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Review of NJ Point System

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16. Abstract

The purpose of this study is to investigate the comparative effectiveness of point-based versus incident-based negligent driver monitoring systems and to explore how certain changes to the existing point-based system used in New Jersey might improve the New Jersey Motor Vehicle Commission's (MVC) ability to properly identify and address problem drivers. This study seeks to address an existing gap in the literature and advance the current state of knowledge regarding the effectiveness of point- versus incident-based monitoring systems. The results of this study further confirm the results of previous studies that the interventions used by MVC to correct problem driver behavior are effective. As part of this study, the research team used survival analysis to show that the average time to next offense for driver's subjected to MVC interventions increases significantly for all three interventions used. Three primary alternatives to MVC's current point-based system of driver monitoring and control were investigated. Alternative #1 retained MVC's existing point-based monitoring system but limited or eliminated the practice of plea bargaining motor vehicle offenses. Alternative #2 replaced MVC's current point-based system of monitoring with an incident-based system; and Alternative #3 supplemented the existing point-based system with an incident-based habitual offender license suspension program. Each of the alternatives results in increased system outputs in the form of advisory notices, re-education class enrollments and license suspensions. These additional interventions result in improved safety outcomes in the form of longer periods of safe driving after intervention and fewer future violations and crashes among the drivers in each cohort.

Across the alternatives, improvement in time until next offense is greatest among male drivers. This may be in part due to the fact that male drivers have higher overall rates of violation than female drivers. The best results in terms of time until next offense appear to derive from Alternative #1 Case 1 which presents the highest level of improvement across virtually every age and gender cohort. Interestingly, Alternative #2 which by far subjects the greatest number of drivers to interventions of all types presents improvements slightly below Alternative #1 Case 1. Alternative #3 does appear to result in longer times to next offense among habitual offenders but the times between offenses remain very short. This result highlights the fact that "hard core" habitual offenders are likely to pose significant safety concerns even though more drivers are subject to license suspension, the most strict of the interventions used by MVC. From the analysis it seems clear that there are changes that MVC can make to enhance the agency's ability to address negligent driving behavior and thereby improve highway safety. However, at least two of alternatives explored in this study, Alternatives #1 and #2 present significant and perhaps insurmountable political, systems and operational challenges. Alternative #3 presents the most promise but it too will require careful consideration of the costs and benefits of any change.

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EXECUTIVE SUMMARY

The New Jersey Motor Vehicle Commission (MVC) currently monitors driving behavior by means of a "demerit" point system. The point system has been in effect since March 1, 1977. The system allows MVC to assess drivers varying numbers of demerit points for different moving violations based on the severity of the infraction. The point system is a central component of MVC's driver management and control program which is designed to address negligent driving behavior via a series of progressively severe interventions and administrative sanctions.

In 2009, the Alan M. Voorhees Transportation Center at Rutgers, The State University of New Jersey (VTC) completed two research studies for the New Jersey Department of Transportation on behalf of MVC. The first study examined the impact of plea bargaining motor vehicle violations on roadway safety and lost revenue to MVC from remedial driver program fees, restoration fees and insurance surcharges (hereinafter "MVC Plea Bargaining Study"). (2) The second study evaluated the effectiveness of administrative actions taken as part of the MVC's driver management/control program in terms of reducing future violations and crashes among drivers sanctioned by MVC for negligent driver behavior (hereinafter "MVC Recidivism Study").(3)

The MVC Plea Bargaining study found that since July 2000 the rate of plea bargaining point-carrying moving violations to zero-point offenses has increased 250 percent. This pattern appears to present clear evidence that the creation of the "unsafe operation" moving violation in 2000 encouraged the practice of plea bargaining point-carrying moving violations to no-point offenses. The study also found that over the same period, the number of drivers subjected to MVC negligent driver countermeasures declined by 36 percent. (2) At the same time, the MVC Recidivism Study concluded that "the countermeasures used by MVC to address negligent driving behavior are effective at reducing violation and crash recidivism among most negligent drivers."(3) The combined results of these two studies suggest that changes to the MVC's current point-based monitoring system could enhance the MVC's ability to intercede to address problem drivers.

The purpose of this study is to investigate the comparative effectiveness of point-based versus incident-based negligent driver monitoring systems and to explore how certain changes to the existing point-based system used in New Jersey might improve the MVC's ability to properly identify and address problem drivers. This study seeks to address an existing gap in the literature and advance the current state of knowledge regarding the effectiveness of point- versus incident-based monitoring systems.

Summary of Findings

The results of this study further confirm the results of previous studies that the interventions used by MVC to correct problem driver behavior are effective. As part of this study, the research team used survival analysis to show that the average time to next offense for driver's subjected to MVC interventions increases significantly for all three interventions used.

On average, the period of time between violations for drivers that received a point advisory notice increased 25% in the first twelve months after they received the notice when compared to the previous 12 months. The period of time between violations for drivers that completed a re-education class increased by 34% in the first 12 months after completing the class when compared to the period before. Driver re-education classes for experienced drivers were 50% more effective than for probationary drivers. The results for driver's license suspension were less impressive but still positive. Overall, the average time between violations increased by 10% in the first 12 months and 17% in the first 24 months after suspension when compared to the period before.

The research team identified three primary alternatives to the MVC's current system of driver monitoring and control. Alternative #1 retained MVC's existing point-based monitoring system but limited or eliminated the practice of plea bargaining motor vehicle offenses. Alternative #2 replaced MVC's current point-based system of monitoring with an incident-based system; and Alternative #3 supplemented the existing point-based system with an incident-based habitual offender license suspension program. Each of the alternatives results in increased system outputs in the form of advisory notices, re-education class enrollments and license suspensions. These additional interventions result in improved safety outcomes in the form of longer periods of safe driving after intervention and fewer future violations and crashes among the drivers in each cohort.

Across the alternatives, improvement in time until next offense is greatest among male drivers. This may be in part due to the fact that male drivers have higher overall rates of violation than female drivers. The best results in terms of time until next offense appear to derive from Alternative #1 Case 1 which presents the highest level of improvement across virtually every age and gender cohort. Interestingly, Alternative #2 which by far subjects the greatest number of drivers to interventions of all types presents improvements slightly below Alternative #1 Case 1. Alternative #3 does appear to result in longer times to next offense among habitual offenders but the times between offenses remain very short. This result, highlights the fact that "hard core" habitual offenders are likely to pose significant safety concerns even though more drivers are subject to license suspension, the most strict of the interventions used by MVC.

When comparing rates of violations, Alternative #1 Case 1 (No plea bargaining) and Alternative #2 present comparable results. Both reduce future rates of violation across all age cohorts except older female drivers. Again, this counterintuitive result may be due to the limited number of observations in the dataset.

Discussion and Conclusions

The primary objective of this study was to explore alternatives to MVC's current system of driver monitoring and control and compare the effectiveness of MVC's current point system to alternative systems for driver monitoring and improving problem driver behavior. From the analysis it seems clear that there are changes that MVC can make to enhance the agency's ability to address negligent driving behavior and thereby improve highway safety. However, at least two of alternatives explored in this study, Alternatives #1 and #2 present significant and perhaps insurmountable political, systems and operational challenges. Alternative #3 presents the most promise but it too will require careful consideration of the costs and benefits of any change.

INTRODUCTION

Background and Problem Statement

The New Jersey Motor Vehicle Commission (MVC) currently monitors driving behavior by means of a "demerit" point system. The point system has been in effect since March 1, 1977. The system allows MVC to assess drivers varying numbers of demerit points for different moving violations based on the severity of the infraction. The point system is a central component of MVC's driver management and control program which is designed to address negligent driving behavior via a series of progressively severe interventions and administrative sanctions.

In July 2000, the New Jersey Legislature passed legislation (N.J.S.A. 39:4-97.2, effective July 24, 2000) creating a new traffic violation that makes it unlawful to operate a motor vehicle in a "…unsafe manner likely to endanger a person or property." This law change, which created the non-point carrying "unsafe driving" offense, provided an increased opportunity for prosecutors and the courts to downgrade point-carrying violations into penalties that only carry a fine. According to MVC, there are 150-200,000 unsafe driving (39:4-97.2) violations reported to MVC annually by the courts. In addition, there are several other non-point violations believed to be frequently used by prosecutors and the courts to "downgrade" point-carrying violations. For example, there are approximately 25,000 obstructing passage violations (39:4-67) recorded each year. Since the year 2000, when the unsafe driving violation took effect, the percentage of non-point violations increased from 46 percent to 56 percent of total violations, and the percentage of point violations decreased from 54 percent to 44 percent of total.

The widespread practice of plea bargaining point-carrying violations to non-point offenses is perceived within MVC to be hampering its efforts to address negligent driving behavior and undermining the purpose and need for the point system. In fact, the Fix DMV Commission Final Report issued in 2002 identified the MVC's "growing inability to implement remedial and rehabilitative measures as a significant safety concern." They further noted that "the use of plea arrangements and the courts' tendency to reduce or eliminate violations that carry points has weakened the MVC's ability to properly identify problem drivers. This can make problem drivers "invisible" to the MVC while they continue to violate traffic laws."[(1)]

In 2009, the Alan M. Voorhees Transportation Center at Rutgers, The State University of New Jersey (VTC) completed two research studies for the New Jersey Department of Transportation on behalf of MVC. Both studies supported the Fix DMV Commission's conclusions. The first study examined the impact of plea bargaining motor vehicle violations on roadway safety and lost revenue to MVC from remedial driver program fees, restoration fees and insurance surcharges (hereinafter "MVC Plea Bargaining Study").[(2)]The second study evaluated the effectiveness of administrative actions taken as part of the MVC's driver management/control program in terms of reducing future violations and crashes among drivers sanctioned by MVC for negligent driver behavior (hereinafter "MVC Recidivism Study").[(3)]

The MVC Plea Bargaining study found that since July 2000 the rate of plea bargaining point-carrying moving violations to zero-point offenses has increased 250 percent. This pattern appears to present clear evidence that the creation of the "unsafe operation" moving violation in 2000 encouraged the practice of plea bargaining point-carrying moving violations to no-point offenses. The study also found that over the same period, the number of drivers subjected to MVC negligent driver countermeasures declined by 36 percent. [(2)]At the same time, the MVC Recidivism Study concluded that "the countermeasures used by MVC to address negligent driving behavior are effective at reducing violation and crash recidivism among most negligent drivers."[(3)] The combined results of these two studies suggest that changes to the MVC's current point-based monitoring system could enhance the MVC's ability to intercede to address problem drivers.

Research Objectives and Approach

The purpose of this study is to investigate the comparative effectiveness of point-based versus incident-based negligent driver monitoring systems and to explore how certain changes to the existing point-based system used in New Jersey might improve the MVC's ability to properly identify and address problem drivers. This study seeks to address an existing gap in the literature and advance the current state of knowledge regarding the effectiveness of point- versus incident-based monitoring systems. The study approach builds on the findings of the MVC Plea Bargaining and Recidivism Studies and uses data compiled and analyzed as part of those studies to:

- Explore alternatives to the current system, including but not limited to American Association of Motor Vehicle Administrators (AAMVA) model driver improvement program.
- Compare the effectiveness of MVC's current point system and driver management/control program to series of hypothetical alternative systems for driver monitoring and improvement.
- Identify what changes (if any) can be made to the existing point system and driver management and control program to enhance the MVC's ability to address negligent driving behavior and thereby improve highway safety.

PROGRAM, DATA AND LITERATURE REVIEW

As briefly stated above, MVC monitors driving behavior by means of a "demerit" point system (PS). Prior to March 1977, driver history records were monitored for violations and points occurring within a moving three-year window. Each time a point-carrying violation was entered, a computer program scanned three years back in time and added the points for point-carrying violations within that period to determine the driver's total point score. On March 1, 1977, the law was amended to discard the moving three-year window. Under the amended law, all violations from March 1, 1974 forward were to remain on the record indefinitely. A driver who had points, but no violations or suspensions between March 1, 1976 and March 1, 1977, received a one-time "point reduction award" of up to 6 points. Henceforth, the total point score would vary based on points added for new violations and point reductions for unbroken one-year periods of violation and suspension-free driving.(4)

As just described, the present point system has been in effect since March 1, 1977. In recent years, the total number of violations reported to MVC by the courts has remained relatively unchanged. However, since the year 2000, the percentage of non-point violations increased from 46 percent to 56 percent of total violations, and the percentage of point violations decreased from 54 percent to 44 percent of total.(4) Figure 1 depicts the downward trend in the number of point-carrying violations recorded by MVC between 1997 and 2006.

