow down and be prepared to stop when turning or otherwise entering a crosswalk.

APPENDIX B: HUMANFIRST SAFE CROSSING PROTOCOL

Introduction

Pedestrian safety is important for livable communities and relies on the cooperation of drivers to look for and legally stop for pedestrians at crosswalks. This study will measure driver yielding rates in the city of Saint Paul, MN through the use of staged crossings. The safety of the research team is of the utmost importance. Following this protocol is the best way to ensure that our team remains safe and our data quality meets the highest standards.

Staffing Requirements

- Research coding teams must consist of two trained coders who will both alternatively serve as either the staged pedestrian or the recorders. The staged pedestrian will initiate the yield request to on-coming vehicles and cross the street once vehicles yield and the recorder will code the driver behaviors on the coding sheet.
- Both team members should wear solid, weather appropriate clothing (no visible patterns or logos) with jeans and comfortable shoes with little-to-no retroreflective clothing.
- Each member should have a clipboard holding safety protocol and multiple coding sheets and a pencil to take notes and easily correct entry errors. The Safe Crossing Protocol should be taped to the back of the clipboard to easily reference and read aloud.
- Team members must be junior or senior undergraduate students studying in a related field/discipline (e.g., engineering, psychology, urban studies) or professional research staff and who have received in-person training of the procedures.

Coding Session Requirements

- Coding sessions should occur only under clear weather conditions (i.e., not during rain, snow, or icy/wet surface conditions) and during daylight hours (i.e., not during dawn, dusk, or dark conditions).
- Coding sessions should occur between the hours of 8:30 am and 4:00pm to avoid rush hour traffic conditions. Coding sessions should be approved or assigned by supervisors.
- Pavement markings should be visible from recorder coding position. Markings will be spray painted by supervisors at each site prior to data collection. Notify supervisors if markings are no longer fully visible so that they can be re-touched. Markings should be on the curbside to mark "dilemma zone" for both directions of traffic and in-street to mark 10 and 40 feet yielding distances.

General Instructions

- The team member first serving as staged pedestrian will read the ***Safe Crossing Protocol*** aloud to the recorder then proceed with 10 staged crossings.
- The second team member will then assume the role of staged pedestrian by first reading the ***Safe Crossing Protocol*** aloud to the newly assigned recorder before proceeding with the final 10 staged crossings.
- Recorders will follow ***Coding Instructions*** as they observe the staged and natural (*if applicable*) pedestrian crossing

- The coding team will step back to observe and score the vehicle behavior in the presence of any natural pedestrians who initiate a yielding request (i.e., step off or near the edge of the curb) in the presence of oncoming traffic. Each code-able natural pedestrian crossings will take the place of a planned staged crossing.

Safe Crossing Instructions

All crossing should follow the standard safe crossing protocol. The safety crossing protocol involves the following procedure:

Step 1: Place one foot into the crosswalk, and do not take additional steps until a vehicle yields or a sufficient gap presents itself.

> Place one foot when the car is just beyond the marked "dilemma" zone. If there is on street parking, you will need to step out to the edge of parked cars if cars are parked close to the crosswalk.

Step 2: If the vehicle makes no attempt to stop, do not proceed to cross.

> If the vehicle is traveling at excessive speeds or is traveling close to the curb face or parking lane, step back as the vehicle approaches.

Step 3: If the vehicle clearly begins to yield and the next lane is free, begin lane crossing.

> Wave to the first yielding vehicle to give indication of your intention to cross and thank them for stopping. **NOTE: If you see a vehicle rapidly approaching the stopped vehicle in the same lane ensure it comes to a safe stop before proceeding into the lane of the stopped vehicle.**

Step 4: On multilane roads, **always stop at the lane line, make sure the next lane is clear.**

> This step is essential to prevent the possibility of being involved in a Multiple Threat crash. **Looking is not enough because you have a limited reaction time and if crossing at a normal speed, you will not be able to react in time unless you stop. Get into the habit of making a brief stop even if the car yields further back.**

Step 5: If the vehicle yields in the next lane of multilane roads, wave to the vehicle and proceed to the centerline or median.

Step 6: At four lane roads with a median or pedestrian refuge island treat the second half of the crossing the same as the first half.

That is place, a foot in the crosswalk and wait for any oncoming cars to yield before entering the lane. At four lane roads without a median or pedestrian refuge island, stop at the lane edge and wait for any oncoming traffic to yield before crossing the centerline.

Step 7: If a large gap appears in traffic, proceed through the crosswalk and do not wait.

Safe Crossing Protocol

This protocol should be read aloud before each staff members serves as the staged pedestrian for each coding section (i.e., 10 staged crossings).

- Always stay alert and be aware of traffic from all sides and all lanes.
- Follow the Safety Crossing Instructions closely.
- Always ensure that the oncoming vehicle is clearly yielding or stops before proceeding.
- Make eye contact and signal to the driver that you intend to cross in front of them.
- Do not put yourself in an unsafe situation. If a vehicle is traveling too fast or too close, step back to a safe position.
- On multi-lane roads, always stop at the lane line, search and make sure the next lane is clear.
- Above all, do not attempt to cross if it cannot be done safely!

<u>Coding Instructions</u>

Use for both staged and natural pedestrian crossings

Step 1: Place yourself according to your training in a position away from the crosswalk, as to not give false indication of an intention to cross, but where you are able to view the movements of the staged pedestrian and "dilemma zone" markings for both direction of travel. You should be able to see in-street markings from this position as well.

Step 2: Observe vehicles approaching from the lanes of travel on the pedestrian's side of the street.

- Any vehicle approaching which is on the <u>outside</u> of the "dilemma zone" marking once the staged pedestrian steps off the curb should be coded. If the vehicle makes no attempt to stop, score it as "**Cars Not Yielding**". Any subsequent vehicles which do not stop should also be scored as "**Cars Not Yielding**".
- Any vehicles that are <u>inside</u> the "dilemma zone" when the pedestrian steps off the curb should not be scored if they do not stop, but can be scored if they chose to yield (see Step 3).

Step 3: Once a vehicle stops at the crosswalk, score them as "yielding" in one of the *Distance Cars Yielded* from Crosswalk bins:

- If no in-street dots are visible (i.e., they are stopped very close to the crosswalk), score them in the "**Less than 10ft**" yielding bin.
- If one in-street dot is visible (i.e., stopped slightly further back from the crosswalk), score them in the "**10-40ft**" yielding bin.
- If two in-street dots are visible (i.e., stopped at a distance back from the crosswalk), score them in the "**More than 40ft**" yielding bin.

Step 4: On multilane roads, if a vehicle yields in one lane and other vehicles in the same direction of travel do not stop, score them as "**Cars Not Yielding**" <u>and</u> make note of each one in the "**Pass**" bin under the Multiple Threat Conflicts.

Step 5: If one of the vehicle brakes hard (e.g., audible tires screech or visible downward vehicle nose), score it as "**Hard Brake**" under the Multiple Threat Conflicts section.

Step 6: Score vehicles in the opposing lane of travel in the same manner as the first direction. Begin scoring vehicles outside of "dilemma zone" once the pedestrian has either been yielded to in all lanes in the first direction of the roadway or has a large gap and is proceeding to walk across the opposite lanes of travel. If the vehicles in the opposite lane of travel do not yield so that the pedestrian is forced to stand on the centerline with vehicles moving in both lanes of travel, code this event as "**Trapped**"

Step 7: If the pedestrian (most likely natural ped) must move themselves out of harm's way to avoid a vehicle (e.g., step back out of the road, or move quickly forward to avoid the vehicle), then code it as an "**Evasive Action: Ped**", if a vehicle must quickly swerve to avoid the pedestrian or another yielding vehicle, then code it as an "**Evasive Action: Veh**"

Step 8: Importantly, you serve as a second set of eyes to help keep your partner safe. If the staged pedestrian fails to follow protocol (e.g., does not stop at lane's edge or check for Multiple Threat Conflicts), code the crossing under "**Failure in Protocol**". Give real-time feedback to your partner and review protocol with them. Alert supervisors for any safety concerns you have about safety training of you or your partners or of specific crosswalks.

APPENDIX C: DATA CODING SHEET

Location: ____

Describe condition: ______________________ Coder #1__________ Coder #2__________

Date: ________________ Start Time:__________ Stop Time:__________

	Staged Crossings	Cars Not Yielding	Distance Cars yielded from crosswalk: Less than 10 ft	Distance Cars yielded from crosswalk: Between 10 ft - 40	Distance Cars yielded from crosswalk: More than 40 ft	Multiple Threat Conflict: Pass	Multiple Threat Conflict: Hard Brake	Evasive Action: Ped	Evasive Action: Veh	Trap	Failure in Protocol
Staged Pedestrian #1	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10										
Staged Pedestrian #2	11										
	12										
	13										
	14										
	15										
	16										
	17										
	18										
	19										
	20										
TOTAL											
Percent											

	Natural Crossings	Cars Not Yielding	Distance Cars yielded from crosswalk: Less than 10 ft	Distance Cars yielded from crosswalk: Between 10 ft - 20	Distance Cars yielded from crosswalk: More than 40 ft	Multiple Threat Conflict: Pass	Multiple Threat Conflict: Hard Brake	Evasive Action: Ped	Evasive Action: Veh	Trap	Failure in Protocol
Natural Pedestrians	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10										
TOTAL											
Percent											

APPENDIX D: STUDY HANDOUT TO COMMUNITY

Pedestrian Safety Study

This study aims to add value to livable communities in St. Paul

1) We are working to analyze the effectiveness of previous and newly implemented treatments to improve *safe yielding to pedestrians* and *lower speeds*
2) We are looking at many sites across the city to determine if city-wide changes are occurring
3) We will be looking at sites for over a year to see if long-term improvements in pedestrian safety have occurred

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University of Minnesota
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APPENDIX E: OFFICER TRAINING WORKSHOP PRESENTATION

Courtesy Promotes Safety

Crosswalk Enforcement Program

Welcome and Introductions

Many Say Pedestrian Safety is a Shared Responsibility

The Problem: Each Year

- ✓ Pedestrian fatalities and injuries represent a growing percentage of all traffic fatalities and injuries
- ✓ In the US, almost 6000 pedestrians were killed and about 80,000 were injured in 2016
- ✓ Nearly 75% in urban areas

Pedestrian Related Causes

- ✓ Darting out or forced yield
- ✓ Crossing against traffic signal
- ✓ Inattention
- ✓ Alcohol

Driver Related Causes

- ✓ Failure to look for pedestrians
- ✓ Failure to yield to pedestrians
- ✓ Excessive speed
- ✓ Driver inattention
- ✓ Alcohol

Crashes in St. Paul

- ✓ In Saint Paul 706 pedestrians struck in last five years.
- ✓ That amounts to almost 3 pedestrians struck per week.
- ✓ 18 pedestrians were killed in the last five years and 65 received a serious injury.

An Important Rule

- ✓ If people understand the problem and agree that it should be solved, your job is a lot easier
- ✓ If they think it's a bunch of crap, it will be hard to change their behavior

Changing the Community Safety Culture

- ✓ The values piece (a motivating operation)
- ✓ Focus on one thing
- ✓ Keep all elements focused on that one thing
- ✓ Approach the problem from many direction
- ✓ Keep materials simple

Three Legged Stool

- ✓ Enforcement
- ✓ Engineering
- ✓ Education

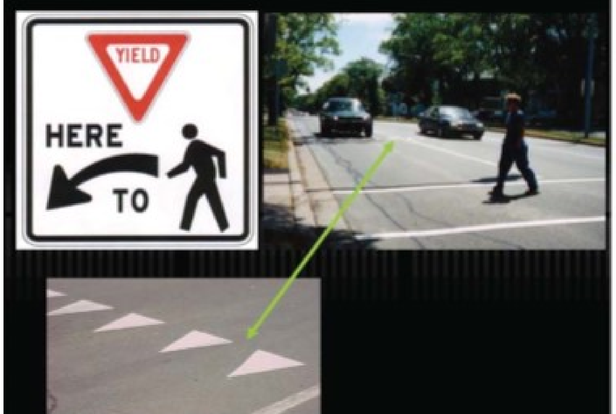
Due Care Provisions

- ✓ Although motorists may have right-of-way, they never have right to hit pedestrian if they could have avoided the crash
- ✓ Driver inattention and excessive speed are few of factors to consider
- ✓ Reckless Endangerment if they pass a vehicle stopped for a pedestrian at a crosswalk at speed

LOW COST ENGINEERING

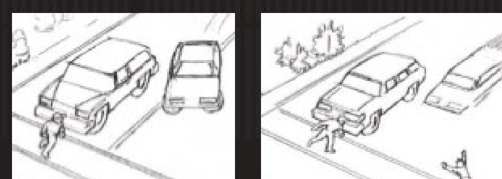
Low Cost Engineering at Uncontrolled Crosswalks - RRFB

Raised Medians and Refuge Islands

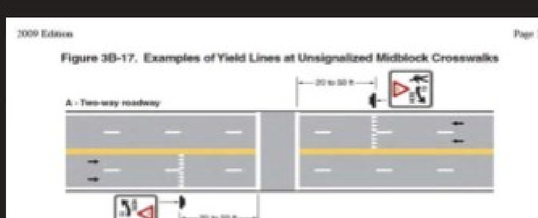


Most Important

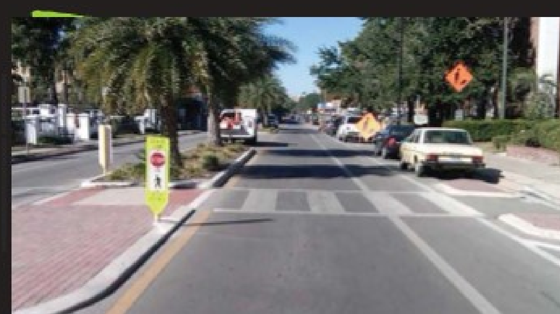
Drivers may not overtake other drivers stopped at marked or unmarked crosswalk



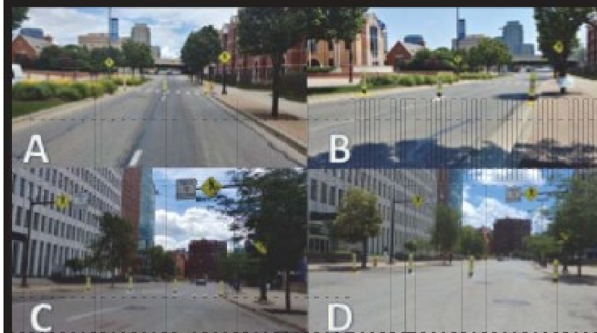
Prior to Beginning we Refreshed Crosswalk and Added Advance Stop/Yield Markings

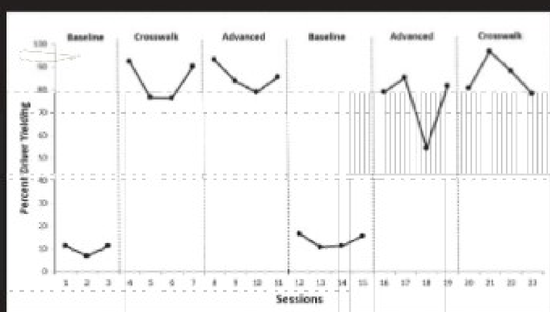


In-Street Signs

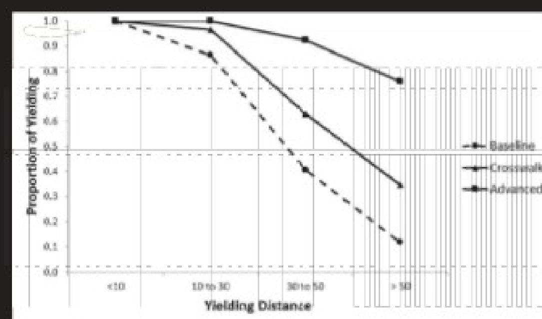


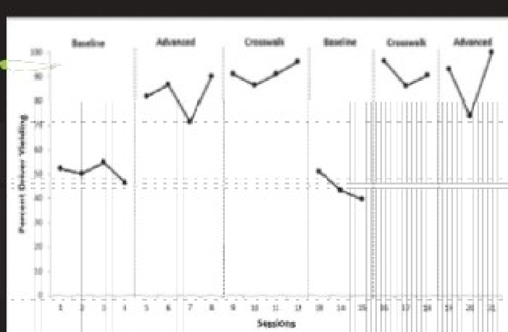
Gateway Treatment of In-Street Signs



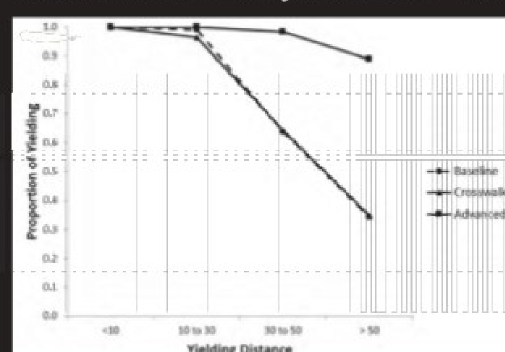


Data from two-way multilane site





Data from one-way multilane site



EDUCATION

Earned Media: Are You the Center of Your Media Market?

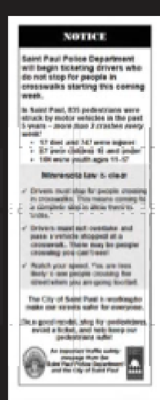
- ✓ You need new things to get media attention
- ✓ It works best if your city is the center of the media market rather than on the periphery

Earned Media

Month	The Gainesville Sun	T.V. News	Radio	UF News
February	3	3	2	
March	1		1	1
April	2			
May	1			
June	1			
July	1			
August		1		
September	2			
October				
November				
December				

1. Warnings distributed to residents just prior to the beginning of the first wave (warnings) and second wave (citations)
2. Earned attention by media (make it interesting and the media will come!)
3. Large highway feedback signs (social norming and implied enforcement)
4. Partnerships between city agencies and community partners

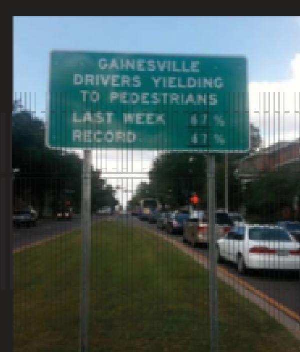
"Heads Up" To Community


NOTICE

Saint Paul Police Department will begin ticketing drivers who do not stop for people in crosswalks starting this coming week.

Minnesota law is clear

Social Norming Feedback Signs Speeding, Seatbelt Use, and Yielding to Pedestrians



HIGH VISIBILITY ENFORCEMENT

The Need for Enforcement

- ✓ Rules not enforced are often ignored
- ✓ Enforcement give credibility to engineering and education efforts
- ✓ Enforcement increases compliance and awareness
- ✓ Following the rules increases safety

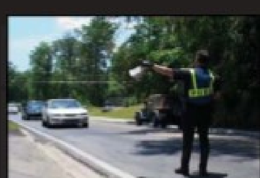
Pedestrian Enforcement

The problem

- ✓ Subjectivity of failure to yield
- ✓ The issue of shared responsibility
- ✓ Down time while team waits for pedestrians to cross
- ✓ Drivers and pedestrians generally unaware of the law or have a pattern of violating them

The Solution at Uncontrolled Crosswalks

- ✓ Operational definition of failure to yield and specific standardized procedure
- ✓ Use decoy pedestrians
- ✓ Warning flyers to inform about law and magnitude of the problem



Operational Definition of Not Yielding

- ✓ We use the signal timing formula used to time yellow duration to calculate the dilemma zone.
- ✓ If a driver can avoid running a light they can yield.
- ✓ We place a cone at the location

The Signal Timing Formula:
Time = signal clearance interval in seconds

Time = t + v/(2a +2Gg)

- t = driver reaction time
- v = vehicle velocity
- a = safe deceleration rate
- G = gravitational constant
- g = grade of road

The time is multiplied by the posted speed to calculate the distance.

The driver must be just beyond this spot called the dilemma zone when the pedestrian enters the crosswalk for a valid stop.

Assuming no grade

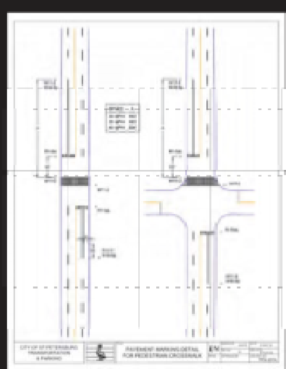
Speed Limit (mph)	15	20	25	30	35	40
Distance (ft)	46	73	104	141	183	234

Assuming no significant grade, table shows cone placement distance based on vehicle speeds

Distances measured from nearest crosswalk line to where cone is to be placed

These distances hold for dry pavement and daylight

Marking to Define Dilemma Zone



Decoy Pedestrian

- ✓ Crosses in a standard way in accordance with the pedestrian statues
- ✓ Also crosses in a safe manner

Standard Crossing Protocol

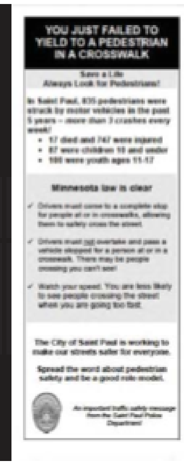
- ✓ Start to cross only when vehicle is close to but has not yet reached the cone.
- ✓ Begin by placing one foot off curb between crosswalk lines
- ✓ Do not begin to cross in front of vehicle unless driver is clearly slowing to yield for you.
- ✓ If a gap appears finish crossing

Multilane Roads

- ✓ If a vehicle yields close to crosswalk do STOP AND LOOK WHEN YOU REACH THE LANE LINE before proceeding
- ✓ Passing a stopped vehicle at a crosswalk is an infraction. Cite people who do this.

Impact Multiplier 1. Use of Warnings

- ✓ Warnings allow more stops
- ✓ Warning flyers help to sell the program
- ✓ Warnings allow a transition from no enforcement to enforcement of rules



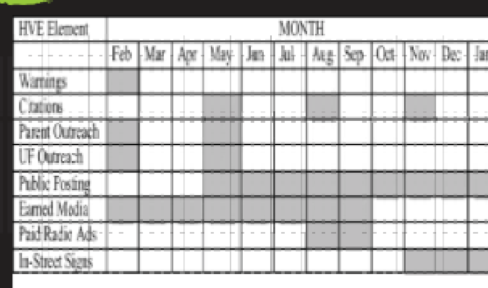
Impact Multiplier 2. Signs That Clearly Delineate What Law is Being Enforced

Suggested Script

You failed to stop for a pedestrian in a crosswalk. We are working to make walking safer in St. Paul and we need your help. Be a good model and tell your friends to look out for pedestrians in crosswalks. Driver don't hit people if they see them and you don't see them unless you look for them.

Another Idea: Screen sign on Police Cruisers

Treatment Strategy



Common Excuses

I did not see the pedestrian

The Pedestrian Was Not In The Crosswalk

20

Didn't Know I Had To Yield

They Don't Even Yield To A Blind Pedestrian!

Pedestrians Offences

- ✓ That cross against traffic signal
- ✓ That cross when drivers have protected left turn arrow
- ✓ Cross midblock **and** disrupt traffic
- ✓ Cross between two consecutive signals

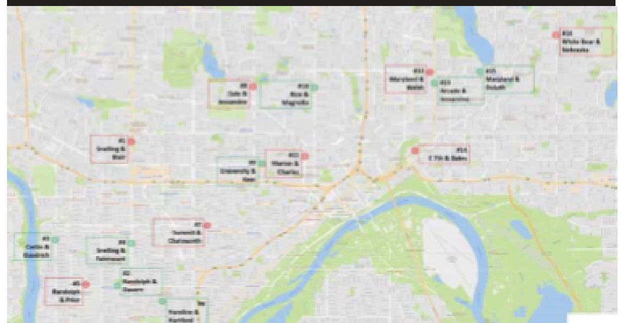
Why Focus First on Drivers?

