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MNDOT

HIGH ENFORCEMENT OF AGGRESSIVE TRAFFIC 2009-2012



An Evaluation of Minnesota's Three-Year HEAT Project
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Executive Summary

In July of 2009, the Minnesota Department of Transportation (MnDOT) Office of Traffic Safety, and Technology (OTST), Department of Public Safety (DPS) Offices of Traffic Safety (OTS) along with the Minnesota State Highway Patrol (MSP) collaborated to develop an aggressive driving education and enforcement campaign – High Enforcement of Aggressive Traffic (HEAT).

The HEAT Project began July 2009 and concluded July 2012. The three-year program aimed to improve roadway safety through education and heightened traffic enforcement. Minnesota State Patrol troopers and local law enforcement officers provided heightened enforcement through overtime hours.

In order to identify corridors with a concentration of aggressive driving related crashes, MnDOT OTST analyzed several years of crash data. MnDOT District Traffic Engineers, MSP, and local law enforcement agencies provided input and narrowed the list of enforcement corridors. Law enforcement agencies nominated one or two additional corridors from local roadways.

The project team assigned each enforcement district with a minimum of three enforcement zones plus one enforcement zone on the county road system. Enforcement waves lasted two-week and enforcement schedules rotated between night and day shifts.

The project team identified males and young drivers as the target audience of the HEAT Education Campaigns. Analysis of the crash data confirmed that males account for nearly two out of three fatal and serious injury crashes at all ages, with young drivers of both sexes over-represented. This priority informed our evaluation methods.

Prior to HEAT, compliance with the posted speed limit was relatively low on most roadways; during HEAT Enforcement, the compliance rate increased. However, after HEAT, compliance with the Posted Speed Limit (PSL) returned to baseline levels on most roadway types. Sustained enforcement presence aligns travel speeds with the posted speed limits!

A survey of Minnesota roadway users showed a high level of awareness of traffic safety messages; most respondents said they saw messages about impaired driving and impaired driving enforcement followed by the dangers of texting, seat belt usage, and finally speed related messages. Respondents also

THE HEAT Project aimed to improve roadway safety

- *Effect MN highways' 85th percentile speeds so they are closer to the posted speed limit.*
- *Heighten driver awareness of aggressive traffic related safety issues through multi-media education campaign.*
- *Improve efficiency and effectiveness of aggressive traffic enforcement efforts to positively affect 85th percentile speeds and aggressive traffic related crashes.*

reported high levels of support for the messaging, which may indicate general receptiveness to traffic safety messaging.

Introduction

In collaborative meetings with DPS-OTS, MSP, and MnDOT-OTST, representatives identified those driver groups who are at highest risk of being involved in an aggressive driving related fatal or serious injury crash. Every participant identified young male drivers followed by younger drivers and male drivers of all ages as the highest risk drivers.

Figure 1 shows the percentage of fatal and serious injury crashes by age and sex of driver over the percentage of licensed drivers for the same age and sex. Overall the split between male and female licensed drivers is relatively even for each age. The distribution of licensed drivers across age groups corresponds closely with the distribution of the general population. In general, the distribution for licensed drivers is as expected and relatively even. The light overlay shows the percentage of drivers by age and sex who were involved in a fatal or serious injury crash.

The most salient characteristic of Figure 1 is the disproportionate number of younger drivers involved in fatal and serious injury crashes. Additionally, males are overrepresented in each age group by nearly 3 to 1! Young drivers, age 15-20 years, represent roughly 20% of drivers involved in fatal and serious injury crashes, yet 15-20 year old drivers represent 6.5% of licensed drivers.

Minnesota's 2009 HEAT Project

The 2009 HEAT Campaign aims to reduce traffic fatalities by reducing dangerous driving behavior. To reach this goal, (MnDOT) Office of Traffic Safety and Technology (OTST), Minnesota Department of Public Safety (DPS) Office of Traffic Safety (OTS) and Minnesota State Patrol (MSP) partnered in a high visibility targeted enforcement and public education campaign.

A crash data analysis by MnDOT OTST revealed corridors with high frequency of aggressive driving-related crashes. Minnesota State Patrol and local enforcement agencies provided input on the potential enforcement corridors. Local law enforcement agencies also nominated one local zone.

The project team assigned each enforcement district with a minimum of three enforcement zones on the state roadway system plus one enforcement zone on the county roadway system. Using overtime hours offered to MSP and local law enforcement agencies, each enforcement wave ran for two-week.

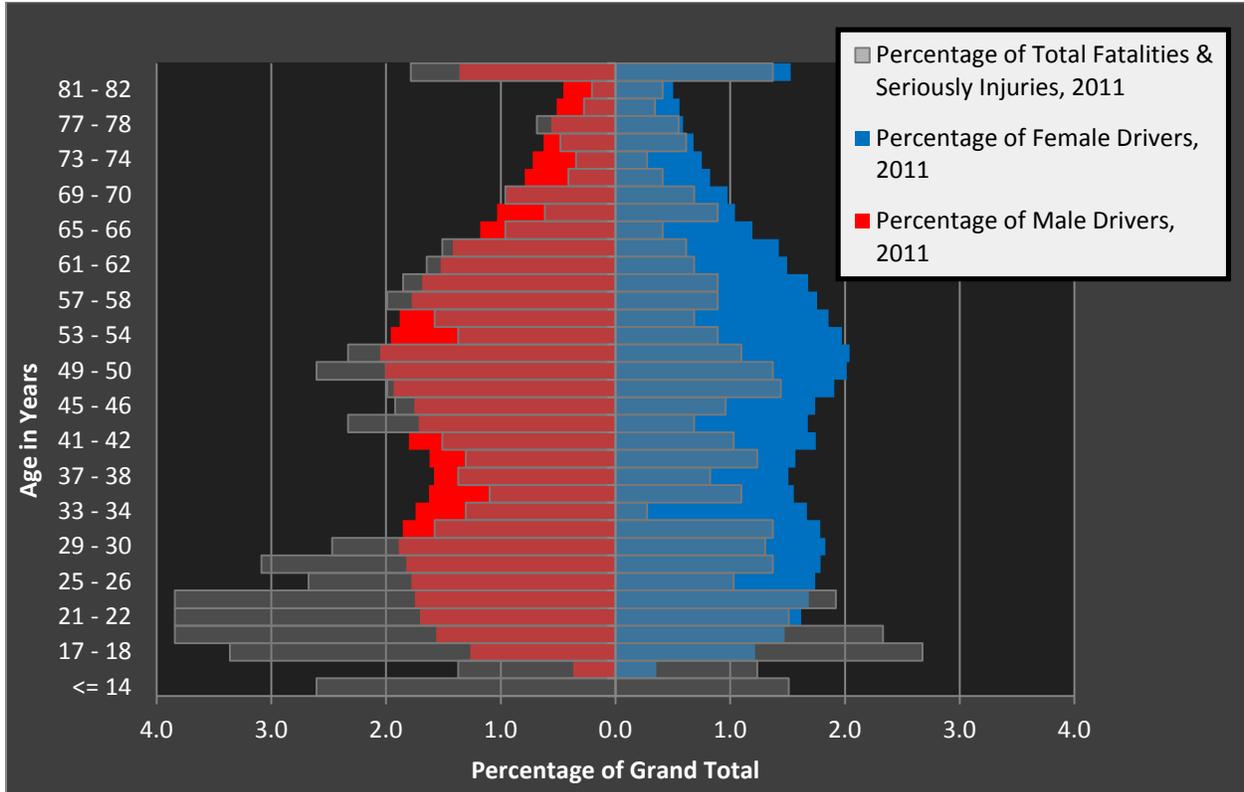
From July 2009-July 2012, law enforcement officers patrolled 57 HEAT Enforcement Zones. Figure 2 shows the HEAT Enforcement Zones (represented by gold highlight over the roadway). Some enforcement zones included one or more roadway speed, data collection device. Figure 3 shows the

DRIVERS at highest risk of a fatal or serious injury crash: young drivers age 16 to 30 and young, male drivers.

Male drivers account for nearly two out of three fatal and serious injury crashes for every age group.

HEAT Enforcement Zone, indicated with gold, and the roadway speed, data collection devices, represented by maroon dots.

Figure 1: Minnesota Licensed Drivers by Sex and Age Overlaid Fatal and Seriously Injured Drivers by Sex and Age



Source: ¹ Aggregated Minnesota Licensed Drivers by Age and Sex (Minnesota Department of Public Safety, 2011).
² Crash Data MnDOT 2011 Crash Data.

Table 1: Number of Miles of Roadway Eligible for HEAT Enforcement by Roadway Type

Roadway System	Miles of Enforcement Zones
County Roads	530
Trunk Highways	930
Interstate	419

Figure 2: Minnesota HEAT Enforcement Zones 2009-2012

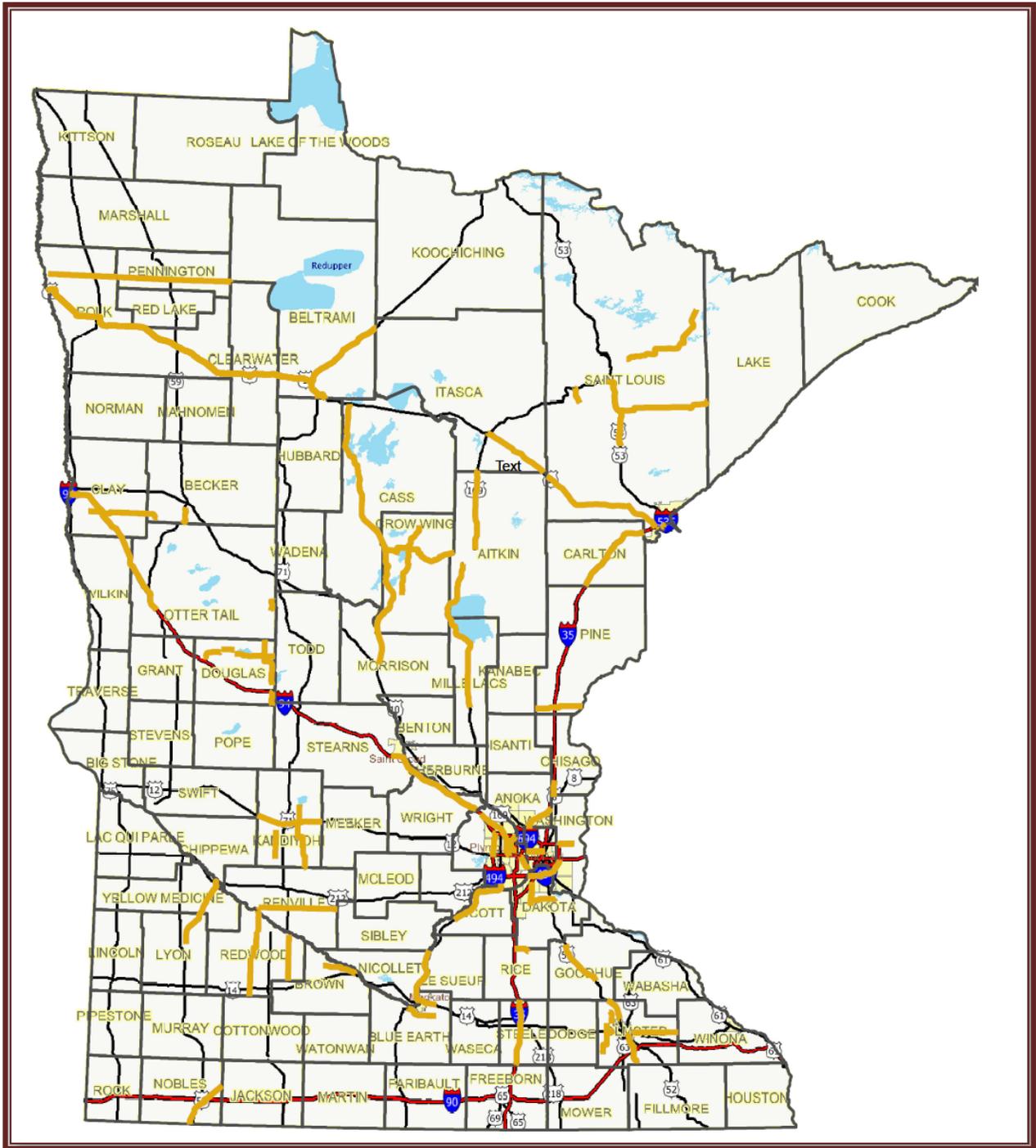
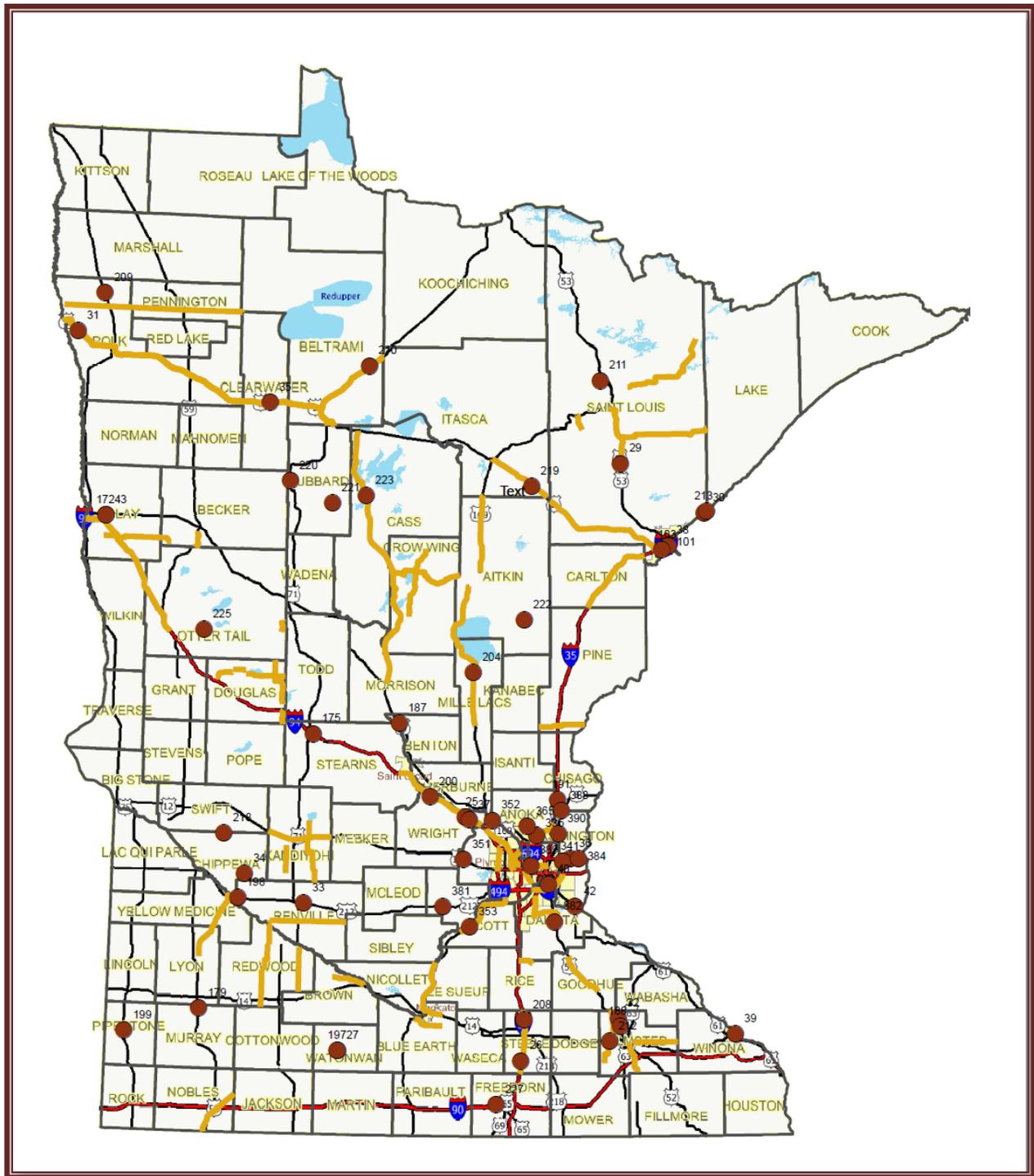


Figure 3: Minnesota Speed Enforcement Zones and Speed Recording Devices



How to Read This Report

This report includes four analysis sections: analysis of citation data, analysis of speed data, analysis of crash data, and analysis of public perception and attitudes toward aggressive driving. Within these sections are several terms that are repeated. Below is a description of the terms used in this report.