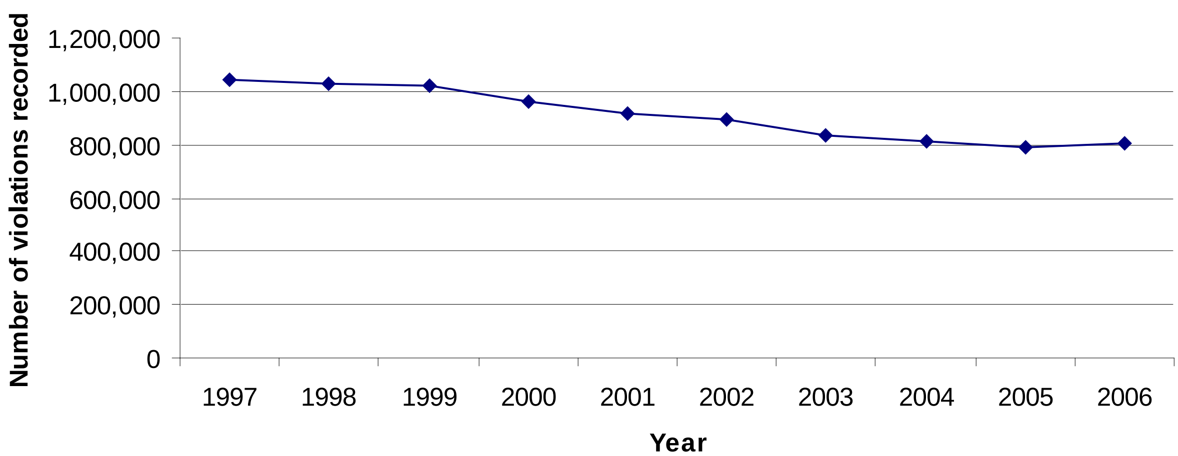

Figure 1. Number of point-carrying violations recorded by MVC – 1997 to 2006

Source: MVC driver history records, April 2007

Before the "unsafe driving" law, the non-point plea bargaining violations of choice were "obstruction of passage", N.J.S.A. 39:4-67, and "failure to obey directional signals", N.J.S.A. 39:4-215. Since the "unsafe driving" violation was created, plea bargains involving the above mentioned violations have declined. The number of downgrades to "unsafe driving" has exceeded the combined total of the other two. Further, these plea bargains have become almost a standing offer by the prosecutor which drivers can avail themselves of without the necessity of an attorney in court to represent them.[4]

New Jersey's Current Driver Monitoring and Control Program

Under the current point system and driver management/control program, driver history records are constantly monitored by computer programs for violations and points. The intervention regime includes the following elements: point advisory notice, warning letter-notice of proposed suspension, Driver Improvement Program (DIP), Probationary Driver Program (PDP), pre-hearing conference, and license suspension. Unless associated with a point-carrying violation, currently crash incidents are not counted as part of the monitoring program.

A driver who accumulates a total of six to 11 points receives a point advisory notice to remind them of their record status and encourage them to drive more safety in the future. A driver who accumulates 12 or more points within a two year period or 15 or more points in a greater than two year period receives a warning letter-notice of scheduled (proposed) license suspension. A driver who accumulates 12 to 14 points in a period greater than two years is entitled to attend the DIP in lieu of suspension. The others have two options: a) accept the suspension or b) request a hearing. Drivers who request a hearing must attend a pre-hearing conference at MVC. The purpose of the conference is to review the record and to settle the case if possible without the necessity of a formal hearing. The MVC employees who conduct conferences have discretion to reduce suspensions for good reason subject to guidelines and the approval of their supervisor. Most contested cases are settled at the conference stage. Novice drivers who accumulate two moving violations totaling four or more points during the two year period after they received their first driving permit are required to participate in the PDP.[4,5]

Figure 2 shows the basic sequence of driver violation and MVC intervention starts with negligent driver behavior followed by actions taken by MVC in response to that behavior. The sequence continues through a series of increasingly severe MVC interventions as the driver continues to accumulate violations. Points are reduced for unbroken 12-month periods of violation-free driving and for attending mandatory state-run DIP, PDP and voluntary Defensive Driving Programs (DDP) approved by MVC. The DIP is a 3-hour classroom program scheduled at 15 locations throughout the state. The fee to attend the program is $100. Drivers are scheduled to attend at the location nearest their homes. Once a driver completes the program, he receives a point reduction of up to 3 points and begins a strict one year probation period. If he commits any violations during probation, he receives a new scheduled license suspension. Drivers who fail to appear for their scheduled class without good reason and notice to MVC are suspended for the original proposed period of suspension.[4]

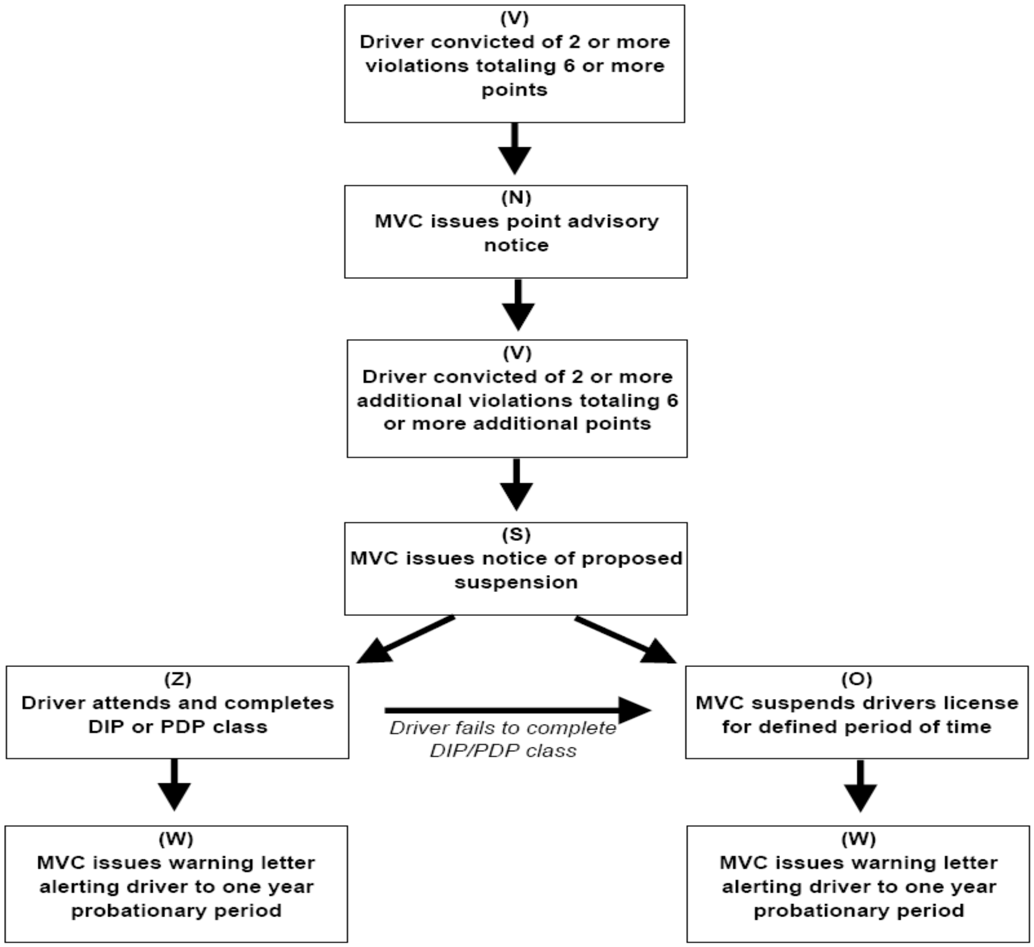

Figure 2. Basic sequence of driver violation and MVC administrative intervention

Source: Carnegie et al. (2009) [(3)]

Table 1 - New Jersey Point Schedule

N.J.S.A. Section	Offense	Points
	NJ Turnpike, Garden State Parkway and Atlantic City Expressway	
27:23-29	Moving against traffic	2
27:23-29	Improper passing	4
27:23-29	Unlawful use of median strip	2
	All roads and highways	
39:3-20	Operating constructor vehicle in excess of 45 mph	3
39:4-14.3	Operating motorized bicycle on a restricted highway	2
39:4-14.3d	More than one person on a motorized bicycle	2
39:4-35	Failure to yield to pedestrian in crosswalk	2
39:4-36	Failure to yield to pedestrian in crosswalk; passing a vehicle yielding to pedestrian in crosswalk	2
39:4-41	Driving through safety zone	2
39:4-52 and 39:5C-1	Racing on highway	5
39:4-55	Improper action or omission on grades and curves	2
39:4-57	Failure to observe direction of officer	2
39:4-66	Failure to stop vehicle before crossing sidewalk	2
39:4-66.1	Failure to yield to pedestrians or vehicles while entering or leaving highway	2
39:4-66.2	Driving on public or private property to avoid a traffic sign or signal	2
39:4-71	Operating a motor vehicle on a sidewalk	2
39:4-80	Failure to obey direction of officer	2
39:4-81	Failure to observe traffic signals	2
39:4-82	Failure to keep right	2
39:4-82.1	Improper operating of vehicle on divided highway or divider	2
39:4-83	Failure to keep right at intersection	2
39:4-84	Failure to pass to right of vehicle proceeding in opposite direction	5
39:4-85	Improper passing on right or off roadway	4
39:4-85.1	Wrong way on a one-way street	2
39:4-86	Improper passing in no passing zone	4
39:4-87	Failure to yield to overtaking vehicle	2
39:4-88	Failure to observe traffic lanes	2
39:4-89	Tailgating	5
39:4-90	Failure to yield at intersection	2
39:4-90.1	Failure to use proper entrances to limited access highways	2
39:4-91-92	Failure to yield to emergency vehicles	2
39:4-96	Reckless driving	5
39:4-97	Careless driving	2
39:4-97a	Destruction of agricultural or recreational property	2
39:4-97.1	Slow speed blocking traffic	2
39:4-97.2	Driving in an unsafe manner (pts assessed for the third or subsequent violation(s) w/in 5 year period.)	4
39:4-98 and 39:4-99	Exceeding maximum speed 1-14 mph over limit	2
	Exceeding maximum speed 15-29 mph over limit	4
	Exceeding maximum speed 30 mph or more over limit	5
39:4-105	Failure to stop for traffic light	2
39:4-115	Improper turn at traffic light	3
39:4-119	Failure to stop at flashing red signal	2
39:4-122	Failure to stop for police whistle	2
39:4-123	Improper right or left turn	3
39:4-124	Improper turn from approved turning course	3
39:4-125	Improper U-turn	3
39:4-126	Failure to give proper signal	2
39:4-127	Improper backing or turning in street	2
39:4-127.1	Improper crossing of railroad grade crossing	2
39:4-127.2	Improper crossing of bridge	2
39:4-128	Improper crossing of railroad grade crossing by certain vehicles	2
39:4-128.1	Improper passing of school bus	5
39:4-128.4	Improper passing of frozen dessert truck	4
39:4-129	Leaving the scene of an accident - No personal injury	2
39:4-129	Leaving the scene of an accident - Personal injury	8
39:4-144	Failure to observe stop or yield signs	2
39:5D-4	Moving violation out of State	2

The PDP is a 4-hour classroom program aimed at novice drivers. The fee is $100. Drivers are scheduled as above. This program is for new drivers who have accumulated 2 violations and 4 or more points during the 2-year period from the date they receive their first driving permit. Similar to the DIP, drivers completing the PDP receive a point reduction and are placed on one year probation. Drivers who fail to appear for class have their driving privilege suspended indefinitely, until they appear and complete the program and the restoration fee is paid.[(4)]

Drivers who have completed the DIP or PDP receive a point reduction credit of up to 3 points against any points on their driving record. These credits may only be received once in any given 2 year period. Drivers are also warned they are subject to license suspension for any motor vehicle violation committed within one year after completing the course, with the precise suspension period dependent upon how soon the violation is committed following program completion. Drivers who complete a voluntary DDP approved by MVC receive a point reduction credit of up to 2 points against any points on their driving record. DDP credit is given for participating in one program every five years.[(4)]

As described above, DIP and PDP participation is an important component of MVC's driver management/control program. Enrollment in the programs is predicated on point accumulation. As such, program enrollment has declined significantly since 2000 when the unsafe driving violation was created. The steep decline in enrollment is widely perceived to be strongly linked to the widespread use of the unsafe driving plea arrangement and evidence that New Jersey's current point-based system of driver monitoring is not working well. Figure 3 shows the steep decline in DIP and PDP enrollment for the period 1997 to 2005.

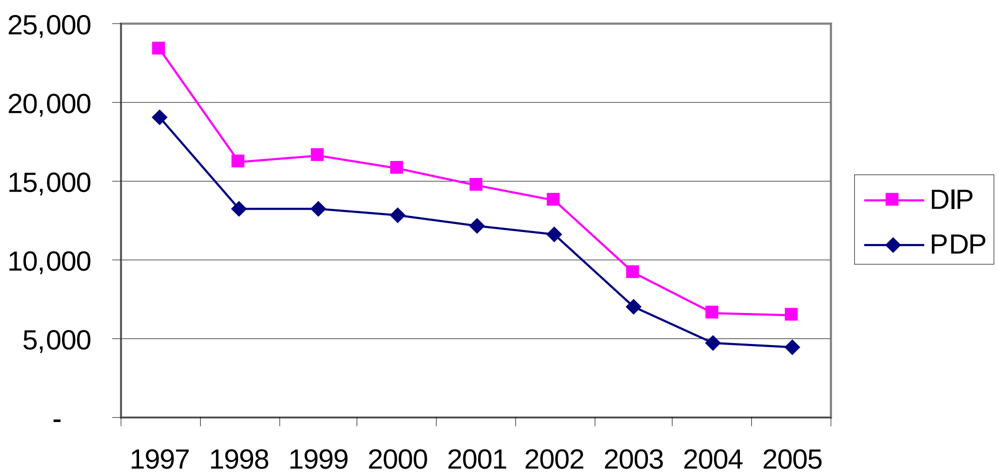

Figure 3 - Enrollment in MVC's DIP and PDP programs 1997 to 2005

Source: NJMVC

AAMVA Model Driver Improvement Program

New Jersey's driver management/control program shares many characteristics with the model driver improvement program developed by the American Association of Motor Vehicle Administrators (AAMVA) in the 1990's. These similarities include the use of warning letters, record review and license suspension. However, it differs in one fundamental way. The AAMVA driver improvement program does not use a point system to monitor driver behavior. Instead, it uses a system of "countable incidents," which include both convictions for moving violations and reportable crashes. According to AAMVA, the model driver improvement program is designed to: identify problem drivers, change behavior, and if necessary, impose sanctions.[(6)]

The goal of the program is crash prevention and the steps in the program are geared to the seriousness of the driver's record. A warning letter is sent after a driver accumulates three countable convictions or two reportable crashes within any two year period. A record review is completed after a driver receives four convictions or three crashes in any two year period. A record review may result in a counseling session interview, medical or vision examination, skills testing, driver improvement course, restricted licensure or any other action deemed appropriate. A license withdrawal is imposed when a driver accumulates five countable convictions within any two year period. Under the program, novice drivers are treated in an accelerated program for two years from the issuance of a permit/license. Finally, drivers are prohibited from completing any type of driving improvement program to avoid or reduce a conviction.[(6)]

Driving behavior is monitored based on a moving two year window. After entering the system (i.e., having at least one countable incident recorded on their record), drivers must work their way out of the system gradually. Those drivers who are violation-free for a period of time do not leave the program abruptly. A driver who operates for two years without a crash or a violation resulting in a conviction is viewed as no longer representing a "problem" and therefore is no longer considered for actions within the model driver improvement program. According to AAMVA, an entry- or incident- based system (such as the model driver improvement program) results in fair and equitable treatment for problem drivers. Rather than arbitrarily assigning point values to each type of conviction, all "countable" traffic convictions are of equal value.[(6)]

Driver Improvement Program Evaluation Studies

Driver monitoring and improvement programs, including the use of administrative sanctions to address problem drivers, have been commonplace in the United States for decades. Highway safety professionals employ many types of strategies to reduce highway crashes, including countermeasures that address the influence of human factors on highway safety. Research has consistently shown that drivers who repeatedly violate motor vehicle laws pose higher public safety risks.[(7,8)] Consequently, motor vehicle administrators in every state in the country have some system of post-licensure driver monitoring and control in place and impose sanctions on repeat traffic offenders.