- ✓ Pedestrians include children, youth, persons with disabilities, and seniors who can not drive. Drivers are expected to meet a higher standard
- ✓ Pedestrians are the vulnerable road user, they are most at risk
- ✓ Pedestrians can't be expected to use crosswalks if drivers do not yield at crosswalks

Selling The Program

- ✓ Information on seriousness of problem
- ✓ Information on objectivity is built into the operation
- ✓ Information on why greater focus is on the driver
- ✓ Support your case with videos

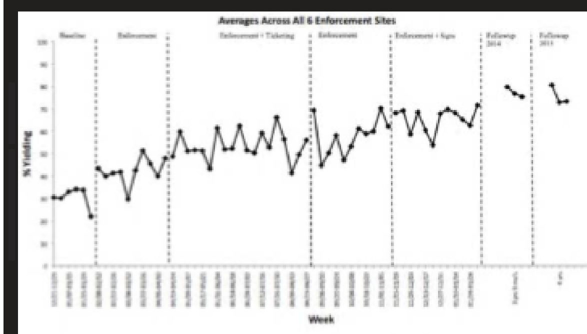
Distribution of Sites



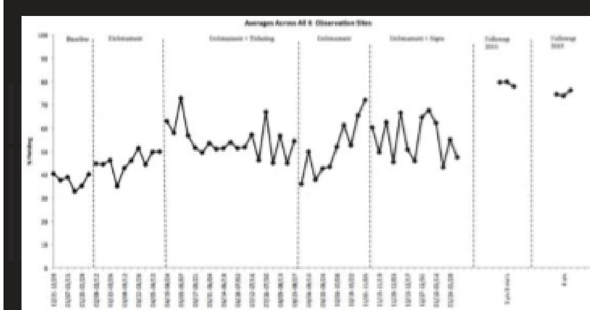
How Well Does it Work (Baseline)

Street Name	Cross Street	% Yielding	% Passing	Street Name	Cross Street	% Yielding	% Passing
7th Street	Bates	23	11	Randolph	Davern	43	4
Arcade	Jessamine	24	3	Randolph	Prior	30	11
Cretin	Goodrich	42	16	Rice	Magnolia	32	4
Dale	Jessamine	17	24	Snelling	Blair	30	36
Hamline	Hartford	48	6	Snelling	Fairmount	51	23
Marrion	Charles	27	12	Summit	Chatsworth	46	2
Maryland	Duluth	32	0	University	Kent	34	13
Maryland	Walsh	19	1	White Bear	Nebraska	23	6

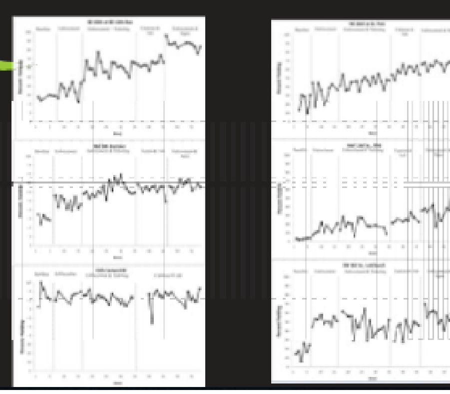
Weekly yielding at Weekly yielding at Enforcement sites

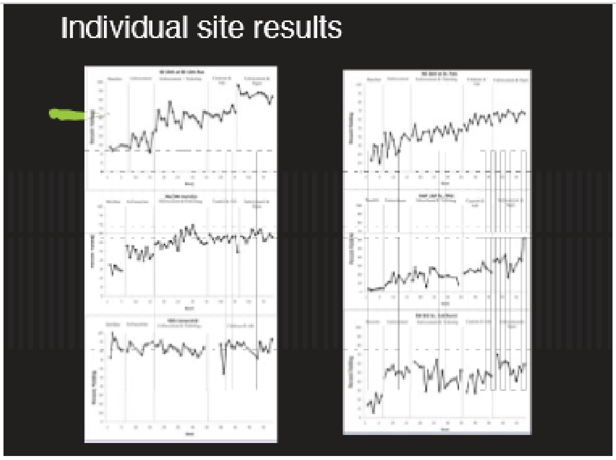


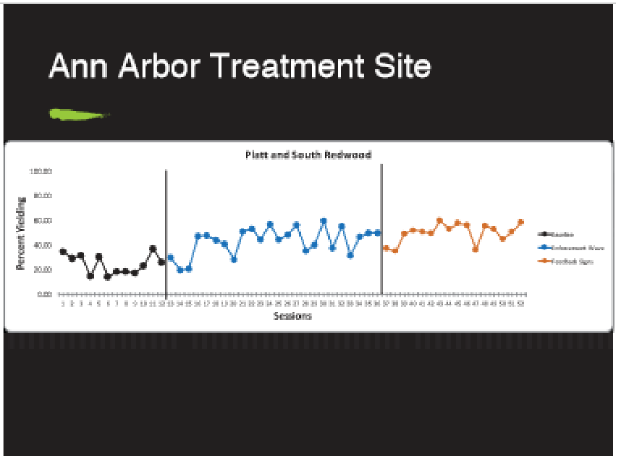
Weekly yielding at Sites That Did Not Receive Enforcement

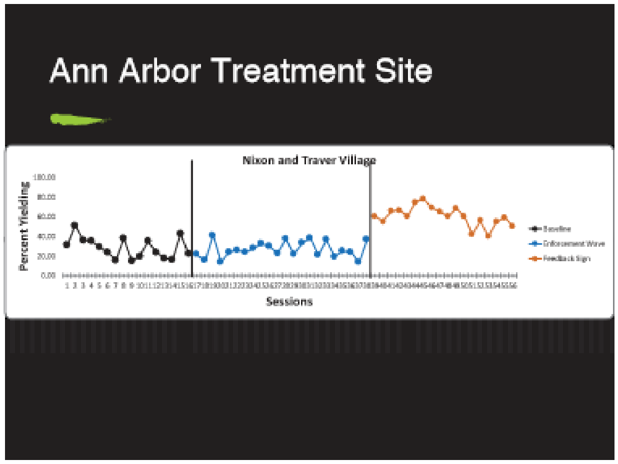


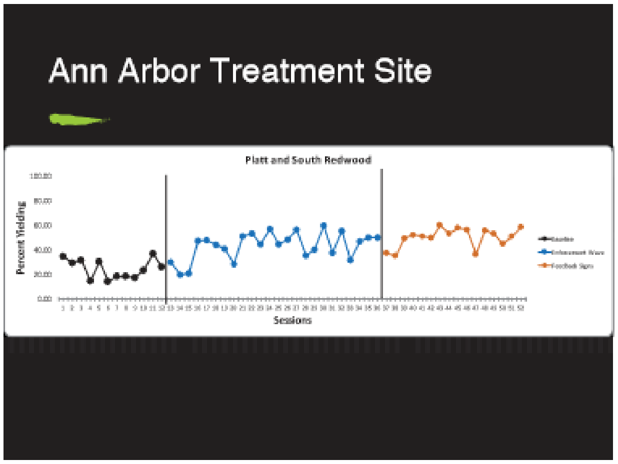
Individual site results

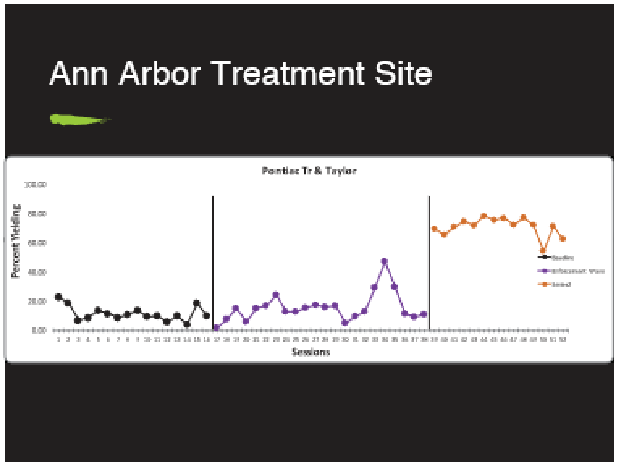


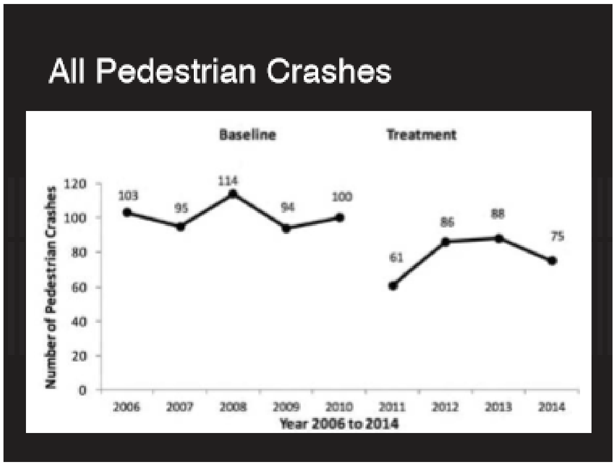

Individual site results


Ann Arbor Treatment Site
Platt and South Redwood
Percent Yielding
Sessions


Ann Arbor Treatment Site
Nixon and Traver Village
Percent Yielding
Sessions
Baseline
Enforcement Wave
Feedback Sign


Ann Arbor Treatment Site
Platt and South Redwood
Percent Yielding
Sessions


Ann Arbor Treatment Site
Pontiac Tr & Taylor
Percent Yielding
Sessions


All Pedestrian Crashes
Baseline
Treatment
Number of Pedestrian Crashes
103
95
114
94
100
61
86
88
75
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year 2006 to 2014

Orange City Story

- ✓ At that time 10,000 people
- ✓ Hitting a dozen children a year going to and from school
- ✓ No sidewalks
- ✓ People in a hurry to get to work and drop children off at school

---

- ✓ Warning flyers gave reasons why drivers should not speed
- ✓ Featured that two children had been struck
- ✓ Asked them to be good models

IT DOESN'T MAKE SENSE TO SPEED ON MOUNT EDWARD ROAD

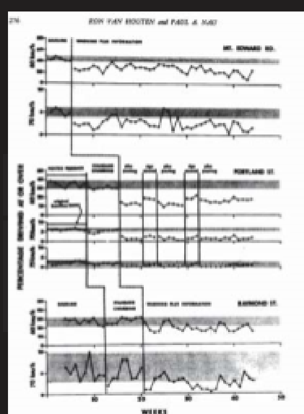
DAMAGE TO VEHICLES WAS WORTH OVER $14,275.

THE TWO PEDESTRIANS INJURED ON MOUNT EDWARD ROAD LAST YEAR WERE CHILDREN

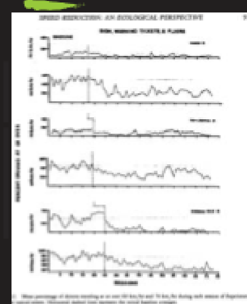
AT THE SPEED YOU WERE GOING

SLOW DOWN

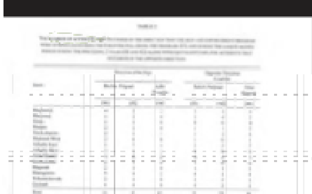
- ✓ Speed reductions for a 1 week program with large numbers of stops produced effects that persisted for a year
- ✓ Combining the program with posted feedback produced even larger reductions

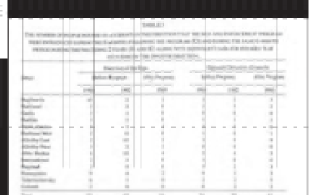


Replicated in Israel



Crash Reduction





Advance preparation checklist

- ❑ Support from command staff
- ❑ Support from government
- ❑ Briefing traffic magistrates
- ❑ Support from the public
- ❑ Briefing the public through press release

Materials Checklist

- ❑ Four cones, card with placement distances and violation statute numbers
- ❑ Measuring wheel or laser radar
- ❑ Enforcement flyers
- ❑ Radios and predetermined frequency selected
- ❑ Reflective vests
- ❑ Clipboards, log sheets

1st Site – Summit Ave at Chatsworth Two Lane, Speed Limit 30 mph

2nd Site – Maryland Ave E. at Walsh Three Lane, Speed Limit 30 mph

3rd Site Dale St N. at Jessamine Four Lane, Speed Limit 30 mph

Questions?

Debrief

APPENDIX F: AVERAGE BASELINE SCORES SEPARATED BY SITE

		Mean	Std. Deviation
Not Yielding Percent	**7th & Bates**	77.38	11.74
	Arcade & Jessamine	76.27	8.94
	Cretin & Goodrich	57.59	18.09
	Dale & Jessamine	83.49	6.13
	Hamline & Hartford	52.34	10.67
	Marion & Charles	72.76	8.44
	Maryland & Duluth	67.65	13.08
	Maryland & Walsh	81.03	7.13
	Randolph & Davern	57.21	13.19
	Randolph & Prior	70.03	13.55
	Rice & Magnolia	67.59	14.55
	Snelling & Blair	69.81	11.28
	Snelling & Fairmount	49.27	10.46
	Summit & Chatsworth	53.98	11.05
	University & Kent	65.94	8.05
	White Bear & Nebraska	77.23	4.61
Cars Yielding Percent	**7th & Bates**	22.62	11.74
	Arcade & Jessamine	23.73	8.94
	Cretin & Goodrich	42.41	18.09
	Dale & Jessamine	16.51	6.13
	Hamline & Hartford	47.66	10.67
	Marion & Charles	27.24	8.44
	Maryland & Duluth	32.35	13.08
	Maryland & Walsh	18.97	7.13
	Randolph & Davern	42.79	13.19
	Randolph & Prior	29.97	13.55
	Rice & Magnolia	32.41	14.55
	Snelling & Blair	30.19	11.28
	Snelling & Fairmount	50.73	10.46
	Summit & Chatsworth	46.02	11.05
	University & Kent	34.06	8.05
	White Bear & Nebraska	22.77	4.61

		Mean	Std. Deviation
Cars Yielding < 10 ft. Percent	**7th & Bates**	8.63	6.55
	Arcade & Jessamine	3.29	4.47
	Cretin & Goodrich	6.04	6.92
	Dale & Jessamine	3.78	5.86
	Hamline & Hartford	3.57	7.14
	Marion & Charles	3.49	3.78
	Maryland & Duluth	5.29	4.82
	Maryland & Walsh	2.35	2.99
	Randolph & Davern	0.00	0.00
	Randolph & Prior	5.29	4.32
	Rice & Magnolia	4.00	8.94
	Snelling & Blair	1.83	2.49
	Snelling & Fairmount	1.92	3.45
	Summit & Chatsworth	7.83	1.12
	University & Kent	2.28	3.92
	White Bear & Nebraska	1.59	4.20
Cars Yielding btw 10 to 40 ft. Percent	**7th & Bates**	45.37	12.33
	Arcade & Jessamine	36.85	14.51
	Cretin & Goodrich	37.41	22.01
	Dale & Jessamine	51.10	18.37
	Hamline & Hartford	39.47	29.86
	Marion & Charles	15.61	11.02
	Maryland & Duluth	31.21	6.28
	Maryland & Walsh	34.97	16.46
	Randolph & Davern	29.21	13.93
	Randolph & Prior	47.07	13.13
	Rice & Magnolia	27.74	30.71
	Snelling & Blair	16.89	13.12
	Snelling & Fairmount	39.32	10.32
	Summit & Chatsworth	52.65	8.81
	University & Kent	47.65	17.87
	White Bear & Nebraska	30.68	13.37

		Mean	Std. Deviation
Cars Yielding > 40 ft. Percent	**7th & Bates**	46.00	11.02
	Arcade & Jessamine	52.29	22.54
	Cretin & Goodrich	36.55	23.01
	Dale & Jessamine	38.32	21.91
	Hamline & Hartford	56.95	23.80
	Marion & Charles	55.90	35.10
	Maryland & Duluth	55.34	22.51
	Maryland & Walsh	62.67	16.43
	Randolph & Davern	70.79	13.93
	Randolph & Prior	47.64	15.78
	Rice & Magnolia	28.26	32.23
	Snelling & Blair	59.05	34.31
	Snelling & Fairmount	58.75	11.84
	Summit & Chatsworth	39.53	8.51
	University & Kent	45.72	22.60
	White Bear & Nebraska	59.51	25.67
MT Pass Percent	**7th & Bates**	11.00	8.22
	Arcade & Jessamine	2.76	5.42
	Cretin & Goodrich	16.18	19.69
	Dale & Jessamine	24.00	18.17
	Hamline & Hartford	6.25	12.50
	Marion & Charles	11.73	11.44
	Maryland & Duluth	0.00	0.00
	Maryland & Walsh	0.71	1.89
	Randolph & Davern	3.57	7.14
	Randolph & Prior	11.44	9.36
	Rice & Magnolia	4.00	6.52
	Snelling & Blair	36.14	25.70
	Snelling & Fairmount	23.13	11.67
	Summit & Chatsworth	2.00	4.47
	University & Kent	12.50	11.73
	White Bear & Nebraska	6.43	6.90

		Mean	Std. Deviation
MT Hard Brake Percent	7th & Bates	7.00	4.47
	Arcade & Jessamine	2.11	2.63
	Cretin & Goodrich	4.26	5.88
	Dale & Jessamine	1.00	2.24
	Hamline & Hartford	3.57	7.14
	Marion & Charles	6.16	5.14
	Maryland & Duluth	1.63	2.52
	Maryland & Walsh	3.54	4.75
	Randolph & Davern	0.00	0.00
	Randolph & Prior	3.36	4.34
	Rice & Magnolia	5.86	6.28
	Snelling & Blair	4.17	3.31
	Snelling & Fairmount	4.68	2.67
	Summit & Chatsworth	4.31	5.96
	University & Kent	3.33	6.06
	White Bear & Nebraska	0.71	1.89
Ped Evade Percent	7th & Bates	1.00	2.24
	Arcade & Jessamine	0.00	0.00
	Cretin & Goodrich	1.18	2.63
	Dale & Jessamine	0.00	0.00
	Hamline & Hartford	0.00	0.00
	Marion & Charles	0.00	0.00
	Maryland & Duluth	0.00	0.00
	Maryland & Walsh	0.00	0.00
	Randolph & Davern	0.00	0.00
	Randolph & Prior	1.25	2.50
	Rice & Magnolia	0.00	0.00
	Snelling & Blair	0.00	0.00
	Snelling & Fairmount	0.00	0.00
	Summit & Chatsworth	0.80	1.79
	University & Kent	0.00	0.00
	White Bear & Nebraska	0.00	0.00

		Mean	Std. Deviation
Veh Evade Percent	**7th & Bates**	0.00	0.00
	Arcade & Jessamine	0.00	0.00
	Cretin & Goodrich	1.00	2.24
	Dale & Jessamine	0.00	0.00
	Hamline & Hartford	0.00	0.00
	Marion & Charles	0.63	1.77
	Maryland & Duluth	0.00	0.00
	Maryland & Walsh	0.00	0.00
	Randolph & Davern	0.00	0.00
	Randolph & Prior	0.00	0.00
	Rice & Magnolia	0.00	0.00
	Snelling & Blair	0.00	0.00
	Snelling & Fairmount	0.00	0.00
	Summit & Chatsworth	0.00	0.00
	University & Kent	0.83	2.04
	White Bear & Nebraska	0.00	0.00
Trap Percent	**7th & Bates**	0.00	0.00
	Arcade & Jessamine	0.00	0.00
	Cretin & Goodrich	0.00	0.00
	Dale & Jessamine	1.00	2.24
	Hamline & Hartford	0.00	0.00
	Marion & Charles	0.00	0.00
	Maryland & Duluth	0.00	0.00
	Maryland & Walsh	0.71	1.89
	Randolph & Davern	0.00	0.00
	Randolph & Prior	0.00	0.00
	Rice & Magnolia	0.00	0.00
	Snelling & Blair	3.33	5.59
	Snelling & Fairmount	0.00	0.00
	Summit & Chatsworth	0.00	0.00
	University & Kent	0.00	0.00
	White Bear & Nebraska	0.00	0.00

APPENDIX G: YIELDING AT INDIVIDUAL SITES

Study locations are listed by treatment type (i.e., Enforcement and Generalization sites) and in alphabetical order.