Common Terms Found in This Report

- **Baseline Period** includes data from July 2008 through June 2009 roadway speed data and July 2006 through June 2009 for crash data.
- **Treatment Period** includes data from July 2009 through July 2012.
- **Post-treatment Period** includes data from July 2012 through June 2013.
- **HEAT Zones** refers to designated corridors where there was heightened enforcement through the HEAT Project.
- **Treatment Section** is a designated HEAT Zone with HEAT Enforcement.
- **Control Sections** are roadway randomly segments that share characteristics to one or more HEAT zone, but were not part of the HEAT Project.

Prior to the start of the HEAT Project, the research team developed an Evaluation Plan that reflects the overarching goals alongside the evaluation metrics for these goals. The Evaluation Plan section offers a detailed description of the [Evaluation Metrics](#) and the original Evaluation Plan.

For clarity, a list of acronyms is provided in [Appendix A](#).

Background and Literature

What is Aggressive Driving

To define aggressive driving is somewhat complex and yields many possible behaviors to formulate the idea of aggressive behavior. One's personal experience, knowledge, and field of practice influence how one defines aggressive driving. For our purposes, the existing literature guided the foundation of the operational definition of aggressive driving.

The National Highway Traffic Safety Administration (NHTSA), defines aggressive driving as occurring when "an individual commits a combination of moving traffic offenses so as to endanger other persons or property" (National Highway Traffic Safety Administration). One report from NHTSA states that aggressive driving "is generally understood to mean driving actions that markedly exceed the norms of safe driving behavior and that directly affect other road users by placing them in unnecessary danger" (National Highway Traffic Safety Administration, 2009). NHTSA further specifies, "exceeding the posted speed limit, following too closely, erratic or unsafe lane changes, improperly signaling lane changes, and failure to obey traffic control devices (stop signs, yield signs, traffic signals, railroad grade cross signals, etc.)" as typical aggressive behaviors. Law enforcement agencies should include red light running as part of their definition of aggressive driving" (National Highway Traffic Administration).

In *Strategies for Implementing Best Practices for Aggressive Driving Enforcement*, NHTSA encourages programs to form a definition of aggressive driving based on state laws, individual agency customs and practices, and by the public's understanding (National Highway Traffic Administration). Based on these sources and recommendations the project team adopted the following operational definition:

Aggressive drivers operate their vehicle in a manner that threatens other drivers, passengers, pedestrians, and/or bicyclists. This includes unlawful speed, unsafe speeds, inattentive driving, driving under the influence of drugs or alcohol, texting while driving, failure to follow traffic signals (running red lights/stop signs), failure to yield, following at an unsafe distance, unsafe or illegal lane changes (weaving in and out of traffic), driving without a seatbelt, and/or improperly belted/seated child.

Motorist surveys show similar results. Motorists consistently identify tailgating, inattentive/distracted driving, driving while intoxicated, unsafe lane/erratic lane changes, and failure to obey traffic signals as serious threats to their safety. Speed often ranked lower on the list of threatening behaviors (AAA Foundation for Traffic Safety, 2008). The AAA Foundation Traffic Safety Culture Index also shows that 90% of respondents identified cell phone use and texting as very serious threats to their safety. Eighty percent identified distracted driving as a threat to safety. Ninety percent identified red light running and tailgating as "unacceptable" behaviors and 63% stated traveling 15 mph over the speed limit was "unacceptable" (AAA Foundation for Traffic Safety, 2008).

One NHTSA report indicated that driver perceptions of unsafe behavior are not completely static across age groups. Younger age groups tended to view speed as less unsafe, and generally, older respondents rated speed as more unsafe. Most respondents consistently ranked the following as actions as threats to their own safety (Schulman, Ronca, and Bucuvalas Inc., 1998):

- driving under the influence
- passing a school bus that has its red lights flashing and the stop arm is in full view
- failure to yield to traffic signals/devices
- racing another driver
- cutting in front of another driver
- using the shoulder to pass
- crossing a railroad when light is blinking
- driving 20mph faster than other drivers
- driving 10mph over the speed limit in a residential neighborhood.

A nationally representative Gallup survey confirmed motorists' perceived threats were: cutting too close in front, passing in a dangerous manner, and cutting-off at an intersection or at an exit, and. The study further identifies, obscene gestures driving too close behind or beside, speeding, and running red lights as threatening behaviors. When asked about the sufficiency of specific types of enforcement levels to prevent specific behaviors, most felt behaviors other than speed required more law enforcement. For example, 60% identified tailgating as insufficient, 57% identified weaving in and out of traffic, 47% identified running red lights, 44% identified failure to stop, and 41% identified speeding enforcement as insufficient. Although roadway users identify specific behaviors as unacceptable or a threat to their safety, a large percentage of respondents report engaging in the same behaviors (The Gallup Organization, 2003).

The Challenges of the Aggressive Driver

There are two challenges to identifying and addressing the aggressive driver: (1) the strategies to motivate or deter risk taking by those who are prone to taking high risk is somewhat complicated and (2) some aggressive driving behaviors, such as speeding are ubiquitous across all types of drivers.

One Minnesota study found that male drivers self-report significantly higher frequency of speeding, driving while intoxicated, and safety belt non-compliance; age was a significant covariate meaning older drivers reported lower frequency of the same behaviors. The same study also found that perceived danger of speed was lower for younger respondents, rural respondents perceived driving while intoxicated as less dangerous than urban respondents, and male respondents associated less danger with seat belt non-use than females (Rakauskas M. E., Ward, Gerberich, & Alexander, 2007).

The motivating factors of higher risk drivers differ from low risk drivers. One study surveyed nighttime drivers and found drivers with a higher blood alcohol content, exhibited lifestyles lacking in self-control. The certainty of apprehension, recognition of impairment levels, and peer intervention showed no impact on the likelihood of driving while impaired (Kean, Maxim, & Teevan, 1993). Understanding the factors that motivate a high-risk driver aids in development of effective prevention strategies.

The Evaluation Plan

Prior to implementation, the HEAT Project Team adopted an evaluation plan. In conjunction with DPS and MSP, MnDOT developed the evaluation plan. Through a series of focused meetings with the collaborating agencies and an exhaustive literature review of similar programs, the project team identified the target risk group and developed an operational definition of aggressive traffic.

The data and team input clearly identify young drivers and male drivers bear the highest risk of involvement in an aggressive driving crash. Figure 1 shows that there are 2.7 male drivers involved in a crash for every female driver involved in a crash. Additionally, Figure 1 shows that younger drivers under the age of thirty years of age are over involved in fatal and serious injury crashes and drivers 16-24 years of age are significantly over involved in fatal and serious injury crashes.

The target high-risk group informed data collection methods from MSP and the media education campaign provided by DPS OTS.

The HEAT Project had three objectives:

1. Effect MN highways' 85th percentile speeds so they are closer to the posted speed limit.
2. Heighten driver awareness of aggressive traffic related safety issues through multi-media education campaign.
3. Improve efficiency and effectiveness of aggressive traffic enforcement efforts to affect the 85th percentile speeds and aggressive traffic related crashes.

In order to identify viable data sources for the final project evaluation, the evaluator surveyed each participating department. The Minnesota Department of Transportation offered roadway speed data from 36 data collection devices locations throughout Minnesota. Minnesota State Patrol agreed to log all vehicle stops and outcomes while conducting a HEAT patrol. The Minnesota Department of Transportation and MSP developed a custom data collection tool, the [HEAT Officer Activity Report](#). The Minnesota State Patrol collected all paper Activity Reports and organized those data into an electronic

AGGRESSIVE TRAFFIC:

Driving in a manner that presents a threat to other drivers, passengers, pedestrians, and/or bicyclists. This includes unlawful speed, unsafe speeds, inattentive driving, driving under the influence of drugs or alcohol, texting while driving, failure to follow traffic signals (running red lights/stop signs), failure to yield, following at an unsafe distance, unsafe or illegal lane changes (weaving in and out of traffic), driving without a seatbelt, and/or improperly belted/seated child.

file. MnDOT hired a consultant to conduct a three-wave survey to measure education outcomes before, during, and after active enforcement and education campaigns.

The evaluation research design offers a holistic assessment of the project outcomes using multiple data to measure performance. For this report, MnDOT used four available data sources, which offer metrics by which to measure program outcomes.

Evaluation Metrics

Key metrics identified in the HEAT Evaluation Plan measure the impact of the HEAT Project.

Evaluation Metrics – Citation Data

- **Violator Stops by Age and Sex:** the proportion of violators within a given age range and sex stopped during an active HEAT Patrol

Evaluation Metrics – Roadway Speeds

- **The 85th Percentile Speed:** the roadway speeds at which up to 85% of drivers travel in a given time period (sometimes referred to as the operational speed). The HEAT Project aims to align the 85th percentile speeds with the posted speed limit.
- **Percent Compliant:** the percent of drivers traveling up to, but not over, the posted speed limit.
- **Percent within Compliance Range:** the percentage of drivers who travel up to ten miles per hour over the Posted Speed Limit.

Evaluation Metrics – Crash Data

- **Severe Crashes:** the count of crashes that result in one or more person killed and/or seriously injured¹.

Evaluation Metrics - Public Perception and Attitudes Toward Aggressive Driving – Three Wave Survey

- **Education Campaign Recognition:** the percent of survey respondents who saw or heard a HEAT-related media message.
- **Internalization of Messaging:** high rating of self and friends feeling compelled to adopt the behavior suggested in the media campaign.

¹ Fatal and serious injury crashes are the primary focus of the HEAT Program, which is in harmony with the mission of [Minnesota Toward Zero Deaths](#).

Table 2: HEAT Project Evaluation Plan 2009-2012

Objectives	Measure of Effectiveness	Data Source	Agency
Heightened enforcement will affect MN highways' 85 th percentile speeds so they are closer to the posted speed limit.	85 th percentile speed will more closely reflect the posted speed limit	ATR ² and WIM ³ devices located throughout MN.	Travel speed data provided by Mn/DOT Traffic Forecast and Analysis Section.
Heightened enforcement will affect MN highways' 85 th percentile speeds so they are closer to the posted speed limit.	Effect and residual effect of Heightened Enforcement on roadway speeds will be measured. ATR and WIM data will be analyzed before, during, and after enforcement periods to measure change in the 85 th percentile speed and relationship between changes in 85 th percentile speed and proximity of an enforcement zone	ATR and WIM devices located throughout MN	Travel speed data provided by Mn/DOT Traffic Forecast and Analysis Section.
A multi-media education campaign will improve driver awareness of aggressive traffic related safety issues through multi-media education.	Type and duration of media campaigns will be recorded and compared to population survey respondents identify where they first learned about the HEAT Project	Media campaign types will be tracked and three-wave population survey will be administered.	DPS will facilitate the multi-media campaign. Mn/DOT Market Research Services and Office of Traffic Safety and Technology in conjunction with a hired consultant will facilitate the population survey.
A multi-media education campaign will improve driver awareness of aggressive traffic related safety issues through multi-media education.	Responses to a three wave population survey of driver knowledge of and attitudes toward aggressive traffic will be used to assess driver awareness of aggressive driving behaviors and efforts directed at reducing aggressive traffic	Three-wave population survey that measures attitudes toward aggressive traffic and awareness of heightened enforcement efforts.	DPS will facilitate the multi-media campaign. Mn/DOT Market Research Services and Office of Traffic Safety and Technology in conjunction with a hired consultant will facilitate the population survey.

² ATR or Automatic Traffic Recorders are in road traffic speed and volume recording [devices owned and operated by MnDOT](#).

³ WIM or Weight in Motion devices are in road traffic speed, volume, and vehicle classification recording [devices owned and operated by MnDOT](#).

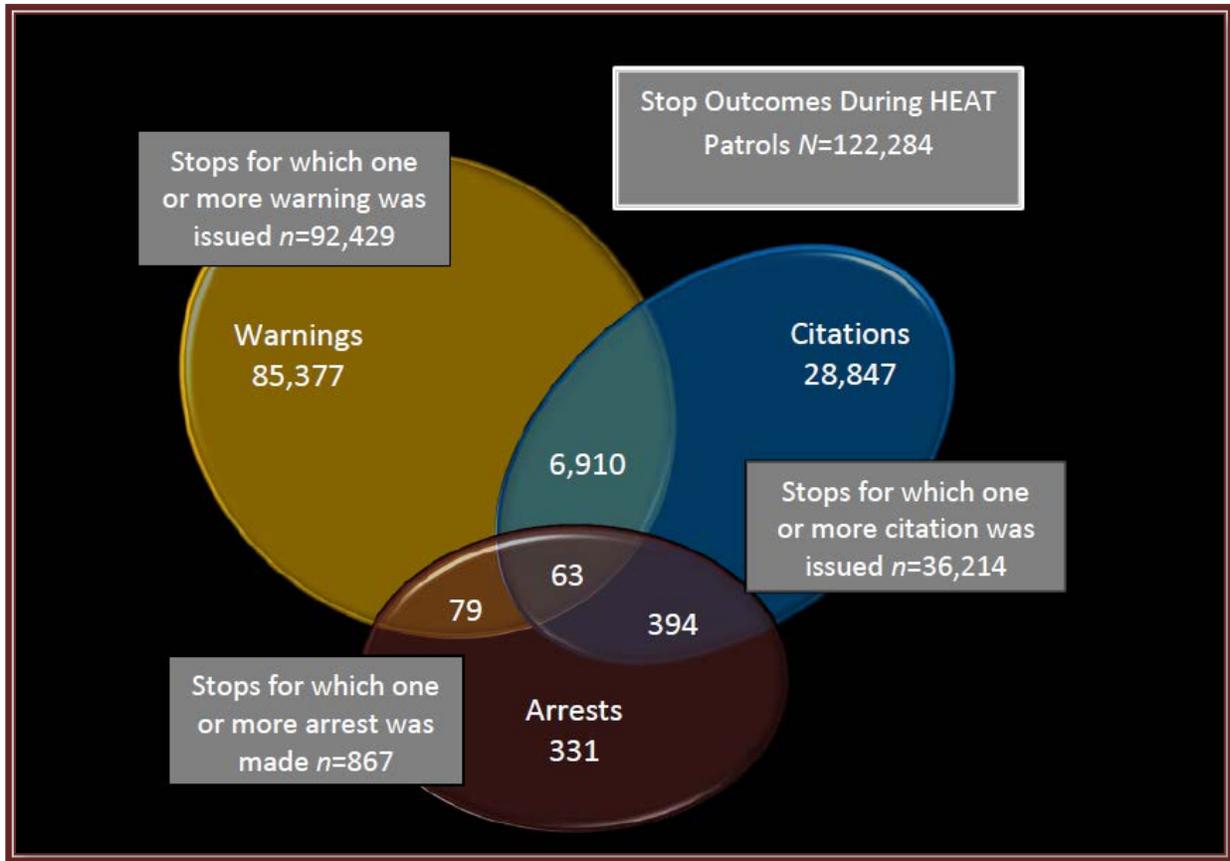
Objectives	Measure of Effectiveness	Data Source	Agency
<p>Heightened aggressive traffic enforcement efforts will positively affect 85th percentile speeds.</p>	<p>Measure relationship between enforcement and 85th percentile speed</p>	<p>MSP will track hours of enforcement, traffic stops and citation by type and number. Citations will also be tracked by age-group and sex of violator within enforcement zones during Heightened Enforcement periods.</p> <p>ATR and WIM devices located in enforcement zones</p>	<p>MSP and local law enforcement agencies will collect data pertaining to HEAT enforcement schedules, citations issued during HEAT enforcement periods, specific to targeted enforcement zones.</p> <p>Travel speed data provided by Mn/DOT Traffic Forecast and Analysis Section.</p>
<p>*Heightened aggressive traffic enforcement efforts will positively affect aggressive traffic related crashes.</p>	<p>Measure relationship between enforcement and roadway crash data</p>	<p>MSP will track traffic stops and citation by type and number. Citations will also be tracked by age-group and sex of violator within enforcement zones during Heightened Enforcement periods</p> <p>Roadway crash data extracted from TIS</p>	<p>MSP and local law enforcement agencies will collect data pertaining to HEAT enforcement schedules, citations issued during HEAT enforcement periods, specific to targeted enforcement zones.</p> <p>Mn/DOT OTST will extract and analyze TIS Crash Data.</p>