A review of the literature reveals an extensive body of research evaluating the effectiveness of various driver improvement interventions, including novice driver education, warning letters of various types, recidivism and crash prevention courses, as well as driver's license suspension. Unfortunately, the evaluative research completed to date is not conclusive. The degree to which different interventions are effective appears to vary widely, depending on the nature of the study.

For example, in 1989, Struckman-Johnson et. al conducted a comprehensive review of 65 past studies that evaluated the effectiveness of various driver improvement programs. Based on their review, they found: a) that driver improvement activities generally result in a reduction in future violations; However, they found that driver improvement programs have an unpredictable and sometimes undesirable effect on future crashes even in the presence of desirable violation effects. They further found that past studies revealed no strong evidence documenting differential effects related to the characteristics of some interventions. Based on their review they found no strong evidence to indicate that direct participant contact (i.e., in-person interview or counseling session) was more effective than indirect contact (i.e., telephone interview) or that individual contact (i.e., one-on-one counseling session) was better than group contact (i.e., small group counseling session) at reducing violation and/or crash recidivism.[9]

California's negligent driver intervention programs appear to be the most extensively studied in the literature. The earliest studies conducted by the California Department of Motor Vehicles date back to 1965 and continue for almost three decades. The most recent evaluation of California's Negligent-Operator Treatment System (NOTS) was completed in 1995. In California, drivers become eligible for the NOTS program by accumulating negligent-operator points. Points are assigned for safety-related traffic convictions and for accidents in which the driver is at least partially responsible. As drivers continue to accumulate points, they progress from level 1 through level 4 of NOTS, with each level bringing a more severe departmental action.[10]

The 1995 study was based upon an experimental design that randomly assigned negligent operators to either a treatment or a control group. Members of the treatment group received the NOTS treatments for which they were eligible and members of the control group were not contacted. Researchers found that the NOTS program produced statistically significant reductions in traffic citations and accidents. Specifically, drivers receiving the Level 1 or Level 2 warning letters had fewer accidents than their no-contact control counterparts (reductions of 4.4% and 0.8% respectively). These differences were statistically significant in the first 6 months after treatment for Level 1 but not for Level 2. The probation hearing treatment at level 3 produced a statistically significant reduction in subsequent accidents (11.6%) and the probation-violator suspension treatment at Level 4 resulted in an even greater reduction in accidents (estimated to be 17.6%). Overall, the treatments were effective in reducing serious accidents (those involving an injury or fatality) as well as those involving only property damage. Finally, consistent with other past studies, researchers found no indication that the use of telephone hearings, which were introduced in 1992 as an alternative to in-person hearings at Level 3, had any adverse impact on traffic safety.(10)

Masten and Peck (2004) also report statistically significant reduction in incidence of crashes and violations following a driver intervention program using 35 studies from different states.(8) Warning letters resulted in improvements of 2.3% for crashes and 4.2% for violations. Suspensions resulted in improvements of 11% for crashes and 19% for violations. Similar findings have been reported in studies in few other states. Grosz and Zeller (2002) found that traffic violation and crash rates reduced following the group of drivers' completion of traffic safety courses in the state of Florida.(11) McKnight et al. (1997) reported a reduction in number of violations and crashes in Arizona following both a recidivism reduction program and a license suspension.(12) Similarly improvements in traffic violations and crashes were observed following driver improvement program in Pennsylvania.(13) Raub et al. (2000) reported reductions in traffic citations in drivers following their enrollment into traffic safety school after a set of citations.(14)

While the evidence is strong that some interventions aimed at problem or negligent drivers can be effective, there appears to be no scholarly research or programmatic evaluation examining the effectiveness of point- versus incident-based driver monitoring systems. In addition, there has been no comprehensive evaluation of AAMVA's model driver improvement program since it was proposed in 1997.

DATA ANALYSIS AND MODELING

Most past analyses that have investigated the effectiveness of problem driver countermeasures has focused on whether the countermeasures reduce the number of future violations or crashes a driver is involved in when comparing behavior before and after intervention. In this study we argue that additionally, the elapsed time between intervention and next violation is also important to consider. In other words, the length of time a driver is driving “safely” after the intervention is also important. This type of “longevity” analysis is a common research approach in medical, public health and engineering studies. The approach is known as “survival analysis.”

In order to illustrate this method, the following hypothetical example was created. Consider a time frame of 12 months and two drivers, Driver 1, “Jill Lerner,” and Driver 2, “Dan Gerous,” both commit four motor vehicle violations during the 12-month period. Jill has her offense in the first month, second offense in the second month, third offense in the third month and fourth in the twelfth month. Dan has his first offense in the first month, second offense in the third month, third in the fifth month and the fourth offense in the seventh month. Between Jill and Dan, who poses a bigger danger in terms roadway safety?

If we consider only the number of violations then both the drivers pose an equal amount of risk. But if we analyze at the elapsed time between the violations then the conclusion may be different. Jill commits three of her violations in the first three months, but Dan has his violations spread out over the year. A possible explanation could be that Jill after committing her three violations has realized her “mistakes” and corrected her driving behavior, whereas Dan is more “careless” and keeps committing his violations without any change in his driving behavior.

Now consider a third driver, “Re Peter,” with similar violation pattern as Dan, Driver 2, but he plea-bargains at the end of the 12-month time period. Then we can really analyze the effect plea-bargaining, as one intervention, will have on driver behavior by comparing the time until the next violation for the three drivers. A schematic representation of the driver violation and intervention history is shown in Figure 4.

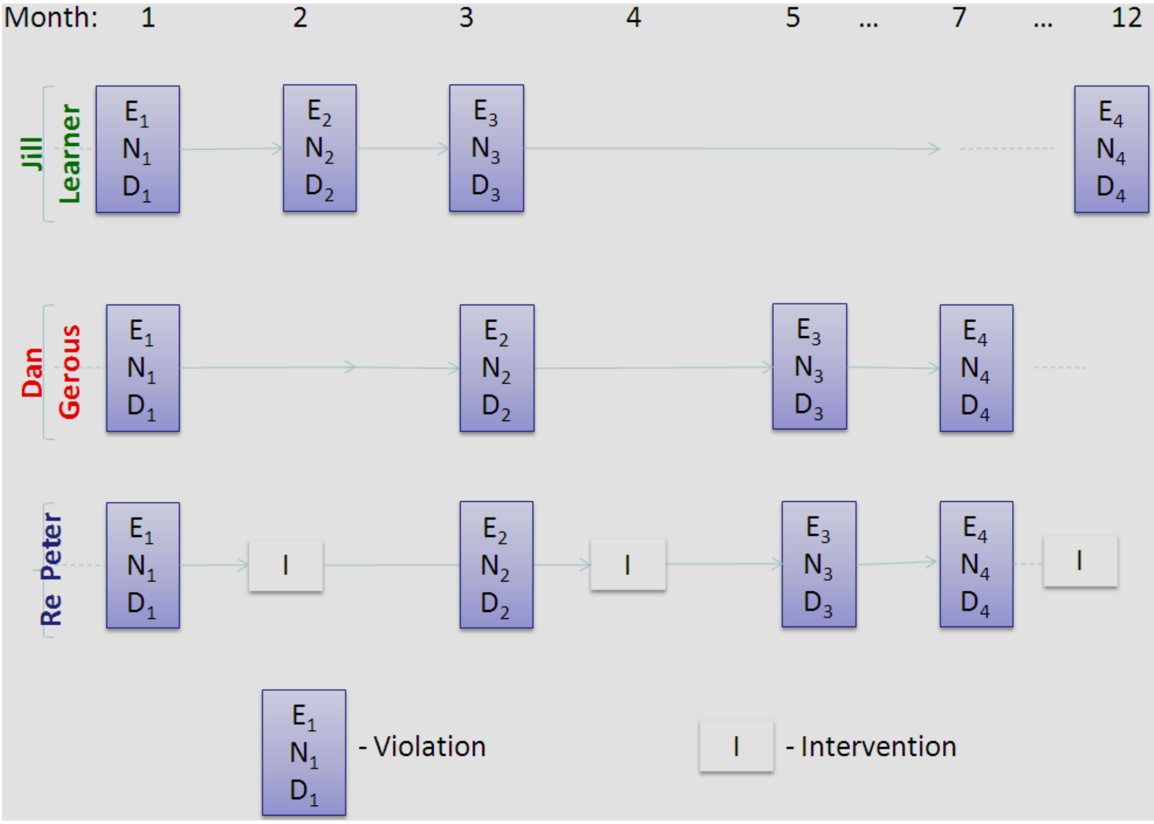

Figure 4. Schematic representation of violation and intervention history of three hypothetical drivers

In addition to the elapsed time between violations, there may be many other factors such as: age, gender, types of violation, and number of cumulative points on a driver's record that may influence a driver's behavior. Also the frequency of interventions used to correct negligent driving behavior [3,15] and whether drivers can avoid negligent-driver interventions by plea-bargaining violations in local traffic court [2] must be considered.

All these factors can be incorporated in statistical models such as those used in survival analyses. Survival models are used extensively in clinical studies when determining the effect of a certain drug on the recovery of a patient.[16,17] These models are also used in engineering when determining the reliability of a structure and the time until which it will last without failing.[18,19] The advantage of using survival analysis methods over other aggregate methods has been well documented in literature.

Willett and Singer (1991) showed the advantages of using survival analysis over other more traditional methods in evaluating the student dropout rate and teachers' attrition rate.[20] Walker (1998) showed the advantages of using survival analysis over traditional regression models, such as logistic regression, for employee turnover data.[21] Fox (2001) illustrates that survival methods offer several advantages over ANOVA methods in that they can handle repeated measurements over time on the same sampling units, including censored observations, and account for failure times (i.e., death) that are not normally distributed.[22] Jinkerson and Mattox (2001) have shown that using survival methods analyze the effect of training (an intervention) on employee performance is more accurate when compared with ANOVA models.[23]

Additional drawbacks of using the more traditional approaches such as linear regression models are:

- The linear regression model does not treat time interval between the events as an independent variable. If the model can be generalized, time difference between events can be considered. But the time interval has to be assumed for each model and is fixed for each model.

- The model estimates the number of events that might take place in the next *t time units* or whether or not an event might take place, but it does not predict the probability of an event happening in the future.

- The linear regression model assumes that the number of violations in time period t-1 could be correlated to the number of violations in time period t-2 and so on. Linear regression model will give a problem with these autocorrelations.

- Conventional linear regression will have major complications with the treatment of time-varying covariates. In our case, clearly covariates of the individuals are time varying (age, points, events, etc.)

- Linear regression model does not deal with the obvious problem of censored data. In this case, the data is right censored (observations on any individuals who did not yet commit a violation are definitely censored).

An illustration of how survival analysis can be used to determine which type of driver has a greater chance of being a safe driver, for the example presented above is shown in Figure 5.