Enforcement Sites

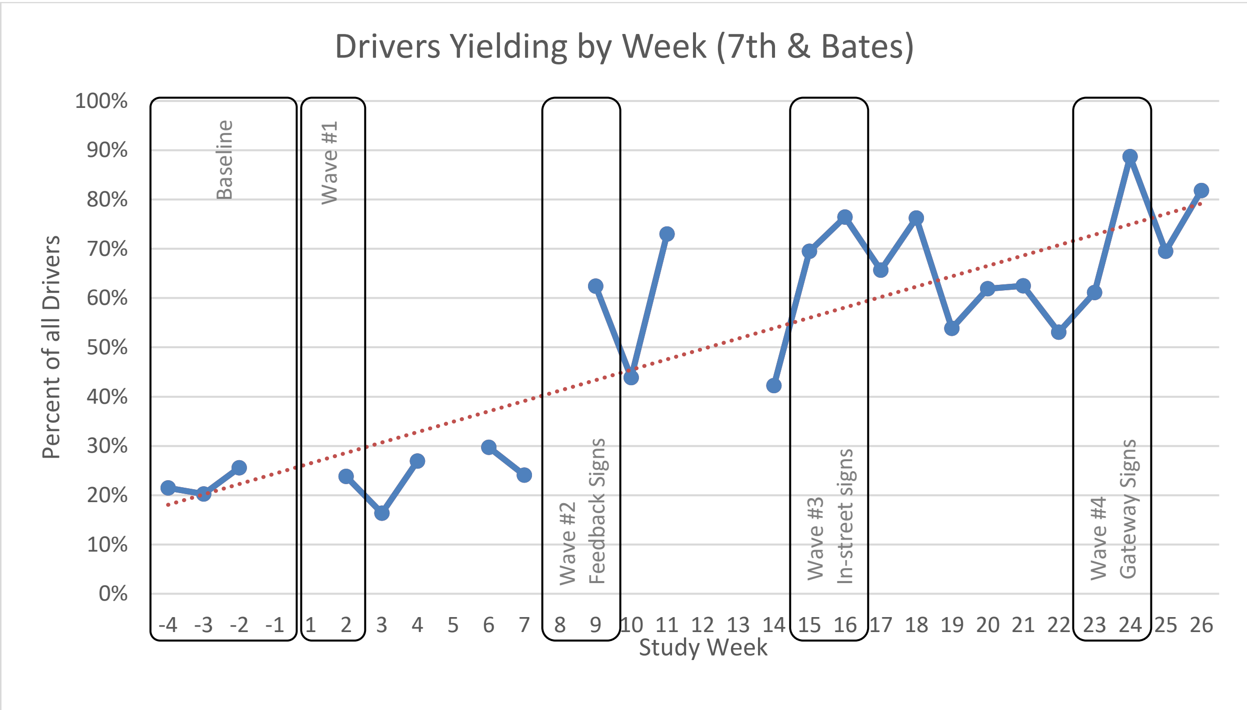


Figure G.1. 7th & Bates

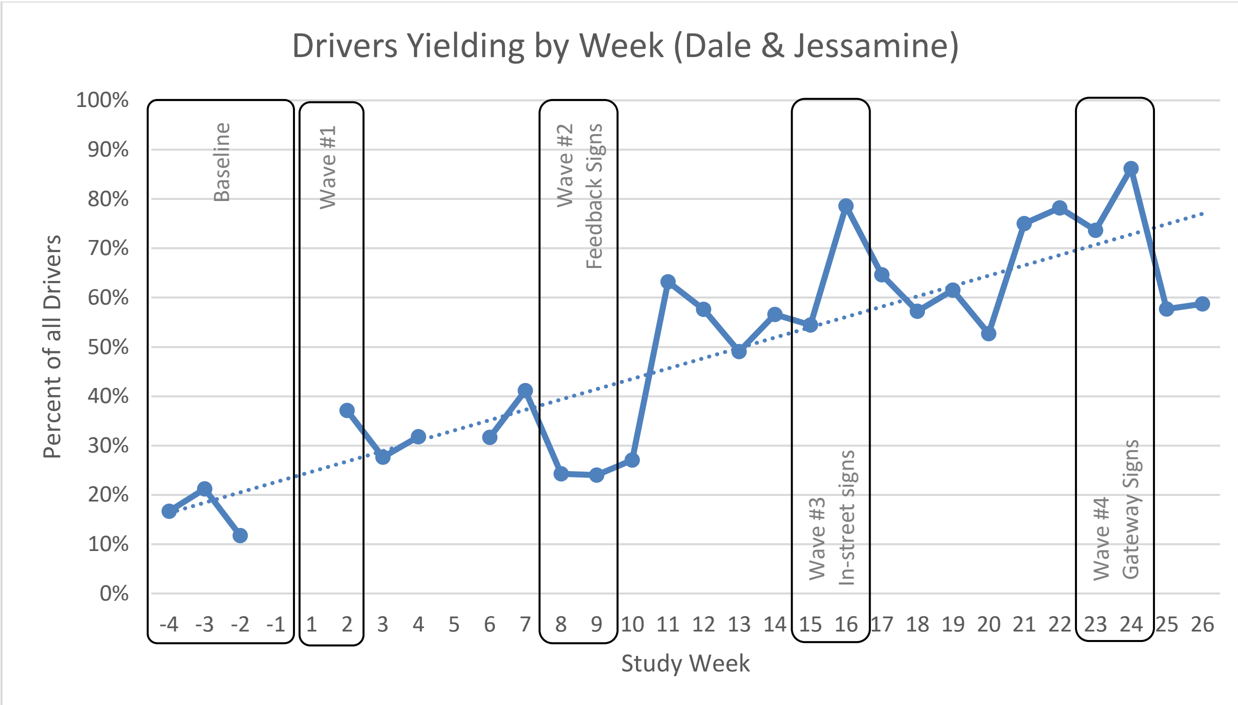


Figure G.2. Dale & Jessamine

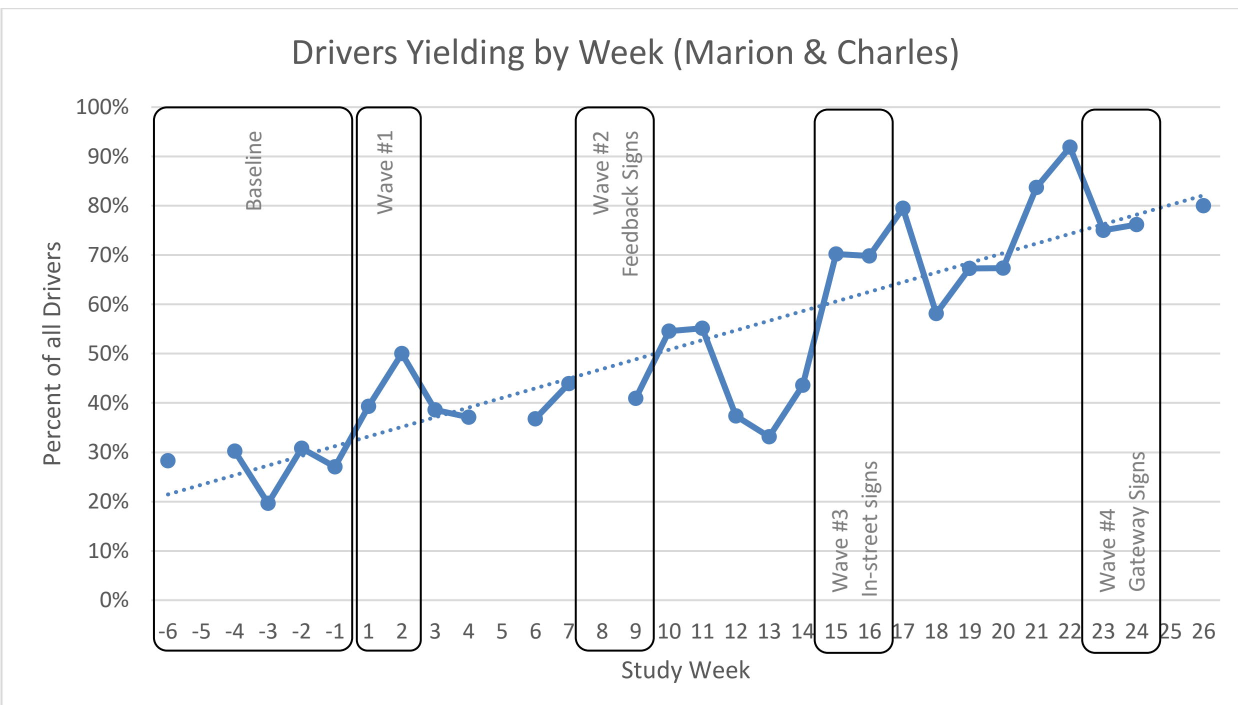


Figure G.3. Marion & Charles

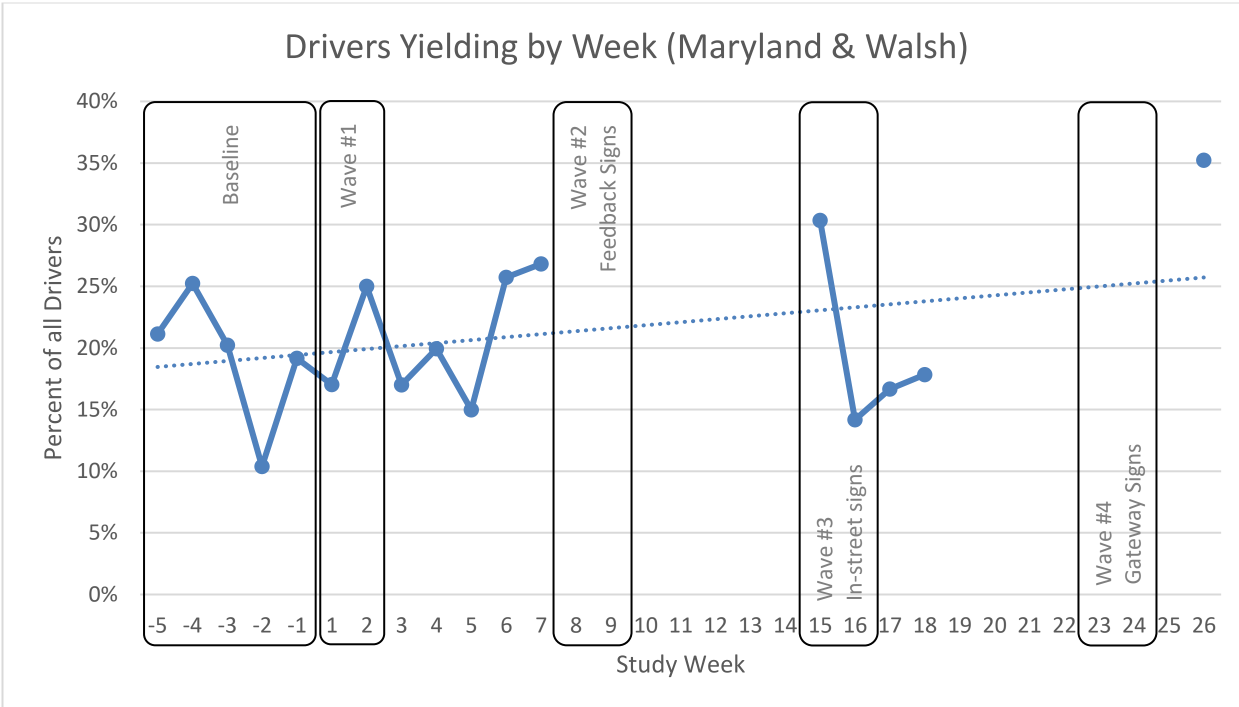


Figure G.4. Maryland & Walsh

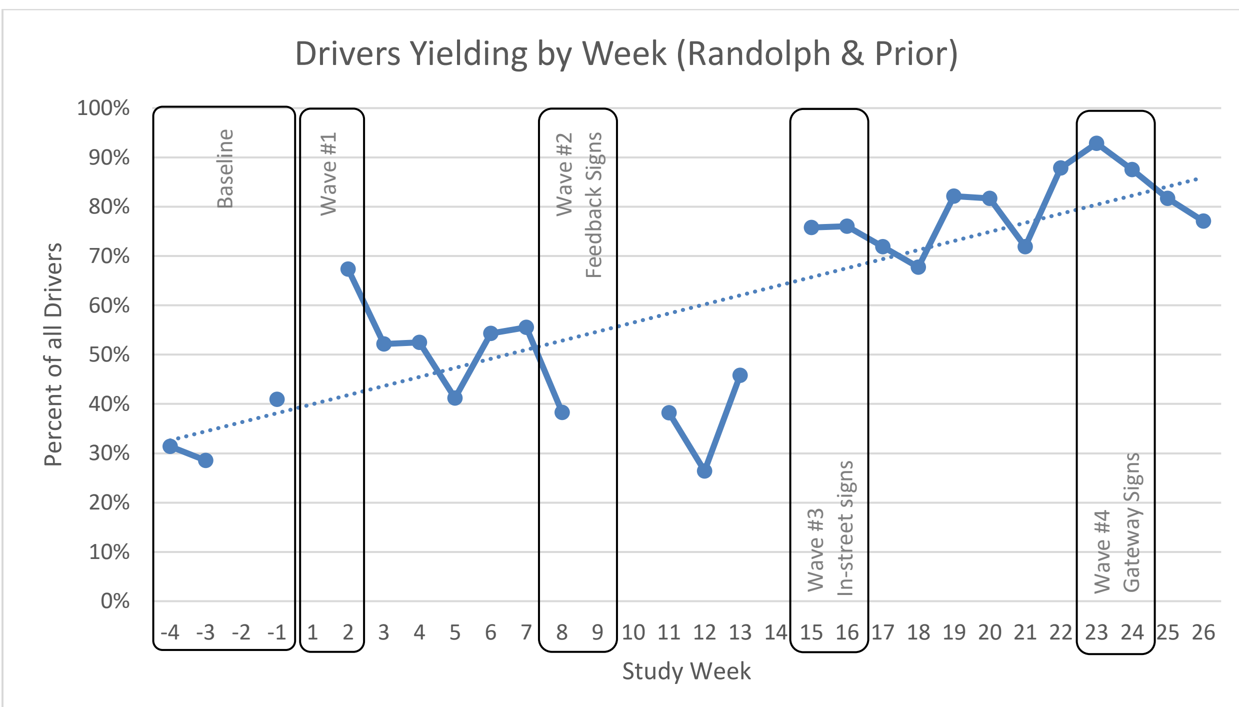


Figure G.5. Randolph & Prior

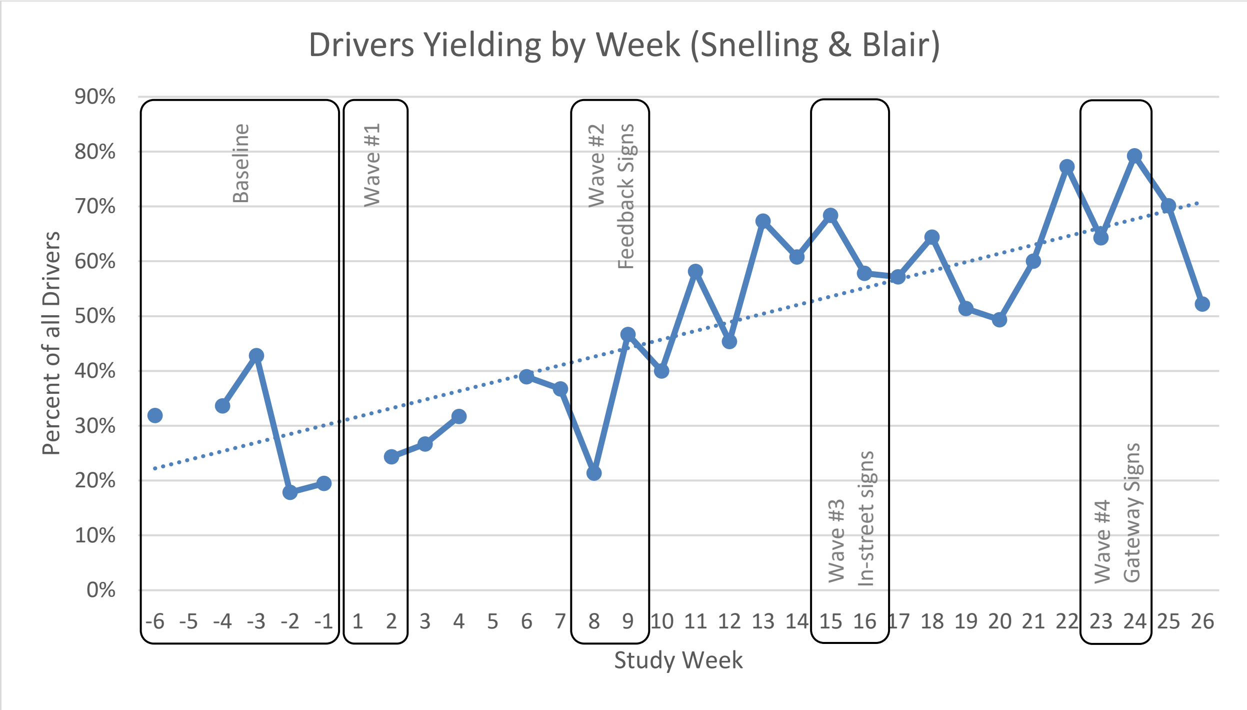


Figure G.6. Snelling & Blair

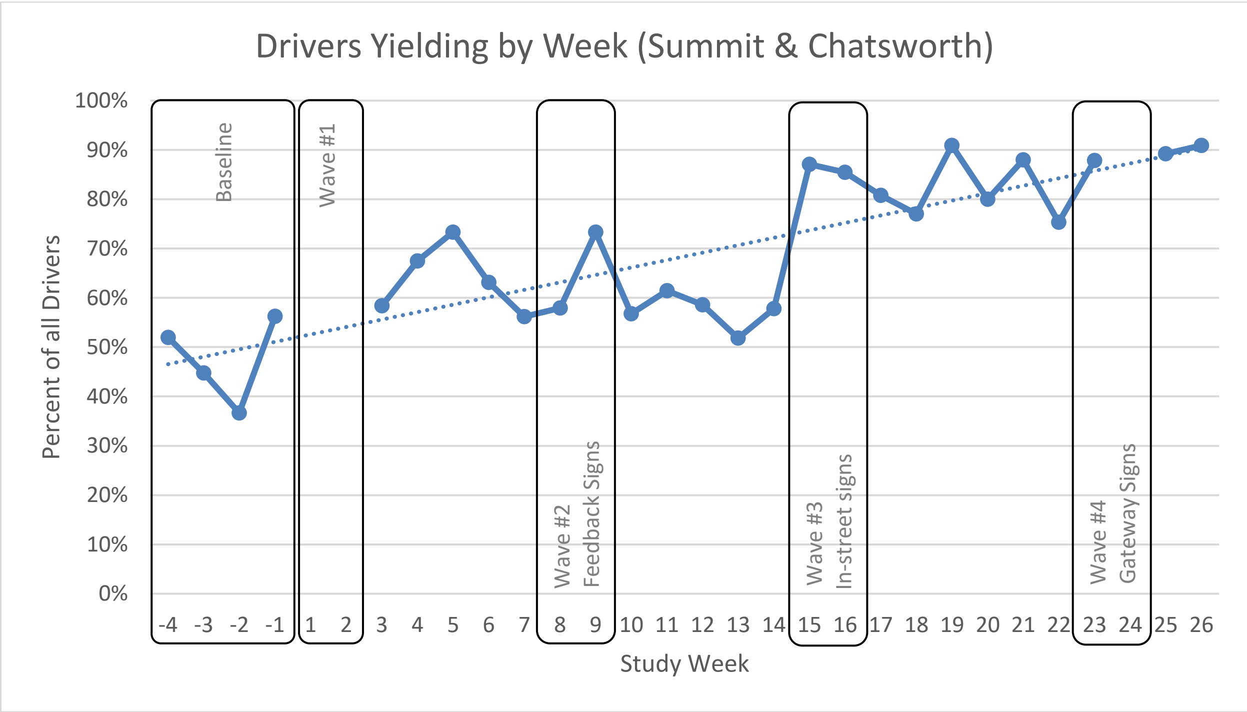


Figure G.7. Summit & Chatsworth

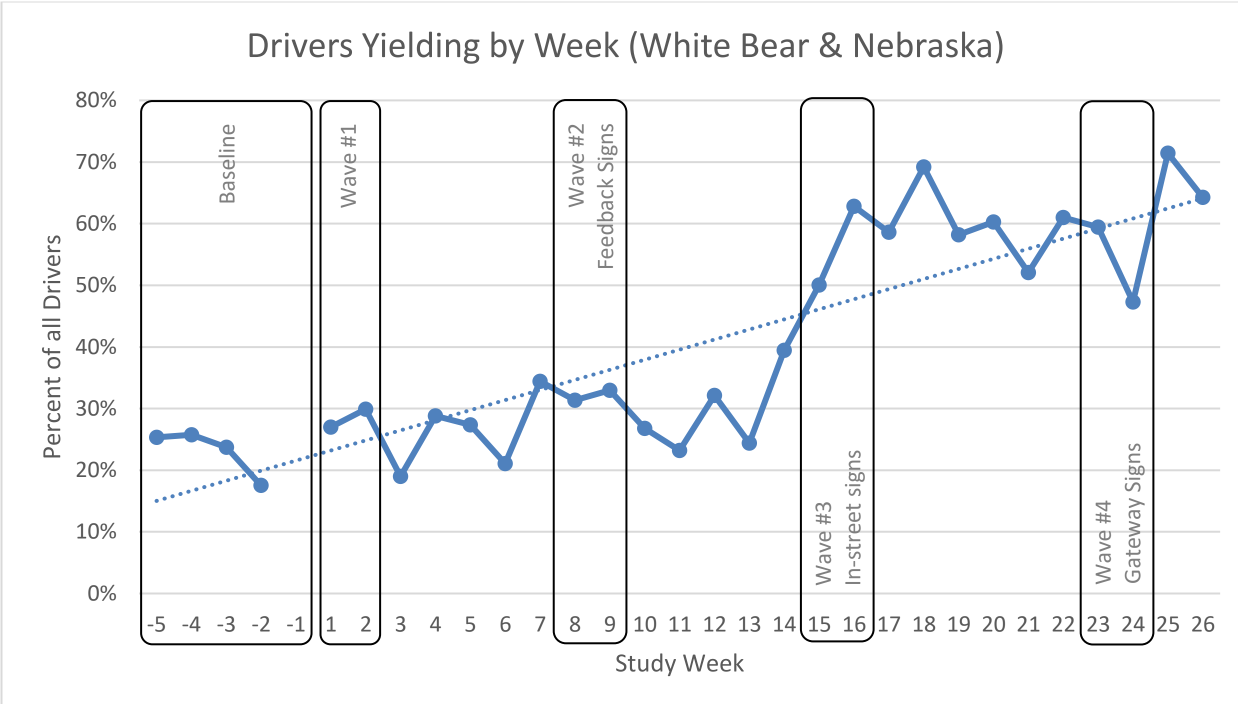


Figure G.8. White Bear & Nebraska

Generalization Sites

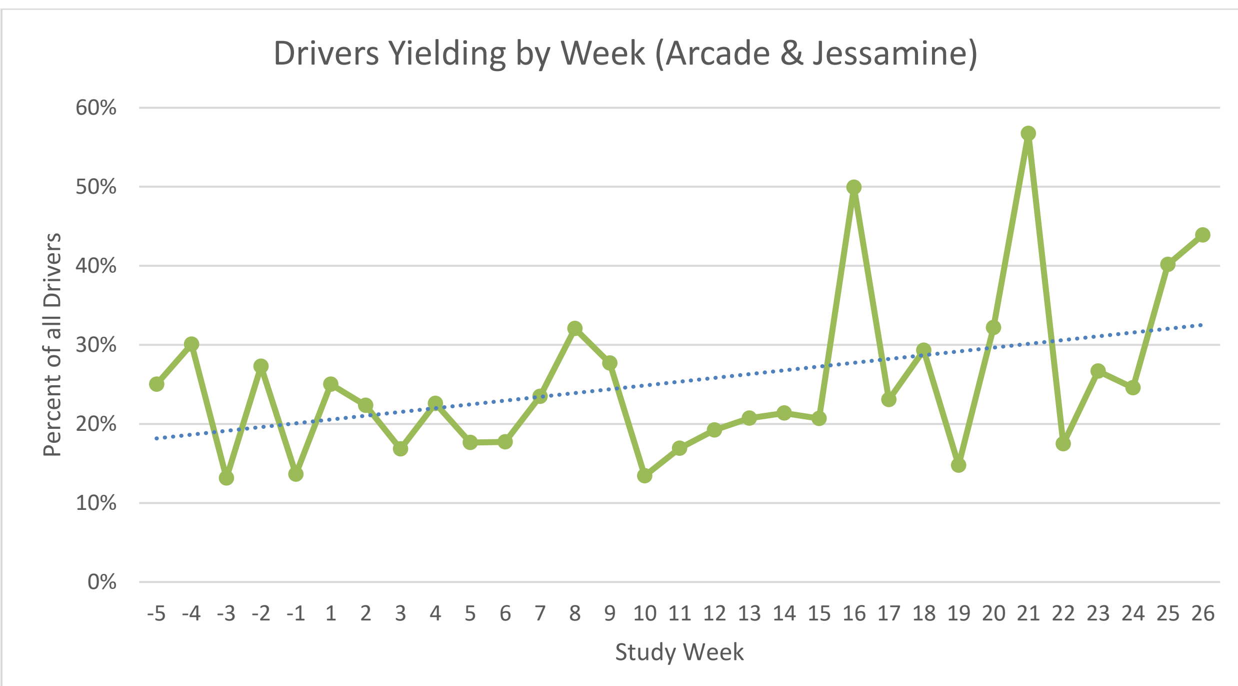


Figure G.9. Arcade & Jessamine