*This is a long-term goal which will require analyses at least one year following the HEAT campaign.

Analyses of Citation Data

From July 2009 through August 2012, law enforcement officers stopped 122,284 stops during active HEAT patrols. Each stop may result in one or more possible warnings, citations, or arrests. Seventy-five percent of stops resulted in at least one warning in addition to a citation or arrest; nearly 70% of all stops resulted in one or more warning alone. Thirty percent of the HEAT stops resulted in one or more citation.

Figure 4: Violator Stop Outcomes During HEAT Patrols, N=122,284 Stops



Note. 122,284 stops represent traffic stops for which complete data were available. Actual number of traffic stops may be greater than 122,284.

The benefits of the HEAT Project extended beyond just traffic safety! Through HEAT traffic patrols, law enforcement took into custody over 300 persons with an outstanding warrant. Additionally during HEAT Patrols, law enforcement officers arrested 200 impaired drivers!

As determined prior to the start of the 2009 HEAT Project, young drivers and male drivers bear the greatest risk of involvement in a fatal and serious injury crash. As shown in Figure 5, a similar pattern also exists among traffic law violations. Figure 5 shows the percent within sex and age group of all violators stopped during HEAT Patrols. Here we can see that, like traffic fatalities and serious injuries, young adult

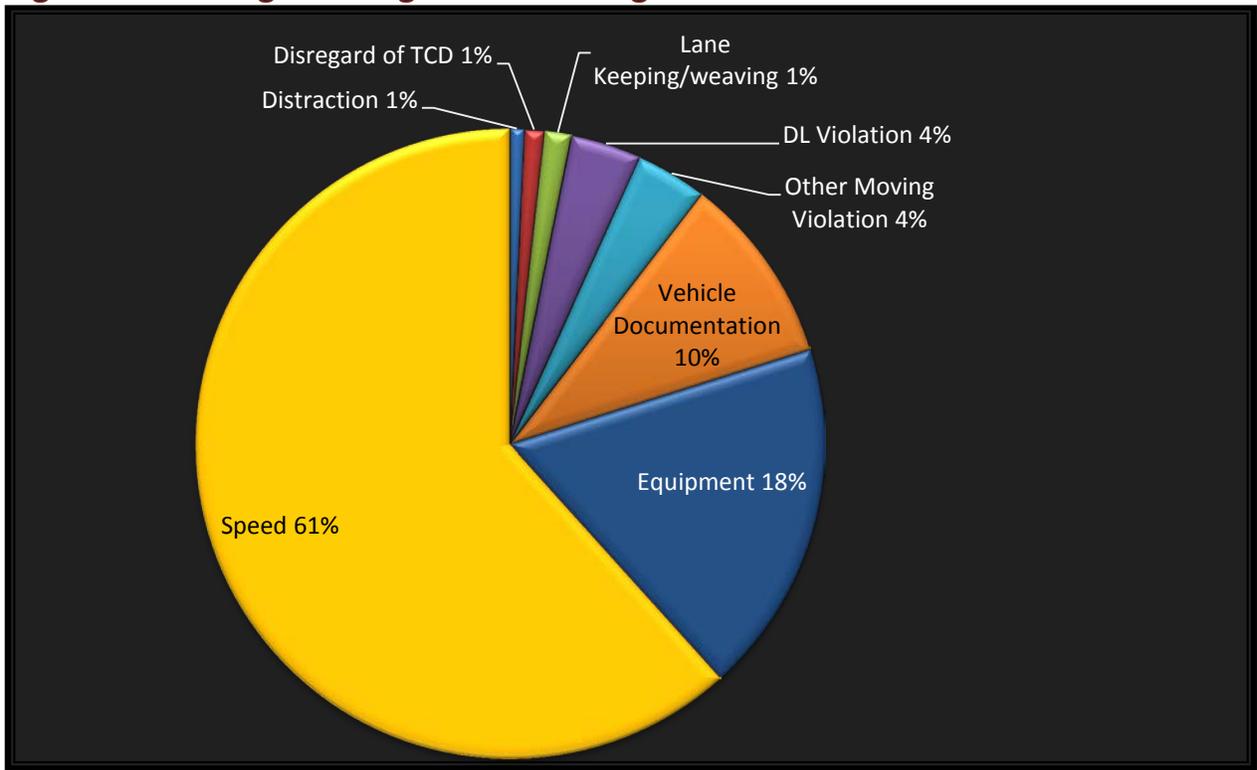
drivers account for a disproportionate number of traffic stops. As a group, male drivers, account for nearly two out of three traffic stops. Overlaid is the outline of the percent of fatal and serious injuries for the same age group and sex. We can see that young drivers and male drivers account for a disproportionate number of fatalities.

The proportion of citations for each age group in Figure 5 offers an assessment of observed unsafe driver choices juxtaposed with the outcomes of unsafe driver choices. Traffic fatalities and serious injuries among males between 30 and 50 years old drop dramatically; however, the proportion of citations issued for the same group only drops slightly. A similar pattern exists for females in their mid-twenties through mid-forties. For drivers 57 years and older, the proportion of fatalities and serious injuries is only slightly greater than the proportion of violators stopped during HEAT patrols.

Figure 5: Traffic Fatalities and Serious Injuries by Age and Sex of Driver Overlaid Violator Stops by Sex and Age Group of Driver

During HEAT Patrols, officers stopped drivers engaged in a behavior that threaten themselves or other roadway users. These stops may result in one or more warning, citation, or arrests. Figure 6 shows the leading warning types issued in HEAT Patrol stops. Speed violations account for over half of all warnings, and driver's license violations, vehicle documentation, and equipment violations accounted for 32% of warnings issued.

Figure 6: Leading Warnings Issued During HEAT Patrols

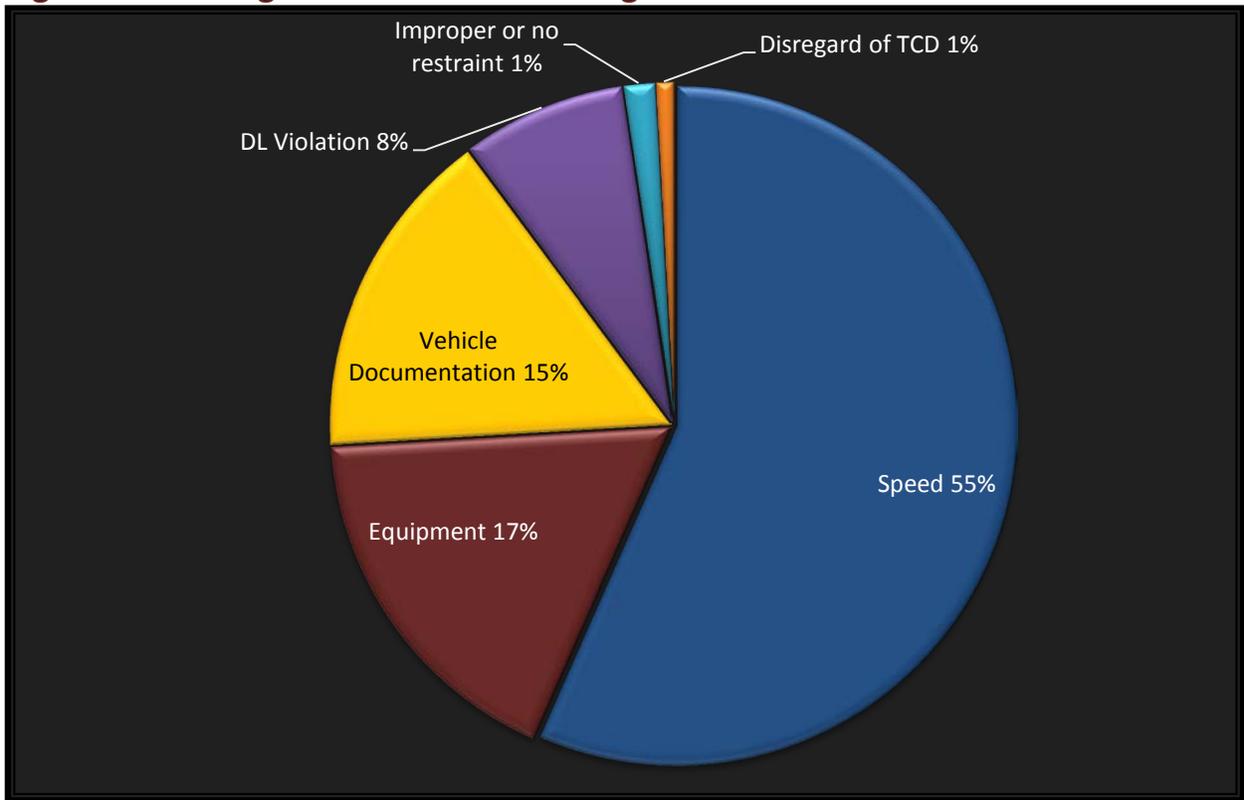


Note. This graph shows the leading warnings issued during HEAT Patrols. This graph shows 109,266 of 109,599 total citations issued. Violator stops may result in one or more warning issued.

During HEAT Patrols, law enforcement officers issued 41,403 citations. Speed violations accounted for just more than half of all citations, and driver’s license violations, vehicle documentation, or equipment violations accounted for 40% of citations. Figure 7 shows the leading citation types issued during HEAT Patrols. Seat belt violations accounted, disregard for traffic control devices, and distraction each account for only one percent of citations issued. Reckless driving, lane keeping, and tailgating accounted for less than one-percent of all citations issued.

HEAT PATROLS RESULTED IN 110,000 violator stops; of which, illegal or excessive speed accounted 61% of all citations!

Figure 7: Leading Citations Issued During HEAT Patrols

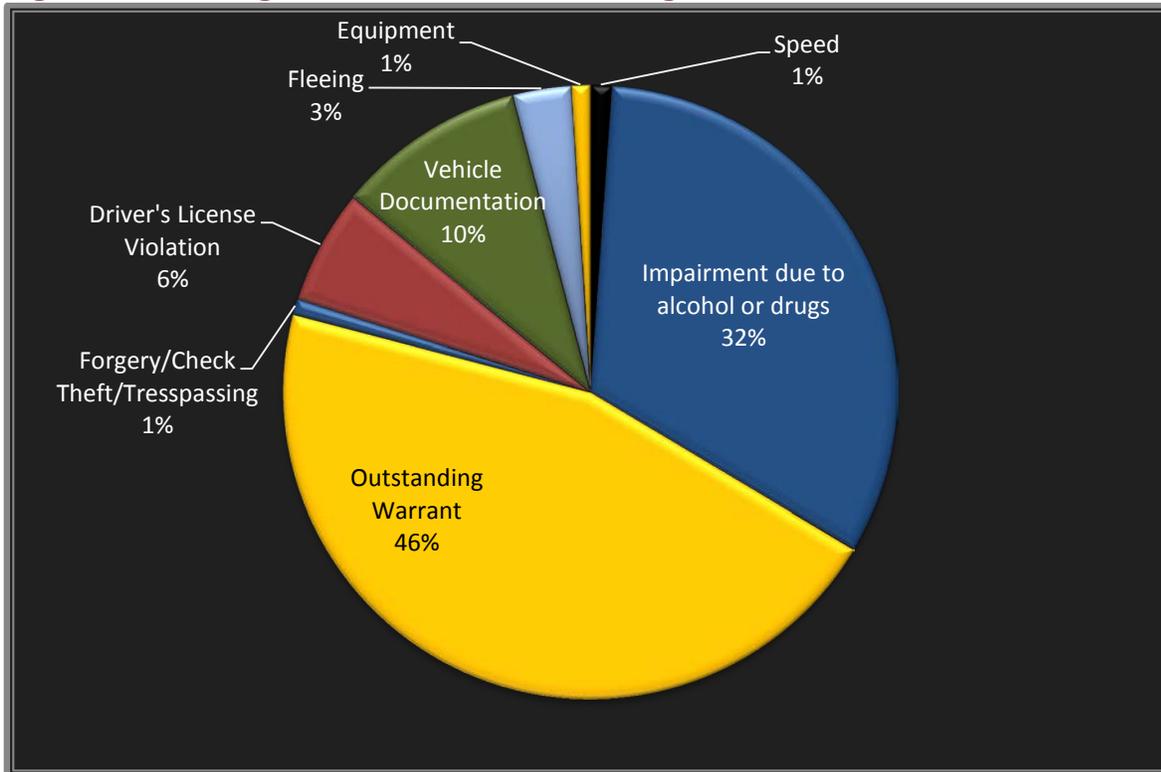


Note. This graph shows the leading citations issued during HEAT Patrols. This graph shows 40,125 of 41,403 total citations issued. Violator stops may result in one or more citation issued.

The HEAT Patrols did not aim to target impaired driver. However, HEAT Patrols resulted in over 200 impaired driver arrests! HEAT did not only influence traffic safety, but also affected criminal apprehension. Nearly half of all arrests were of persons who had an outstanding warrant!

HEAT Patrols resulted in 41,000 citations, of these, illegal or excessive speed accounted for 55% of these citations!

