pennsylvania
DEPARTMENT OF TRANSPORTATION

The Impact of the Sanctioning Process on Driver Safety

Final Report

Submitted to:
PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

Safety Administration
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Executive Summary

The Pennsylvania Department of Transportation's Bureau of Driver Licensing administers a driver sanctioning system to help improve driving habits and to ensure safe driving. Improvements to this system should be evidence-based. Driver records, which the Bureau maintains for every licensed Pennsylvania driver (as well as unlicensed drivers who are convicted of violations), contain histories of points incurred for each moving violation and sanctions imposed when point totals reach six (6) or more. These records were analyzed to test the effectiveness of sanctions and, together with observations of Pennsylvania's sanctioning system in action, interviews with stakeholders, a review of relevant research, and review of best practices of other states, informed a set of recommendations for system improvements to foster a safer motoring environment for all who travel Pennsylvania's roadways.

Literature Search

A literature search on the effects of sanctions on subsequent driver behavior was conducted. This addressed such topics as effects of sanctions on driver behavior, design of driver point and sanction systems, licensing practices, effectiveness of driver safety education programs, and attitude change and safe driving behavior. A report was produced as a stand-alone product that organized and summarized 239 studies.

Best Practices Survey

A survey/questionnaire to collect information from other state departments of transportation and departments of motor vehicles was conducted. The purpose of this survey was to provide knowledge of the state of practice concerning the sanctioning procedures of other agencies and evidence available regarding their effectiveness. Eighteen states responded, including Arkansas, California, Georgia, Idaho, Iowa, Kentucky, Maryland, Minnesota, New Jersey, Nevada, Ohio, South Carolina, Tennessee, Texas, Utah, Washington, and West Virginia.

Stakeholder Interviews

A series of meetings were held among the researchers, the project technical advisor, and key stakeholders who are responsible for administering PennDOT's driver sanctioning system. These individuals possess a wealth of knowledge, information, and insight concerning operation of the sanctioning system. We conducted targeted focus groups and individual interviews of knowledgeable insiders to gain a detailed understanding of the system. In addition, we saw the sanction process in action by attending as observers Special Point Examination sessions and Departmental Hearings in Harrisburg, Philadelphia, and State College, and Traffic Court sessions in Philadelphia and Pittsburgh. We supplemented stakeholder interviews and sanction process observations by reviewing available documentation concerning the design, application, and effectiveness of PennDOT's sanctioning system.

Analyses of Driver Records

Analyses of driver records were conducted to answer several specific research questions that collectively elaborated the general theme of whether or not drivers who have been sanctioned "…become safer drivers as a result of the penalties incurred." Three primary analytic approaches were used: (1) descriptive statistics, such as frequency distributions, percentages, and cross tabulations, to characterize drivers and the violations they committed; (2) survival analyses, including life tables and graphs of survival functions, to determine whether and when violations occurred among samples of drivers; and (3) random coefficient modeling, including graphs of point accumulation trajectories, to test whether sanctions have their intended effects in reducing post-sanction rates of violations.

Findings from analyses of driver records:

(1) 46% of drivers are convicted of zero driving violations, 13% of drivers are convicted of one driving violation, and 41% of drivers are convicted of two or more driving violations during their driving careers;

(2) first driving violations are likely to occur within a few years of Pennsylvania licensure, and second driving violations, if they occur, are likely to occur within a few years of first violations;

(3) males, especially young males, are more likely to be convicted of violations than females;

(4) drivers who incur sanctions typically do so within a few years of Pennsylvania licensure;

(5) all sanction types (Special Point Examinations, Type II Hearings, Type III Hearings, Suspensions, Speed Hearings, and Young Driver Hearings) are effective in reducing post-sanction rates of violations and associated accumulations of points, although they vary in effectiveness.

Final Report with Recommendations

The qualitative and quantitative findings of this research were integrated to (1) provide an evaluation of the effectiveness of PennDOT's driver sanctioning process, (2) identify opportunities for improvement to the system, and (3) formulate practical recommendations for improvements to the sanctioning process. A final report with improvement recommendations and an oral presentation with Powerpoint briefing slides of project findings were provided. Recommendations addressed the following topics: (1) sanctions and the sanctioning process; (2) violations and points; (3) communications with drivers; (4) PennDOT staff; (5) database; and (6) visibility recommendations.