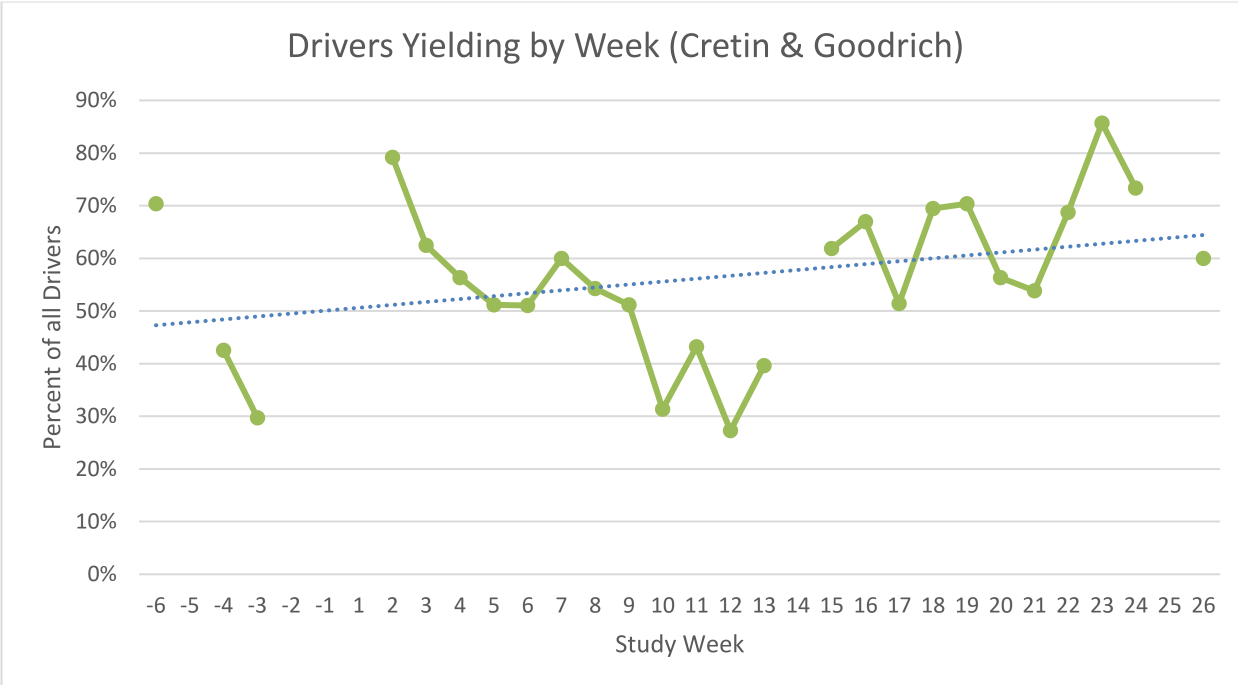


Figure G.10. Cretin & Goodrich

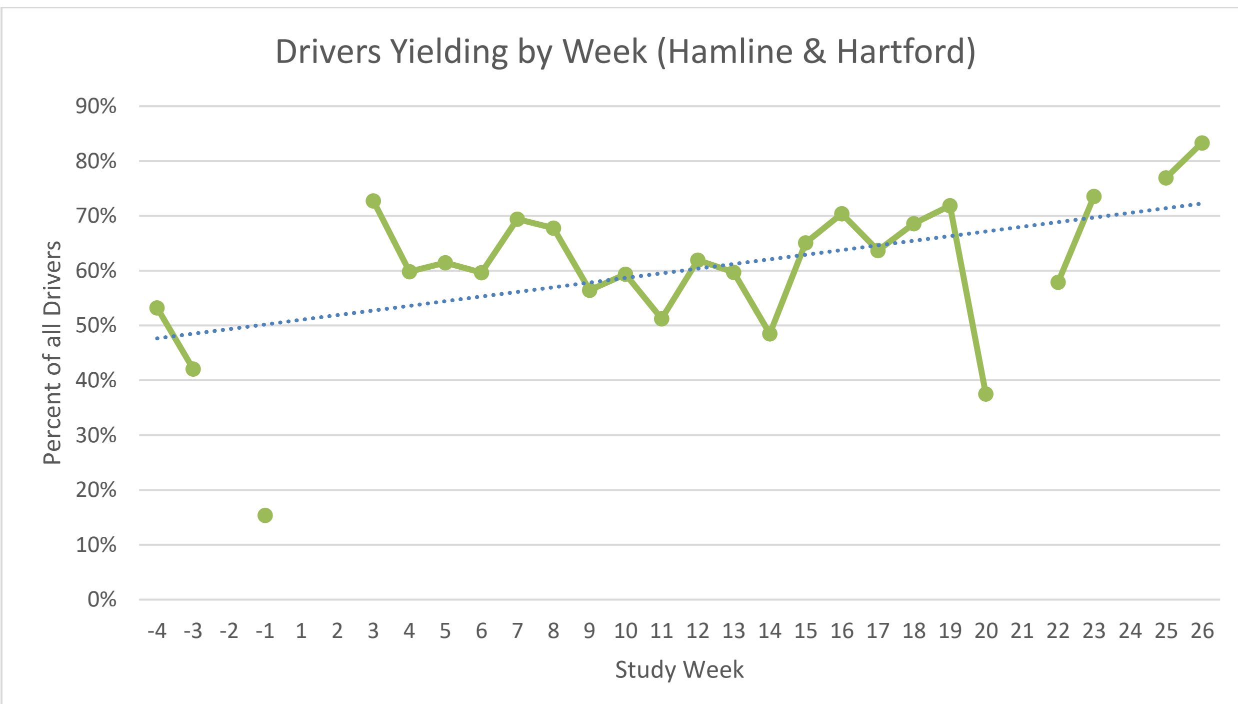


Figure G.11. Hamline & Hartford

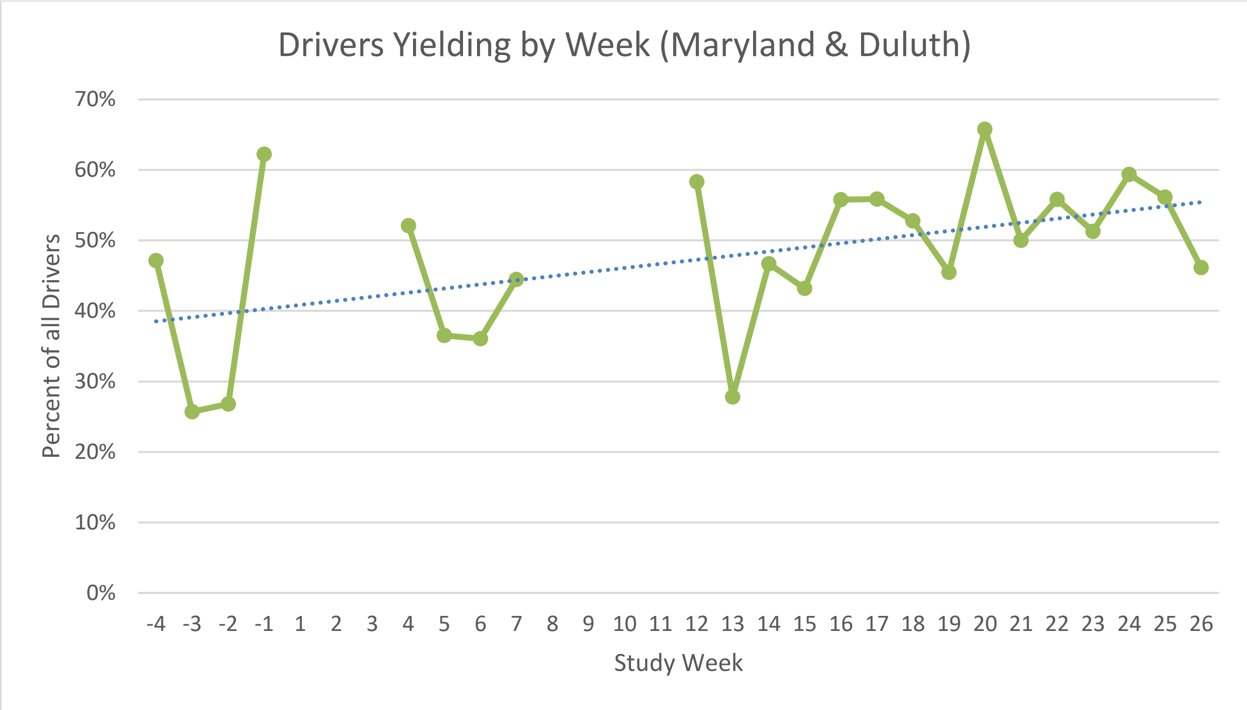


Figure G.12. Maryland & Duluth

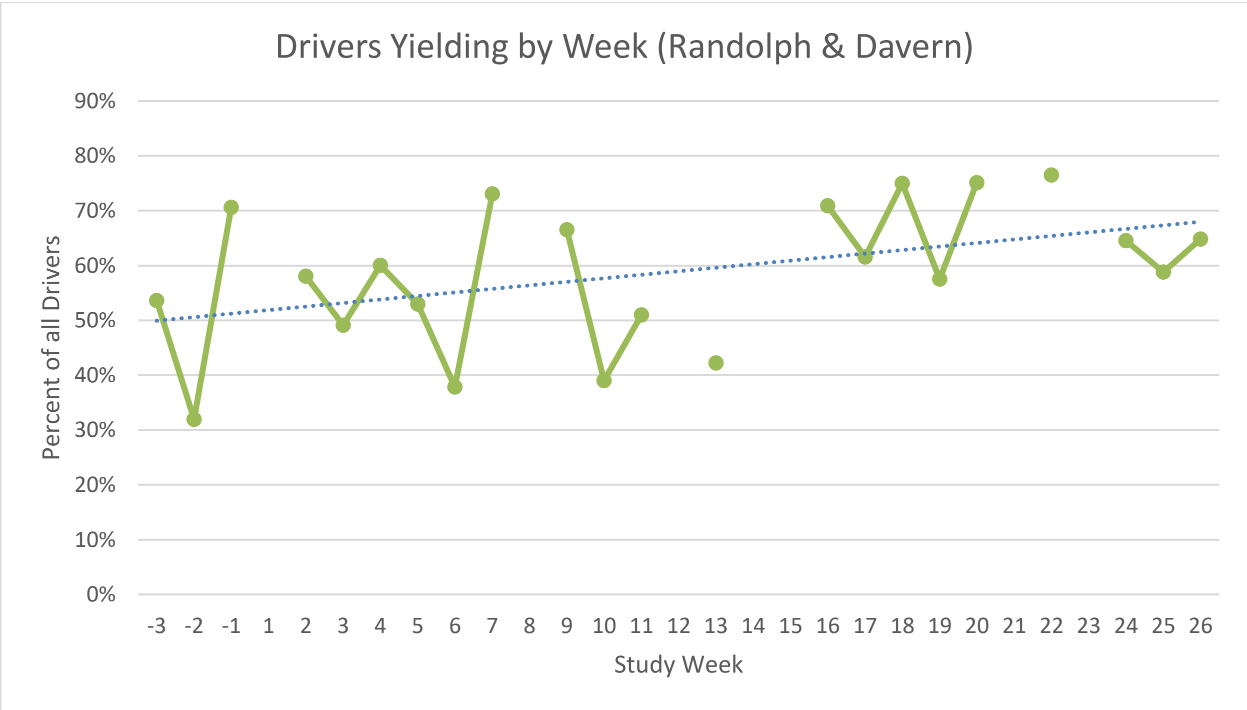


Figure G.13. Randolph & Davern

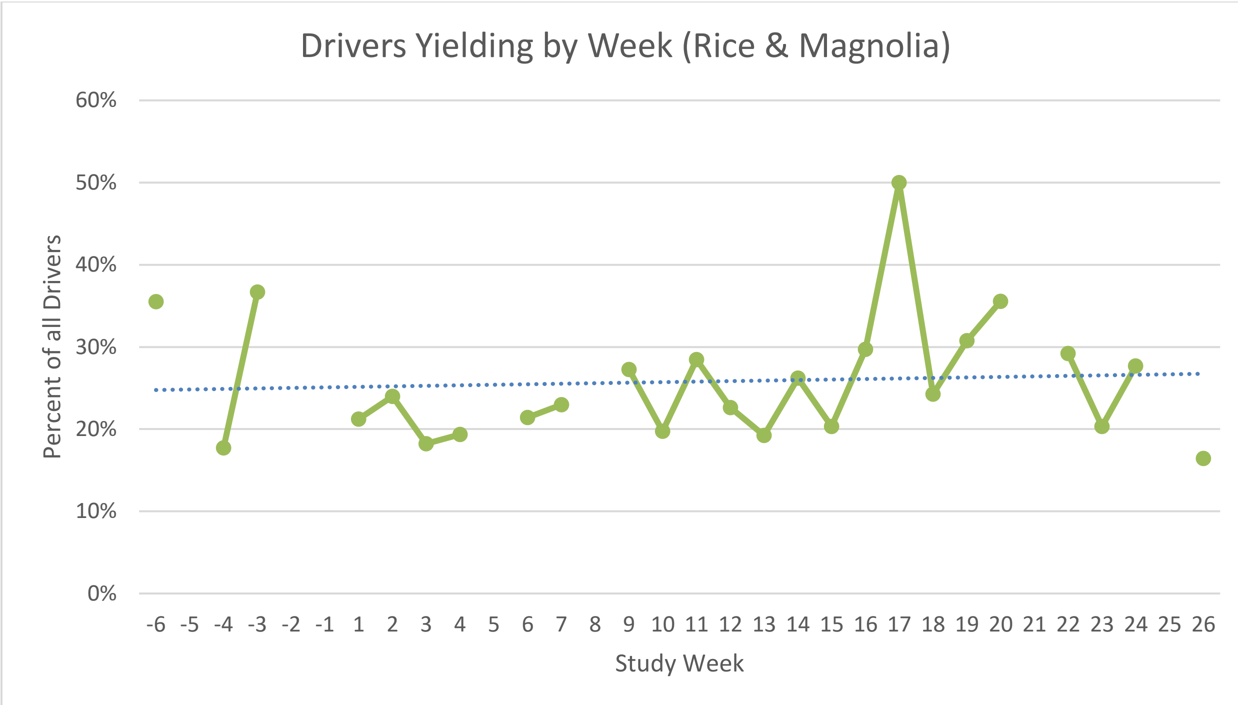


Figure G.14. Rice & Magnolia

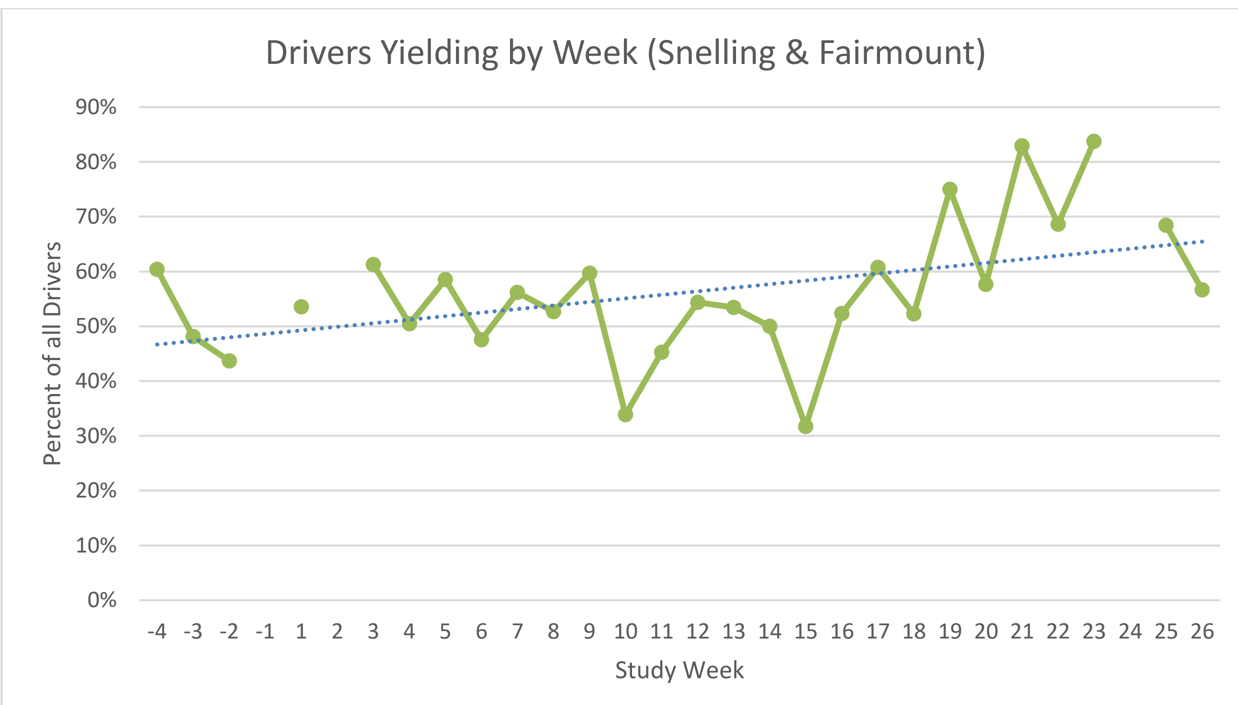


Figure G.15. Snelling & Fairmount

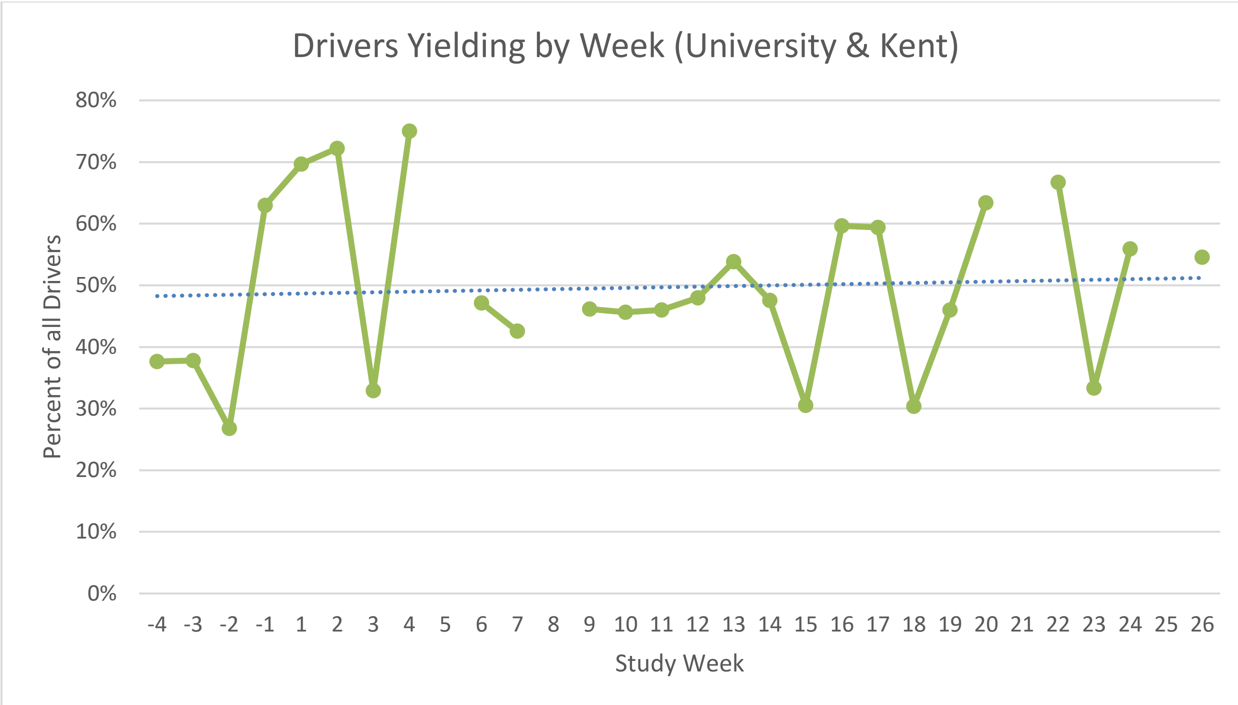


Figure G.16. University & Kent

APPENDIX H - YIELDING DISTANCES AT INDIVIDUAL SITES

Enforcement Sites

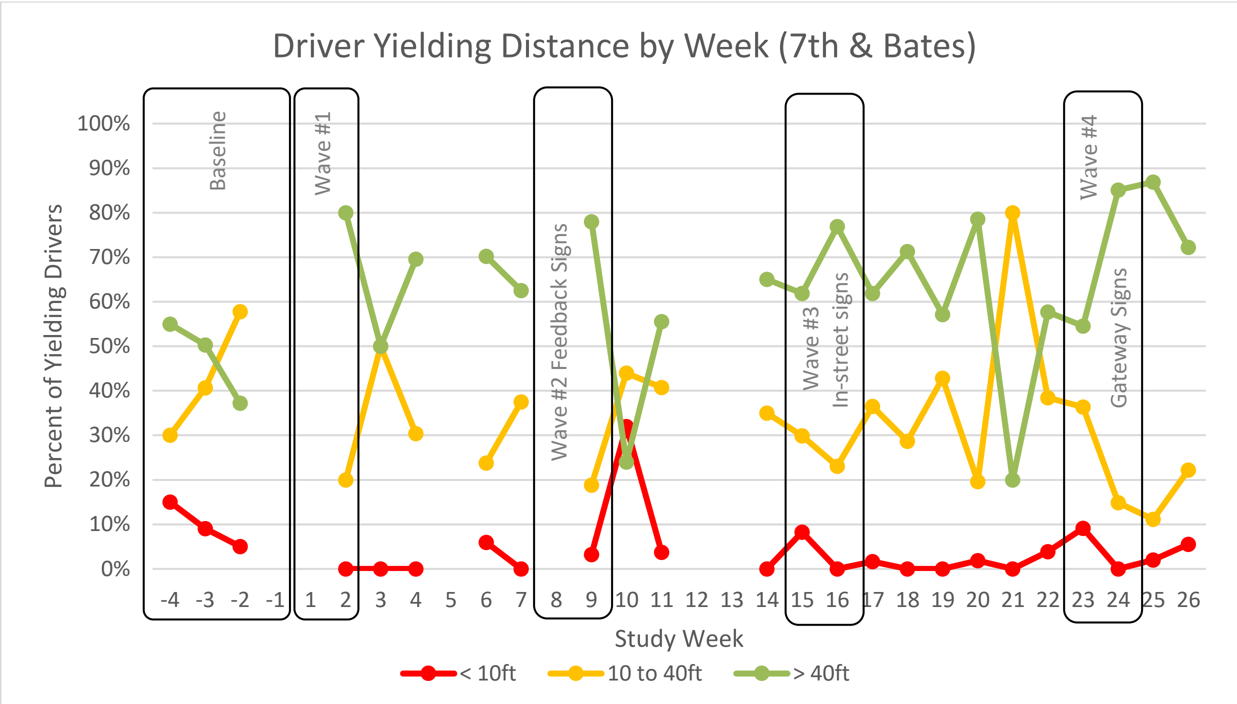


Figure H.1. 7th & Bates

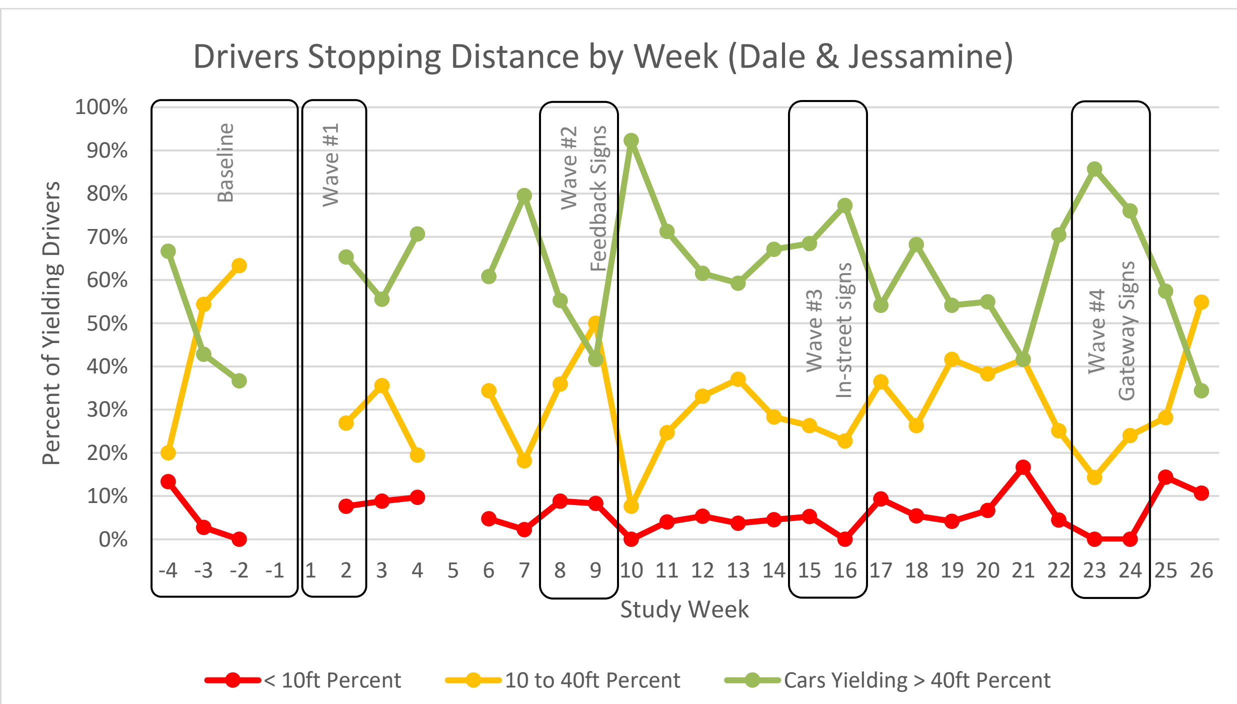