Figure 8: Leading Reasons for Arrest During HEAT Patrols



Note. This graph shows the leading reasons for arrest. This graph shows 712 of 867 arrests made. Violator stops may result in one or more arrest.

The HEAT Project aims to improve traffic safety. The number and reason for vehicle stops offers some perspective on the prevalence and type of unsafe choices drivers make. The ambition of HEAT Patrols is to eliminate unsafe driving choices.

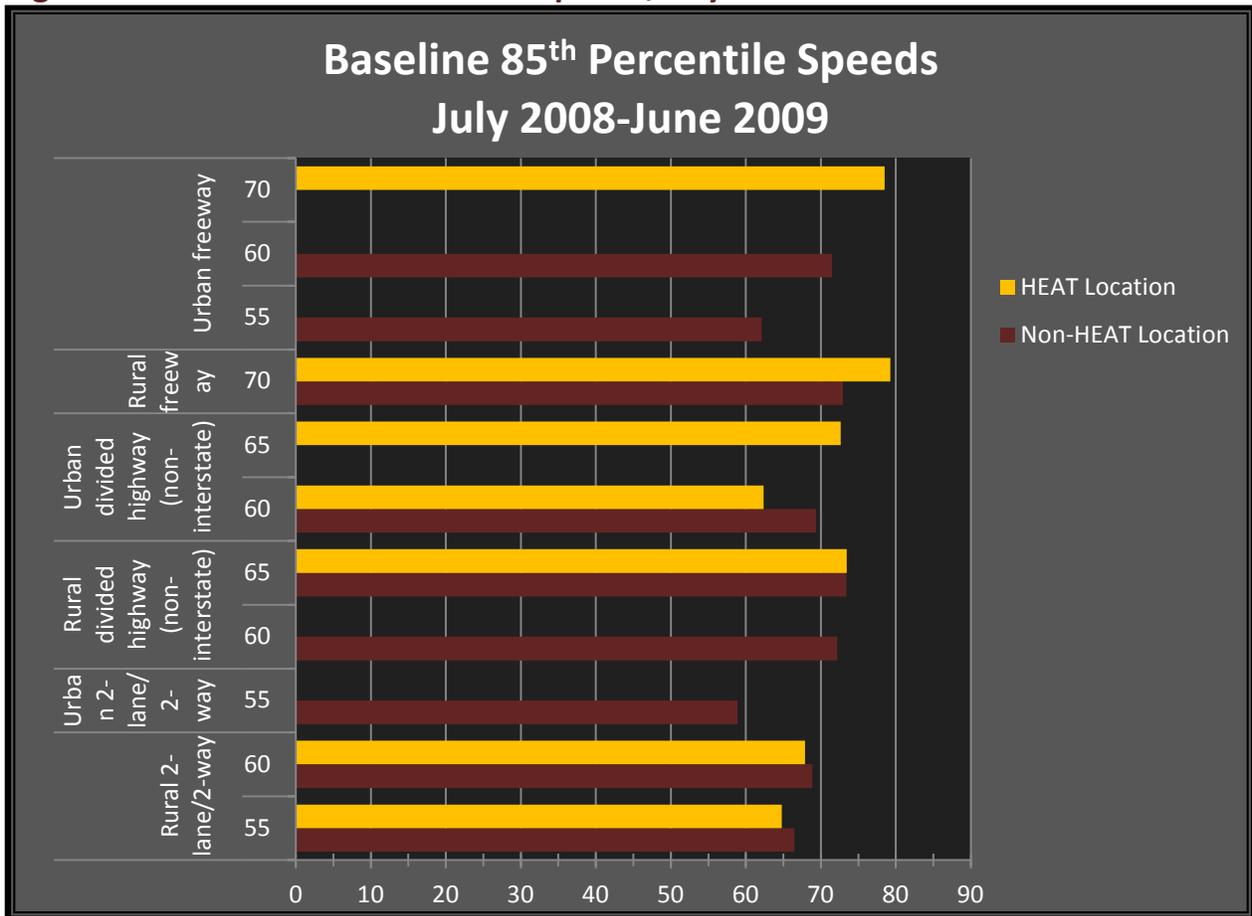
OVER 300 outstanding warrants were served and 200 impaired drivers were arrested during HEAT patrols!

Analyses of Roadway Speed Data

The HEAT Project strives to reduce travel speeds so they are closer to the posted speed limit. The 85th percentile speed measures the operating speed of specific roads. The 85th percentile speed is the speed at which 85% of the observed vehicles travel at or below.

In order to recognize the impact of the HEAT Project on driver behavior, the project team added two more measures to the original Evaluation Plan: the percent of drivers compliant with the PSL and the percent of drivers traveling up to 10mph over the PSL.

Figure 9: Baseline 85th Percentile Speeds, July 2008-June 2009



Source: MnDOT Roadway Speed Recording Devices July 2008- June 2009.

85th Percentile speed will more closely reflect the posted speed limit

During the HEAT Project, the 85th percentile speed decreased for most roadway types. The evaluation team analyzed roadway speed data aggregated by roadway type and posted speed limit

A Friedman's Non-Parametric test determined whether speeds across three time points, before HEAT (July 2008-June 2009), during HEAT (July 2009-July 2012), and after HEAT (August 2012-May 2013), were statistically different. On roadway types with statistically significant reductions of roadway speed, the

research team applied a post-hoc analysis with Wilcoxon signed-rank tests with a Bonferroni correction applied. The evaluation team found that the roadway speed dataset available did not fit the assumptions of normal distribution and homoscedasticity; therefore, these methods are ideal (IBM Corporation, 2011). The evaluation team applied the same method to other measures of speed compliance, which showed promising improvements in driver behavior!

For some designated HEAT corridors, the 85th percentile speed changed significantly.⁴ On rural 65 mph divided highways, the 85th percentile speeds dropped significantly from the baseline period to active enforcement and post enforcement.⁵ Analyses of roadway speeds on urban divided highways with a posted speed limit of 65 mph also revealed a statistically significant reduction of speed from the baseline and during enforcement to the post enforcement period.⁶

In order to understand the impact of HEAT enforcement on the 85th percentile speed, the research team conducted a post-hoc analysis, which offers granular comparisons of each time point for all roadway types with statistically significant variance in the 85th percentile speed.

During active HEAT enforcement on 65mph divided highways, roadway speed data show a statistically significant reduction of the 85th percentile speed compared to the baseline condition. The 85th percentile speed decreased from 74.8mph during the baseline period, to 74.1mph during the active HEAT enforcement and 74.0mph after the HEAT project.^{7,8, & 9}

⁴ Comparisons that are reported as 'significant' or 'statistically significant' indicate sufficient variance across each time point to rule out random fluctuations i.e. attributable to the HEAT Program.

⁵ Comparison of 85th percentile speeds on 65mph rural divided highways $\chi^2(2) = 6.727$, **$p = 0.035$** .

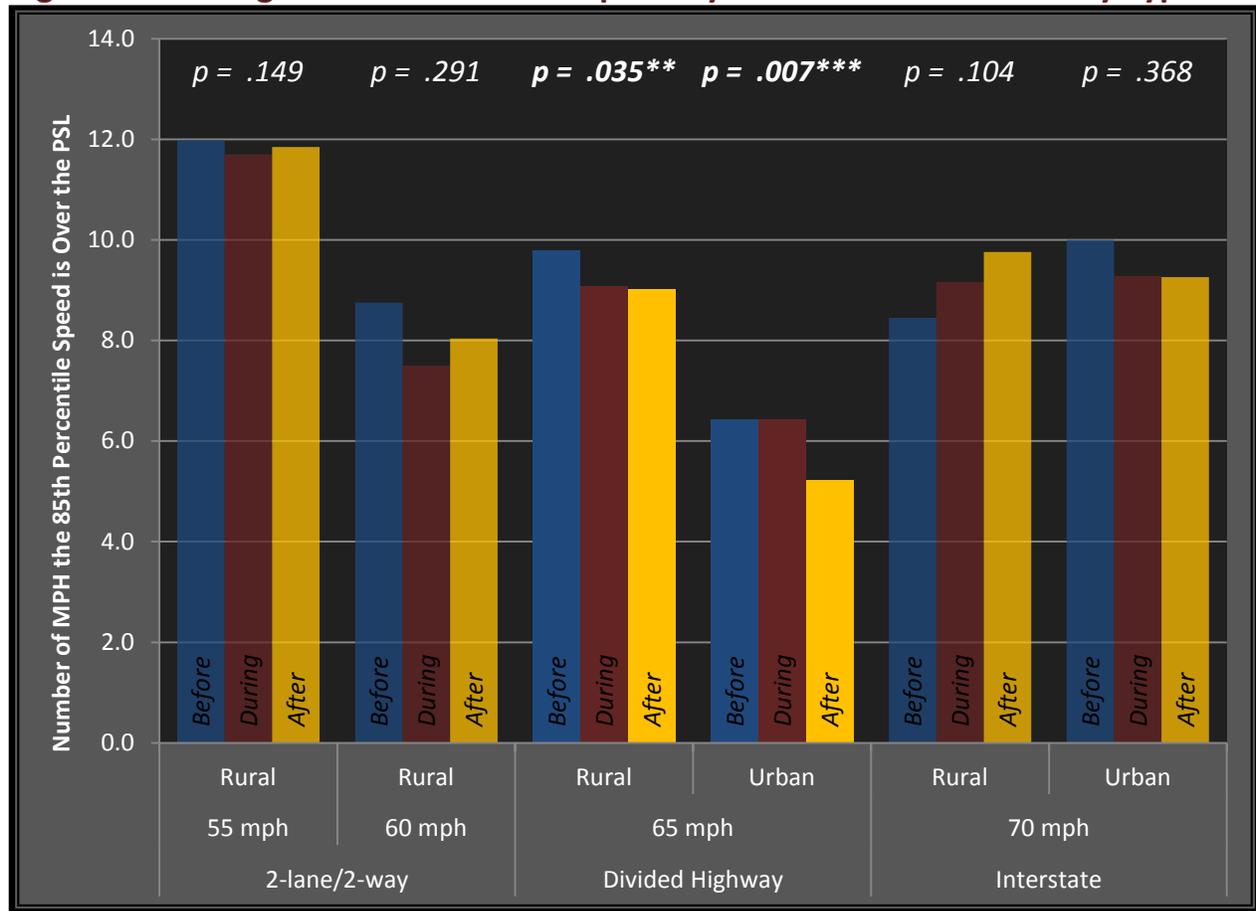
⁶ Comparison of 85th percentile speeds on 65mph urban divided highways $\chi^2(2) = 10.000$, **$p = 0.007$** .

⁷ Comparison of 85th Baseline to Treatment Period on 65mph rural divided highways ($Z = -2.668$, **$p = 0.008$**).

⁸ Comparison of 85th percentile speed baseline to post-treatment period on 65mph rural divided highways ($Z = -1.857$, **$p = 0.063$**).

⁹ Comparison of 85th percentile speed treatment to post-treatment period on 65mph rural divided highways ($Z = -0.190$, $p = 0.850$).

Figure 10: Change in 85th Percentile Speed by Time Point and Roadway Type



Source: MnDOT Roadway Speed Recording Devices 2008-2013 and HEAT Officer Activity Reports 2009-2012. Note.¹ Baseline data and active HEAT enforcement data are matched by locations, hour of day, and day of year, which is then adjusted for day of week. ²Outputs for statistical tests are available in [Appendix D](#).

*Statistically Significant at $p < .10$

**Statistically Significant at $p < .05$

***Statistically Significant at $p < .01$

****Statistically Significant at $p < .001$

On rural 55mph and 60mph 2-lane/2-way roads, roadway speed data show no significant residual impact on travel speed the year following the HEAT Project. However, roadway speed data for rural, 65mph, divided highways show significant speed reductions.

Compliance with the Posted Speed Limit

The percent of drivers traveling up to the posted speed limit measures the level of driver compliance. During the HEAT Project, on rural, 55mph, 2-lane/2-ways¹⁰ and urban, 70mph, interstates, driver compliance with the speed limit increased significantly.¹¹

¹⁰ Proportion compliant with PSL on rural, 55mph 2-lane/2-way $\chi^2(2) = 5.643, p = 0.060$.

¹¹ Proportion compliant with PSL on urban, 70mph, interstates $\chi^2(2) = 14.000, p = 0.001$.

Generally, the average percentage of drivers compliant with the PSL for before, during, and after HEAT periods at treated rural. On 55mph, 2-lane/2-ways roads 19.1% of drivers complied with the speed limit, during active HEAT enforcement 20.4% of drivers complied with the speed limit, and after the HEAT Project 19.0% of drivers complied with the speed limit. Significantly, more drivers complied with the speed limit during HEAT enforcement compared to the baseline period.¹²

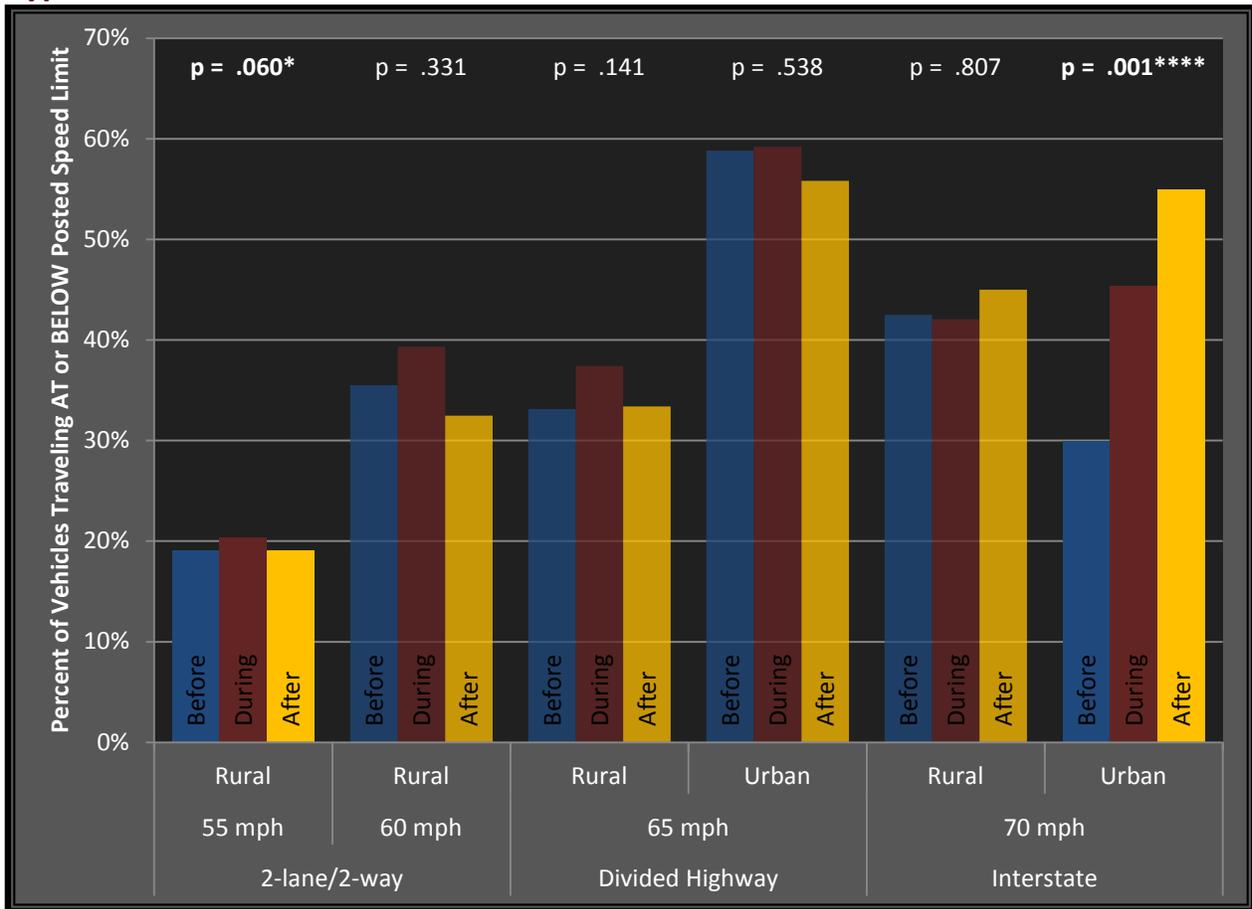
The average percentage of drivers compliant with the PSL before, during, and after HEAT periods at treated urban, On 70mph interstates, 30.0% of drivers complied with the speed limit during the baseline period, 45.4% of drivers complied with the speed limit during HEAT enforcement, and 55.0% of drivers complied with the speed limit after the HEAT Project. Compliance increased significantly across each period.¹³

The residual effect of the HEAT Project on the percent of drivers compliant with the posted speed limit varies. Urban, 70mph interstates showed the greatest increase in compliance with the posted speed limit and compliance increased one year following the HEAT Project. On most other roadway types, driver compliance decreased following the HEAT Project.