Introduction

The Pennsylvania Department of Transportation's Bureau of Driver Licensing administers a driver sanctioning process to help improve driving habits and to ensure safe driving. Improvements to this system should be evidence-based. Driver records, which the Bureau maintains for every licensed Pennsylvania driver, contain histories of points incurred for each moving violation and sanctions imposed when point totals reach six (6) or more. These records contain a wealth of information that shed light on the effectiveness of sanctions and, together with results of a process evaluation of Pennsylvania's sanctioning system and review of best practices of other states, inform a set of recommendations for system improvements and a safer motoring environment for all who travel Pennsylvania's roadways.

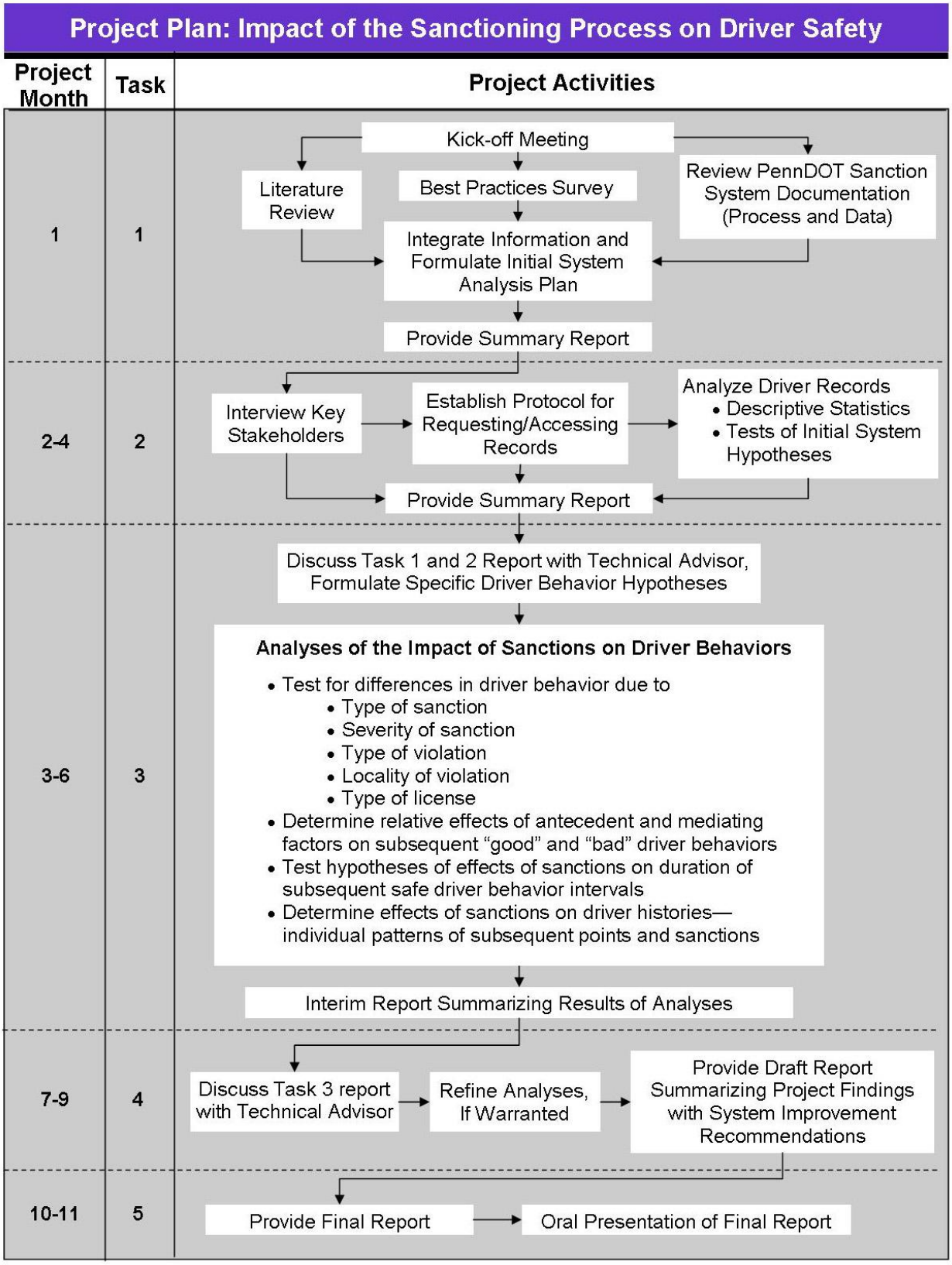
This report summarizes the work performed for this project. Figure 1 presents the original Project Plan. As shown, the work was organized into five major tasks and numerous subtasks. Sections of this report correspond to the five major tasks: (1) Literature Search and Best Practices Review, (2) Review of PennDOT Data, (3) Analyses of Driver Records, (4) Draft Final Report with Recommendations, (5) Final Report Presentation. Before describing the work performed for each task, we provide a conceptual overview of driving and driver sanctioning. These considerations relate closely to the specific research questions addressed in this report.