Figure H.2. Dale & Jessamine

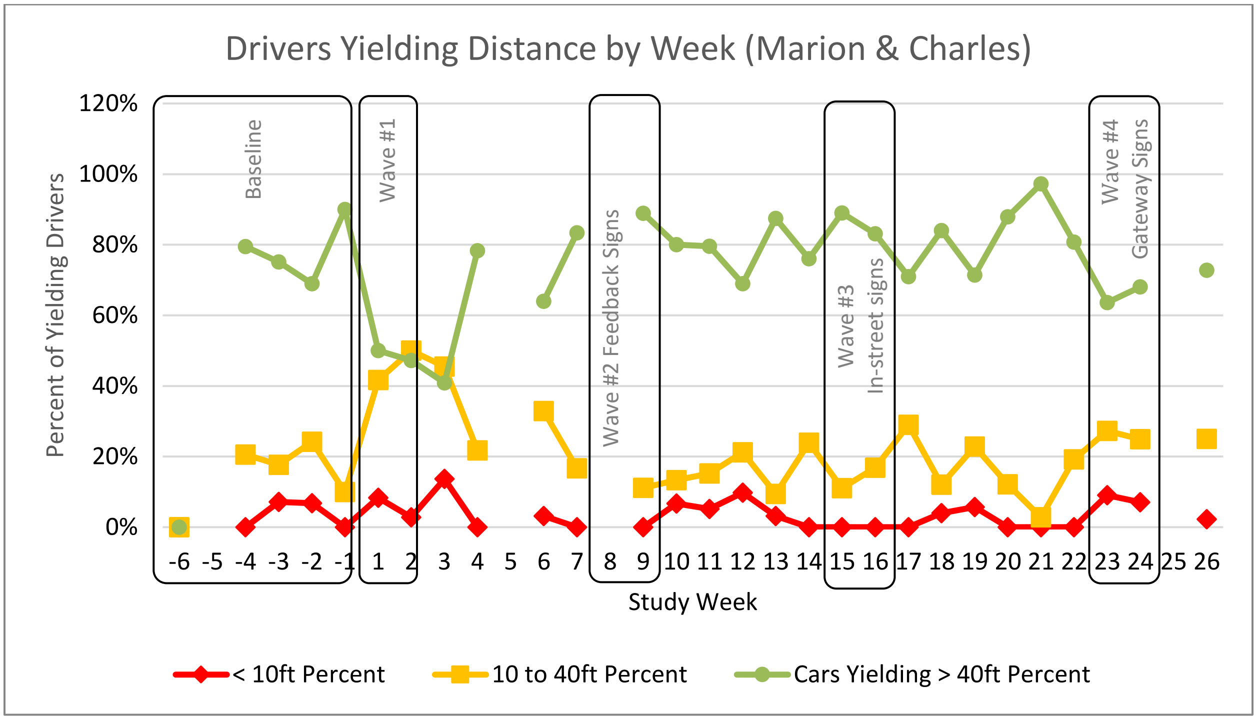


Figure H.3. Marion & Charles

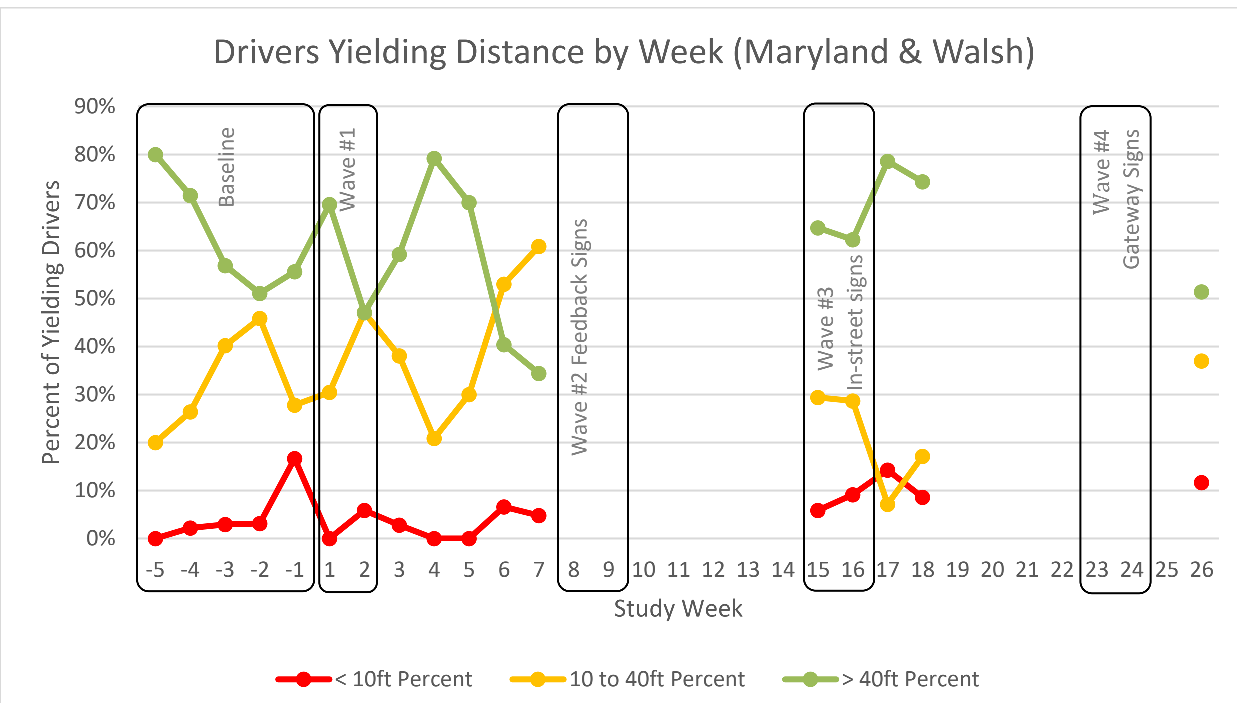


Figure H.4. Maryland & Walsh

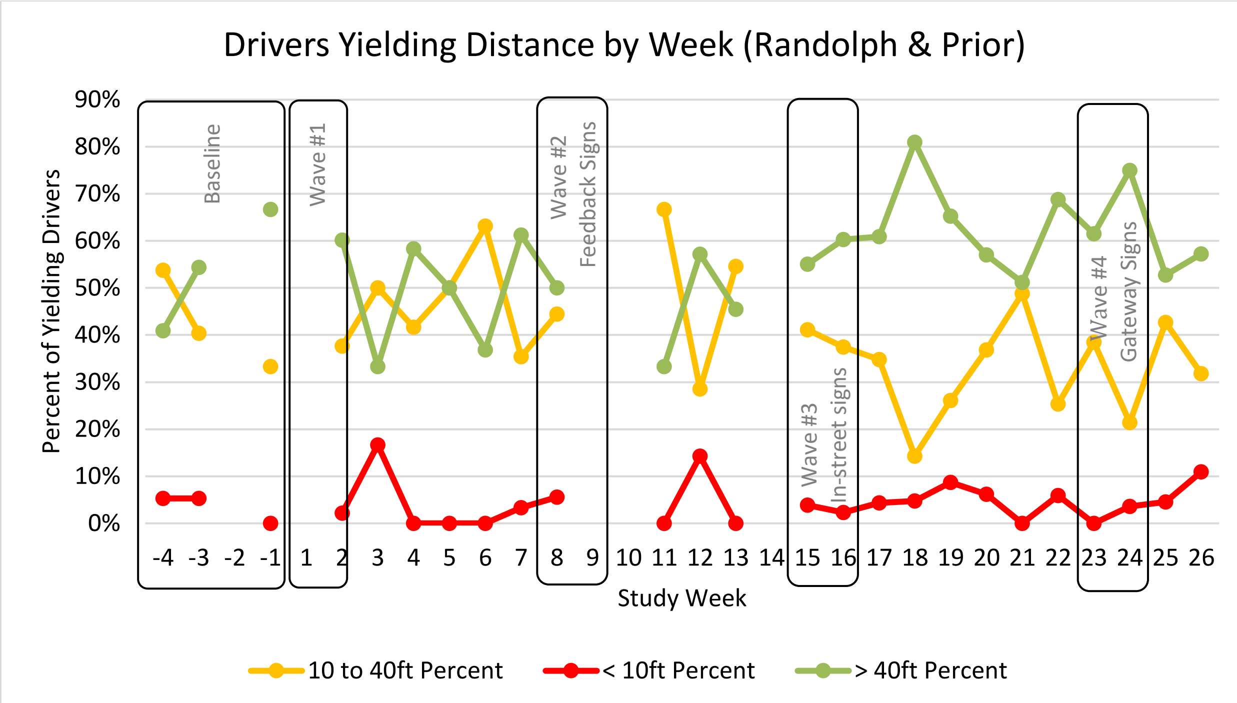


Figure H.5. Randolph & Prior

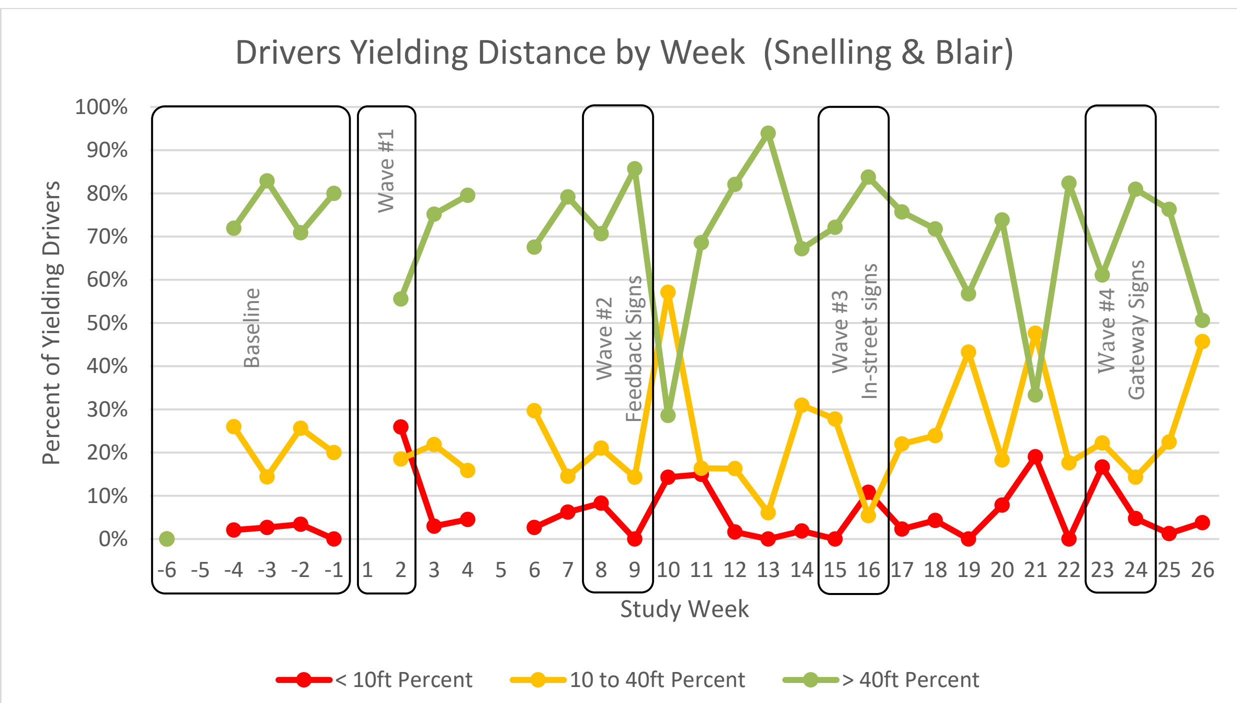


Figure H.6. Snelling & Blair

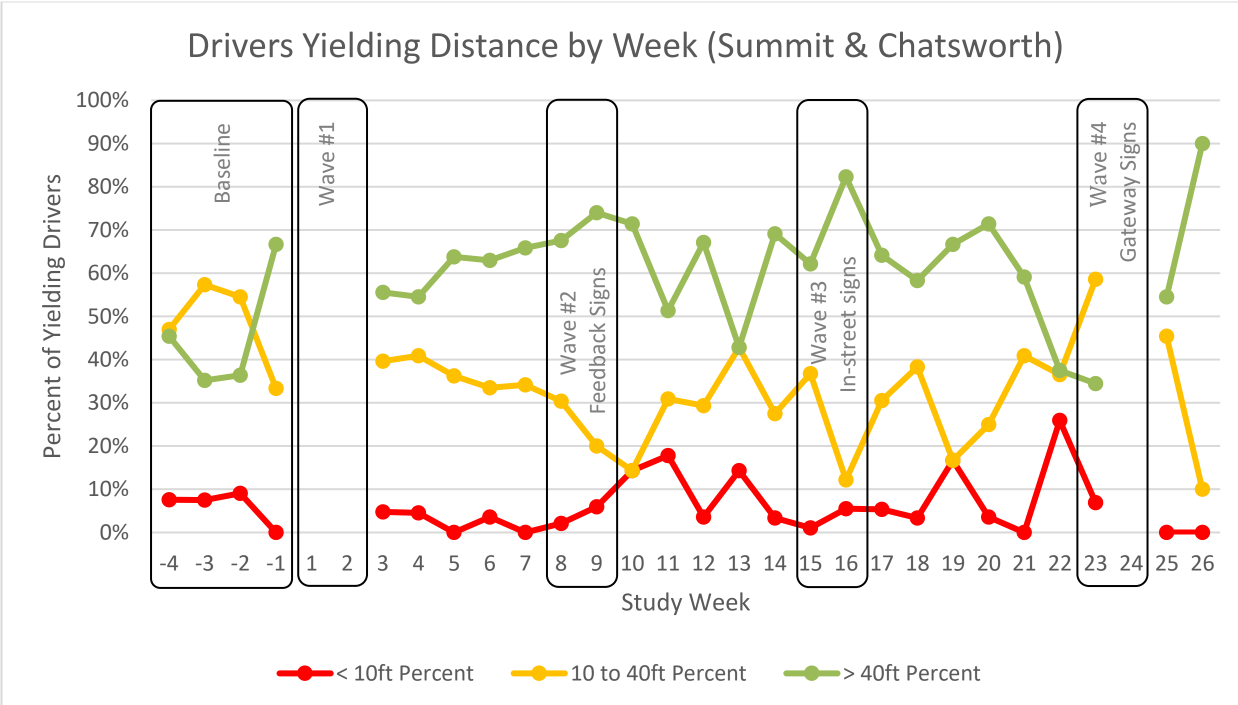


Figure H.7. Summit & Chatsworth

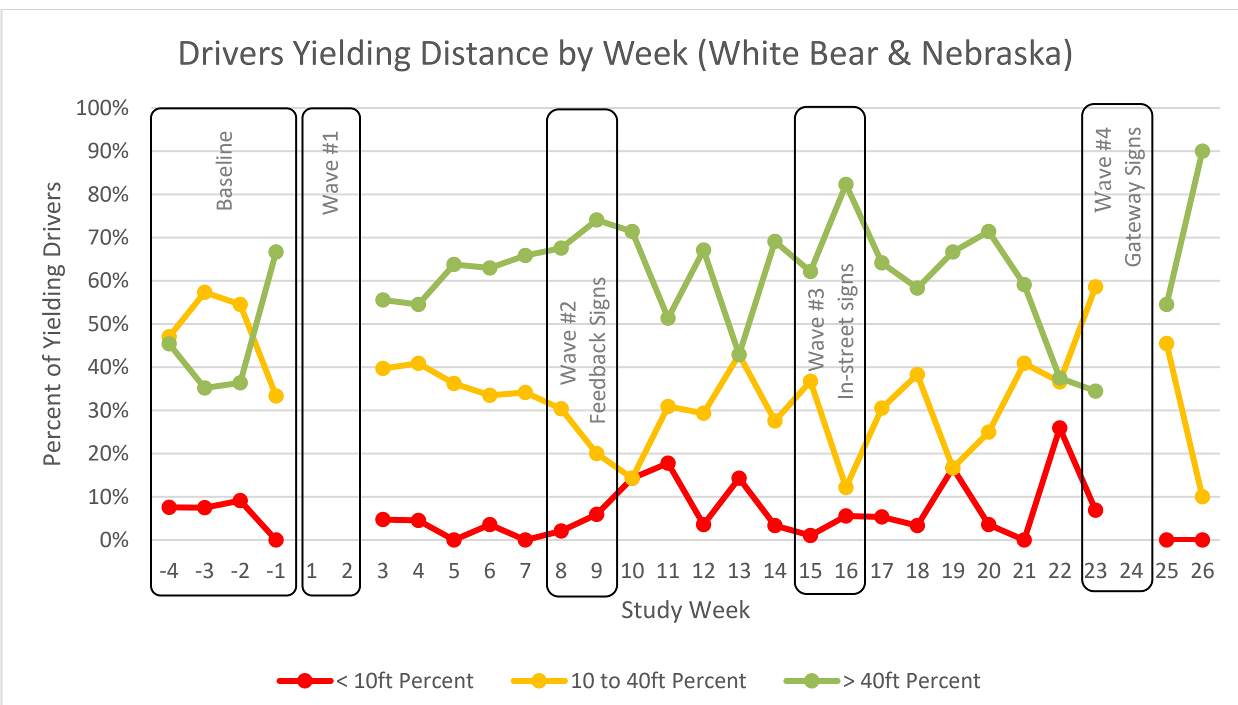


Figure H.8. White Bear & Nebraska

Generalization Sites

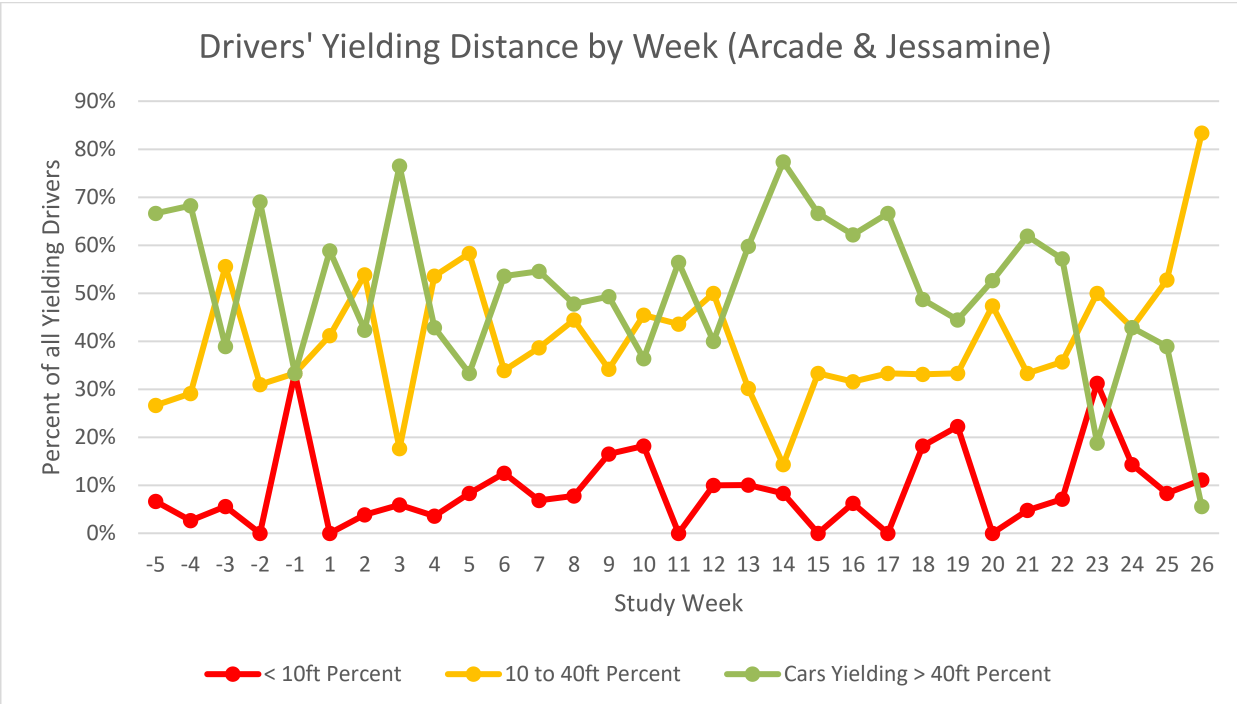


Figure H.9. Arcade & Jessamine

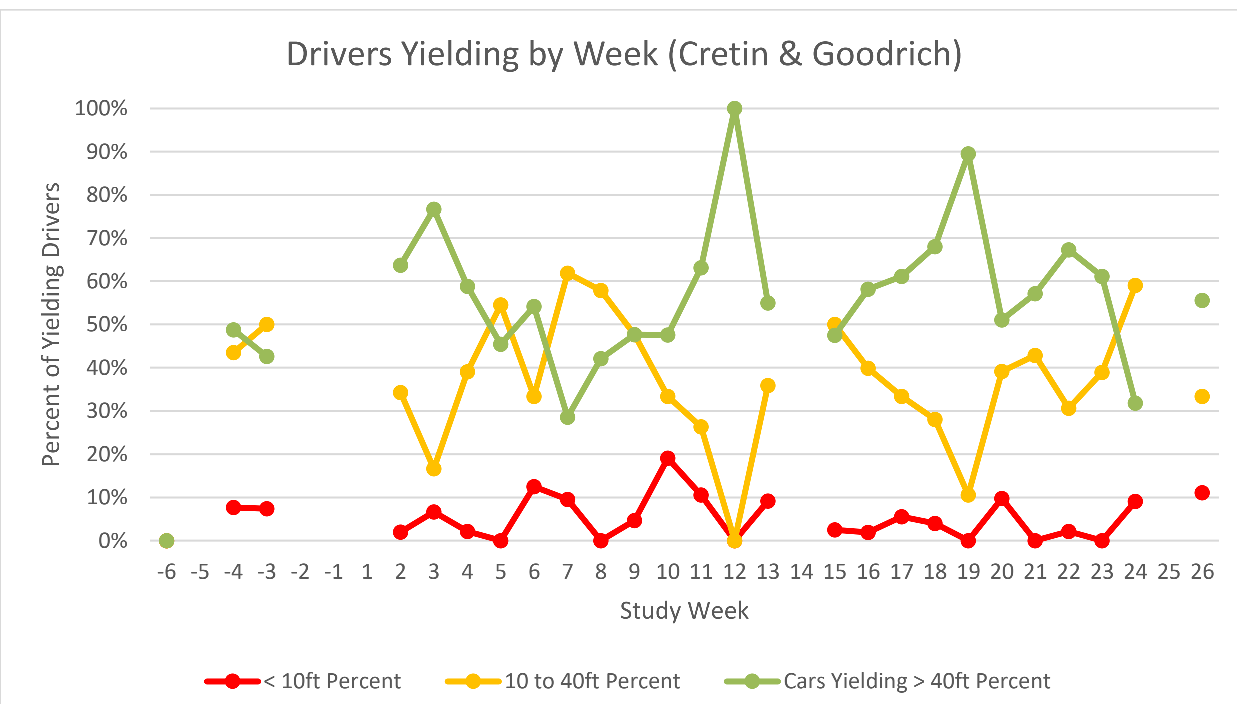


Figure H.10. Cretin & Goodrich

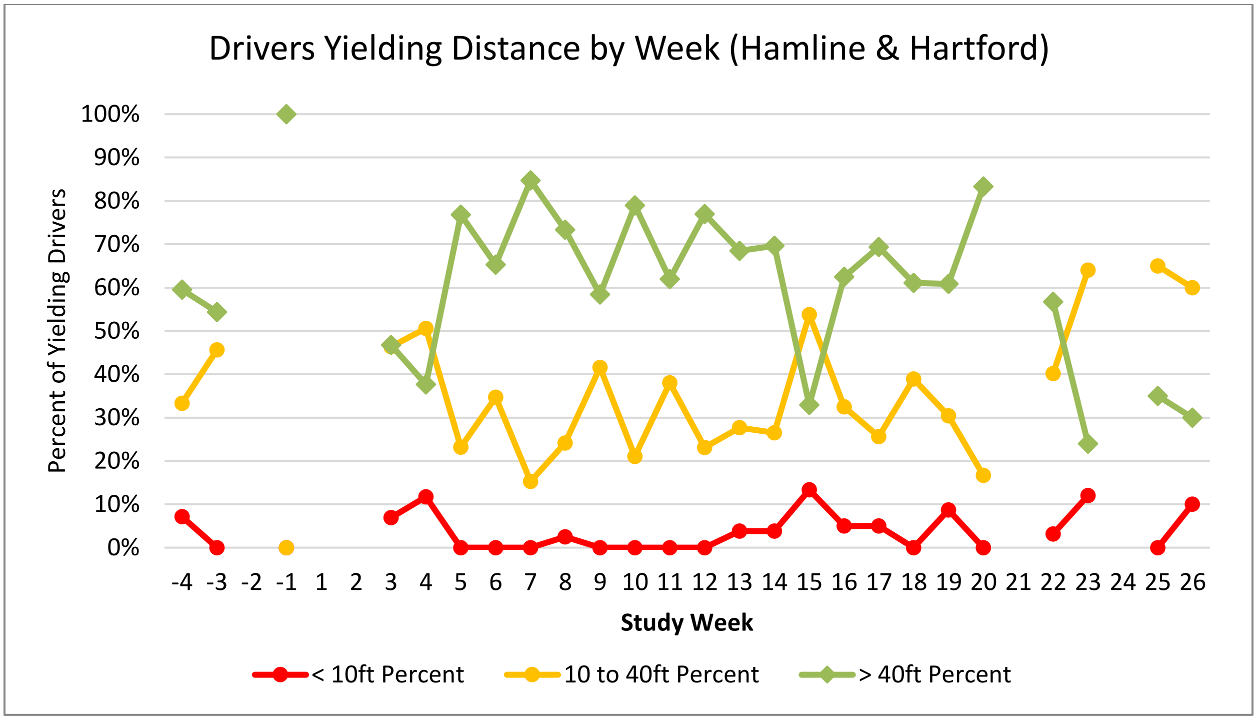