¹² Comparison of proportion of compliant with PSL on rural, 55mph, 2-lane/2-way baseline to treatment period ($Z = -0.798$, $p = 0.425$).

¹³ Comparison of proportion compliant with PSL on urban, 70mph, interstates baseline to treatment and the treatment to post-treatment periods ($Z = -2.366$, $p = \mathbf{0.018}$).

Figure 11: Percent of Drivers Compliant with PSL by Time Point and Roadway Type



Source: MnDOT Roadway Speed Recording Devices 2008-2013 and HEAT Officer Activity Reports 2009-2012.

Note.¹ Baseline data and active HEAT enforcement data are matched by locations, hour of day, and day of year, which is then adjusted for day of week. ²Outputs for statistical tests are available in [Appendix D](#).

*Statistically Significant at $p < .10$

**Statistically Significant at $p < .05$

***Statistically Significant at $p < .01$

****Statistically Significant at $p < .001$

The percent of drivers traveling up to 10mph over the posted speed limit measures a broader range of driver compliance. On rural, 65mph, divided highways,¹⁴ rural, 70mph, interstates,¹⁵ and urban, 70mph interstates¹⁶ driver compliance increased significantly. Specifically, driver compliance increased

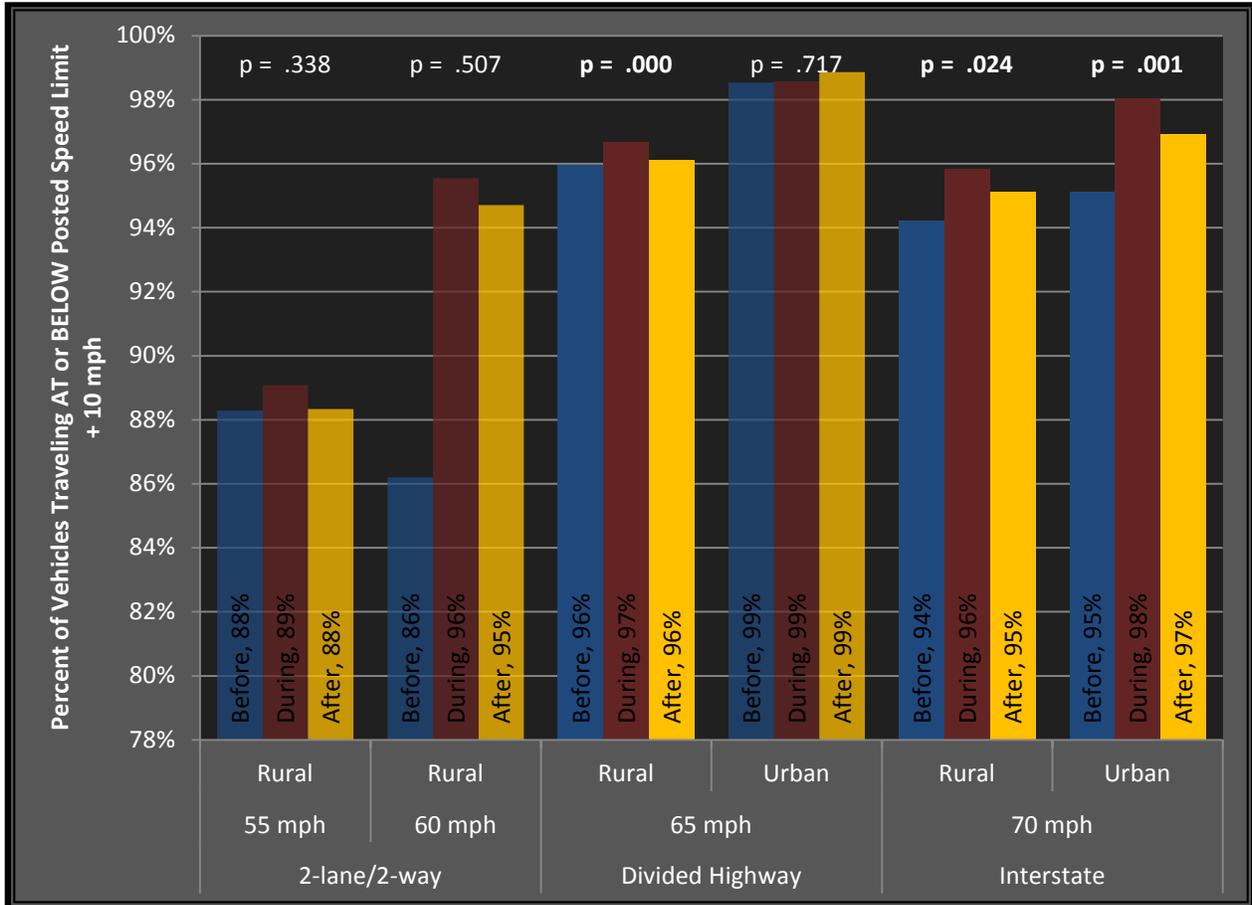
¹⁴ Percent up to 10mph over PSL on rural, 65mph, divided highways $\chi^2(2) = 21.922, p = 0.000$.

¹⁵ Percent up to 10mph over PSL on rural, 70mph, interstates $\chi^2(2) = 7.429, p = 0.024$.

¹⁶ Percent up to 10mph over PSL on urban, 70mph, interstates $\chi^2(2) = 14.000, p = 0.001$.

significantly between the baseline and active HEAT enforcement¹⁷ followed by statistically significant compliance reductions following the HEAT Project.¹⁸

Figure 12: Percent of Vehicles Traveling up to 10mph Over Posted Speed Limit



Source: MnDOT Roadway Speed Recording Devices 2008-2013 and HEAT Officer Activity Reports 2009-2012.

Note.¹ Baseline data and active HEAT enforcement data are matched by locations, hour of day, and day of year, which is then adjusted for day of week. ²Outputs for statistical tests are available in [Appendix D](#).

*Statistically Significant at $p < .10$

**Statistically Significant at $p < .05$

***Statistically Significant at $p < .01$

****Statistically Significant at $p < .001$

On urban 70mph interstates, 95.1% of drivers complied within 10mph of the posted speed limit during the baseline period, 98.0% of drivers complied during active HEAT enforcement, and 96.9% of drivers complied within 10mph following the HEAT Project, respectively. The roadway speed data shows

¹⁷ Comparison of percent up to 10mph over PSL on rural, 65mph, divided highways baseline to treatment period ($Z = -5.913$, $p = 0.000$)

¹⁸ Comparison of percent up to 10mph over PSL on rural, 65mph, divided highways treatment to post-treatment period ($Z = -3.037$, $p = 0.002$).

statistically significant changes in driver compliance within 10mph of the posted speed limit.¹⁹ Driver compliance increases significantly between the baseline and active HEAT enforcement period,²⁰ followed by a smaller but statistically significant compliance decrease between active HEAT enforcement and following the HEAT Project.²¹

One year following the HEAT Project, the percentage of drivers traveling up to 10mph over the PSL dropped below that of the treatment period, but not below the baseline period. There effect of HEAT enforcement appears to wane after one year.

The Impact of HEAT on Roadway Speeds and Driver Compliance with the Posted Speed Limits

Most roadway types show a positive change in overall speed and or increased compliance with the posted speed limits.

- Urban, 70mph interstates showed a less than one mile per hour change in the 85th percentile speed, but showed a tremendous increase in the percent of drivers who were compliant with the posted speed limit during and after the HEAT Project – a profound increase in compliance during and after the HEAT Project.
- Rural, 70mph interstates showed a slight, non-significant increase in the 85th percentile speed, but there was a statistically significant increase in the percentage of drivers traveling up to 10mph over the PSL – a promising increase in compliance during the HEAT Project
- Urban, 65mph, divided highways showed a slight decrease in the 85th percentile speed after the HEAT Project and only slight, non-significant changes in the percent compliant with the PSL and percent within 10mph over the PSL.
- Rural, 65mph, divided highways showed a significant decrease in the 85th percentile speed, slight, non-significant increase in the percent of drivers compliant with the PSL, and slight but significant increase in the percent of drivers within 10mph of the PSL.
- Rural, 60mph, 2-lane/2-way roads showed a noticeable, but non-significant decrease in the 85th percentile speed and percentage of drivers compliant with the PSL. The percentage of drivers within 10mph over the PSL was 10 percentage points higher during and after the HEAT Project, but these variations were not statistically significant.

¹⁹ Comparison of percent up to 10mph over the PSL, urban, 70mph, interstate baseline to post-treatment periods ($Z = -2.366$, $p = 0.018$).

²⁰ Comparison of percent up to 10mph over the PSL, urban, 70mph, interstate baseline to treatment periods ($Z = -2.366$, $p = 0.018$).

²¹ Comparison of percent up to 10mph over the PSL, urban, 70mph, interstate treatment to post-treatment periods ($Z = -2.366$, $p = 0.018$).

- On rural, 55mph, 2-lane/2-way roads the 85th percentile speed decrease and percentage of compliance with the posted speed limit increased. The percent of drivers traveling up to 10mph over the posted speed limit hovered at only 88% for every time point.
- The residual effects of the HEAT Project, with some exceptions, begin to wane within the year following the heightened enforcement.
- Rural 2-lane/2-way roads show an interesting story; in 2005, MnDOT increased some 55mph speed limits to 60mph. At these locations heightened speed enforcement occurred in 2005-2006. In that time, most drivers traveled roughly 12mph over the posted speed limit on the rural, 55mph, 2-way/2-lane roads (66-67mph), even with additional enforcement. During this HEAT Project, on roads where the posted speed limit increased to 60mph, most drivers traveled roughly 8mph over the posted speed limit (67-69mph).
- At the 60mph locations, the 85th percentile speed dropped slightly more with active HEAT enforcement. These differences are not statistically significant, but may warrant further observation.

Analysis of Crash Data

The primary aim of the HEAT Project is to reduce fatal and serious injury crashes by addressing aggressive driving behaviors. This section shows the findings from analyses of crash data within designated HEAT Zones and from a random selection of crashes on non-HEAT Zone roadways.

HEAT enforcement occurred on county roads, trunk highways, and interstates throughout Minnesota. Because enforcement corridor criteria included crash history, these analyses are at higher risk of sampling bias.²² One strategy to overcome the potential selection bias is to compare the treatment segments between time points and against randomly selected comparison (control) roadway segments.

Within HEAT Enforcement Zones, fatal and serious injury crashes dropped 4% from the baseline period to the treatment period; whereas, fatal and serious injury crashes in control segment dropped 17%. A Chi Square test determine whether changes between the baseline and treatment period for both groups significantly differ. When comparing HEAT roadway segments to control roadway segments, the difference between the baseline and treatment period did not statistically differ.

These analyses indicate the HEAT Project had little to no impact on road fatalities or serious injuries.

Table 3: Crosstab Fatal and Serious Injury Crashes Within HEAT Zones and Within Non-HEAT Zones by Baseline and During the HEAT Project Time Points

Roadway Type	Treatment Group	Baseline July 2006 - June 2009	During HEAT July 2009 - June 2012	χ^2	p
Interstates	HEAT Roadway Segments	58	56	2.382	0.122
	Control Roadway Segments	26	14		
Trunk Highways	HEAT Roadway Segments	148	140	0.987	0.320
	Control Roadway Segments	119	94		
County Roads	HEAT Roadway Segments	64	60	0.032	0.858
	Control Roadway Segments	164	148		
Total	HEAT Roadway Segments	269	258	1.317	0.251
	Control Roadway Segments	308	257		

Source: MnDOT Oracle Crash Data July 2006-June 2012.

²² A sampling bias is an error caused by non-random sampling of a population i.e. high or low performers being selected for a trial. In these situations, causality is uncertain.

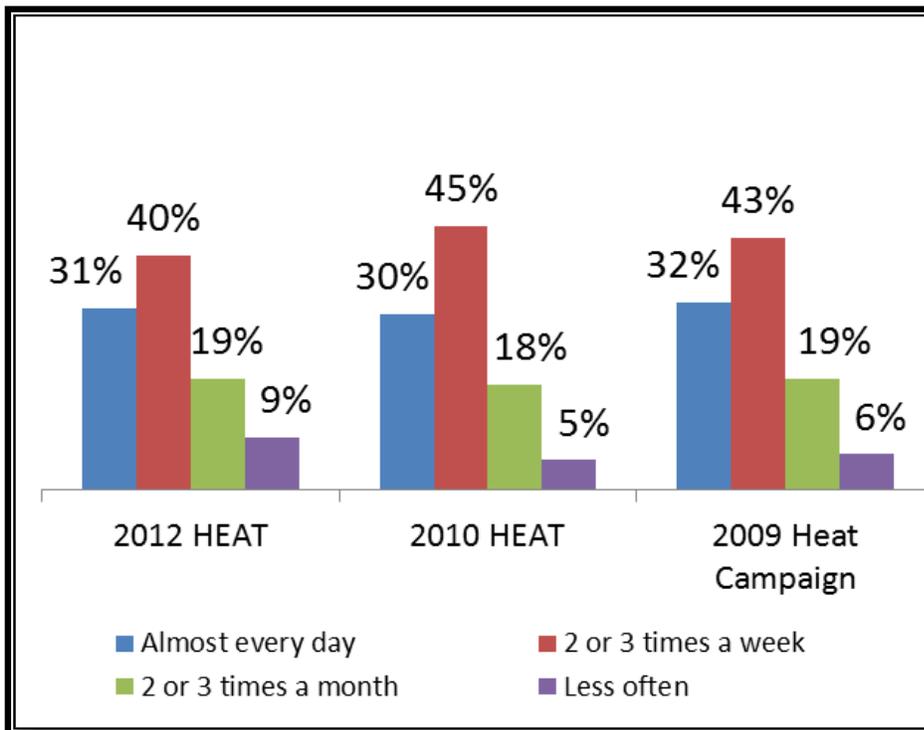
2012 Survey Results: Attitudes and Perceptions of Aggressive Driving Behaviors and Related Enforcement Messaging

In order to assess the effectiveness of the aggressive driving messaging, MnDOT conducted a state-representative survey before the HEAT campaign began - 2009, just over one year into the program - 2010, and just after the program concluded - 2012. This survey revealed public perception and attitudes toward speed, enforcement of traffic safety laws, and the education campaign associated with the HEAT Project. Generally, respondents remained consistent across survey wave.