Driver Behavior and the Sanctioning Process

An overarching goal of this research project is to determine if PennDOT's driver sanctioning process is effective in encouraging safer driver behaviors. Driver safety can be conceptualized along three dimensions, shown in Figure 2. The first dimension is a societal dimension, encompassing the laws, regulations, and sanctions intended to encourage safe driving and to punish transgressors. As shown, society's rules act both as deterrents to unsafe driving and as punishments for drivers who violate them. The deterrence value of the sanction process arises from drivers' awareness of laws, the consequences of violating them, and their desire to avoid these consequences. Its punishment value is realized when violators are apprehended, suffer the penalties imposed, and seek to avoid future penalties by obeying the law.

A driver's interaction with society (driver X society) is the second dimension of this model. Through driver licensing, PennDOT grants driving privileges to individual drivers. Driver knowledge and skill qualifications are established. Each prospective driver must demonstrate driving competence before PennDOT issues a license to operate a motor vehicle. A driving privilege may be revoked if a driver becomes incapable of safe driving (e.g., due to illness, disability). Driving privileges may also be revoked, temporarily or permanently, for violations of laws.

Figure 1.


Project Plan: Impact of the Sanctioning Process on Driver Safety
Project Month
Task
Project Activities
1
1
Kick-off Meeting
Literature Review
Best Practices Survey
Review PennDOT Sanction System Documentation (Process and Data)
Integrate Information and Formulate Initial System Analysis Plan
Provide Summary Report
2-4
2
Interview Key Stakeholders
Establish Protocol for Requesting/Accessing Records
Analyze Driver Records
• Descriptive Statistics
• Tests of Initial System Hypotheses
Provide Summary Report
3-6
3
Discuss Task 1 and 2 Report with Technical Advisor, Formulate Specific Driver Behavior Hypotheses
Analyses of the Impact of Sanctions on Driver Behaviors
• Test for differences in driver behavior due to
• Type of sanction
• Severity of sanction
• Type of violation
• Locality of violation
• Type of license
• Determine relative effects of antecedent and mediating factors on subsequent "good" and "bad" driver behaviors
• Test hypotheses of effects of sanctions on duration of subsequent safe driver behavior intervals
• Determine effects of sanctions on driver histories—individual patterns of subsequent points and sanctions
Interim Report Summarizing Results of Analyses
7-9
4
Discuss Task 3 report with Technical Advisor
Refine Analyses, If Warranted
Provide Draft Report Summarizing Project Findings with System Improvement Recommendations
10-11
5
Provide Final Report
Oral Presentation of Final Report

Driver psychology is the third dimension. Safe driving requires application of one's knowledge of and skill in vehicle operation, awareness of relevant laws and regulations, and intentions to obey laws and avoid risky maneuvers. Driver psychology includes stable attributes that affect driving behavior such as personality (e.g., sensation seeking), maturity (e.g., taking responsibility for one's actions), and skill, and changeable or momentary attributes such as attitudes toward safety, intentions to obey laws, and specific driving decisions (e.g., whether to slow down or speed up as a traffic light changes from green to yellow).

Each dimension of driver safety is useful in interpreting results of analyses of driver records. For example, one can ask whether suspensions of violators' driving privileges reduce the likelihood of further violations. It is also useful, in this regard, to consider the proportion of drivers who commit one or more violations (and suffer the consequences) relative to the proportion of drivers who have no convictions (and who are presumably deterred by awareness of the laws and consequences of violations).

In general, it is helpful to think about sanctions in terms of drivers to whom they are applied (because of one or more violations) compared to sanction-free drivers (presumably, those who are effectively deterred from violating). Figure 3 provides a summary of a driver's history that helps to illustrate this point. Simply stated, as shown in the top portion of the figure, a driver must commit a violation before a sanction is applied. A driver may then fall into a cycle of repeat violations and sanctions.