Figure H.11. Hamline & Hartford

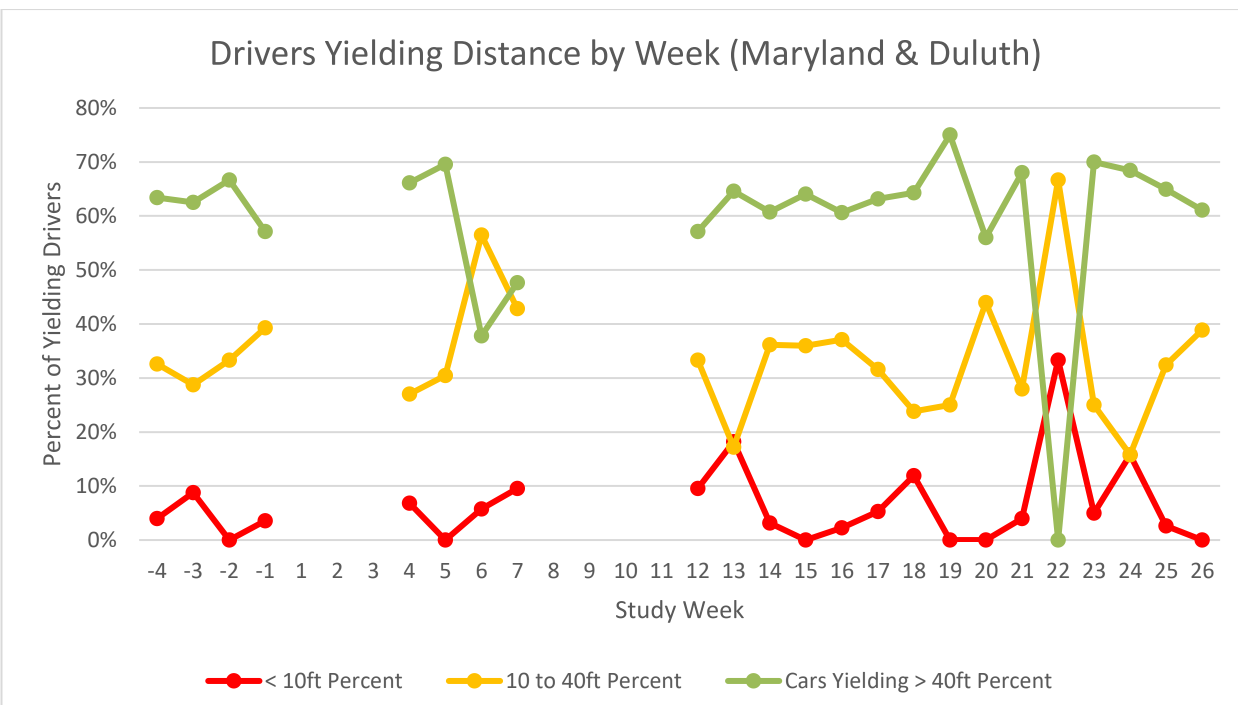


Figure H.12. Maryland & Duluth

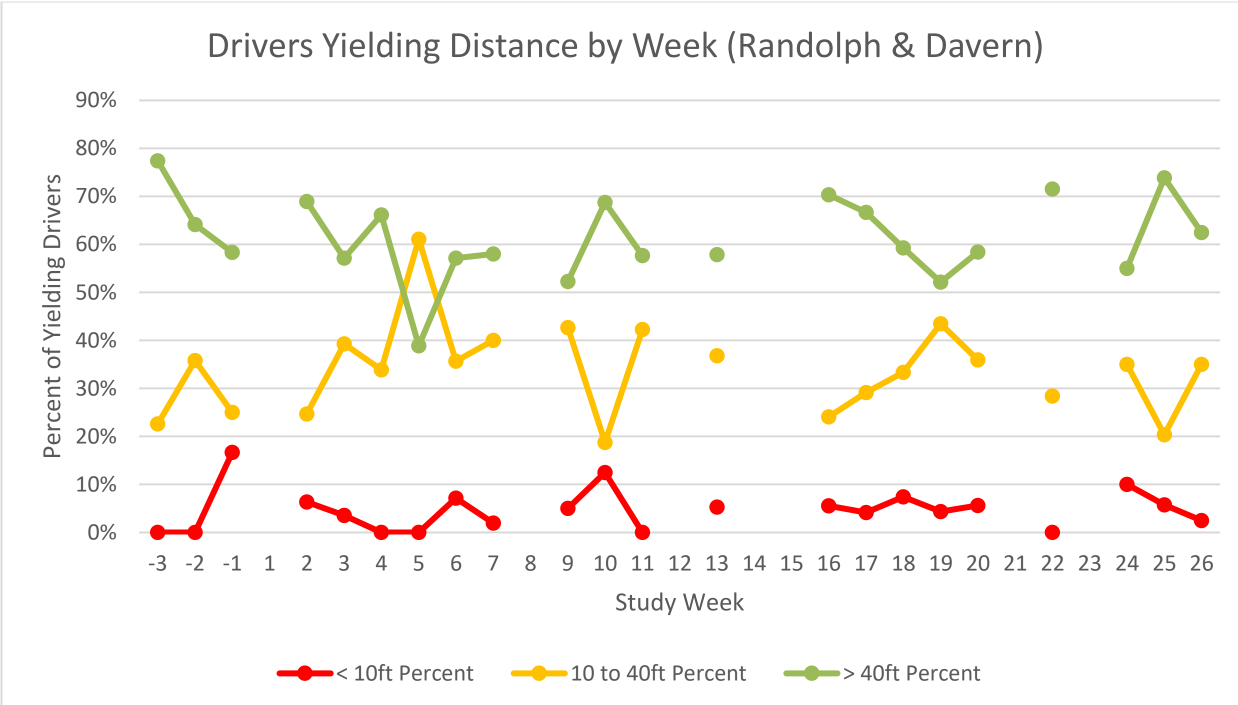


Figure H.13. Randolph & Davern

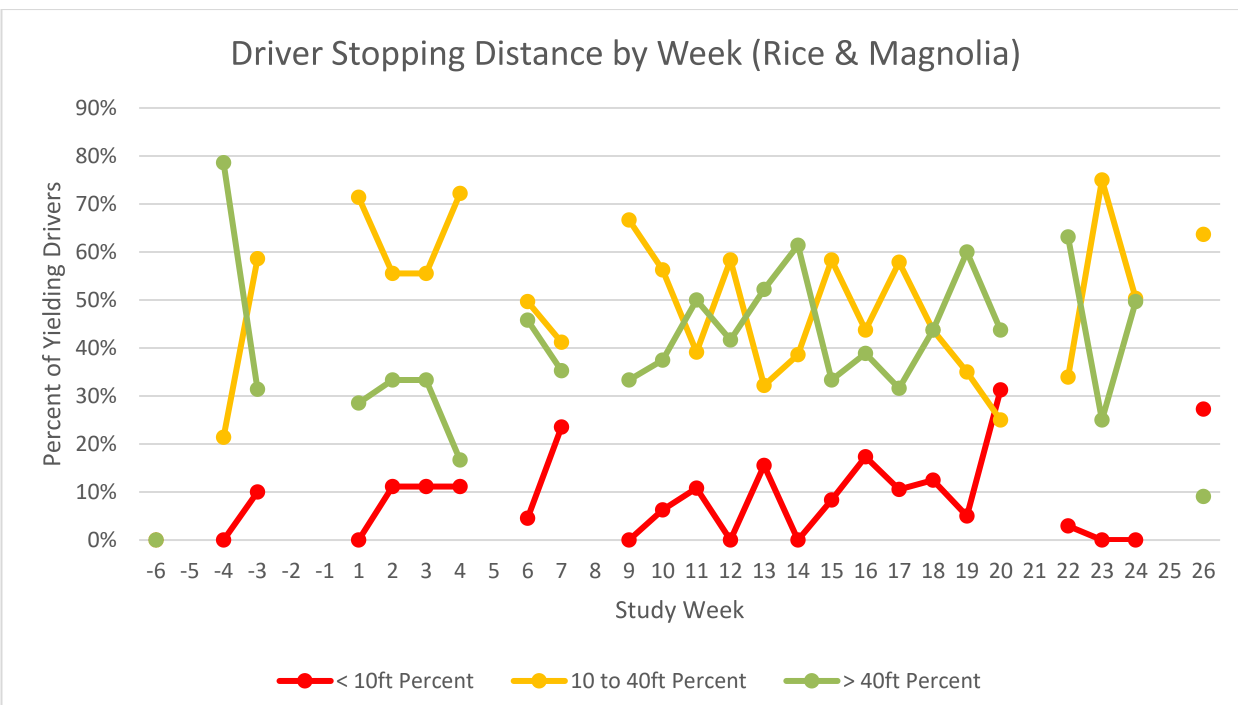


Figure H.14. Rice & Magnolia

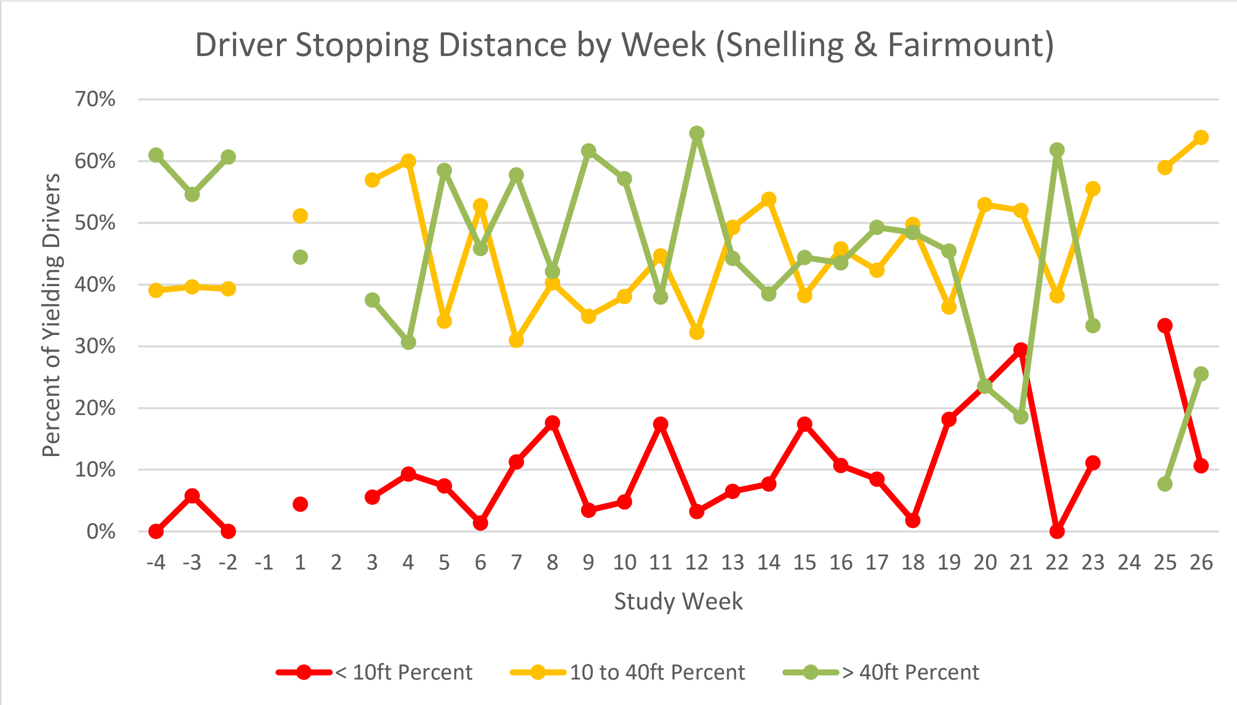


Figure H.15. Snelling & Fairmount

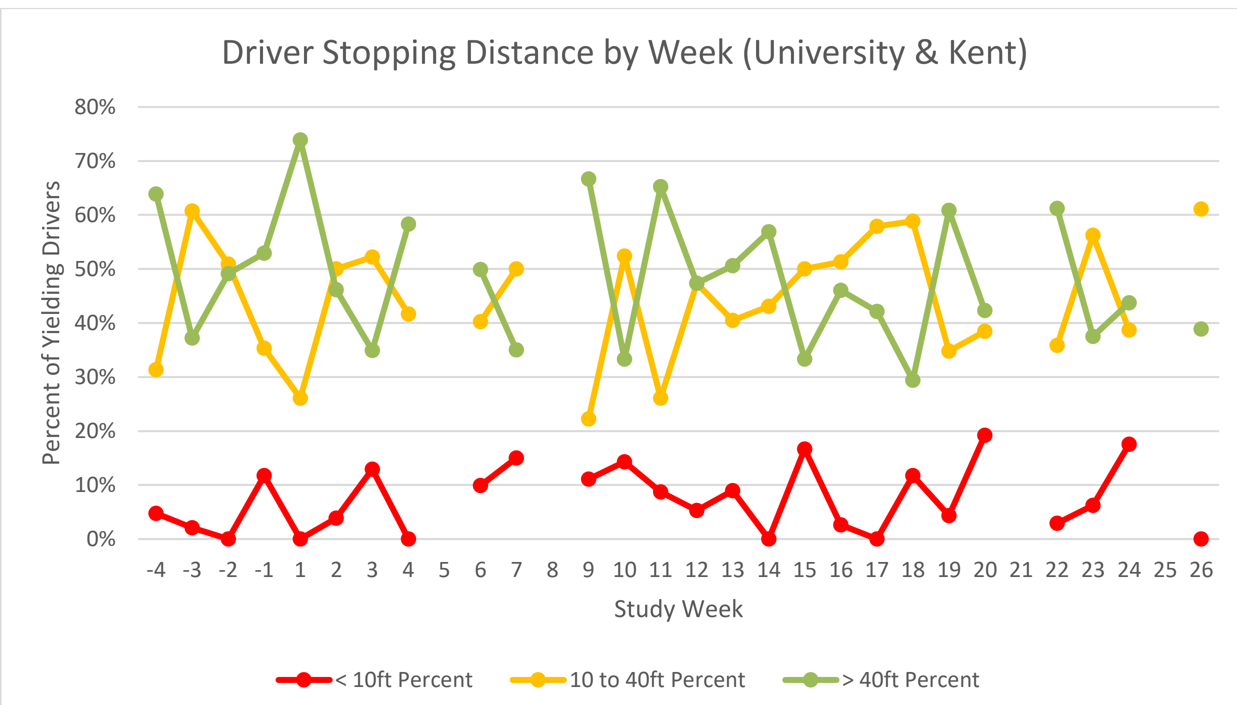


Figure H.16. University & Kent

APPENDIX I: DRIVER PASSING AND HARD BRAKING

Enforcement Sites

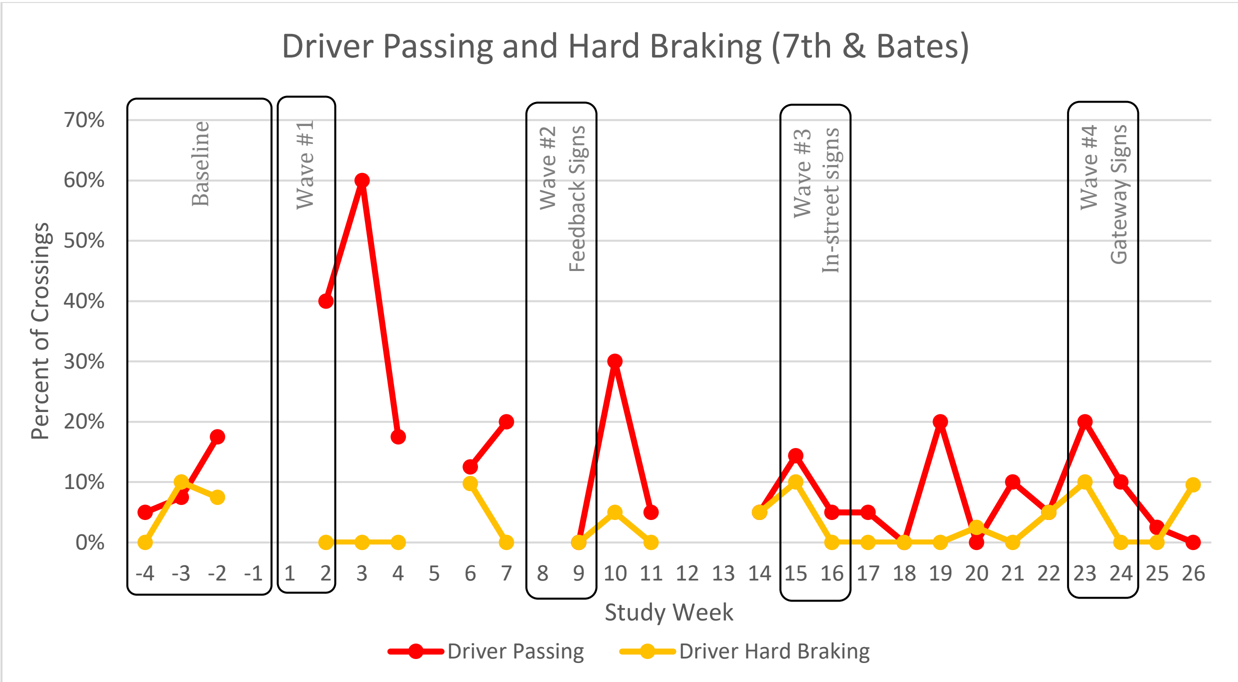


Figure I.1. 7th & Bates

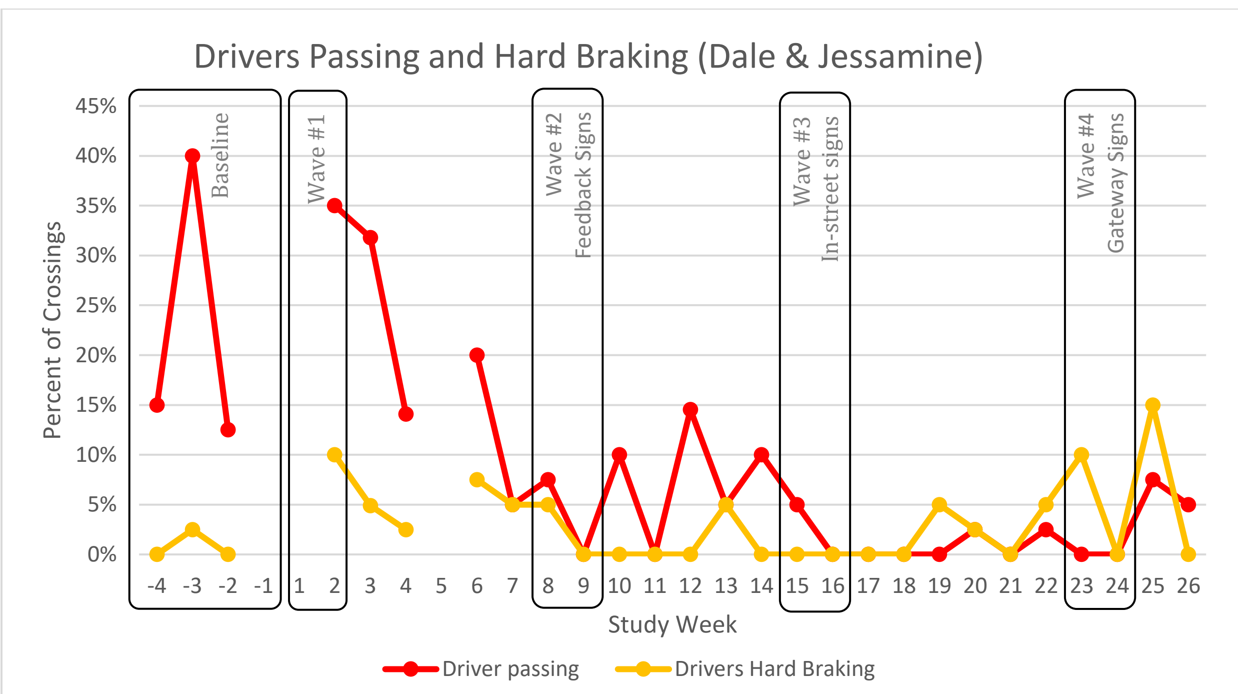


Figure I.2. Dale & Jessamine

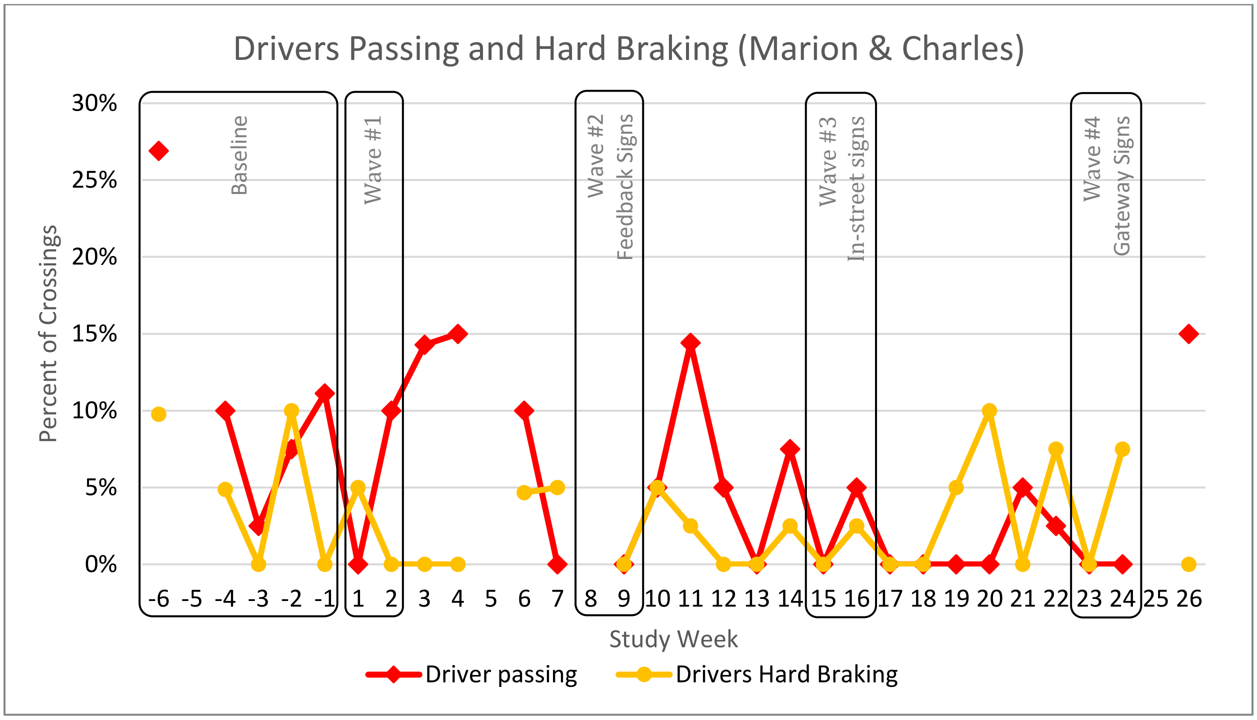


Figure I.3. Marion & Charles

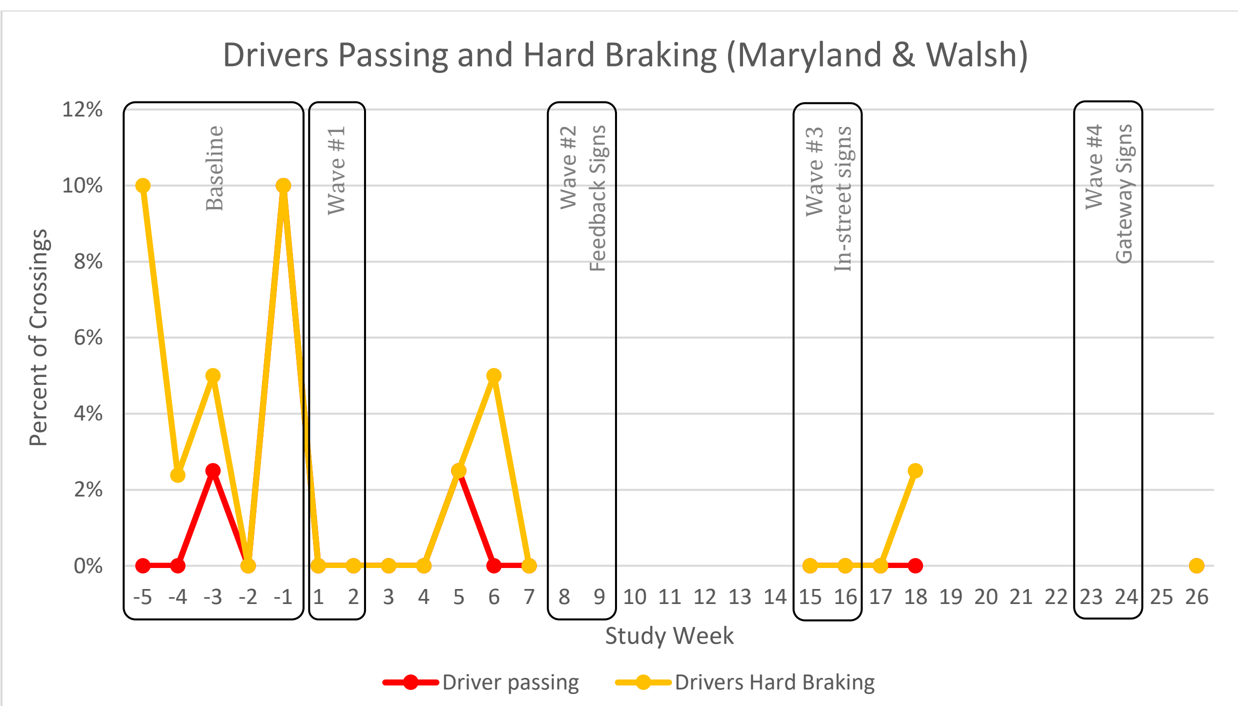