This section shows the key findings from all three surveys. Figure 14 shows that the frequency in which respondents saw a law enforcement officer varied little from 2009-2012. Unfortunately, over half of drivers felt they could exceed the posted speed limit by up to five miles per hour without being stopped and nearly one-third said they could drive between six and 15 miles over the speed limit!

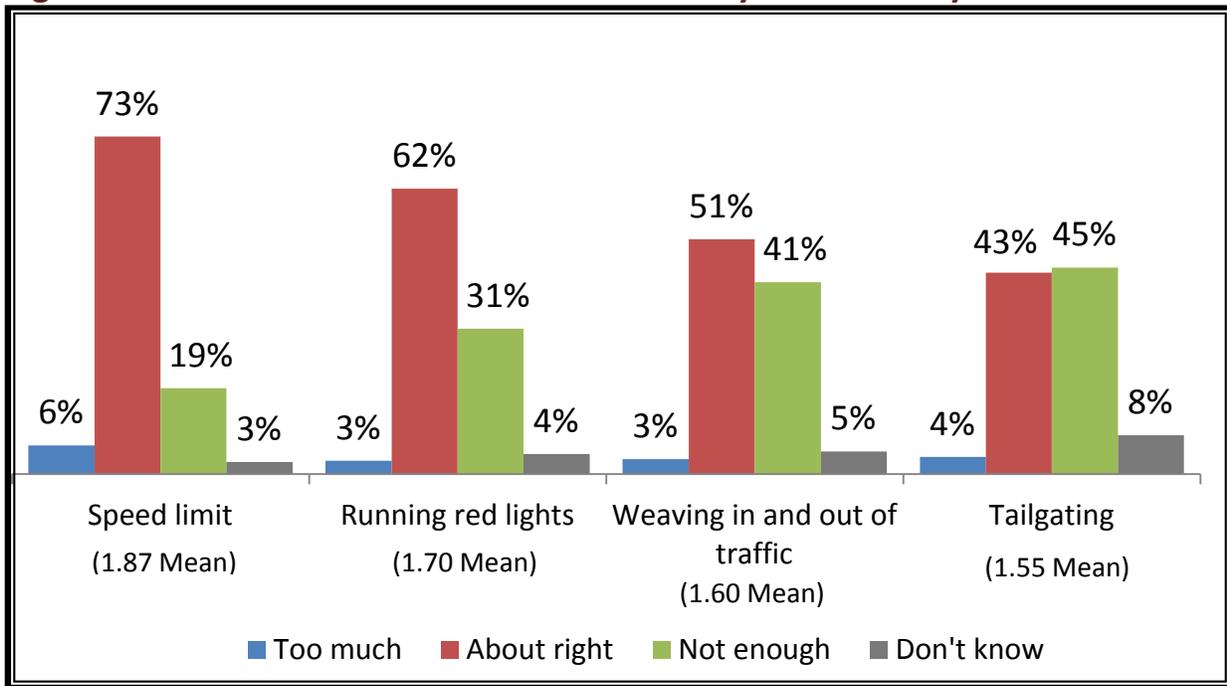
When asked whether the amount of law enforcement for specific traffic safety issues was sufficient, most drivers said enforcement for speeding and red light running was 'about right'. They also felt the amount of enforcement for tailgating was insufficient. Respondents did not recognize the connection between speeding and tailgating. This finding may serve to inform future programs.

Figure 13: Frequency of Seeing a Law Enforcement Officer



Source: Heightened Enforcement of Aggressive Traffic (HEAT) Speed Management Program, 2012 Survey Results: Attitudes and Perceptions of Aggressive Driving Behaviors and Related Enforcement and Messaging.

Figure 14: Perceived Amount of Enforcement by Traffic Safety Issue

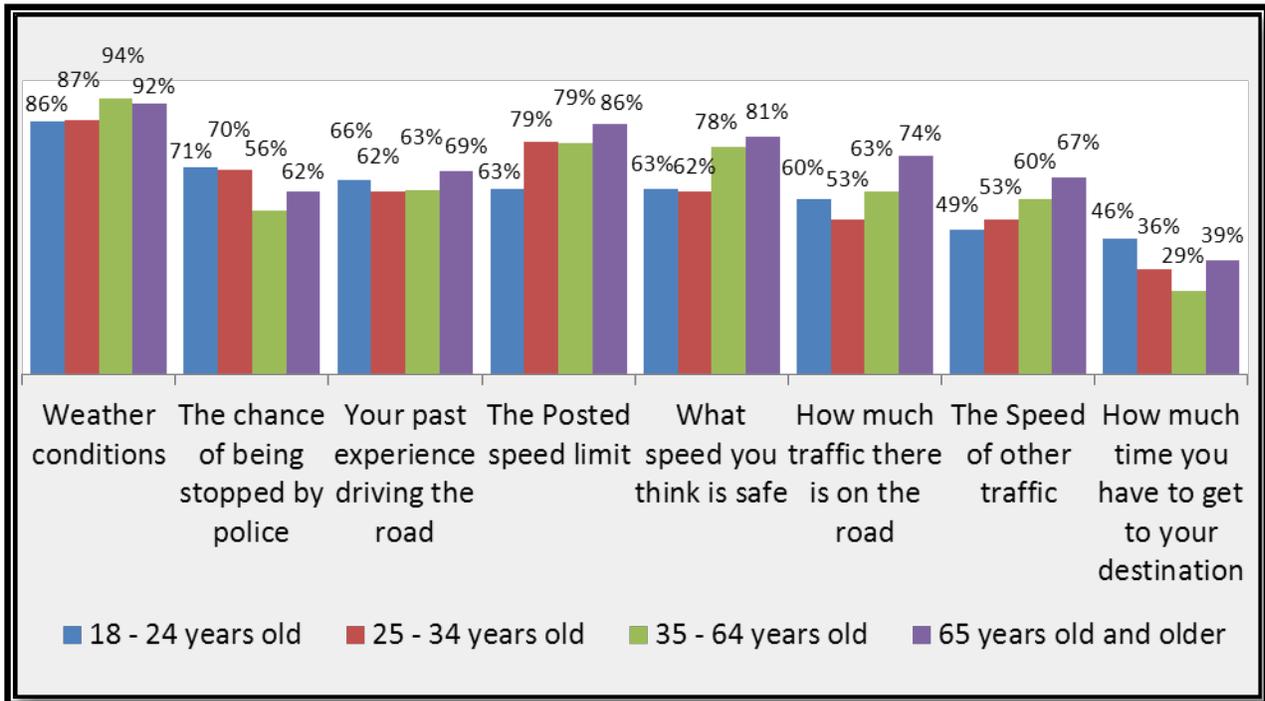


Source: Heightened Enforcement of Aggressive Traffic (HEAT) Speed Management Program, 2012 Survey Results: *Attitudes and Perceptions of Aggressive Driving Behaviors and Related Enforcement and Messaging*.

Younger drivers tended to consider internal factors when deciding how fast to drive. Compared to their older counterparts, 18-34 and 18-24 rate ‘the chance of being stopped’ and ‘time to get to destination’ as important factors for speed selection. A greater percentage of drivers 35 years and older considered weather conditions, the posted speed limit, what they thought was safe, speed of traffic, and amount of traffic as important factors for speed selection.

MOST respondents felt that the amount of speed enforcement was sufficient, but the amount of enforcement to prevent tailgating was not sufficient.

Figure 15: Factors Respondents Said Are Very Important When Deciding How Fast to Drive



Source: Heightened Enforcement of Aggressive Traffic (HEAT) Speed Management Program, 2012 Survey Results: *Attitudes and Perceptions of Aggressive Driving Behaviors and Related Enforcement and Messaging*.

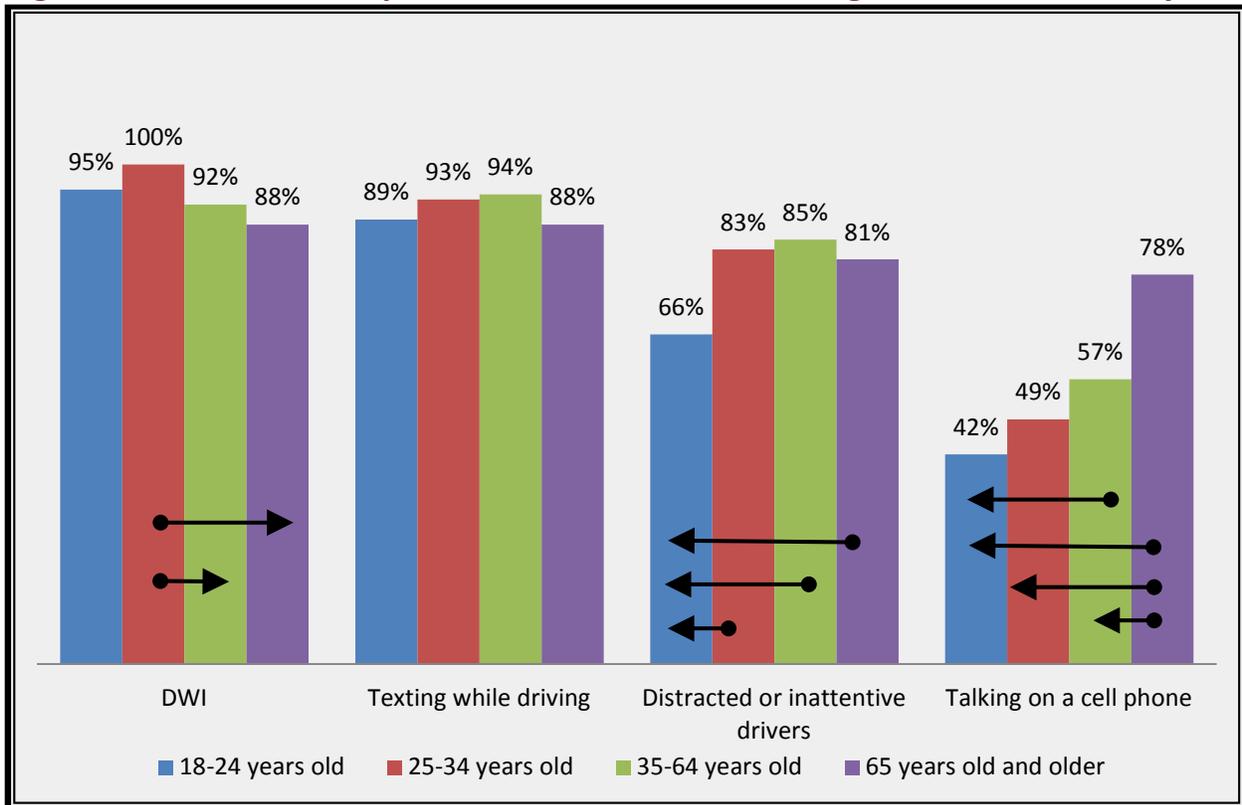
In regards to aggressive driving behavior, the perception of safety threats varied significantly differences between age groups. Younger respondents were significantly less likely than other age groups to rank distracted and inattentive driving, talking on a cell phone, disobedience of traffic signals, weaving in out of traffic, tailgating, and driving 10 miles per hour below the speed limit as major threats to safety.

- Two-thirds (66%) of younger respondents ranked distracted and inattentive driving as a major threat, compared to 83 percent of 24 to 34 year olds, 85 percent of 35 to 64 year olds, and 81 percent of respondents 65 years of age or older.
- Forty-two percent of younger respondents viewed talking on a cell phones threatening behavior, compared 57 percent (35 to 64 year olds) and 78 percent (65+).
- Fifty-four percent of younger drivers reported disobeying traffic signals as a personal threat, compared to 69 percent of 35 to 64 year olds, and 77 percent of respondents 65 years of age or older.
- Forty-two of younger respondents said weaving in and out of traffic was a major threat compared to 70 percent of respondents 65+.

YOUNGER drivers tend to consider more internal factors when deciding how fast to drive.

- Just over one-third of younger respondents (34%) said they perceived tailgating as a major threat, a significantly lower percentage than all other age groups (57% of 24 to 34 year olds, 63% of 35 to 64 year olds, and 67% of 65+ respondents).
- Seventeen percent of younger respondents identified driving 10 miles below the speed limit as a threatening behavior, compared to 32 percent of 25 to 34 year olds.
- **One exception** - younger respondents were significantly more likely to say driving 10 miles above the speed limit was a major threat than 25 to 34 year olds (46% to 28%).

Figure 16: Behaviors Respondents Rated as Threatening to Their Own Safety

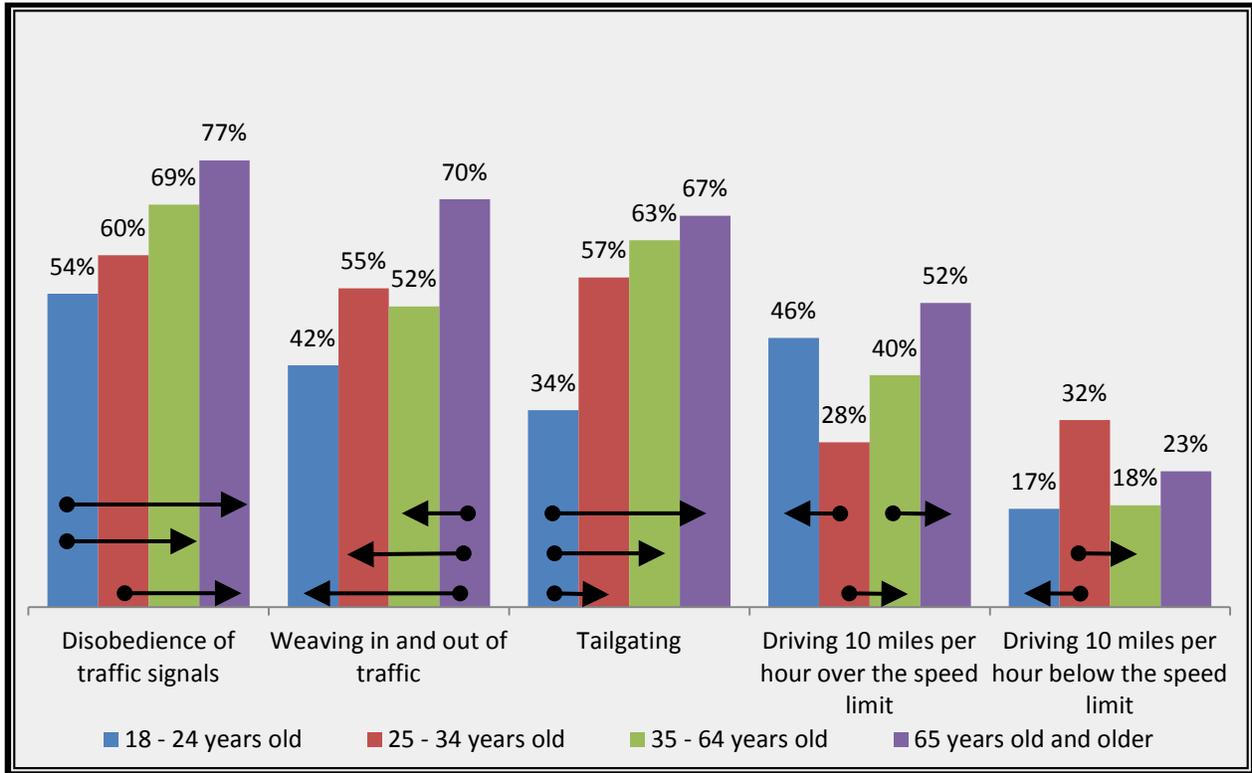


Note. Arrows denote statistically significant differences between groups.