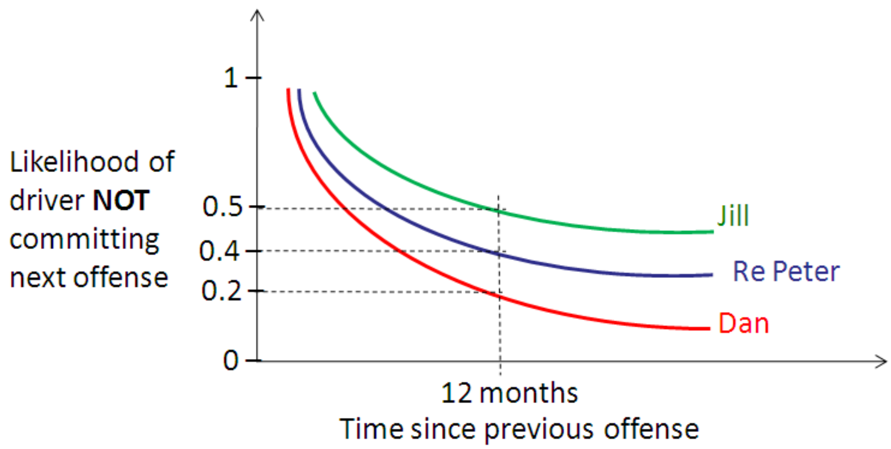

Figure 5. Illustration of the use of Survival Analysis

The following is a brief summary of studies analyzing negligent driver behavior and the effect of various interventions. To analyze and predict the effect of recidivism of driving under influence (DUI) drivers, Baca et al. (2001) used risk factor analysis.[24] Rodgers (1994) used relatively rudimentary survival curves to find the effect of impoundment laws on recidivist DWI drivers.[25] Ferrante et al. (2001) studied the relationship between drunk driving, crashes and recidivism using Cox-proportional hazard modeling.[26] McCartt et al. (2003) used telephonic survey data among teen drivers, in selected communities in Northeastern United States, to study the time of incidence of crashes using Kaplan-Meier curves.[27] Lapham et al. (2006) analyzed the effect of a supervision program against DUI in Multnomah County, Oregon.[28] The authors estimated a Cox-proportional hazard model in the analysis process. Lawpoolsri et al. (2007) used survival analysis to find the effect of speeding citations on subsequent driver behavior.[29] Fu (2008) used Cox-proportional hazard model to identify the severity, site and driver-specific factors influencing crashes involving DUI.[30] Robertson et al. (2009) studied the impact of remedial intervention among first-time DUI offenders using survival analysis on recidivism rates[31] Masten and Foss (2010) used survival analysis to analyze the effect of graduated licensure program in North Carolina.[32]

Description of the Data Used

For this study, the research team utilized driver history data obtained from MVC. The data consists of 8.8 million drivers with a history of motor vehicle violations over a 10 year period of time from 1997 to 2007. Drivers with no violation history do not appear in this dataset. In addition to the driver history data, the research team also utilized data obtained from the New Jersey Administrative Office of the Courts (AOC). The AOC data consists of motor vehicle traffic violations adjudicated through the municipal court system in New Jersey between November 1, 2004 and November 1, 2007. These data include 1.3 million records of court-amended (plea bargained) driver citations over this three year period. The AOC data were combined with the MVC driver history data so that each driver's violation and plea-bargain history could be analyzed in combination. A brief characterization of the combined dataset is shown in Table 2.

Table 2 - Characterization of combined dataset

(a) Distribution of Moving Violations

Age Group (years)	Male	Female	Total	Percent of total
16-17	209,300	77,658	286,958	4%
18-24	1,520,197	609,387	2,129,584	27%
25-34	1,431,987	611,967	2,043,954	26%
35-44	1,119,736	554,763	1,674,499	21%
45-54	678,311	343,354	1,021,665	13%
55-64	306,956	138,803	445,759	6%
65-84	145,431	66,680	212,111	3%
85 and more	6,382	3,314	9,696	0%

(b) Distribution of Crashes

Age Group (years)	Male	Female	Total	Percent of total
16-17	42,560	36,501	79,061	4%
18-24	213,077	164,096	377,173	19%
25-34	230,813	173,050	403,863	20%
35-44	243,591	185,066	428,657	22%
45-54	191,575	140,279	331,854	17%
55-64	115,832	79,010	194,842	10%
65-84	92,268	64,856	157,124	8%
85 and more	7,249	4,896	12,145	1%

Variables and Groups Considered in the Modeling Process

As mentioned previously, the literature suggests that age and gender are key variables to be considered in models involving driver behavior analysis.[25-32] Typically male drivers and younger drivers are more likely to commit a traffic violation. These effects diminish with driving experience and age. Additionally, Lapham et al. [28] and Rodgers [25] considered number of violations and number of DUI offenses in modeling recidivism of DUI offenses. McCartt et al. [27] considered number of crashes in analyzing the crash rates in teen drivers. Strathman et al. [34] used number of crashes and number of convictions in their analysis of driver improvement programs in Oregon.

Therefore, in order to analyze the effect of different negligent driver interventions (e.g., warning letter, driver improvement classes, and license suspension) on driving behavior in New Jersey the research team examined several variables and aggregated drivers into various groups by age and gender; the nature of their violation history and their plea-bargaining history. The following set of covariates was selected for the analysis:

1. *CUMUVIOLP* is the cumulative number of moving violations carrying 1-3 points (minor violations) in a driver's history since November 1, 2004.

2. *CUMUVIOHP* is the cumulative number of violations carrying four or more points (serious violations) in a driver's history since November 1, 2004.

3. *CUMUPB* is the cumulative number of plea-bargains in the driver's history.

4. *VIOL_AGE* is the variable for the driver's age at the time of intervention. To simplify grouping the drivers the covariate age was divided into the following age groupings: 16-19, 20-24, 25-34, 35-64, 65-more.

5. *CUMUPTS* is the total points on the driver's record at the time of each violation.

6. *GENDERGRP* is the indicator variable for a driver's gender.

7. *PREVDUR* is duration of time between the previous two violations.

To simplify grouping the drivers into control and treatment groups, different "cohorts" were created for each of the above covariates. These cohorts are shown in

Table 3.

Some literature also indicates that the type of initial violation (i.e., minor or serious) may have a bearing on the elapsed time between the initial violation and subsequent violation(s). In other words, the time between violations may be influenced by whether the initial violation is a minor offense or a serious offense or if the offense has been plea-bargained to an offense that carries a lower number of points.

To facilitate analysis of the length of time until the next moving violation after the driver's first moving violation since 2004 (hereinafter referenced as "initial violation"), the research team also parsed the data based on the type of initial violation. The parsing process resulted in the additional "cohorts" identified in Table 4.

Table 3 - Representation of the different variables and corresponding cohorts

Cumulative No. Minor Violations	Cohort
0-1	1
2-3	2
4-5	3
6-more	4
Cumulative No. Serious Violations	
0	1
1	2
2	3
3-more	4
Cumulative No. Plea-bargaining Events	
0	1
1	2
2	3
3-more	4
Cumulative No. Points	
0	1
1-5	2
6-11	3
11-more	4
Age Groups	
16-19	1
20-24	2
25-34	3
35-64	4
65-more	5

Table 4- Cohorts based on initial event type

Type of Initial Violation (VIOLTYPE)	Cohort
Minor	1
Serious	2
Plea-bargained Serious to Minor violation	3
Plea-bargained Serious to Zero point violation	4
Plea-bargained Minor to Zero point violation	5
Crash	6

Model Specification

To be able to use a survival analysis model a "hazard rate" must be specified. In the case of this analysis, the "hazard rate" of various events (i.e., violations or crashes were specified. The hazard rate of an event is defined as "the instantaneous probability that the event (or offense) will occur given that the driver has not committed an offense for a certain time" [(33)].

Mathematically, the hazard rate function can be expressed as: $\lambda\{t \mid N(t), Z(t)\}$, where λ is the hazard rate, *N(t)* is the number of offenses prior to time *t*, and *Z(t)* is the vector of covariates at time *t*. The covariates that can be considered in the model as independent variables include number of violations and crashes, cumulative number of points, driver-related characteristics (e.g., age, gender), etc. The estimation process essentially involves the estimation of the hazard rate function $\lambda\{t \mid N(t), Z(t)\}$ using the Maximum Likelihood Estimation method and also considering and adjusting the model appropriately for the fact that there can be multiple events possible in a driver's record.

In this study, only moving violations were considered because other violations, such as driving with an expired registration or equipment violations appear to have limited bearing on safe driving behavior. In *Z* the driver-related characteristic such as age can be defined as a time-dependent variable in this model structure. So, if it can be assumed that the same stochastic process governs the driver and event, a different model need not be estimated for drivers in different age groups. The other changes in the characteristics of the drivers other than age such as the number of plea bargains, number of advisory notices, etc., are captured by using semi-parametric Cox-Proportional Hazard model. Events may include moving violations and crashes.

Model Estimation

The Statistical Analysis System (SAS) Version 9.1 was used to estimate the Cox-proportional hazard model discussed above.[(35)] SAS has the capability to handle huge datasets with a large number of fields. It also provides a wide variety of procedures for statistical modeling. Since the raw dataset obtained from NJMVC is in the form of a flat dataset with close to 4,300 fields, it was decided that SAS will be an ideal software package for the study. For the purpose of estimating the model a random sample of 20,000 drivers with violations or crashes between 2004 and 2007 was chosen.

<u>Parametric and Non-parametric Approaches</u>

The modeling of survival processes usually involves two broad types, parametric models and non-parametric models. Parametric models assume that the survival time follows a particular distribution. These models usually tend to give relatively "tighter" bounds for the parameter estimates. But due to the distribution assumption, if the assumed distribution is not correct, these models may lead to inaccurate models. Another drawback in parametric models is that their structure is such that they cannot incorporate time-dependent variables, which is an important requirement in this study.

Hence a non-parametric approach to the modeling procedure was used. The non-parametric models do not make any distributional assumption; hence these are more accurate in representing the survival process. Also time-dependent variables can be incorporated in the models in various ways.

Modeling the Effect of Interventions

As mentioned earlier, MVC has the system of post-licensure driver monitoring and control in place and imposes sanctions on repeat traffic offenders. In other words, each intervention is preceded and often succeeded by one or more violations. Hence the modeling process should take into account the time between violations before and after the intervention. For this purpose the dependent variables in the model are the average of time between violations before and after the intervention. Figure 6 represents the schematic of the modeling of violations and interventions.

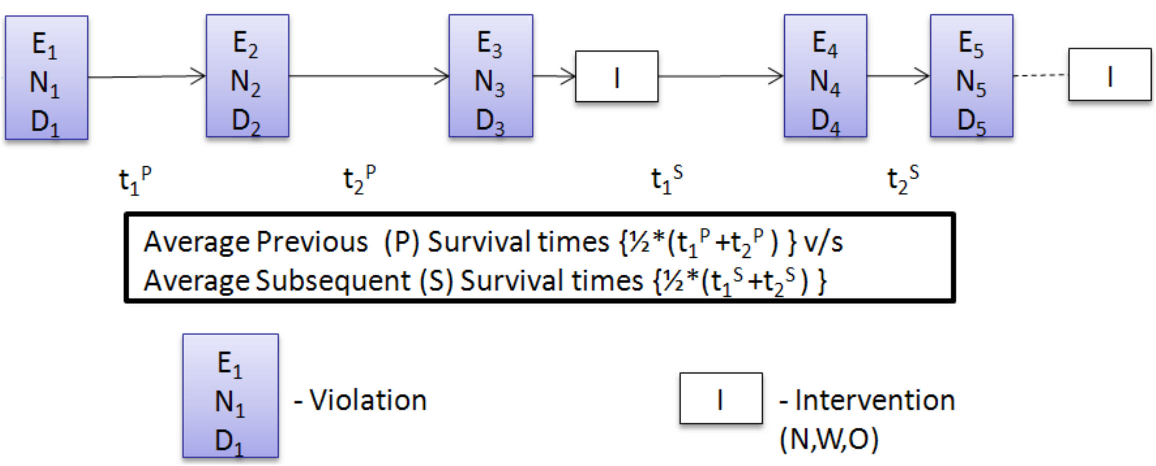

Figure 6. Schematic representation modeling violations and interventions

Mathematically, the Cox-proportional hazard model for the effect of interventions can be expressed as shown in [1]. The survival probability ($S(t)$) is used to make inferences about the driver behavior. Hazard rate ($h(t)$) is estimated as a function of various covariates using maximum likelihood estimation.

$$h^j(t) = h_0{}^j(t) * \exp(\sum \beta_i X_i + \delta)$$

$$S^j(t) = [S_0^j(t)]^{h^j(t)}$$

S^j - Survival probability for driver type j

$h_0{}^j$ – base hazard rate for driver type j [1]

X_i – covariates such as age, gender,

number of different types of violations, etc.

δ = 0 before intervention,1 after intervention

Modeling Multiple Events

Unlike traditional studies where the survival analysis is used to model death, in the case of this analysis, a "failure" can occur more than one time in the case of traffic violations. One important need in the modeling procedure is to take into account the effect of multiple events in the drivers' history on the drivers' behavior. Multiple events and the time intervals between each of them will give a much more comprehensive model. In addition, and more importantly, taking into account multiple events helps in considering any unobserved heterogeneity in the variables considered in the model. Also if multiple events are not considered, the hazard rates are biased downwards, the parameter estimates are skewed and standard errors are high.

There are various ways of incorporating occurrence of multiple events over time.(36,37) For the current study, the stratified models for total time and gap time proposed by Prentice, Williams, and Peterson (1981),(36) also called the PWP method, was used. This method is documented as one of the better methods to be used for modeling multiple events.(38) Equation [2] shows how the Cox-proportional hazard model can be depicted. Using the information about number of different offenses from the data, a stratified model for each j-th offense of type k is estimated.

$$h^{jk}(t) = h_0{}^{jk}(t) * \exp(\sum \beta_i X_i) \qquad [2]$$

$h_0{}^{jk}$ – base hazard rate for j-th offense of type k

X_i – covariates such as age, gender, number of different types of violations, etc.

Testing the Significance of Variables

The set of covariates described above have to be tested for their significance. Also it is necessary to test whether the covariates satisfy the proportionality assumption in the Cox-Proportional Hazard models that were used in the modeling process. For testing the significance of the covariates, the Wilcoxon signed-rank and the Log-rank statistical tests were used. All the variables have been found to be significant with a p-value of 0.001 at 95% significance.

For testing the proportionality assumption, one of the standard procedures is to plot the survival curves for each of the cohort for a covariate. If the curves are parallel to each other then the proportionality assumption is satisfied. In the case that any of the variables do not satisfy the proportionality assumption, the standard procedure to deal with such a case is to make the variable stratified. For this study and using the above referenced variables, it was observed that type of intervention does not satisfy the proportionality assumption. So, the estimated models were stratified for the type of intervention.