Figure I.4. Maryland & Walsh

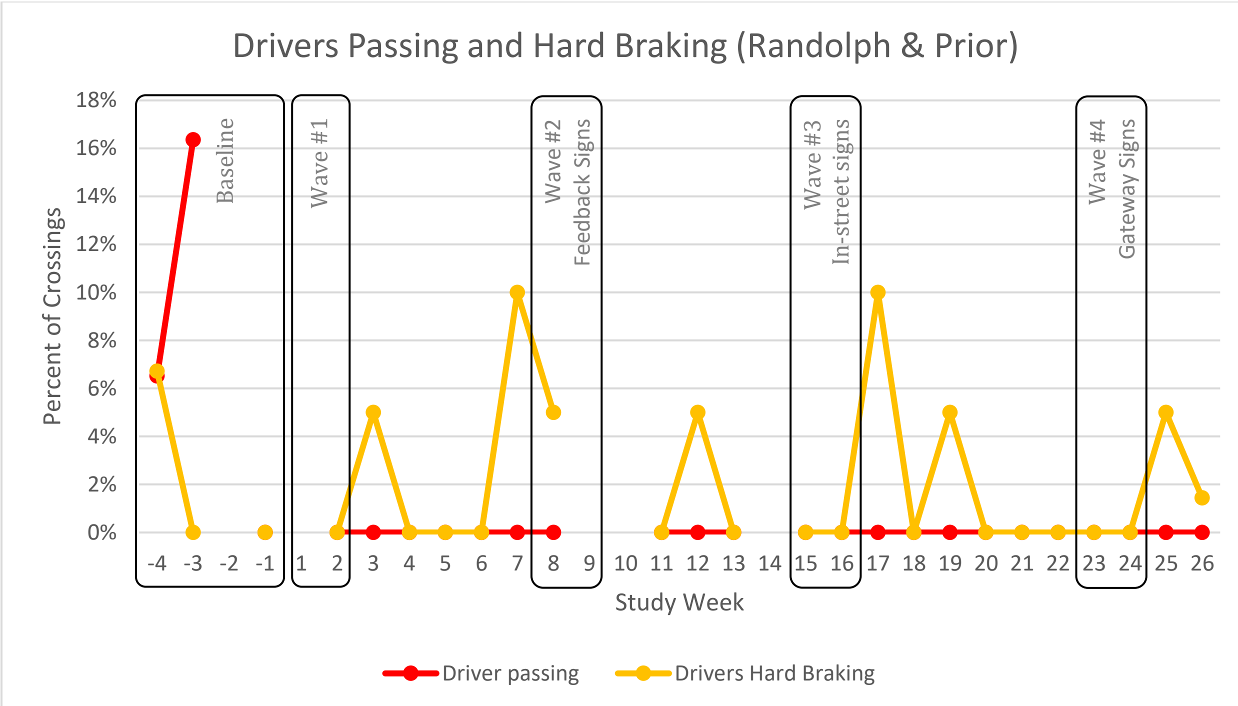


Figure I.5. Randolph & Prior

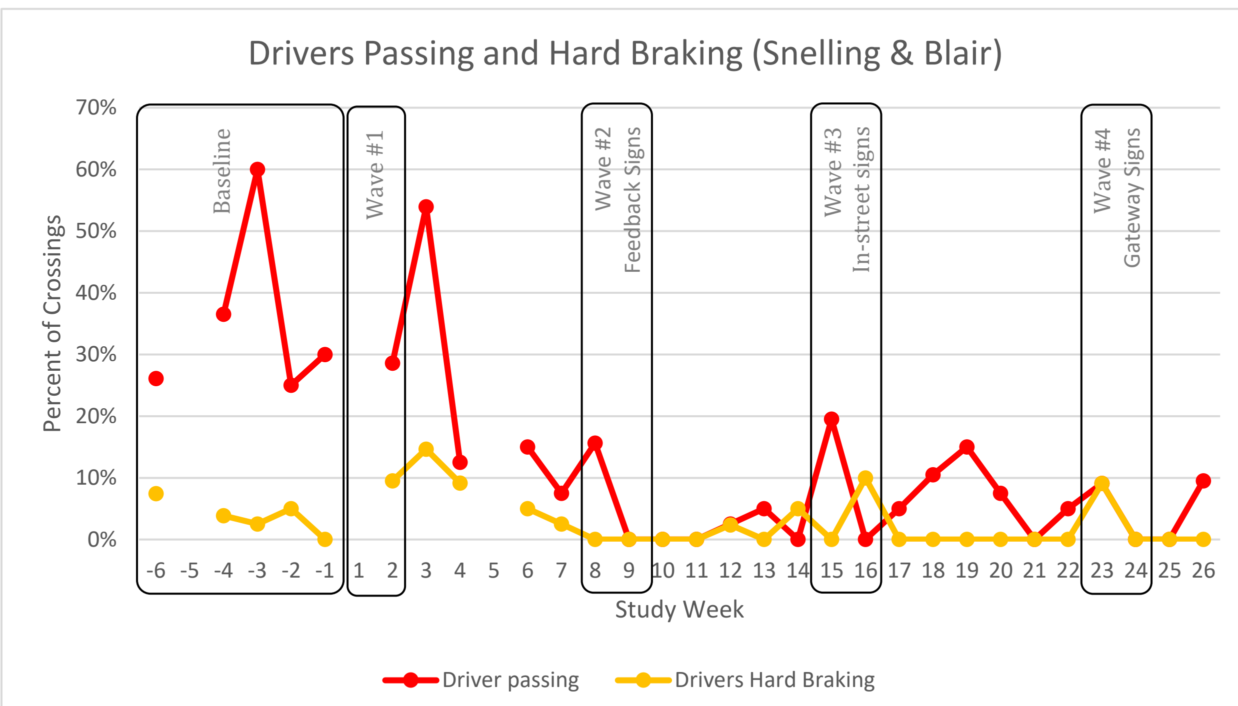


Figure I.6. Snelling & Blair

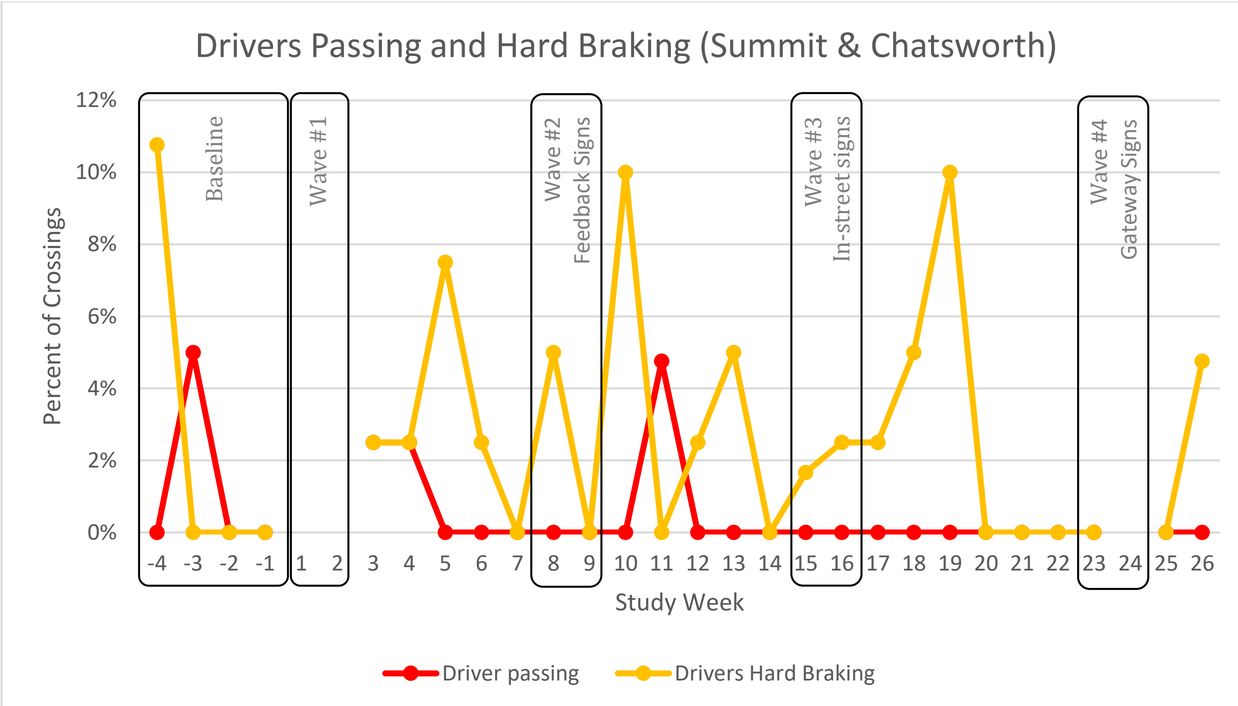


Figure I.7. Summit & Chatsworth

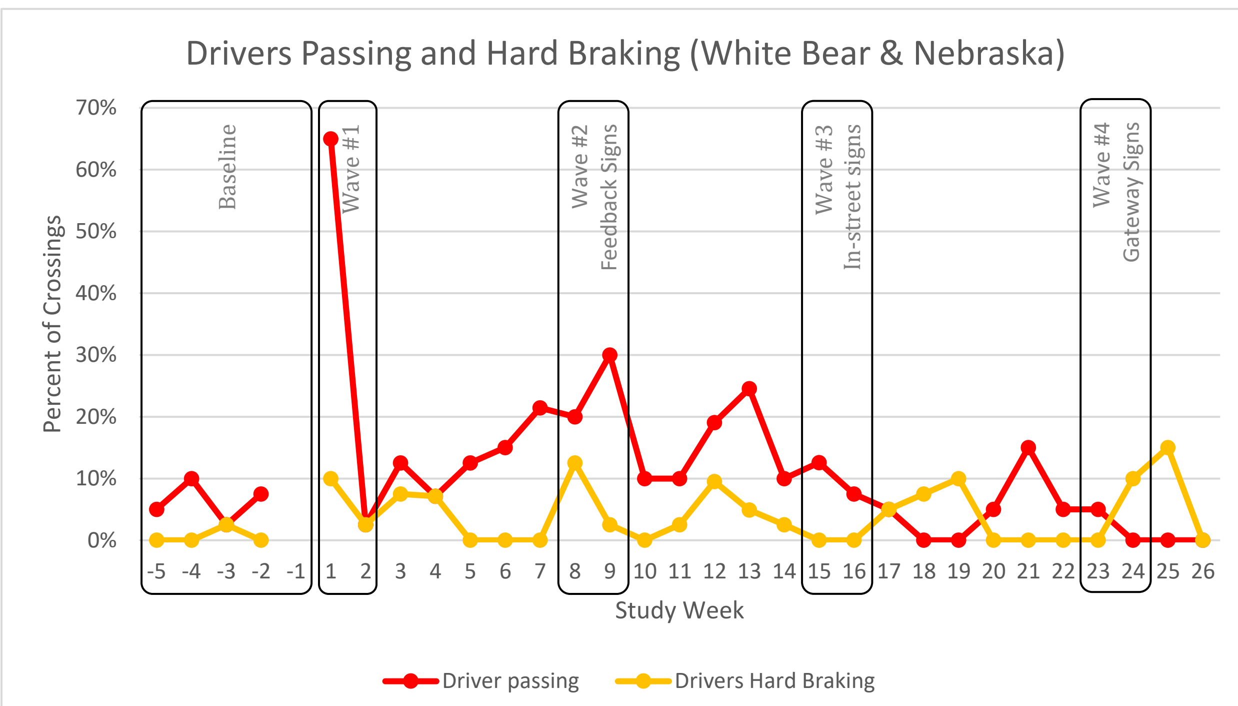


Figure I.8. White Bear & Nebraska

Generalization Sites

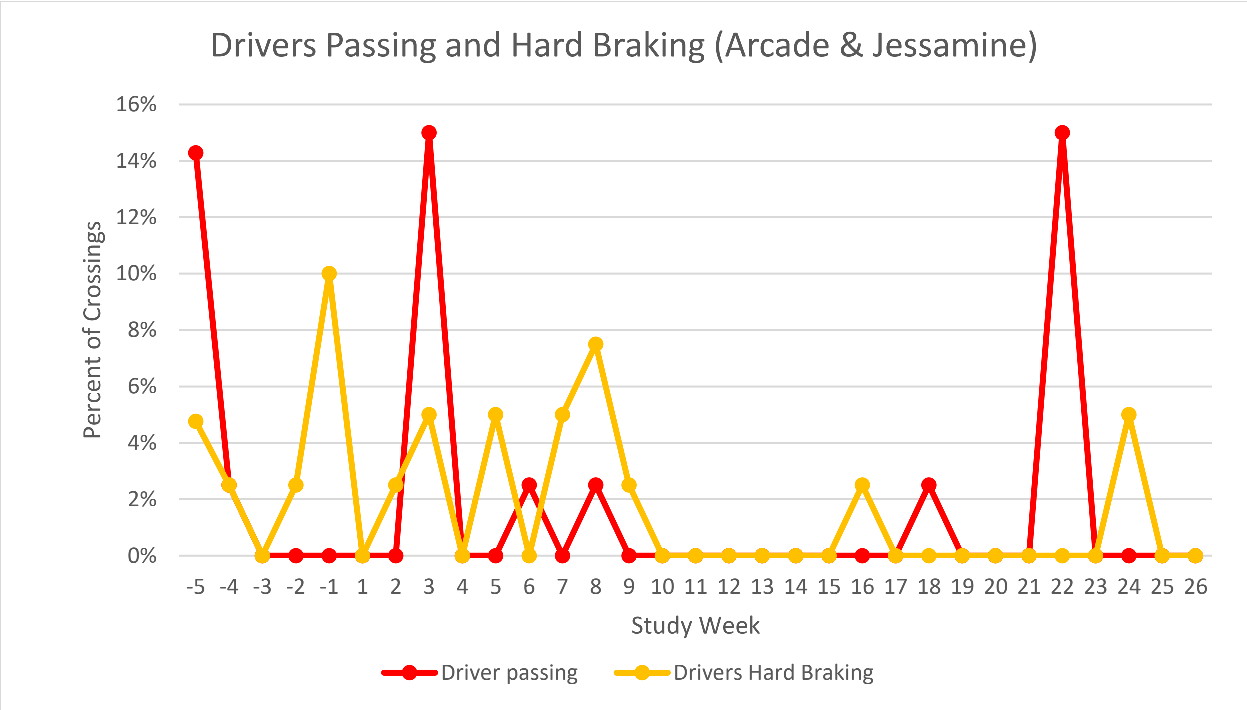


Figure I.9. Arcade & Jessamine

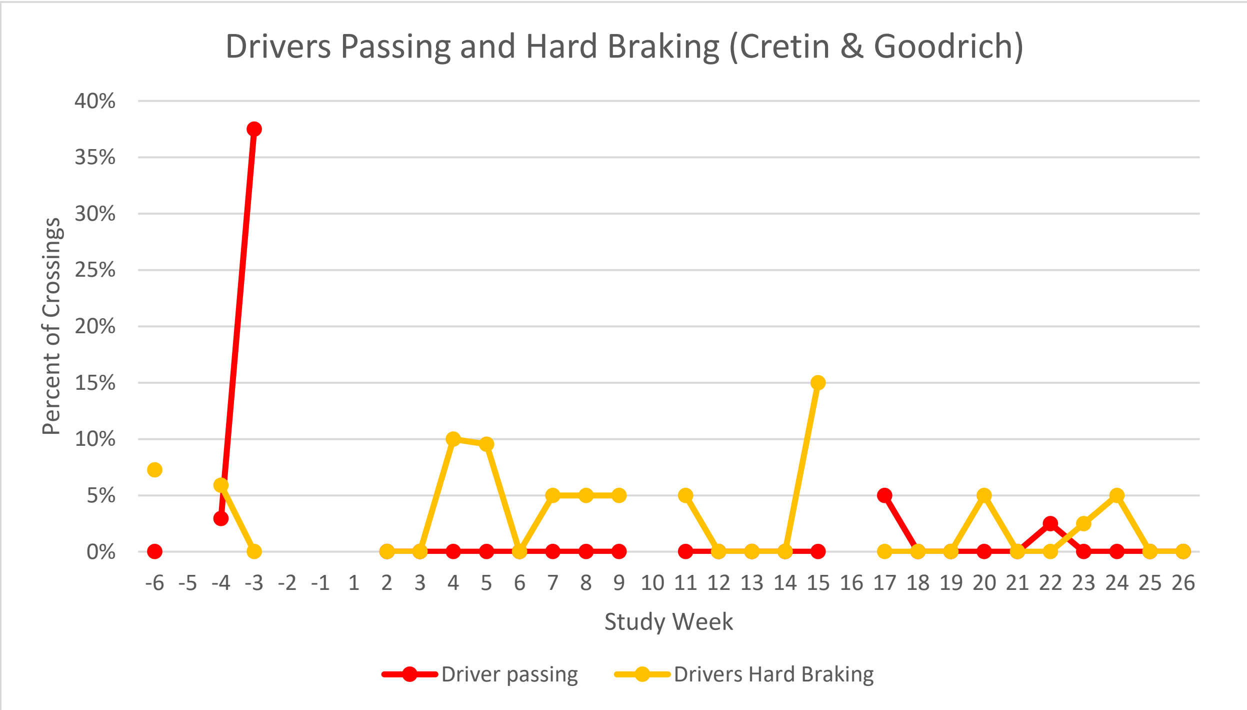


Figure I.10. Cretin & Goodrich*

*Note: abnormally high pass rates observed in in the two sessions in baseline week -3. ADT was particularly high in afternoon testing sessions. One of the sessions was halted early for safety.