Source: Heightened Enforcement of Aggressive Traffic (HEAT) Speed Management Program, 2012 Survey Results: *Attitudes and Perceptions of Aggressive Driving Behaviors and Related Enforcement and Messaging*.

On a positive note, respondents perceive driving while intoxicated, texting, and inattention as major threats to their safety. These topics receive a great deal of media attention and have become part of the public discourse. The responses shown may be a reflection of exposure on the subject matter. The perceptions of speed may be malleable through strategic messaging and media attention.

Figure 17: Behaviors Respondents Rated as Threatening to Their Own Safety (Cont'd)



Note. Arrows denote statistically significant differences between groups.

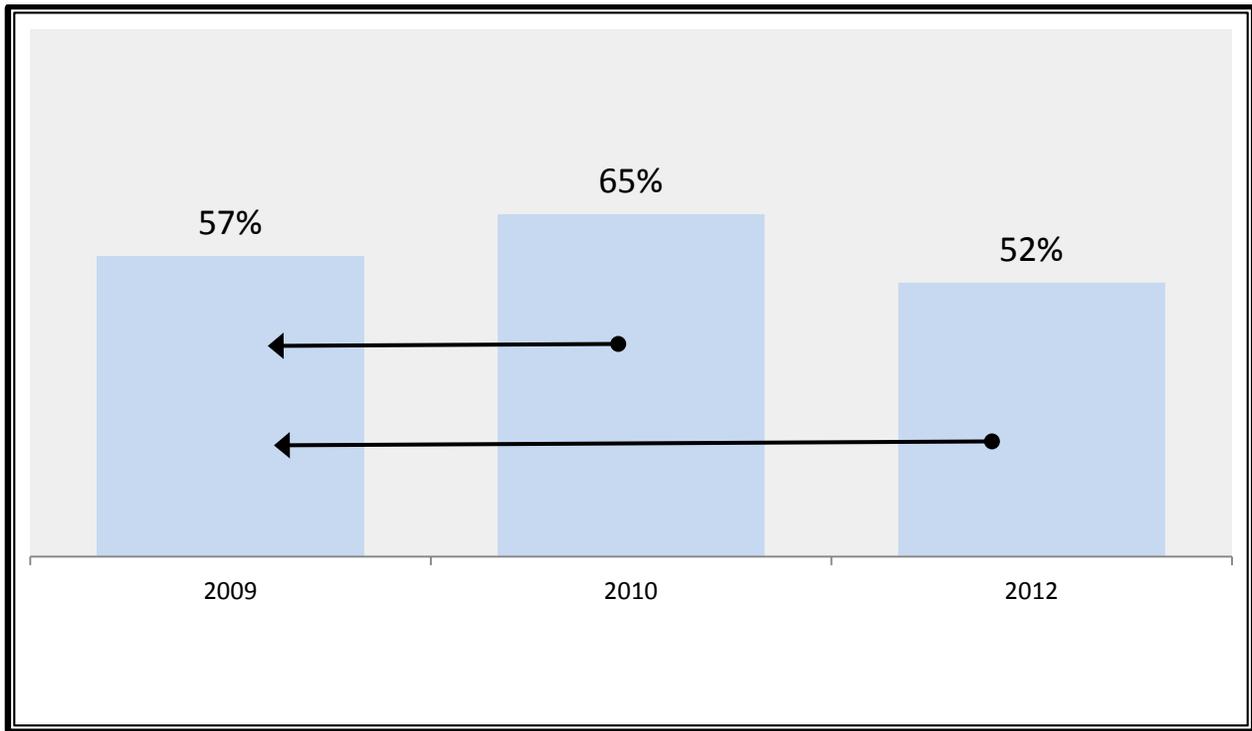
Source: Heightened Enforcement of Aggressive Traffic (HEAT) Speed Management Program, 2012 Survey Results: *Attitudes and Perceptions of Aggressive Driving Behaviors and Related Enforcement and Messaging*.

HEAT survey results from 2009 to 2012 showed a significant reduction of respondents who say weaving and tailgating were major threats. In 2009, 62% said weaving in and out of traffic was a major threat; this dropped to 54% in 2012.

Respondents recalled visible law enforcement presence on the roads; most saw an officer two or more times per week. Most respondents reported enforcement of speeding and red light running as sufficient. A majority reported enforcement to prevent tailgating as insufficient. Respondents rated tailgating as a major threat to safety, yet they did not rate speeding as a threat to safety. The disconnection between perceived safety risk of speeding and the true threat of speeding may be worthy of further study.

THE public recognizes the safety risks associated with DWI, texting while driving, and inattention.

Figure 18: Respondents Who Report Having Seen, Heard, or Read about Increased Enforcement



Note. Arrows denote statistically significant differences between groups.

Source: Heightened Enforcement of Aggressive Traffic (HEAT) Speed Management Program, 2012 Survey Results: *Attitudes and Perceptions of Aggressive Driving Behaviors and Related Enforcement and Messaging*.

Note. Respondents who report they have seen a message are not confirmed to have seen a message from the HEAT Education Campaign.

The HEAT Survey included questions that help evaluate impact of the education campaign. To assess the level of saturation of the HEAT education campaign, the survey asked respondents to report the subject matter of recently viewed/heard traffic safety messages. In order of frequency, respondents reported DWI enforcement along with buzzed drinking awareness, not to text and drive, seatbelt enforcement, and speed enforcement. Many respondents said one or more item, such as speeding and drinking or distraction and texting.

By asking questions about a respondent’s level of support for the subject of safety messages and their liking of the presentation style, researchers can determine whether respondents internalized a safety message. Seventy-six percent of respondents stated that they support the message and 59 percent said they liked the presentation style.

By asking respondents whether they felt the safety message would compel their friends, researchers can determine the safety message’s impact on behavior (Nan, Attitude, The Influence of Liking for a Public Service

PUBLIC recognition of the safety risks associated with speed remains a challenge.

Announcement on Issue, 2004). Two-thirds of respondents reported they and their friends would feel compelled to change their behavior due to the safety message. Twenty-one percent of respondents said they would not feel compelled to drive more safely and sixteen percent said their friends would not feel compelled to drive more safely. These findings are positive; however, the challenge to reach those less responsive to current education campaigns remains.

Table 4: Perceived Message Impact on Self and Friends

Responses	“Do you think this advertising about unsafe driving compelled you to drive more safely?”	“Do you think this advertising about unsafe driving compelled your friends to drive more safely?”
Rank 6 (strongly compelled to drive more safely)	30 %	22 %
5	16 %	21 %
4	16 %	24 %
3	14 %	16 %
2	6 %	7 %
1	4 %	3 %
0 (not at all compelled)	11 %	6 %

While we cannot pinpoint the exact message that respondents were referring to, we do have a general sense that from the public’s perspective, safety messages merge into a larger construct of traffic safety. As traffic-safety, education moves forward, two key challenges are before traffic safety professionals: (1) help the public recognize the safety risk associated with speed and (2) to reach those audiences for whom current education strategies do not resonate.

Recommendations to Bolster Existing Traffic Safety Education Campaigns

Reconcile the gap between what the public perceives to be high-risk driving behaviors and truly dangerous driving behaviors in order to build an effective public discourse on traffic safety.

Findings from the HEAT Wave II survey and existing literature show a gap between behaviors the public perceives as high-risk and endorsed high-risk behavior. By building on existing beliefs about traffic safety, traffic safety professionals can address this gap (Farrelly, et al., 2002) (Riordan, 2010) (Wilde, 1993). For example, traffic safety organizations can promote a public construct (brand) of traffic safety that consists of a series of topics within traffic safety that are incremental and disseminated over time (Wilde, 1993). A construct or brand of traffic safety would acknowledge more publicly recognized

dangerous driving behaviors while simultaneously introducing less recognized dangerous behaviors into the construct.

Customize the messaging for those who are at highest risk of violating traffic safety laws.

In the HEAT Wave II survey, respondents indicated a high level of awareness of traffic enforcement related messages; however, only six percent were verifiably aware of the HEAT campaign. The next mass media campaign should strive to reach a wider audience through effective messaging and media venues used by the target audience. Higher-risk target audiences require proven messaging our target audience specifically (Moan, 2011).

Mass media education includes four key components: the source (who is saying it/messenger), the characteristics of the recipient (target audience), the content (what is the message and how/where is it presented), and the channel of communication (method of persuasion) (Wilde, 1993).

The messenger and the audience: The HEAT Wave II survey asked how well the respondents liked the presentation style of the traffic-safety, enforcement message (including HEAT and non-HEAT media). Sixty-three percent of 18-24 year olds and 53% of 25-34 year olds liked the presentation style, which indicates some opportunity for improvement.

Public Service Announcements (PSAs) should resonate with the target audiences, which will vary depending on the intended target audience.

One way to effectively alter higher-risk behaviors is to address attitudes toward those behaviors, address the descriptive norms (peer behaviors), and initiate autonomy to avoid the high-risk behavior; this is particularly true for younger male drivers (Moan, 2011).

Effective PSAs improve toward traffic safety. By measuring target audiences' liking of the PSA, traffic safety professionals can determine the impact of a PSA. Previous research shows that PSA's liked by the target audience, impact attitudes more than PSAs disliked by the target audience (Nan, The Influence of Liking for a Public Service Announcement on Issue Attitude, 2008). Note liking is in reference to the presentation style of the PSA, not whether the audience likes or dislikes the intended message.

Effective PSA messages portray persons who the target audience can identify with (Farrelly, et al., 2002) (Riordan, 2010) (Wilde, 1993).

Content: Both the message and the tone of the message are critical for an effective PSA .

Research shows that authoritarian, lecturing, and punitive message styles are ineffective in changing attitudes and behaviors (Farrelly, et al., 2002) (Riordan, 2010) (Wilde, 1993) (Wakefield, et al., 2006). Such messaging strategies trigger *psychological reactance*, commonly referred to as "reverse psychology." Additionally, threats of punishment have little to no effect on those drivers likely to engage in aggressive driving behaviors (Constantinou, 2011).

Public Service Announcements and education strategies should promote the desired behavior. Effective PSAs offer positive messages that reinforce or model the desired behavior. Positively toned messages persuade more effectively than negatively toned messages (Wilde, 1993) (Nan, The Influence of Liking for a Public Service Announcement on Issue Attitude, 2008) or fear evoking messages which lead to defensive avoidance (Lewis, Watson, Withe, & Tay, 2009).

It is also important that PSA messaging include strategies to avoid the undesired behavior (Wilde, 1993) (Lewis, Watson, Withe, & Tay, 2009) and feasible strategies to engage in the desired behavior (Moan, 2011). The persuasiveness of a message is lost if the audience is left with a sense of helplessness.

The advocated behavior change should occur in incremental steps rather than promoting drastic behavior changes (Wilde, 1993).

Draw on the power of peer pressure. Descriptive norms (what one's friends think and do) are strong predictors to behavior for teens and young adults (Moan, 2011).

Channel of communication: The media sources used should be one that is accessible in relation to driving and the target audience.

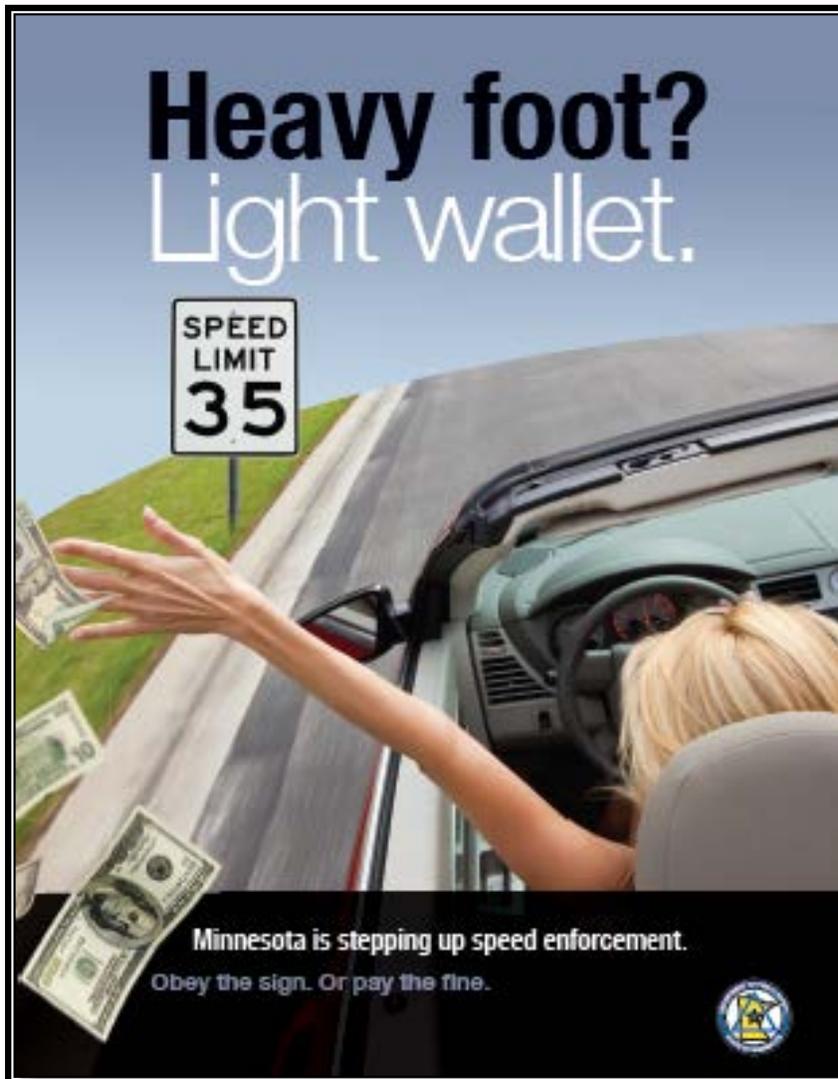
Messages are more likely effective if they have high immediacy to the act of driving (Wilde, 1993). Television reaches a large audience, but most drivers experience little to no exposure television messages during the act of driving. On the other hand, messages presented via a roadside billboards and radio offer high exposure during the act of driving (Wilde, 1993). Furthermore, the venue of messaging should be one utilized by the target audience – young and young male drivers.

The field of public health offers several decades of experience promoting or changing health behaviors through media education campaigns; therefore, those lessons should inform traffic safety, education campaigns.