Testing Multicollinearity and Correlation of the Variables

Before presenting the parameter estimates for different models, the applicability of the variables used in the model has to be evaluated. It is possible that some of these variables have collinearity which will lead to biased and unstable parameters estimates. In other words, if the variables are a linear combination of one another, then the parameter estimates are unstable. Also, since estimating the Cox-proportional hazard model, as does any regression model, involves inverting a matrix, it is important to check the ill-conditioning in the matrix. Condition index measures the extent of ill-conditioning of a matrix. The condition for testing for multicollinearity is that if the maximum value of 'condition index measure' is more than 30, then there is multicollinearity.(34) Table 5 shows that the maximum value for the condition index is 11.58.

Another measure to gauge the collinearity is the variance proportion. A collinearity problem occurs when a component associated with a high condition index contributes strongly (variance proportion greater than about 0.5) to the variance of two or more variables.(34) The values under each variable listed in Table 5 shows the variance proportion. The variance proportion for almost all of the covariate combinations is less than 0.5.

Another method of evaluating multicollinearity is by evaluating the variance of inflation for the above set of variables. Variances of inflation (VIF) measure the inflation in the variances of the parameter estimates due to collinearities that exist among the independent variables. A variable whose VIF value is greater than 10 may merit further investigation.[34] Tolerance is the reciprocal of VIF. Table 5 shows that the VIF and tolerance values are not high enough to disregard the inclusion of any covariate from the model. These three results show that there is no indication of multicollinearity between the covariates considered in the modeling procedure.

Another test necessary for the current set of variables is to check for the correlation between them. It is probable that there is some correlation between number of events and number of points. Table 6 shows the Spearman correlation coefficients [33] between *CUMUVIOLP*, *CUMUVIOHP, CUMUPB,CUMUPTS*. *CUMUVIOLP*, *CUMUVIOHP, CUMUPTS* are partially correlated but it is important that both number of events and number of points be included in the models to observe their possible effects of driver behavior. So it was decided to retain *CUMUPTS*.

In addition a variable selection routine (based on log-likelihood and Akaike Information Criterion (AIC)) is used to evaluate the effectiveness of having each variable. It was found that the full model is very close to the best set of variables.

Table 5- Multicollinearity output

				Variance Proportion for each Covariate						
Covariate	Tolerance	Inflation	Condition Index	CUMUVIOHP	CUMUVIOLP	CUMUPB	VIOL_AGE	GENDERGRP	CUMUPTS	PREVDUR
CUMUVIOHP	0.601	1.663	3.65	0.70	0.02	0.11	0.00	0.00	0.06	0.04
CUMUVIOLP	0.664	1.506	4.25	0.01	0.23	0.11	0.00	0.00	0.62	0.02
CUMUPB	0.877	1.140	4.60	0.15	0.38	0.19	0.00	0.00	0.01	0.16
VIOL_AGE	0.948	1.056	5.94	0.00	0.04	0.47	0.04	0.02	0.01	0.68
GENDERGRP	0.626	1.599	7.31	0.00	0.26	0.09	0.46	0.01	0.00	0.02
CUMUPTS	0.820	1.219	8.86	0.01	0.02	0.01	0.34	0.40	0.13	0.00
PREVDUR	0.762	1.313	11.58	0.00	0.00	0.00	0.00	0.01	0.00	0.00

Table 6- Spearman Correlation Coefficients for *CUMUVIOLP*, *CUMUVIOHP, CUMUPB,CUMUPTS*

	CUMUVIOHP	CUMUVIOLP	CUMUPB	CUMUPTS
CUMUVIOHP	1	0.153	0.131	0.376
CUMUVIOLP	0.153	1	0.448	0.440
CUMUPB	0.131	0.448	1	0.228
CUMUPTS	0.376	0.440	0.228	1

Correction for Regression Towards the Mean

The ideal experimental design for estimating the effect of a treatment is to include a randomly assigned control group, for which the treatment is withheld. In the case of negligent driver intervention systems, this translates to withholding treatment i.e. intervention (driver improvement class, warning letter, etc.) to a randomly chosen set of drivers.

Among the recent safety studies available in the literature on driver interventions, only few studies such as the states of California[(39)] and Oregon[(39)] randomly assigned a group of drivers as a control group. California's ENOTES program used a group size of 4%-20% (based on the type of treatment) who have been delayed treatment for a period of 18 months. In a study of Oregon's Driver Improvement Evaluation System in 1997 the researchers used a control group size of 5% of the study group as a control group for 24 months.

It should also be noted that for a similar study in Oregon in 2002,[(34)] the control group of drivers was not available. Arizona [(41)] evaluated their effectiveness of driver education programs by comparing the high-risk drivers referred to the traffic education school to the low-risk drivers i.e. drivers with at least one citation in one year. Iowa's evaluation of driver improvement program also did not have the experimental design with a randomly assigned control group.[(42)] In this study drivers with satisfactory and unsatisfactory completion of the program were compared. In similar studies, in other states such as Florida[(43)] and Pennsylvania[(44)], control groups were not available.

The study in Florida used a group of drivers who were referred to traffic safety schools as a treatment group and compared them with a group of drivers who were not referred to the school. The period of comparison was 18 months. The Pennsylvania study concluded that the effectiveness of the examination compared to participation in the traditional course was significant at 3-, 6-, 9- and 12-month intervals following completion of the exam. It can be observed that in studies where there was no "true" control group included in the design, the comparisons do not eliminate the effect of regression to the mean. The conclusions drawn in these studies can only be on a relative scale. For instance it was reported in Strathman et al. [(34)] that the relative incidence of crashes of DIP drivers to the general population had been reduced by 55%. Michael [(41)] states that there is "significant" reduction in violations for drivers referred to traffic schools as compared to those who had violations but were not referred.

The discussion of literature presented above shows that it is not always easy for states to design evaluations of driver improvement programs with appropriate control groups. The major reason could be that having a control group may sometimes be not possible, due to legal implications resulting from liability posed by not "treating" a negligent driver when intervention is clearly warranted. Even in cases when there is an appropriate control group, the duration for which the drivers remain in the control group may not be sufficient to obtain statistically significant observations.

Masten and Peck (2004) presented the findings from various studies on driver improvement programs. The authors stress the importance of designing the experimental setup with randomly assigned driver groups to form a control group. Since there is no single study which presented results with and without a control group, the authors compared violation and crash rate changes due to a driver improvement program across different studies. The authors estimate that when comparing studies with and without a true experimental design, the violation rates could be different by 70%.[8] It should be noted that this comparison is across studies from different areas.

When the experimental design does not incorporate an appropriate control group the estimates made thereof may be inaccurate due to a statistical phenomenon called regression toward the mean. This happens when evaluating groups of the population that represent extremes. The extremes of population may not always be "inveterate" negligent drivers and some of the drivers may be involved in violations due to various reasons. These drivers may not be involved in a violation in a long time after the intervention. In other words an extreme event may be followed by a less extreme event.[45] Hence the influence of these drivers on the "after-effect" of intervention may skew the estimate. This has also been reported to be a problem associated with before-and-after studies.[45-49] The difference cannot solely be attributed to the effect of treatment. Hauer [46] states that "We cannot assume that if the treatment had not been applied in a given site, safety in the 'after' period without treatment would have been the same as in the 'before' period".

Hence, it is necessary to resort to alternatives ways of accounting for the effect of regression to the mean. Empirical Bayesian (EB) methods provide means to mitigate the effect of regression to the mean.[49-50] Using the Bayes' theorem, EB method combines information about this distribution (prior) with data collected from a treatment site (likelihood) to offset the impact of a temporary, random increase in crashes. In the before-after studies, the EB approach is usually implemented via the Negative Binomial model (also known as the Poisson/Gamma model) and the model parameters are estimated using a maximum likelihood technique or any other technique involving the use of the observed accident data from the similar sites.[51]

Note that the use of empirical Bayes will not completely eliminate regression to the mean effect. The empirical Bayesian method entails estimation of the survival model for various points of the observed distribution of covariates in the model. This process is performed by continuous sampling using Markov Chain Monte Carlo (MCMC) simulation. For this study the simulation was repeated 6000 times for each of the interventions.

Effect of Interventions: Models and Discussion

The hazard ratios for three types of negligent driver interventions used in New Jersey are shown in Table 7 through Table 9.These tables can be used to find the effect of each covariate. The hazard ratio for the X_i indicates the change in hazard rate of X_i relative to the base ($X_i = 0, \forall i$) hazard rate with a unit change in X_i shown mathematically as, $HR_i = \exp(\beta_i)$. Hence if $HR_i < 1$ it means that increasing X_i reduces the hazard and vice versa. It should be noted that since the model is semi-parametric, the base hazard rate is estimated from the data. The summary of analysis shown after each model is based on changes in times until the next offense. Here, the time until next offense is taken as the 90th percentile of the survival curve, which means that the driver is 90% likely of committing another offense. Thus, the changes in times until the next offense are estimated using the base survival times available from the data and hazard ratios based on the change in the corresponding covariate.

Table 7 presents the model parameters for Point Advisory Notices. As shown in the table, overall, the average time between violations increases by 25% in the first 12 months after intervention compared to the period before. Point Advisory notices for experienced drivers are 20% more effective than for probationary drivers. Drivers with a crash history show longer times between subsequent violations than drivers with no crash history. And finally, drivers receiving their second advisory notice have average times to subsequent violation in the first 12 months 12.5% less than drivers receiving the notice for the first time. This implies that advisory notices have a diminishing effect on “frequent” violators.

Table 8 shows the model parameters for Driver Re-education Classes. Overall, average time between violations increases by 34% in the first 12 months after class compared to the period before. Driver Re-education Classes for experienced drivers (DIP) are 50% more effective than for probationary drivers (PDP). Drivers with a crash history show longer times between subsequent violations than drivers with no crash history. Drivers with a plea-bargain history show shorter times between subsequent violations than drivers with no plea-bargain history.

Table 7 - Model parameters for Point-Advisory Notices

Parameter	Estimate	Std. Error	Chi-Sq.	Pr > Ch.Sq.	Hazard Ratio
nTYPE (0-DIP, 1-PDP)	0.1051	0.00973	278.1024	<.0001	1.176
CUMUVIOHP	-0.0714	0.01193	271.7669	<.0001	1.217
CUMUVIOLP	0.0522	0.00708	2586.343	<.0001	1.434
CUMUPB	0.0741	0.00379	623.7575	<.0001	1.099
CUMUPTS	0.1335	0.00145	16047.3	<.0001	1.202
CUMUA	-0.1347	0.00705	285.3803	<.0001	0.888
CUMUN	0.2241	0.00565	1826.014	<.0001	1.273
CUMUVIOHP*CUMUPTS	-0.0363	0.00156	543.4209	<.0001	n/a
CUMUVIOLP*CUMUPTS	-0.04705	0.000988	2266.086	<.0001	n/a
GENDERGRP	-0.3831	0.00726	236.6925	<.0001	1.118
AGEGRP2	-0.5894	0.0104	1306.906	<.0001	0.687
AGEGRP3	-0.6323	0.01033	3321.532	<.0001	0.551
AGEGRP4	-0.8574	0.01076	3542.896	<.0001	0.527
AGEGRP5	-0.4539	0.03825	498.1814	<.0001	0.426
nHist (0-Before Notice, 1-After Notice)	-0.3831	0.00782	2108.483	<.0001	0.698

Table 8 - Model parameters for Driver Re-education Classes

Parameter	Estimate	Std. Error	Chi-Sq.	Pr > Ch.Sq.	Hazard Ratio
wTYPE (0-DIP, 1-PDP)	0.1587	0.01733	90.2981	<.0001	1.179
CUMUVIOHP	-0.057	0.01757	7.1012	0.0077	1.048
CUMUVIOLP	0.1265	0.0105	723.6888	<.0001	1.327
CUMUPB	0.1113	0.00675	137.9792	<.0001	1.083
CUMUPTS	0.0866	0.00164	4712.596	<.0001	1.119
CUMUA	-0.0608	0.01173	430.2726	<.0001	0.784
CUMUVIOHP*CUMUPTS	-0.00906	0.00167	46.2623	<.0001	n/a
CUMUVIOLP*CUMUPTS	-0.0285	0.0011	957.0556	<.0001	n/a
GENDERGRP	0.0313	0.01249	73.636	<.0001	1.113
AGEGRP2	-0.1907	0.01358	871.6351	<.0001	0.67
AGEGRP3	-0.4101	0.01608	1468.098	<.0001	0.54
AGEGRP4	-0.317	0.01929	1084.288	<.0001	0.53
AGEGRP5	-0.1824	0.15026	11.0885	0.0009	0.606
wHist (0-Before Class, 1-After Class)	-0.7403	0.01552	2140.473	<.0001	0.488

Table 9 shows the model parameters for different types of license suspension. Overall, the average time between violations increases by 10% in the first 12 months and 17% in the first 24 months after suspension compared to the period before. Time until subsequent violations are 16% longer in the first 12 months for suspension for Level A (No Class) drivers than for persistent violators. Drivers with a crash history show longer times between subsequent violations than drivers with no crash history. Drivers receiving their second suspension have average times to subsequent violation in the first 12 months 5% more than drivers receiving the suspension for the first time.