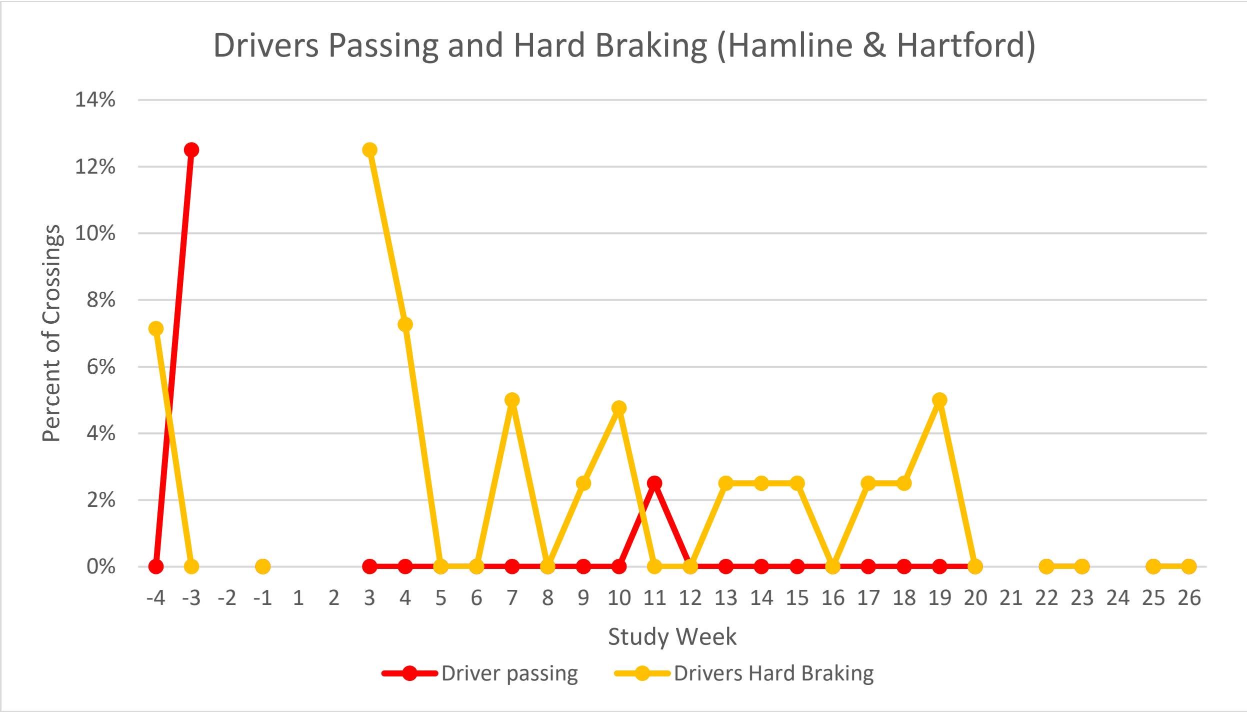


Figure I.11. Hamline & Hartford

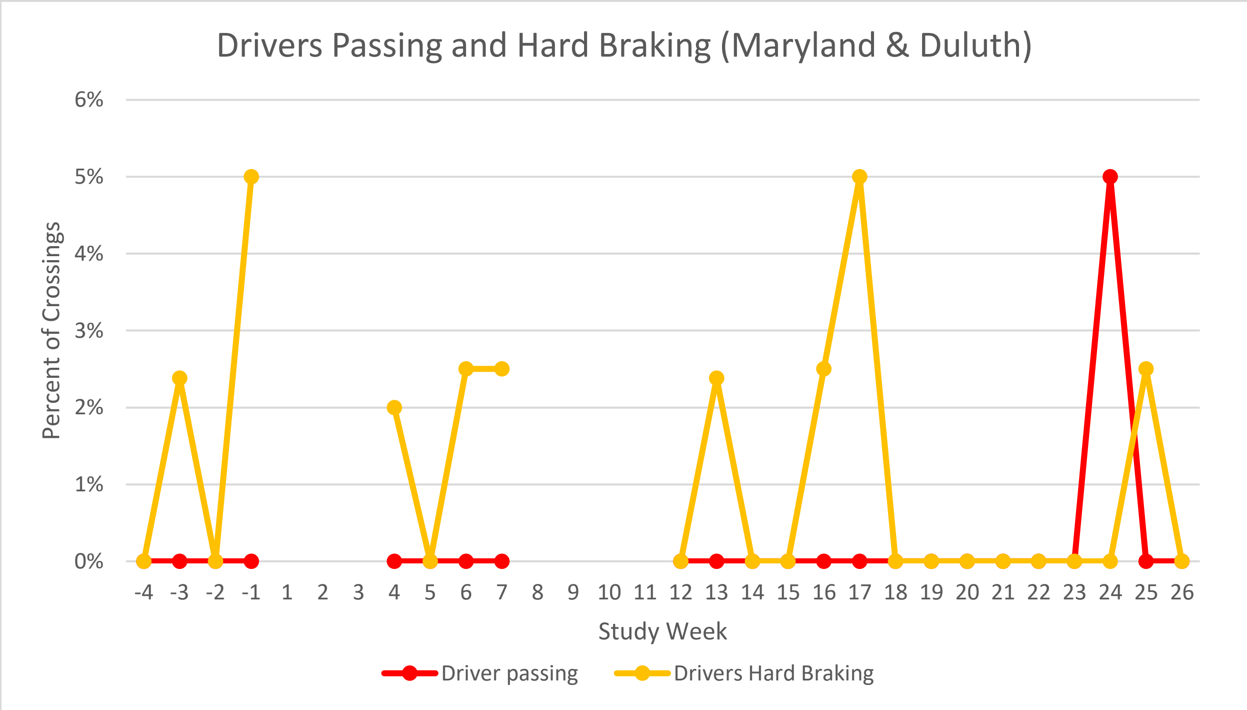


Figure I.12. Maryland & Duluth

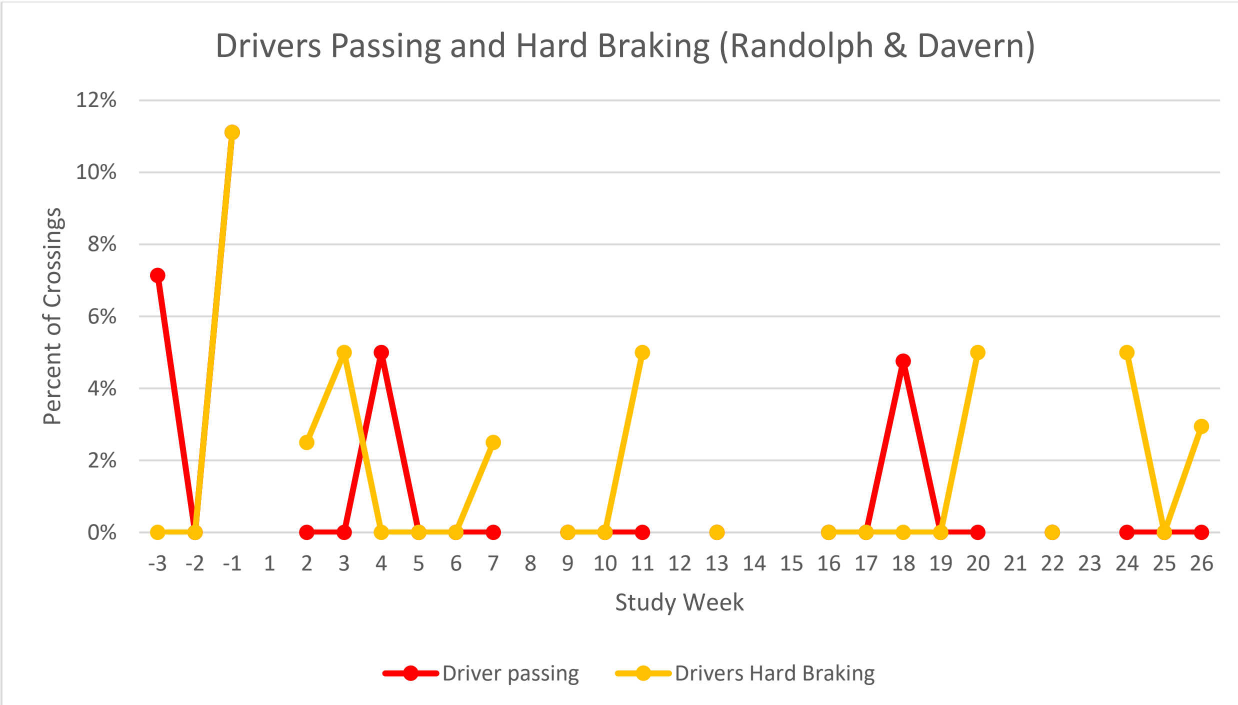


Figure I.13. Randolph & Davern

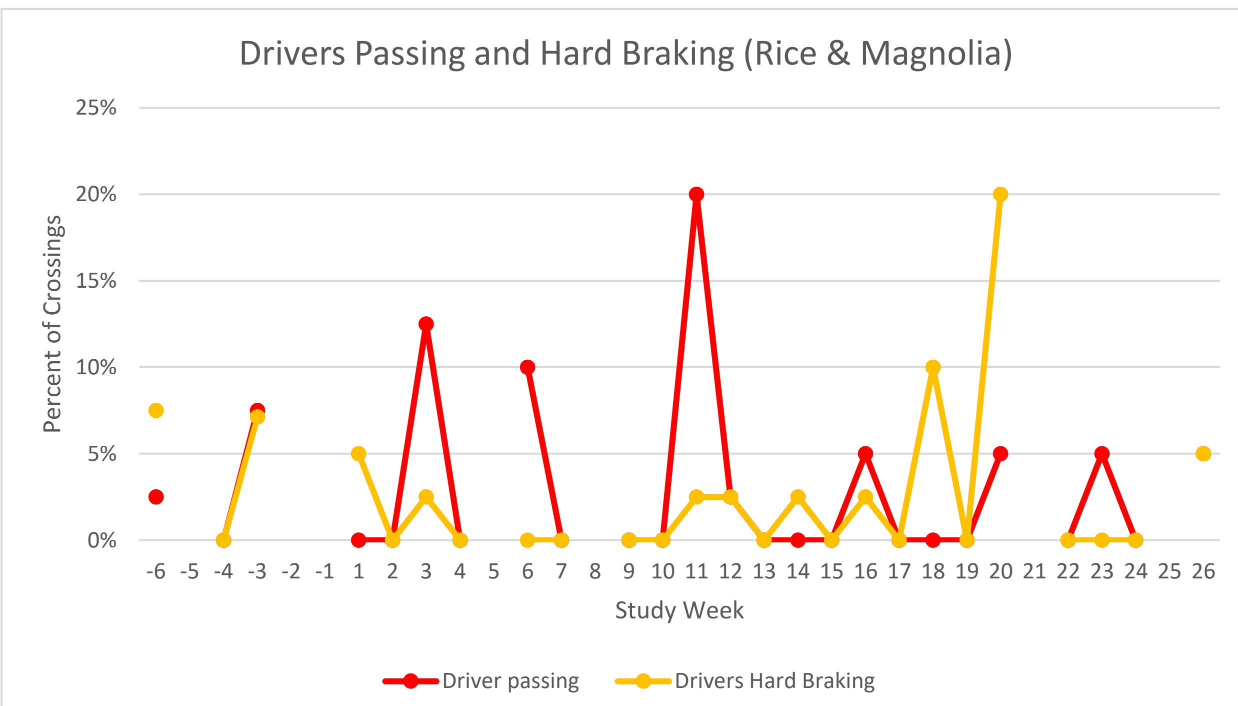


Figure I.14. Rice & Magnolia

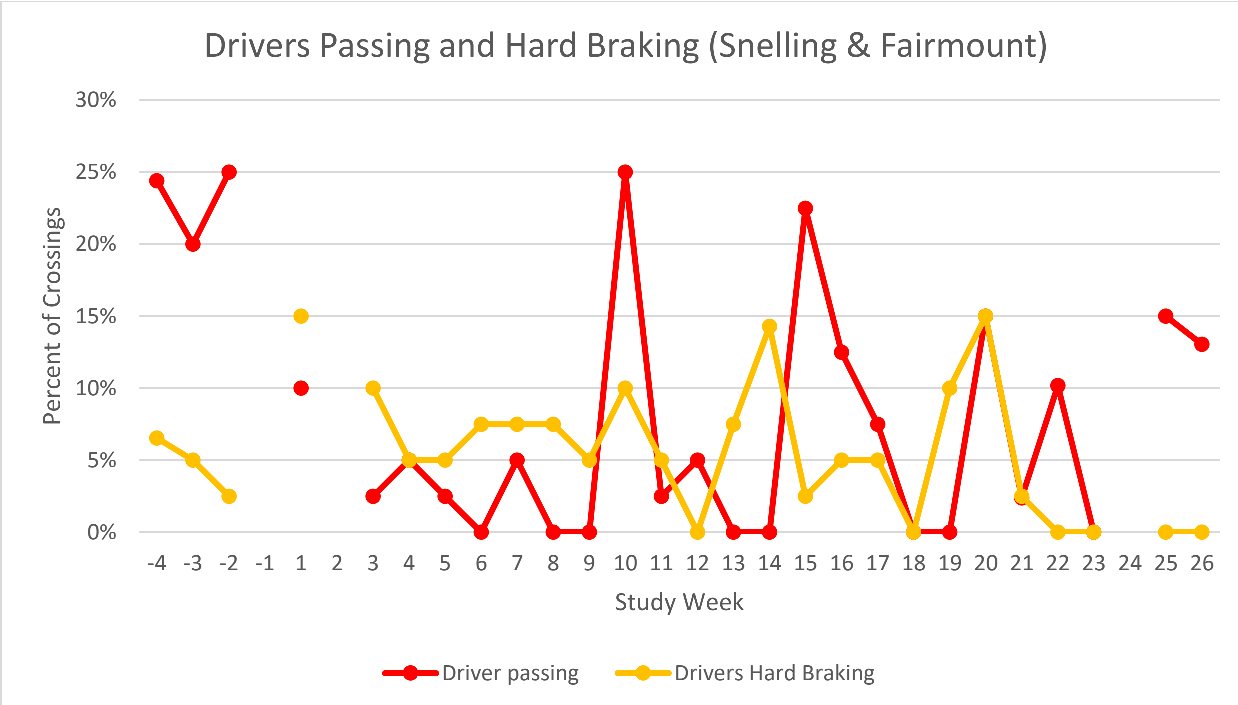


Figure I.15. Snelling & Fairmount

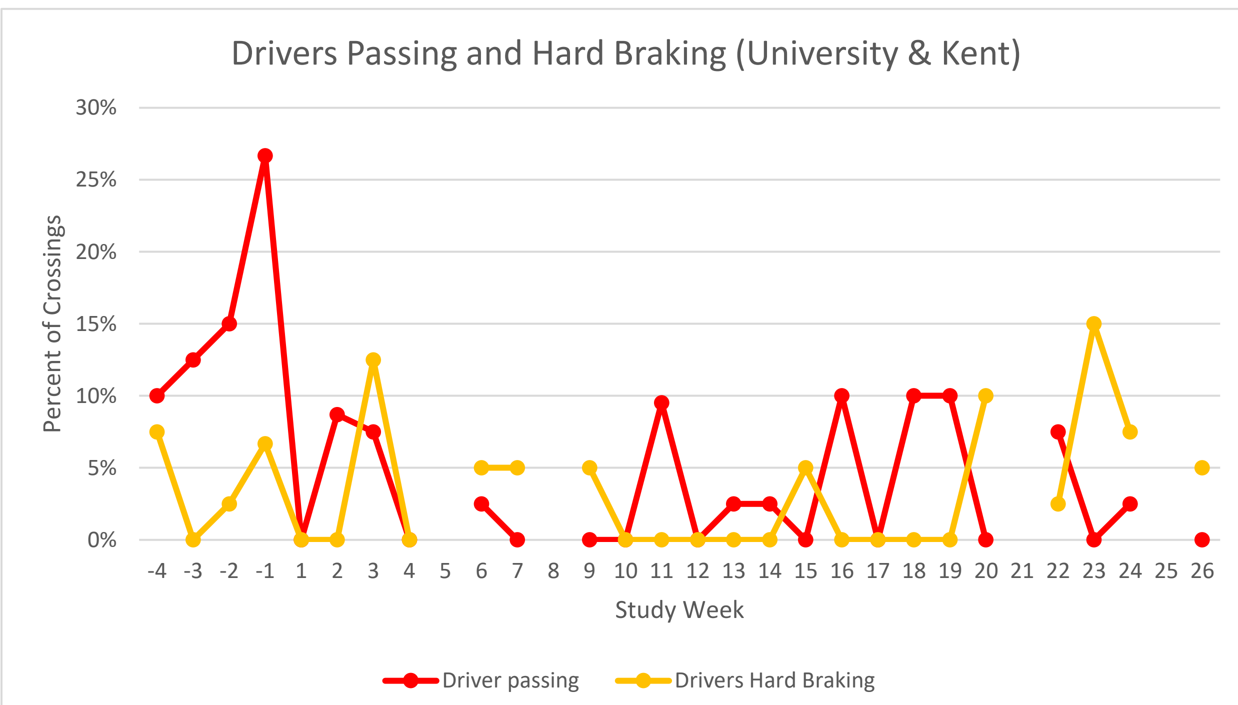


Figure I.16. University & Kent

APPENDIX J: ONLINE MINNESOTA CROSSWALK LAW SURVEY

University of Minnesota Qualtrics Survey Software

Introduction

You are invited to complete this short survey (approx. 5 minutes) relating to pedestrian safety information and pedestrian laws in Minnesota. This study is being conducted by the HumanFIRST Laboratory at the University of Minnesota (www.humanfirst.umn.edu).

Your participation is completely voluntary and you may exit the survey at any time. Please proceed if you agree to complete this survey.

Question 1

Are you currently a licensed driver?

- Yes, full license
- Yes, learner's permit
- No
- Rather not say

Question 2

How many years have you had a driver's license? (best guess or write n/a for not apply)

Question 3

How often do you drive in Saint Paul, MN?

- Daily
- Weekly
- Monthly
- Yearly
- Never

Question 4

Do you know what Minnesota law requires drivers to do when they approach a pedestrian in a crosswalk?

- Yes
- No
- Unsure

Question 5 (If “Yes” to Question 4)

What does Minnesota law require drivers to do when they approach a pedestrian in a crosswalk?

Question 5 (If “No” or “Unsure” to Question 4)

Please give your best guess of what Minnesota law require drivers to do when they approach a pedestrian in a crosswalk? (write "Do not know" if you cannot provide a guess)

Question 6

Is there a difference in what drivers must do if the pedestrian is crossing at an intersection but there is no painted crosswalk?

- Yes
- No
- Unsure

Question 7 (If “Yes” to Question 6)

Please provide your best guess for what the difference is for what drivers must do if the pedestrian is crossing at an intersection but there is no painted crosswalk? (write "Do not know" if you cannot provide a guess)

Question 8

Do you know what Minnesota law requires pedestrians to do when they cross the road in a crosswalk?

- Yes
- No
- Unsure

Question 9 (If “Yes” to Question 8)

What does Minnesota law require pedestrians to do when they cross the road in a crosswalk?

Question 9 (If “No” or “Unsure” to Question 4)

Please give your best guess about what Minnesota law requires pedestrians to do when they cross the road in a crosswalk? (write "Do not know" if you cannot provide a guess)

Question 10

How strictly do you think the police enforce the Minnesota law requiring drivers to stop for pedestrians in a crosswalk?

- Very strictly
- Somewhat strictly
- Not very strictly
- Rarely
- Not at all

Question 11

Have you recently seen any special police enforcement at crosswalks near where you live or typically drive?

- Yes
- No
- Maybe

Question 12

Where did you see special police enforcement at crosswalks? (approximate cross streets or neighborhood?

Question 13

In the past month, have you seen or heard any publicity about drivers stopping for pedestrians in crosswalks?

- Yes
- No

Question 14

Where did you see or hear the publicity about drivers stopping for pedestrians in crosswalks?

- Newspaper
- Radio
- TV
- Banner
- Brochure/Flyer
- Poster
- Information Booth
- Social media (e.g., Facebook, Twitter)
- Website
- Newsletter
- Other

Question 15

What did the publicity you saw or heard say?

Question 16

Have you recently seen a road sign about the percent of Saint Paul drivers stopping for pedestrians?

- Yes
- No

Question 17

Where did you see a road sign about the percent of Saint Paul drivers stopping for pedestrians?

Question 18

Do you live in Saint Paul, Minnesota?

- Yes
- No

Question 19 (If "Yes" to Question 18)

In what neighborhood of Saint Paul do you live?

Question 19 (If "No" to Question 18)

About how many miles from Saint Paul, MN do you live?

Question 20

How old are you? (leave blank if you'd rather not say)

Question 21

To which gender identity do you most identify? (leave blank if you'd rather not say)

Question 22 (Period 2 Survey Only)

Did you take this survey once before in the summer of 2018?

- Yes
- No
- I'm not sure

APPENDIX K: PEDESTRIAN SAFETY MEDIA TRACKING

Media	Date	Web Link
Saint Paul Monitor	4/9/2018	http://monitorsaintpaul.com/stop-for-me-campaign-finds-only-31-stop-for-pedestrians/
Star Tribune	29-Apr-18	http://www.startribune.com/the-drive-drivers-need-a-crosswalk-culture-change/481190871/
Pioneer Press	5/1/2018	https://www.twincities.com/2018/04/30/st-paul-police-kick-off-stop-for-me-campaign-to-ensure-pedestrian-safety/
WCCO Radio	5/2/2018	https://itunes.apple.com/us/podcast/john-hines/id809028210?mt=2&i=1000410487574
LilleNews.com	5/7/2008	http://www.lillienews.com/articles/2018/05/07/st-paul%E2%80%99s-pedestrian-safety-%E2%80%98stop-me%E2%80%99-campaign-kicks
Kare 11	5/8/2018	https://www.kare11.com/video/news/fatal-pedestrian-crashes-are-at-a-28-year-high-heres-one-citys-plan/89-8121915
Youtube	6/1/2018	https://www.youtube.com/watch?v=QOahnV7DJ2s
WCCO	6/12/2018	https://minnesota.cbslocal.com/2018/06/12/st-paul-police-crackdown-drivers-pedestrians/
Pioneer press	6/13/2018	https://www.twincities.com/2018/06/13/editorial-a-little-slower-a-little-safer-on-a-few-st-paul-streets/
WCCO	6/18/2018	https://minnesota.cbslocal.com/2018/06/18/st-paul-police-drivers-pedestrians/
WCCO	6/18/2018	https://minnesota.cbslocal.com/2018/06/18/good-question-laws-pedestrians-drivers-street-crossings/
Pioneer press	6/28/2018	https://www.twincities.com/2018/06/28/drivers-stopping-for-pedestrians-on-the-rise-u-of-m-study-finds/
Crossroads	7/10/2018	https://mntransportationresearch.org/2018/07/10/more-saint-paul-drivers-stopping-for-pedestrians-thanks-to-pilot-study/
Bring Me the News	7/19/2018	https://bringmethenews.com/minnesota-news/road-signs-in-st-paul-are-shaming-drivers-into-stopping-for-pedestrians
Star Tribune	8/6/2018	http://www.startribune.com/the-drive-signs-shame-drivers-into-stopping-for-pedestrians-in-st-paul/490103651/
Kare 11	8/6/2018	https://www.kare11.com/article/news/st-paul-trying-new-pedestrian-safety-signs/89-581109981
Kare 11	8/6/2018	https://www.youtube.com/watch?v=kCKmGxSXhTI
MPR	8/6/2018	https://www.mprnews.org/story/2018/08/06/numbers-say-stop-two-pronged-approach-to-traffic-safety
Pioneer press	10/5/2018	https://www.twincities.com/2018/10/05/st-paul-is-making-headway-in-getting-drivers-to-yield-to-walkers/
KSTP	10/11/2018	https://kstp.com/news/university-of-minnesota-st-paul-team-up-to-improve-pedestrian-safety-at-crosswalks/5104899/
StreetsblogUSA	10/18/2018	https://usa.streetsblog.org/2018/10/18/want-drivers-to-yield-to-pedestrians-you-gotta-play-mind-games/
Minnesota Daily	10/28/2018	http://www.mndaily.com/article/2018/10/n-umn-leads-project-to-bring-awareness-to-pedestrian-fatalaties
Kare 11	1/7/2019	https://www.kare11.com/article/news/pedestrian-safety-improving-despite-recent-crashes/89-de1586ae-16f2-4889-b69c-2f15f3ea18e6
Fox 9	5/22/2019	http://www.fox9.com/news/pedestrians-would-benefit-from-lower-speed-limits-on-mn-city-streets

APPENDIX L: FEEDBACK SIGNS

Figure L.1. Week 7 (first feedback sign week), June 18, 2018, Snelling Ave and Carroll Ave

Figure L.2. Week 9, July 2, 2018, Snelling Ave and Lafond Ave

Figure L.3. Week 11, July 16, 2018, University Ave and Vandalia Ave

Figure L.4. Week 12, July 23, 2018, Marshall Ave and Mississippi River Blvd

Figure L.5. Week 15, Aug 13, 2018, Maryland Ave and Clark Ave

Figure L.6. Week 22, Oct 1, 2018, University Ave and Vandalia Ave

Figure L.7. Week 24, Oct 15, 2018, Marshall Ave and Mississippi River Blvd