Multi Media Public Education Campaign

The multi-media education campaign consisted of print ads, radio spots, pump toppers, television ads, and press releases. Figure 13 shows one of the print advertisements associated with the HEAT Project. Radio spots focused on messages about increased speed enforcement and the consequences of speed citations. Some advertising also noted the safety risk speeders pose.

Figure 19: Print Media Used for the 2010 HEAT Education Campaign



The “Heavy foot? Light wallet.” Message originated from the [National Highway Transportation Safety Administration](#) (NHTSA) as one of their national speed education and enforcement campaign taglines. This same tagline appeared in television messages that informed viewers of increased speed enforcement.

The media campaigns appeared in multiple media sources. Tables 4 through 6 show the media sources and the number of weeks in which the HEAT messages appeared in said media source. In 2010, media messages began in April and ran through September. The 2011 media campaign began in June and ran through September, and the 2012

campaign began in July and concluded the first week of September. Following the media campaign of 2010, the Minnesota Department of Public Safety modified the print media, but the taglines “Heavy Foot? Light Wallet.” and “Obey the sign. Or pay the fine” remained with the campaign throughout the HEAT Project.

The 2011 media campaign was notably shorter, compared to the 2010 media campaign. The 2012 media campaign was the shortest. Drawing on findings from the second HEAT Survey, MnDOT sponsored a normative messaging campaign that augmented the 2012 education campaign.

Table 5: HEAT Media Campaign Calendar 2010

Media	April	May	June	July	August	September	
2010	Television	1 week	1 week	4 weeks	4 weeks	2 weeks	2 weeks
	Radio	1 week	1 week	4 weeks	4 weeks	4 weeks	2 weeks
	Print				1 week	1 week	1 week
	Pump Toppers			3 weeks	4 weeks	4 weeks	4 weeks
	Sport Events	2 weeks		4 weeks			
	Racetrack						
	Transit				3 weeks	4 weeks	4 weeks
	Truck Sides						
	Digital						

Source: Minnesota Department of Public Safety, Office of Traffic Safety.

Table 6: HEAT Media Campaign Calendar, 2011

Media	June	July	August	September	
2011	Television		5 weeks	4 weeks	2 weeks
	Radio	1 week	5 weeks	4 weeks	2 weeks
	Print		1 week	1 week	1 week
	Pump Toppers	3 weeks	5 weeks	4 weeks	4 weeks
	Sport Events		4 weeks		
	Racetrack	3 weeks	5 weeks	4 weeks	4 weeks
	Transit				
	Truck Sides				
	Digital				

Source: Minnesota Department of Public Safety, Office of Traffic Safety.

Table 7: HEAT Media Campaign Calendar, 2012

Media	July	August	September	
2012	Television	2 weeks	2 weeks	
	Radio	2 weeks	2 weeks	
	Print			
	Pump Toppers	2 weeks	4 weeks	1 week
	Sport Events		5 weeks	
	Racetrack			
	Transit			
	Truck Sides	2 weeks	4 weeks	1 week
	Digital	2 weeks	2 weeks	

Source: Minnesota Department of Public Safety, Office of Traffic Safety.

Conclusions

The traffic stop data recorded by law enforcement officers served as a proxy for observed behavior. Ideally, all drivers would comply with all traffic safety laws, thus eliminating the need for traffic stops. By leveraging the traffic stop data, the research team identified prevalent behaviors and some demographic characteristics of those violators. Based on the vehicle stop data, law enforcement officers stopped male just over 2 to 1 over females. The distribution of drivers across sex and age groups is very similar to that of drivers involved in fatal and serious injury crashes.

The HEAT Project afforded some benefit to criminal apprehension. During the HEAT patrols, law enforcement officers arrested over 800 individuals. Outstanding arrests accounted for nearly half of those arrested, followed by impaired drivers. HEAT is not the first traffic enforcement program that has identified benefits to criminal apprehension; Grand Prairie, Texas Police Department found that nearly 30% of their arrests for criminal and traffic related offenses were due to routine traffic stops (Morford, Sheehan, & Sluster). ***The latent benefit of traffic enforcement may imply future partnerships with criminal apprehension programs in order to optimize efforts for both areas.***

HEAT enforcement significantly reduced the 85th percentile speed on rural and urban, 65mph divided highways. Rural, 55mph and 60mph, 2-lane/2way roads and urban, 70mph interstates showed observable, but not statistically significant speed reductions. Enhanced traffic enforcement provided through the HEAT Project showed modest roadway speed reduction. ***Given the more profound reductions of roadway speed were on divided roadways, there may be some characteristic about the road, i.e. presence of a median, that aids the enforcement effort.***

In order to understate the impact of enhanced traffic enforcement on driver behavior, the research team used the secondary measures of roadway speed: percent of vehicles compliant with the PSL and percent of vehicles up to 10mph over the PSL. During HEAT enforcement, significantly higher percent of the drivers traveled at or below the posted speed limit on rural, 55mph, 2-lane/2-way roads and urban, 70mph, interstates.

During HEAT enforcement, a noticeably higher percentage of drivers were compliant on rural, 60mph, 2-lane/2-way roads, and rural and urban, 65mph divided highways. Driver speed compliance increased on all but one roadway type.

At all speed collection sites within designated HEAT Zones, there was an increase in the percentage of vehicles that traveled up to 10mph over the PSL over the baseline period. One year later, this increase began to deteriorate, but the percent of vehicles that traveled up to 10mph over the PSL in the post-treatment period was greater than the baseline period. Ideally, all drivers would drive at the PSL; however, this metric does show progress toward the ideal.

Most drivers travel above the posted speed limits. Based on findings from the survey of attitudes and perceptions toward aggressive driving, this behavior may be rooted in a belief that there is general tolerance for speeding. Most Minnesotan's believe they can travel five miles per hour over the posted speed limit and as many as 30% believe they can travel six to fifteen miles over the posted speed limit

before they will be stopped by law enforcement (Minnesota Management and Budget, Management, Analyses, and Development, 2012). ***In order to achieve greater compliance with the PSL the belief that speeding is a tolerable behavior must be overcome, which may have strong implications for law enforcement, traffic safety related policies, and legislation.***

Although fatal and serious injury crashes dropped by four percent from the baseline to treatment period, the reduction is not statistically significant compared to similar, randomly selected roadway segments.

The HEAT Multi-media Education Campaign was the most challenging area to evaluate. While tools to measure the campaign were in place, survey respondents did not readily identify specific HEAT Messages. In general, respondents supported traffic safety, and traffic safety messages. Future traffic safety, multimedia education campaigns may benefit from multiple messaging strategies. For detailed recommendations, see [Recommendations to Bolster Existing Traffic Safety Education Campaigns](#).

The HEAT Project was a joint effort across multiple disciplines and agencies. The Minnesota State Patrol along with many local law enforcement agencies, county sheriff's departments and city police departments, provided heightened traffic enforcement through overtime hours. The Minnesota Department of Public Safety, Office of Traffic Safety provided the multi-media education campaign and the Minnesota Department of Transportation, Office of Traffic, Safety, and Technology provided project design support, resource support for law enforcement overtime hours, and the evaluation of the HEAT Project. This project targets one of the most ubiquitous and challenging driver behaviors. The road-using public does not fully recognize the real risk of speeding. In order for Minnesota to reach its goal of Zero Roadway Fatalities, multi-discipline strategies should continue.

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Appendices

Appendix A: Frequently Used Acronyms

CRSP	County Road Safety Plan
CTS.....	Center for Transportation Studies at University of Minnesota
DWI	Driving While Intoxicated
DL	Driver’s License
EMS	Emergency Medical Services
Four E’s.....	Education, Engineering, Enforcement, and Emergency Medical and Trauma Services
HEAT.....	High Enforcement of Aggressive Traffic, an education and traffic enforcement program
HSIP	Highway Safety Improvement Project
LEL	Law Enforcement Liaison
MDH.....	Minnesota Department of Health
MnDOT.....	Minnesota Department of Transportation
Mn/DPS.....	Minnesota Department of Public Safety
MSP	Minnesota State Patrol
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NETS.....	Minnesota Network of Employers for Traffic Safety
OTS.....	Office of Traffic Safety, Mn/DPS
OTST.....	Office of Traffic, Safety, and Technology, Mn/DOT
PSL.....	Posted Speed Limit
TCD.....	Traffic Control Device i.e. stop signs or intersection signals
TIS.....	Transportation Information System used by Mn/DOT
TZD	Minnesota Toward Zero Deaths
U of M	University of Minnesota
UMD.....	University of Minnesota, Duluth

Appendix B: HEAT Patrol Officer Data Collection Form

HEAT

Zone Number Assigned:

PROJECT
OFFICER ACTIVITY REPORT

Officer/ Badge #		District/ Agency	
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Date	Start Time	End Time

Total Hours Worked	Total Hours Worked in Zone (enter zone # above)

Patrol Use Only

Time	3001	3002	3003	3007	3044	3035	3171	
Codes								
Mileage	Unit:	Beginning:			Ending:			

UNUSUAL EVENTS OR COMMENTS:

Name:

Date:

Time	(M)male/ (F)female	Date of Birth	(W)arning/ (C)itation/ (A)rrest	Reason/Code

Appendix C: Statistical Tests Used In This Report

Friedman's Non- Parametric Test Algorithms

For k related samples from a continuous field, this tests:

H_0 : The distributions of these k samples are the same.

For each record, the k samples are sorted and ranked, with average rank being assigned in the case of ties. For each sample, the sum of ranks over the records is calculated, incorporating the frequency weight, as follows:

$$C_{l,f} = \sum_{i=1}^n f_i \cdot \text{rank}(x_{il}, D_i, f)$$

where $D_i = \{x_{ij}, j = 1, \dots, k\}$. The average rank for each sample is

$$\bar{R}_{l,f} = \frac{C_{l,f}}{n_f}$$

where $n_f = \sum_{i=1}^n f_i$

The test statistic is:

$$\chi^2 = \left[\frac{12}{n_f \cdot k(k+1)} \right] \cdot \left[\sum_{l=1}^k C_{l,f}^2 - 3n_f \cdot (k+1) \right] / \left[1 - \sum T / (n_f \cdot k(k+1)) \right]$$

where $\sum T = \sum_{i=1}^n \sum_{j=1}^{m_i} (t_{ij,f}^3 - t_{ij,f})$

and m_i is the total number of distinct rank values of the i th record, and t_{ij} is the number of fields at the j th distinct value of the i th record, incorporating the frequency weight.

The one-sided p -value is:

$$p = \Pr(\chi_{k-1}^2 \geq \chi^2) = 1 - \Pr(\chi_{k-1}^2 \leq \chi^2)$$

where χ_{k-1}^2 follows a chi-square distribution with $k - 1$ degrees of freedom.

Chi Square for Cross-Tabulations

The test statistic is:

$$\chi_p^2 = \sum_{ij} \frac{(f_{ij} - E_{ij})^2}{E_{ij}}$$

where the degrees of freedom, $p = (R - 1)(C - 1)$

(IBM Corporation, 2011)

Appendix D: Statistical Comparisons of Roadway Speeds Before, During, and After HEAT

Table 8: Operational Speed Friedman's Non-Parametric Test

Roadway Type	PSL	Urban/Rural	χ^2	Degrees of Freedom	p
2-lane/2-way	55 mph	Rural	3.804	2	0.149
	60 mph	Rural	2.471	2	0.291
Divided Highway	65 mph	Rural	6.727	2	0.035**
	65 mph	Urban	10.000	2	0.007***
Freeway	70 mph	Rural	4.522	2	0.104
	70 mph	Urban	2.000	2	0.368

*Statistically Significant at $p < .10$

**Statistically Significant at $p < .05$

***Statistically Significant at $p < .01$

****Statistically Significant at $p < .001$

Table 9: Operational Speed Friedman's Non-Parametric Test, Post-hoc Analysis

Roadway Characteristics			Operational Speed			Variation Significance p	Post-hoc Comparisons p		
Class	PSL	Urban/Rural	Before	During	After		Before - During	During - After	Before - After
Divided Highway	65 mph	Rural	74.8	74.1	74.0	.035	.008	.850	.063
		Urban	71.4	71.4	70.2	.007	1.000	.025	.025

Note. There were three levels of tests; therefore, the alpha was set at $\alpha = 0.033$. Any comparisons with a p value of $p < 0.033$ is considered statistically significant and are indicated by bold typeface. $\alpha = 0.033$

Table 10: Proportion at or Below Posted Speed Limit, Friedman's Non-Parametric Test

Roadway Type	PSL	Urban/Rural	X ²	Degrees of Freedom	p
2-lane/2-way	55 mph	Rural	5.643	2	0.060*
	60 mph	Rural	2.214	2	0.331
Divided Highway	65 mph	Rural	3.922	2	0.141
	65 mph	Urban	1.238	2	0.538
Freeway	70 mph	Rural	0.429	2	0.807
	70 mph	Urban	14.000	2	0.001****

*Statistically Significant at $p < .10$

**Statistically Significant at $p < .05$

***Statistically Significant at $p < .01$

****Statistically Significant at $p < .001$

Table 11: Proportion at or Below Posted Speed Limit Friedman's Non-Parametric Test, Post-hoc Analysis

Roadway Characteristics			Percent Compliance With Speed Limit			Variation Significance <i>p</i>	Post-hoc Comparisons <i>p</i>		
Class	PSL	Urban/Rural	Before	During	After		Before - During	During - After	Before - After
2-lane/2-way	55 mph	Rural	19%	20%	19%	.060	.057	.128	.425
Interstate	70 mph	Urban	30%	45%	55%	.001	.018	.018	.018

Note. There were three levels of tests; therefore, the alpha was set at $\alpha = 0.033$. Any comparisons with a *p* value of $p < 0.033$ is considered statistically significant and are indicated by bold typeface. $\alpha = 0.033$

Table 12: Percent of Vehicles Traveling up to 10mph Over Posted Speed Limit, Friedman's Non-Parametric Test

Roadway Type	PSL	Urban/Rural	X ²	Degrees of Freedom	p
2-lane/2-way	55 mph	Rural	2.167	2	0.338
	60 mph	Rural	2.214	2	0.331
Divided Highway	65 mph	Rural	21.922	2	0.001***
	65 mph	Urban	0.667	2	0.717
Freeway	70 mph	Rural	7.429	2	0.024**
	70 mph	Urban	14.000	2	0.001****

*Statistically Significant at $p < .10$

**Statistically Significant at $p < .05$

***Statistically Significant at $p < .01$

****Statistically Significant at $p < .001$

Roadway Characteristics			Percent Compliance With Speed Limit			Variation Significance <i>p</i>	Post-hoc Comparisons <i>p</i>		
Class	PSL	Urban/Rural	Before	During	After		Before - During	During - After	Before - After
Divided Highway	65 mph	Rural	96%	97%	96%	.000	.000	.002	.666
Interstate	70 mph	Rural	94%	96%	95%	.024	.103	.047	.285
		Urban	95%	98%	97%	.001	.018	.018	.018

Note. There were three levels of tests; therefore, the alpha was set at $\alpha = 0.033$. Any comparisons with a *p* value of $p < 0.033$ is considered statistically significant and are indicated by bold typeface. $\alpha = 0.0$