Table 9- Model parameters for Point License Suspension

Parameter	Estimate	Std. Error	Chi-Sq.	Pr > Ch.Sq.	Hazard Ratio
oTYPE2 (A Susp)	0.0750	0.01689	18.1937	<.0001	1.075
oTYPE3 (B Susp)	-0.0007	0.01813	0.0006	0.9812	1
oTYPE4 (C Susp)	0.1313	0.01744	55.8175	<.0001	1.139
oTYPE5 (PDP Susp)	0.2105	0.01758	145.6523	<.0001	1.236
CUMUVIOHP	0.249	0.01247	407.1336	<.0001	1.286
CUMUVIOLP	0.3054	0.00689	1983.886	<.0001	1.359
CUMUPB	0.0268	0.00471	33.0427	<.0001	1.027
CUMUPTS	0.0841	0.000992	7223.655	<.0001	1.088
CUMUA	-0.1673	0.00884	366.0497	<.0001	0.844
CUMUO	-0.0506	0.00427	143.1733	<.0001	0.95
CUMUVIOHP*CUMUPTS	-0.0179	0.000924	379.3679	<.0001	n/a
CUMUVIOLP*CUMUPTS	-0.0234	0.000573	1672.132	<.0001	n/a
GENDERGRP	0.0324	0.01357	5.2289	0.0222	1.032
AGEGRP2	-0.3166	0.01734	332.1953	<.0001	0.729
AGEGRP3	-0.5471	0.01915	810.64	<.0001	0.58
AGEGRP4	-0.5076	0.02001	638.5424	<.0001	0.603
AGEGRP5	-0.4553	0.07934	32.0791	<.0001	0.638
oHist (0-Before Suspension, 1-After Suspension)	-0.1326	0.01185	122.7602	<.0001	0.877

It can be observed from the three models that all three interventions are effective in reducing crash or violation incidence. These results are consistent with those found in the MVC Recidivism Study [(3)] and other literature. The hazard ratio for number of serious and minor violations has a greater effect when compared to number of points in each of the models. This appears to indicate that drivers are influenced more by the number of previous violations they commit than the number of points they accumulate.

The effect of the three interventions can also be analyzed over time using hazard model survival curves. Survival curves show the likelihood/probability of the driver committing a violation or crash over time. Figure 7 shows an example that illustrates the effect of a driver re-education class has on elapsed time to next violation. The example compares the driving behavior for a cohort of drivers with similar driving records, gender and age characteristics before and after intervention. For this example the cohort of drivers are probationary male drivers, age 16-19 years old, with similar driving records that include one previous serious violation, one crash, no history of plea bargaining and six points before MVC intervention. The horizontal axis shows the time elapsed since the previous violation in months and the vertical axis shows the probability of committing the next offense. Before completing a driver re-education class (shown in red), drivers in this cohort had a 78% chance of committing their next offense within two years. After taking the driver re-education class (shown in blue) drivers in the cohort had a 52% chance of committing another offense in the next two years. This represents a 26% improvement.

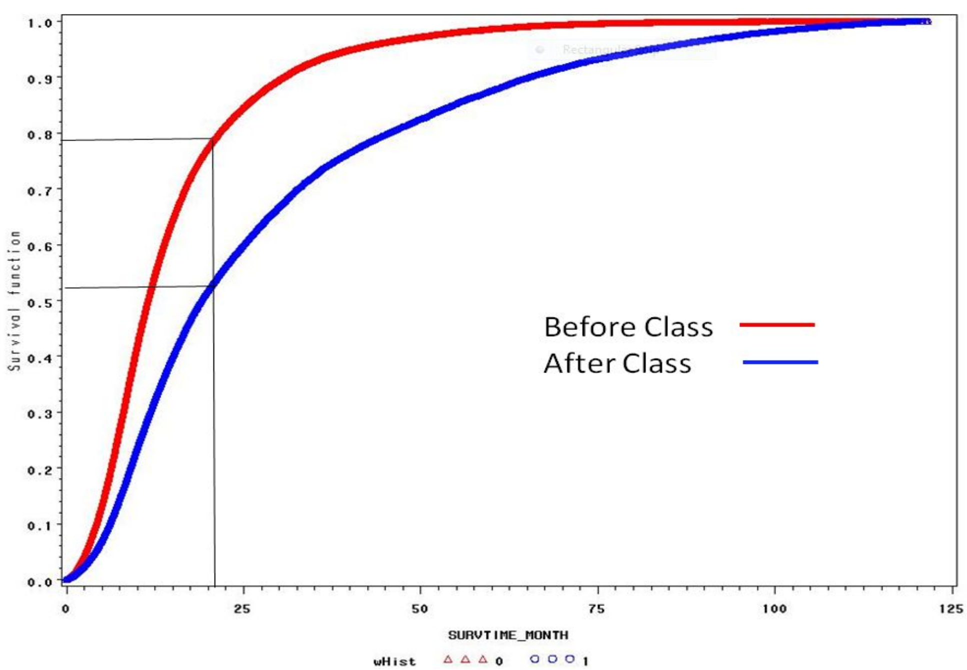

Figure 7. Violation probability curves before (red) &after (blue) the PDP class

In addition to helping to illustrate the effectiveness of different types of intervention, these models can also be useful in testing the effect of a policy change, such as a different triggering threshold for intervention. Figure 8 shows an example that illustrates how changing the trigger for point advisory notices from six demerit points to four might affect safety outcomes. This example examines a cohort of male drivers, 20-24 years old with similar driving records that include two minor violations, one serious violation, no crashes and no history of plea bargaining before and after the issuance of a point advisory notice.

The effect of changing the trigger for a point advisory notice from six to four points results in an overall improvement in time until subsequent violation of 33% in the first 12 months and 55% in the first 36 months after intervention. By comparison, the original trigger of six points results in a marginal improvement of 3% in the first 12 months and 5% in the first 36 months. The violation probability curves before (red) and after (blue) the intervention under the current system (six point trigger for the Point Advisory Notice) and the violation probability curves before (green) and after (cyan) the intervention under the new system (four point trigger for Point Advisory Notice) are shown in Figure 8.

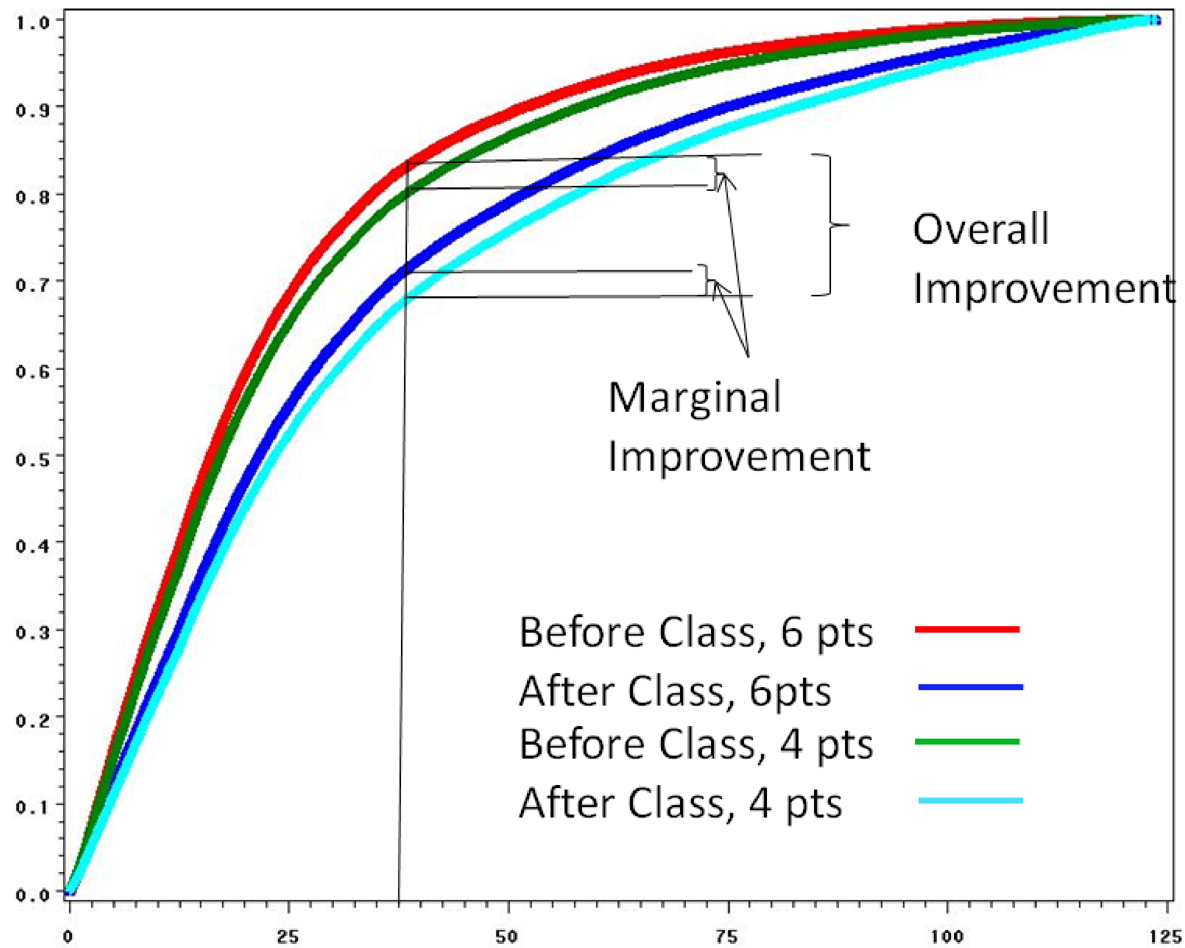

Figure 8. Effect of changing the trigger for Point Advisory Notice from six to four points

COMPARING ALTERNATIVE SYSTEMS OF DRIVER MONITORING AND CONTROL

Introduction

A primary research objective for this study was to compare the effectiveness of MVC's current point system and driver management and control program to alternative systems for driver monitoring and improvement. For the purpose of this study the research team identified three primary alternatives to the current system. These alternatives are shown in Table 7 and described in more detail below.

Table 10 – Description of alternative driver monitoring and control systems

Scenario Name	Brief Description
Base-case	Base-line condition under the existing point-based monitoring system and driver management/control program, including widespread practice of plea bargaining
Alternative #1 (Case 1)	Same as current system, with no plea bargaining
Alternative #1 (Case 2)	Same as current system, with no zero-point plea bargaining (i.e. allows plea bargaining of serious to minor violation)
Alternative #2	Incident-based driver monitoring and control system
Alternative #3	Hybrid system with combination of incident- and point-based monitoring for *habitual offender*, with no change to current intervention regime

Summary of Each Alternative

<u>Alternative #1</u>

Alternative #1 examines a hypothetical scenario that maintains the current system of driver monitoring and control but assumes that plea bargaining of point offenses is limited. There are two cases presented for Alternative #1. Case 1 assumes that plea bargaining is eliminated entirely. Case 2 eliminates zero-point plea bargaining but continues to permit plea bargaining of serious offenses to less serious point-carrying offenses. Case 2 essentially attempts to replicate the situation prior to 2000 when the "unsafe operation" zero-point was created.

Alternative #2

Alternative #2 is an incident-based intervention system. Driver monitoring and control are based on the number of incidents (violations and crashes) a driver is involved in rather than the number of points the driver accumulates based on the offenses they commit. The system represented under this alternative was patterned generally after the AAMVA Model Problem Driver Intervention and Education Program ("model program").[(6)] Under the AAMVA model program driver behavior is monitored and corrective actions are taken based on the accumulation of "countable" incidents recorded on a drivers record. Countable incidents include both crashes and moving violations.

The AAMVA model program recommends an intervention and sanctioning scheme that includes the issuance of a warning letter after three incidents, a driver record review and conference after four incidents and license suspension after five incidents. The MVC no longer conducts record reviews as part of its typical intervention scheme and therefore no data on the effect of record reviews on New Jersey problem drivers was available to support this analysis. As a result, the research team substituted a driver re-education class for the record review recommended under the AAMVA model program. Table 11 presents the final intervention and sanctioning scheme and triggering thresholds utilized for this alternative.

Table 11–Scheme for sanctions under an incident-based system (Alternative #2)

Sanction	# Events
Warning Notice	2
Notice for Re-education program	3
License Suspension	4 or more

Alternative #3

Alternative #3 is a hybrid system that maintains MVC's current system of driver monitoring and control but adds an incident-based habitual offender overlay. This alternative assumes no change to existing plea bargaining practices. The habitual offender overlay would trigger additional driver license suspensionsif any of the following occur:

- 3 serious moving violations within a 5-year period; or
- 6 minor moving violations within a 3-year period; or
- Any combination of 6 minor and/or serious moving violations within a 3-year period.

This triggering scheme was based on a practice scan of U.S. jurisdictions with habitual offender license suspension programs. Table 12 provides an overview of state programs.

Table 12 – Summary of habitual offender license suspension programs in other states

State	Habitual Offender Program Description	Time	Serious Offense	Time	Minor/ Other Offense	Crash
TX	4 violations in 12 month or 7 violations in 24 months	1 yr.	4	2 yr.	7	
SC	3 serious violations or 10 minor violations in 36 month period or 4 reportable crashes in 24 month period	3 yr.	3		10	4 in 2 yr.
WI	12 violations or 4 serious violations in 5 years, or any combination thereof	5 yr.	4		12	
VA	3 serious violations or 12 other violations in 10 year period	10 yr.	3		12	
PA	3 serious violations in 5 year period	5 yr.	3			
IA	3 serious violations in 6 years or 6 other moving violations in 2 year period	6 yr.	3	2 yr.	6	
FL	15 moving violations in 5 year period or 3 serious violations	5 yr.	3		15	
CO	3 serious violations in seven years or 10 or more moving violations in 5 year period	7 yr.	3	5 yr.	10	
WA	3 or more serious violations in 5 year period or 20 moving violations	5 yr.	3		20	
DE	3 or more serious violations in 5 year period or 10 moving violations in 3 year period	5 yr.	3	3 yr.	10	

Alternative Testing Approach

Under ideal circumstances, driver behavior data would be available for each alternative and circumstance described above. Unfortunately, it was not feasible for this study to develop experimental control groups for comparative purposes. Driver behavior data is accurately known only for the base-case which reflects current system conditions in New Jersey. Consequently, system outputs and outcomes for the alternatives must be simulated and approximated based on the driver behavior data under the existing system, the best available data.

For the purpose of this study, system outputs included: point advisory notices, driver re-education classes and point suspensions. System outcomes included measures of traffic safety, including: elapsed time between incidents (violations or crashes) and the average number of violations and crashes under each alternative. System outputs and outcomes are known for the base case which is the point of comparison for each of the alternatives.

System outputs and outcomes for the alternatives were estimated using data from the combined MVC driver history/AOC database which, as indicated previously, includes court data for plea-bargaining. The court data provides information on the original and amended (if any) violations on a driver's record for all cases disposed between 11/01/2004 and 11/30/2007.

For Alternative #1, the research team parsed driver records in the combined dataset to isolate drivers with no plea bargain history from those with a record of plea bargaining. Each of these cohorts was then further parsed into sub-cohorts by gender, driver age, history of violations (minor and serious) etc. See Table 3 and Table 4 for more detail. Once the parsing process was complete, the research team recalculated a "rolling" cumulative point total for each driver that had plea bargained based on the original offense committed and reassembled the datasets. The resulting dataset thereby reflects point accumulation as if plea bargaining were limited or not permitted at all depending on the case being considered. System outputs were estimated based on the new pattern of point accumulation using MVC current intervention scheme and triggers.

For Alternative #2, the research team developed an equivalency table to convert countable incidents under the AAMVA model program to New Jersey-specific moving violations. The combined dataset was then analyzed using the equivalency table to derive a new "moving count" of incidents for each driver, over time, based on the violations and crashes appearing on their records for the analysis period. For drivers that plea bargained, the research team utilized the original offense for the purpose of counting. System outputs were estimated based on the intervention and trigger scheme shown in Table 11.

For Alternative #3, the research team developed an equivalency table to classify moving violations under New Jersey's point system into serious violations (4+ points) and minor violations (2-3 point offenses plus zero-point plea bargain offenses). The combined dataset was then analyzed using the equivalency table to derive a new "moving count" of serious and minor violations for each driver, over time, based on the violations appearing on their records for the analysis period. For this alternative, the only change to system outputs compared to MVC's current intervention scheme is an increase in the number of license suspensions based on the triggers described above.

Alternative Testing Results

Given the size of the combined dataset, the research team utilized a sampling approach to test the alternatives. Multiple randomly selected driver samples were tested for each alternative. Each sample included approximately 22,000 drivers at a time. The same analysis was repeated for each sample. To validate the efficacy of this approach the research team compared the results of three such samples for Alternative #2 against the base case. The output results for the three samples were found to be within 1% of each other. Given the close results of the three random samples, the sampling method was deemed valid for the purpose of this analysis. For each alternative, the sampling results were then factored up to estimate outputs for the entire driver pool under each alternative system.

System Outputs

Table 13 shows a comparison of system outputs generated under each alternative. Under all three alternatives, system outputs increase when compared to the base case. The greatest increase in the number of interventions occurs under Alternative #2, the incident-based driver monitoring and control system. The least difference is seen under Alternative #3 which adds an incident-based habitual driver suspension overlay to MVC's current system.

Table 13 - Comparison of outputs from alternative systems

Output Measure	Base Case	Alternative #1 - Case #1			Alternative #1 - Case #2		
		% Change	Abs. Change	Total	% Change	Abs. Change	Total
Point Advisory Notices	187,881	93%	174,729	362,610	79%	148,426	336,307
DIP/PDP Classes	25,365	115%	29,170	54,535	85%	21,560	46,925
Point Suspensions	54,323	88%	47,804	102,127	68%	36,940	91,263
		Alternative #2			Alternative #3		
		% Change	Abs. Change	Total	% Change	Abs. Change	Total
Point Advisory Notices	187,881	392%	736,118	923,999	0	0	187,881
DIP/PDP	25,365	2770%	702,611	727,976	0	0	25,365
Point Suspensions	54,323	657%	356,902	411,225	89%	48,285	102,608

Under Alternative #1 Case 1, which eliminates the practice of plea bargaining motor vehicle moving violations, the number of point advisory notices issued increases by 93%. The number of drivers subject to driver re-education classes more than doubles, increasing by 115%; and the number of license suspension increases by 88%. Under Alternatives #1 Case 2, which eliminates zero-point plea bargaining but retains plea bargaining to lesser point offenses, interventions also increase but to a lesser extent than Case 1.

Under Alternative #2, which simulates an incident-based driver monitoring and control system, the number of interventions increases substantially. The number of point advisory notices issued would increase from approximately 188,000 per year to more than 735,000 annually. This represents an increase of 392%. The number of driver re-education class enrollments would increase from approximately 25,000 annually to more than 700,000 per year, an increase of more than 2700%. Finally, the number of license suspensions would increase 657% from approximately 54,000 annually to more than 350,000 per year.

As noted above, Alternative #3 maintains MVC's current driver intervention scheme and triggers remain in place with an incident-based habitual offender overlay. As a result, under this alternative, there is no change to the number of point advisory notices issued and there is no change to the number of driver re-education class enrollments. However, the number of license suspensions would nearly double from approximately 54,000 annually to more than 102,000 per year, an increase of 89%.

<u>System Outcomes</u>

Past research and analysis conducted as part of this study demonstrate that problem driver interventions such as MVC's point advisory notices, driver re-education classes and license suspension improve driving behavior among most driver groups. As such, it is logical to conclude that the outcome of more aggressively imposing these problem driver interventions would result in improved traffic safety. To estimate the potential traffic safety outcomes of the alternatives, the research team employed Cox-proportional hazard models, which were described earlier in this report.

This method was selected because the violation data in the available dataset involves censored observations (i.e., some of the drivers do not have a violation at the end of the observation period). For such drivers the time to next event cannot be quantified as an average of all the times between offenses during the observation period. By invoking the Cox-proportional hazard model, the temporal outcome will be measured as the time at which the driver has a 90% chance of committing the next offense (violation, crash). In other words this is the time at which the model predicts with 90% confidence that the driver will have another offense. For the purpose of brevity the outcome shall, henceforth, be called *time until next offense*.

For the purposes of the analysis, it is assumed that drivers that are subjected to additional interventions under the hypothetical alternatives will exhibit driving behavior post intervention similar to the observed behavior of drivers with similar cohort characteristics in the combined dataset.

As observed above, each alternative results in the imposition of additional problem driver interventions. An additional number of advisory notices will be issued, driver re-education class enrollments will increase and the number of license suspensions will increase. As such, for the drivers newly subjected to these interventions, the time to the next offense can be expected to be longer than if not subjected to the intervention. Similarly, it can be expected that drivers subjected to interventions will commit fewer future offenses after the intervention. We know this to be true from the observed data for the base case. Hence, as part of the alternative testing process, the elapsed time to next violation for drivers newly subjected to interventions were updated based on the Cox-proportional hazard models estimated for each intervention type. Similarly estimates of future violations were also updated based on observed driver behavior data from the base case. An average safety "improvement" for each sample was then estimated for each of the interventions based on the proportion of additional interventions imposed from the system output estimates described above. The results for each of the alternatives are shown in Tables 14 through 16. Results are shown by gender and age cohort and represent an overall average improvement for all drivers in each cohort.

Table 14- Comparison of time until next offense (months)

Gender	Age	Base Case	Alternative1 (Case 1)	Percent Change	Alternative1 (Case 2)	Percent Change	Alternative2	Percent Change
Female	16-19	19.50	27.94	43%	22.66	16%	28.56	46%
	20-24	23.23	30.14	30%	29.84	29%	29.64	28%
	25-35	26.30	30.57	16%	30.25	15%	29.86	14%
	35-65	28.19	31.42	11%	31.17	11%	30.81	9%
	66-more	32.43	31.84	-2%	31.30	-4%	31.21	-4%
Male	16-19	18.37	27.16	48%	21.61	18%	27.42	49%
	20-24	21.34	29.53	38%	29.50	38%	29.04	36%
	25-35	22.60	30.09	33%	30.10	33%	29.59	31%
	35-65	24.07	30.71	28%	30.28	26%	30.16	25%
	66-more	22.64	26.21	16%	25.80	14%	25.73	14%

Table 15 - Comparison of time until next offense (months) for habitual offenders

Gender	Age	Base	Alternative 3	Percent Change
Female	16-19	4.00	5.44	44%
	20-24	5.27	6.91	34%
	25-35	5.52	7.27	34%
	35-65	5.70	7.48	35%
	66-more	6.10	8.01	34%
Male	16-19	3.75	5.06	44%
	20-24	4.84	6.53	42%
	25-35	5.15	6.81	37%
	35-65	5.30	6.97	34%
	66-more	5.59	7.33	34%

Table 16 - Comparison of number of violations

Gender	Age	Base Case	Alternative 1 (Case 1)	Percent Change	Alternative1 (Case 2)	Percent Change	Alternative 2	Percent Change
Female	16-19	14,941	10,430	-30%	12,856	-14%	10,204	-32%
	20-24	9,783	7,539	-23%	7,615	-22%	7,668	-22%
	25-35	18,553	15,961	-14%	16,128	-13%	16,339	-12%
	35-65	38,758	34,779	-10%	35,056	-10%	35,467	-8%
	66-more	3,712	3,781	2%	3,846	4%	3,857	4%
Male	16-19	29,371	19,865	-32%	24,962	-15%	19,680	-33%
	20-24	19,351	13,986	-28%	14,001	-28%	14,222	-27%
	25-35	37,663	28,291	-25%	28,275	-25%	28,762	-24%
	35-65	76,281	59,788	-22%	60,643	-21%	60,877	-20%
	66-more	7,061	6,099	-14%	6,197	-12%	6,214	-12%

It should be noted that since the proportion of habitual traffic offenders is so small in the combined dataset, the net effect of Alternative 3 overall number of violations and crashes is limited and therefore is not shown in the tables.

As expected, each of the alternatives results in improved safety conditions. Additional interventions result in longer periods of safe driving and fewer violations and crashes among the drivers in each cohort. The one exception is older female drivers (66 years and over). This cohort exhibited counter intuitive results. This may be due to the limited number of observations in the dataset. Across the alternatives, improvement in time until next offense is greatest among male drivers. This may be in part due to the fact that male drivers have higher overall rates of violation than female drivers. The best results in terms of time until next offense appear to derive from Alternative #1 Case 1 which presents the highest level of improvement across virtually every age and gender cohort. Interestingly, Alternative #2 which by far subjects the greatest number of drivers to interventions of all types presents improvements slightly below Alternative #1 Case 1. Alternative #3 does appear to result in longer times to next offense among habitual offenders but the times between offenses remain very short. This result, while not unexpected highlights the fact that "hard core" habitual offenders are likely to pose significant safety concerns even though more drivers are subject to license suspension, the most strict of the interventions used by MVC.

When comparing rates of violations, Alternative #1 Case 1 and Alternative #2 present comparable results. Both reduce future rates of violation across all age cohorts except older female drivers. Again, this counterintuitive result may be due to the limited number of observations in the dataset.

DISCUSSION AND CONCLUSIONS

In 2009, the MVC Recidivism Study[3]showed that the MVC's driver monitoring and control system is effective at reducing rates of future violation and crashes among drivers who receive point advisory notices, drivers that complete driver re-education classes and drivers that have their driving privileges suspended. In the same year, the MVC Plea Bargaining Study[2] found that the widespread practice of plea bargaining point-carrying offenses to zero-point offenses, especially since 2000, has diverted tens of thousands of problem drivers out of the MVC's driver monitoring and control system.

The results of this study further confirm that the interventions used by MVC to correct problem driver behavior are effective. As part of this study, the research team used survival analysis to show that the average time to next offense for driver's subjected to MVC interventions increases significantly for all three interventions used. For example, on average, the period of time between violations for drivers that received a point advisory notice increased 25% in the first twelve months after they received the notice when compared to the previous 12 months. The period of time between violations for drivers that completed a re-education class increased by 34% in the first 12 months after completing the class when compared to the period before. Driver re-education classes for experienced drivers were 50% more effective than for probationary drivers. The results for driver's license suspension were less impressive but still positive. Overall, the average time between violations increased by 10% in the first 12 months and 17% in the first 24 months after suspension when compared to the period before.

Given the convincing evidence that the MVC's problem driver interventions work, the fact that so many drivers are currently being diverted out of the driver control system should be a legitimate policy concern. One way to address the issue would be to completely or partially eliminate the practice of plea bargain point-carrying motor vehicle moving violations (Alternative #1). Indeed, this analysis demonstrates that such an approach would significantly increase the number of drivers subject to MVC interventions and thereby improve safety outcomes. Such an alternative would not require any change to MVC systems and would promote a return to underlying purpose of driver monitoring and control systems which is to identify problem drivers and address their behavior. It could also increase MVC revenues from the insurance surcharge program, fees from re-education class enrollments and license reinstatement fees.

This approach is however, fraught with difficulty and would require legislative action. As documented in the MVC Plea Bargain Study,[2] the practice of plea bargaining has a long history and provides the municipal court system with flexibility to fairly adjudicated traffic citations and offers the courts efficiency in dealing with the volume of traffic violations that occur each year. Further, an increase in the volume of interventions may require MVC to scale up its operations, most notably in the delivery of re-education classes, which would likely need to increase in frequency and may require more instructors. Scaling up would likely entail costs to the agency.

Another alternative might be to scrap the current point-based system of driver monitoring and control used by MVC in favor of an incident-based system similar to the AAMVA model program (Alternative #2). Incident-based systems are straight forward for drivers to understand and such systems are in use in many other jurisdictions. As described in this report, it would be feasible to adapt New Jersey's program of problem driver interventions to an incident-based system and this analysis demonstrates that the safety outcomes of putting such a system in place would be positive. Many more drivers would be subjected to intervention and the resultant improvements to safety would be on par with the elimination of plea bargaining.

Interestingly, however, while the volume of system outputs–advisory notices, re-education class enrollments, and license suspensions, increase dramatically under the incident-based system, the overall safety results appear only marginally better than the point based system that results in far fewer interventions. This could imply that MVC's existing point system does a better job of identifying truly problem drivers and that the extra volume of drivers subjected to intervention under the incident-based system are less a safety threat and more likely to correct their negligent behavior on their own.

While the significant increase in system outputs could result in sizably more revenue from fees for MVC, switching to an incident-based monitoring system would entail many challenges from a systems and operations perspective. For example, such a transition would likely require legislative action or at the very least a significant reworking of existing regulations. It would likely also require a complete reprogramming of computer systems and a significant scaling up of staff and programs to address the increased volume of interventions. Additionally, the insurance surcharge program is currently tied to point accumulation. A transition to incident-based monitoring would require MVC to either maintain a "shadow" system of point monitoring, which would be very confusing for drivers or legislative changes to the surcharge program.

Finally, MVC could consider more modest changes to the current system that have the potential to improve outcomes without wholesale changes or reworking of existing policies and procedures. One example might be to revisiting the triggers for various interventions. Two examples of this were explored in this study. The first example looked at the potential impact of changing the trigger for point advisory notices from the current six points to four points. The research team examined the cohort of male drivers, 20-24 years old with similar driving records. The effect of changing the trigger for a point advisory notice from six to four points resulted in an overall improvement in time until subsequent violation of 33% in the first 12 months and 55% in the first 36 months after intervention. By comparison, the original trigger of six points resulted in a marginal improvement of only 3% in the first 12 months and 5% in the first 36 months.

The second example explored in this study was creating an incident-based habitual offender program that triggered additional license suspension based on the number and type of violations committed over a specified period of time (Alternative #3). While this alternative results in an apparent safety improvement, the duration of time between offenses for these "hard core" habitual offenders remain very short.

The primary objectives of this study were to explore alternatives to MVC's current system of driver monitoring and control and compare the effectiveness of MVC's current point system to alternative systems for driver monitoring and improving problem driver behavior. From the analysis it seems clear that there are changes that MVC can make to enhance the agency's ability to address negligent driving behavior and thereby improve highway safety. However, at least two of the alternatives explored in this study, Alternatives #1 and #2, present significant and perhaps insurmountable challenges. Alternative #3 presents perhaps the option with the most promise but it too will require careful consideration of the costs and benefits of any change.

REFERENCES

1. Fix DMV Commission Final Report to Governor James E. McGreevey. 2002. Accessed online at: www.state.nj.us/mvc/pdf/About/finalreport.pdf .....

2. Carnegie, J. A., Ozbay, K., and Mudigonda, S., Study of the Effects of Plea Bargaining Motor Vehicle Offenses. New Jersey: New Jersey Department of Transportation. 2009

3. Carnegie, J. A., Strawderman, W. E., and Li W., Study of Recidivism Rates among Drivers Administratively Sanctioned by the New Jersey Motor Vehicle Commission. New Jersey: New Jersey Department of Transportation. 2009

4. Carnegie, J. and Pollak, H. New Jersey Point System Overview. Memorandum to NJ Motor Vehicle Affordability and Fairness Task Force. June 10, 2005.

5. New Jersey Driver Manual. 2006. Accessed online at: http://www.state.nj.us/mvc/About/manuals.htm

6. AAMVA Model Problem Driver Intervention and Education Program. 2009. Accessed online at: http://www.aamva.org/uploadedFiles/MainSite/Content/DriverLicensingIdentification/At_Risk_Drivers/Problem%20Driver%20Intervention%20Program.pdf

7. California Department of Motor Vehicles (2006). Negligent Driver Post-Licensing Control Research. Accessed 6/2/06: <http://www.dmv.ca.gov/about/profile/rd/rde1.htm>

8. Masten, S. C. and Peck, R. C. Problem driver remediation: A meta-analysis of the driver improvement literature. Journal of Safety Research, Vol. 35. 2004 pp. 403-425.

9. David L. Struckman-Johnson, Adrian K. Lund, Allan F. Williams and David W. Osborne. "Comparative effects of driver improvement programs on crashes and violations." Accident Analysis and Prevention. 1989, Jun 21(3):203-15.

10. Healey, E. "Final Report Documents NOTS Benefits." California Department of Motor Vehicles – Research Notes. Winter 95/96. Accessed online at http://www.dmv.ca.gov/about/profile/rd/resnotes/notsbene.htm

11. Grosz, M.J., III., Zeller, R.E. Study of the Effectiveness of Basic Driver Improvement Courses. State of Florida Department of Highway Safety and Motor Vehicles Division of Driver Licenses, 2002.

12. McKnight, A. James, Tippetts, A. Scott. Accident Prevention Versus Recidivism Prevention Courses for Repeat Traffic Offenders. Accident Analysis and Prevention, Vol. 29, No. 1, pp. 25-31, 1997.

13. Staplin, Loren. Cost-Effective Driver Improvement Treatment in Pennsylvania. Transportation Research Record, Journal of Transportation Research Board, 1401, pp. 26 – 36, 1994.

14. Raub, Richard A., Wark, Richard I, Reischl, Broderick E., and Lucke, Roy E. Recorded Traffic Offenses of Graduates of Traffic Safety School, Cook County, Illinois. Transportation Research Record, Journal of Transportation Research Board, 1693, pp. 18 – 24, 2000.

15. Carnegie, J. A., Strawderman, W. E., and Li W., Violation and Crash Recidivism Among New Jersey Drivers and Effectiveness of New Jersey's Driver Monitoring and Control System, CD-ROM. Transportation Research Board of the National Academies, Washington, D.C., 2011

16. Woolson R.F., M.T. Tsuang, and J.A. Fleming, Utility of the proportional-hazards model for survival analysis of psychiatric data, Journal of Chronic Diseases, Volume 33, Issue 3, 1980, Pages 183-195

17. Glidden, D.V. and E. Vittinghoff, Modelling clustered survival data from multicentre clinical trials, Statistics in Medicine 2004, Volume 23, pp. 369–388

18. Ge Y.J., H.F. Xiang and H.Tanaka, Application of a reliability analysis model to bridge flutter under extreme winds, Journal of Wind Engineering and Industrial Aerodynamics, Volume 86, Issues 2-3, June 2000, Pages 155-167

19. Tamura Y., H. Takehara, S. Yamada, Component-Oriented Reliability Analysis Based on Hierarchical Bayesian Model for an Open Source Software, American Journal of Operations Research, 2011, Vol 1, 25-32

20. Willett, B. J., and Singer, J., D., From Whether to When: New Methods for Studying Student Dropout and Teacher Attrition, Review of Educational Research, Winter 1991, Vol. 61, No.4, pp. 407-450

21. Walker, K.D., A Survival Analysis Approach to Employee Turnover: Its Application and Advantages, Ph.D. Dissertation, Texas Tech University, August 1998

22. Fox, G. A. 2001. Failure-time analysis, Design and Analysis of Ecological Experiments, 2nd ed. S. M. Scheiner and J. Gurevitch, eds. Oxford University Press, Oxford, pp 235-266

23. Jinkerson, D.,L., and Mattox, R.,J. II, Using Survival Analysis to Demonstrate the Effects of Training on Employee Retention, American Evaluation Association, 2001

24. Baca, J.C., Miller W.R., and Lapham, S., A multiple risk factor approach for predicting DWI recidivism, Journal of Substance Abuse Treatment, 21, 2001, pp 207– 215

25. Rodgers, A., Effect of Minnesota's License Plate Impoundment Law on Recidivism of Multiple DWI Violators, Alcohol, Drugs and Driving, Vol 10, Number 2, 1994

26. Ferrate, A.M., Rosman, D.L., Marom, Y., Novice drink drivers, next term recidivism and crash involvement, Accident Analysis & Prevention, Volume 33, Issue 2, 1 March 2001, pp. 221-227

27. McCartt, A.T., Shabanova, V.I., Leaf, W.A., Driving experience, crashes and traffic citations of teenage beginning drivers next term, Accident Analysis & Prevention, Volume 35, Issue 3, May 2003, pp. 311-320

28. Lapham, S.C., Kapitula, L.R., C'de Baca, J. and McMillan, G.P., Impaired-driving recidivism among repeat offenders following an intensive court-based intervention, Accident Analysis & Prevention, Volume 38, Issue 1, January 2006, pp. 162-169

29. Lawpoolsri, Saranath, Li, Jingyi and Braver, Elisa R., Do Speeding Tickets Reduce the Likelihood of Receiving Subsequent Speeding Tickets? A Longitudinal Study of Speeding Violators in Maryland, Traffic Injury Prevention, 8:1 (2007), pp. 26-34

30. Fu, H., Identifying repeat DUI crash factors using state crash records, Accident Analysis & Prevention, Volume 40, Issue 6, November 2008, pp. 2037-2042

31. Robertson, A.A., Gardner, S., Xu, X., Costello, H., The impact of remedial intervention on 3-year recidivism among first-time DUI offenders in Mississippi, Accident Analysis & Prevention, Volume 41, Issue 5, September 2009, pp. 1080-1086

32. Masten, S.V., Foss, R.D., Long-term effect of the North Carolina graduated driver licensing system on licensed driver crash incidence: A 5-year survival analysis. Accident Analysis & Prevention, Volume 42, Issue 6, November 2010, pp. 1647-1652

33. Kleinbaum, D., G., and Klein, M., Survival Analysis, A Self-Learning Text, 2 ed., Springer, 2005

34. Strathman, J.G., Kimpel, T.J., Leistner, P., Evaluation of the Oregon DMV Driver Improvement Program, FHWA-OR-RD-07-08, April 2007

35. SAS® User's Guide, Version 9.1. SAS Institute, Cary, NC. 2004.

36. Prentice, R. L., Williams, B. J. and Peterson, A. V. 'On the regression analysis of multivariate failure time data', Biometrika, 68, 373-379 (1981).

37. Wei, L. J., Lin, D. Y. and Weissfeld, L. 'Regression analysis of multivariate incomplete failure time data by modeling marginal distributions', Journal of the American Statistical Association, 84, 1065-1073 (1989).

38. Kelly, P.J., and Lynette, L-Y.L., "Survival Analysis for Recurrent Event Data: An Application to Childhood Infectious Diseases", Statistics in Medicine vol. 19, pp.13-33 (2000).

39. Gerbers, M.A., Enhanced Negligent Operator Treatment Evaluation System Program Effectiveness Report #1 (Summary Of Findings), California Department of Motor Vehicles, CAL-DMV-RSS-09-230, June 2009

40. Jones, B. Age, gender, and the effectiveness of high-threat letters: An analysis of Oregon's driver improvement advisory letters. Accident Analysis and Prevention, 29, pp. 225-234. (1997)

41. Michael, S., What is the Effect of Driver Education Programs on Traffic Crash and Violation Rates?, Final Report 546, Arizona Department of Transportation, FHWA-AZ-04-546, September 2004.

42. Gkritza, K., Zhang, W., Hans, Z. and Nambisan, S., Evaluation of Iowa's Driver Improvement Program, Iowa Department of Transportation, InTrans Project 08-329, December 2009.

43. Grosz, M.J., III., Zeller, R.E. Study of the Effectiveness of Basic Driver Improvement Courses. State of Florida Department of Highway Safety and Motor Vehicles Division of Driver Licenses, 2002.

44. Staplin, Loren. Cost-Effective Driver Improvement Treatment in Pennsylvania. Transportation Research Record, Journal of Transportation Research Board, 1401, pp. 26 – 36, 1994.

45. F.M. Council, D. W. Reinfurt, B. J. Campbell, F. L. Roediger, C. L Carroll, K. D. Amitabh, and J. R. Dunham, "Accident Research Manual." Highway Safety Research Center, University of North Carolina, 1980.

46. E. Hauer. Observational Before-After Studies in Road Safety. Pergamon Publication, England, 1997.

47. D. Harwood, F. Council, E. Hauer, W. Hughes and A. Vogt. "Prediction of the Expected Safety Performance of Rural Two-Lane Highways". Final Report, Report No. FHWA-RD- 99-207, 2000. 77

48. E. Hauer, D.W. Harwood, F.M. Council and M.S. Griffith. "The Empirical Bayes Method for Estimating Safety: A Tutorial". Transportation Research Record, 1784, 2002, pp. 126-131.

49. Ozbay, K., Yanmaz-Tuzel, O., Ukkusuri, S., Bartin, B., Safety Comparison of Roadway Design Elements on Urban Collectors with Access, FHWA-NJ-2009-00, April 2009

50. Casella, G., An Introduction to Empirical Bayes Data Analysis, The American Statistician, May 1985,Vol. 39, No. 2, pp. 83-87.

51. R.B. Patel, F.M. Council and M.S. Griffith. "Estimating the Safety Benefits Of Shoulder Rumble Strips on Two Lane Rural Highways in Minnesota: An Empirical Bayes Observational Before-After Study". In 86th Annual Meeting of the Transportation Research Board. Washington, D.C., 2007.