An effective sanction process breaks this cycle, encouraging a repeat-violator to reform and avoid further violations. The sanction process may be *most* effective for drivers to whom sanctions are not applied because they commit no violations. Many violation-free drivers are undoubtedly law-abiding citizens whose primary motivation is to obey the laws. Other violation-free drivers are motivated to drive safely at least in part by their desire to avoid the unpleasantness of having a sanction imposed; for them, the existence of the sanction process is sufficient deterrent against violations.

We return to these ideas later in this report when discussing findings of analyses of driver records and recommendations for sanction process improvements.

Figure 2.

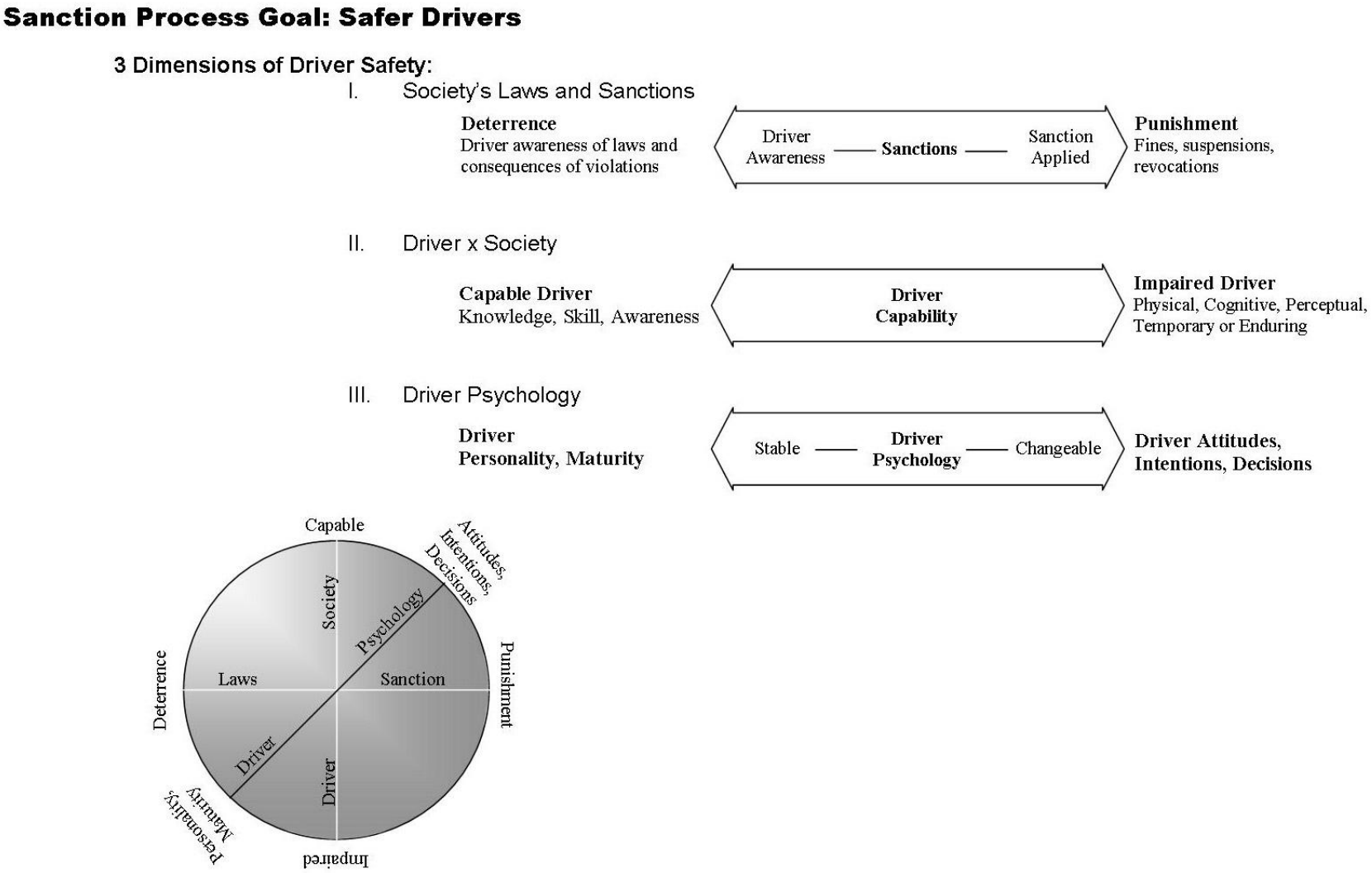
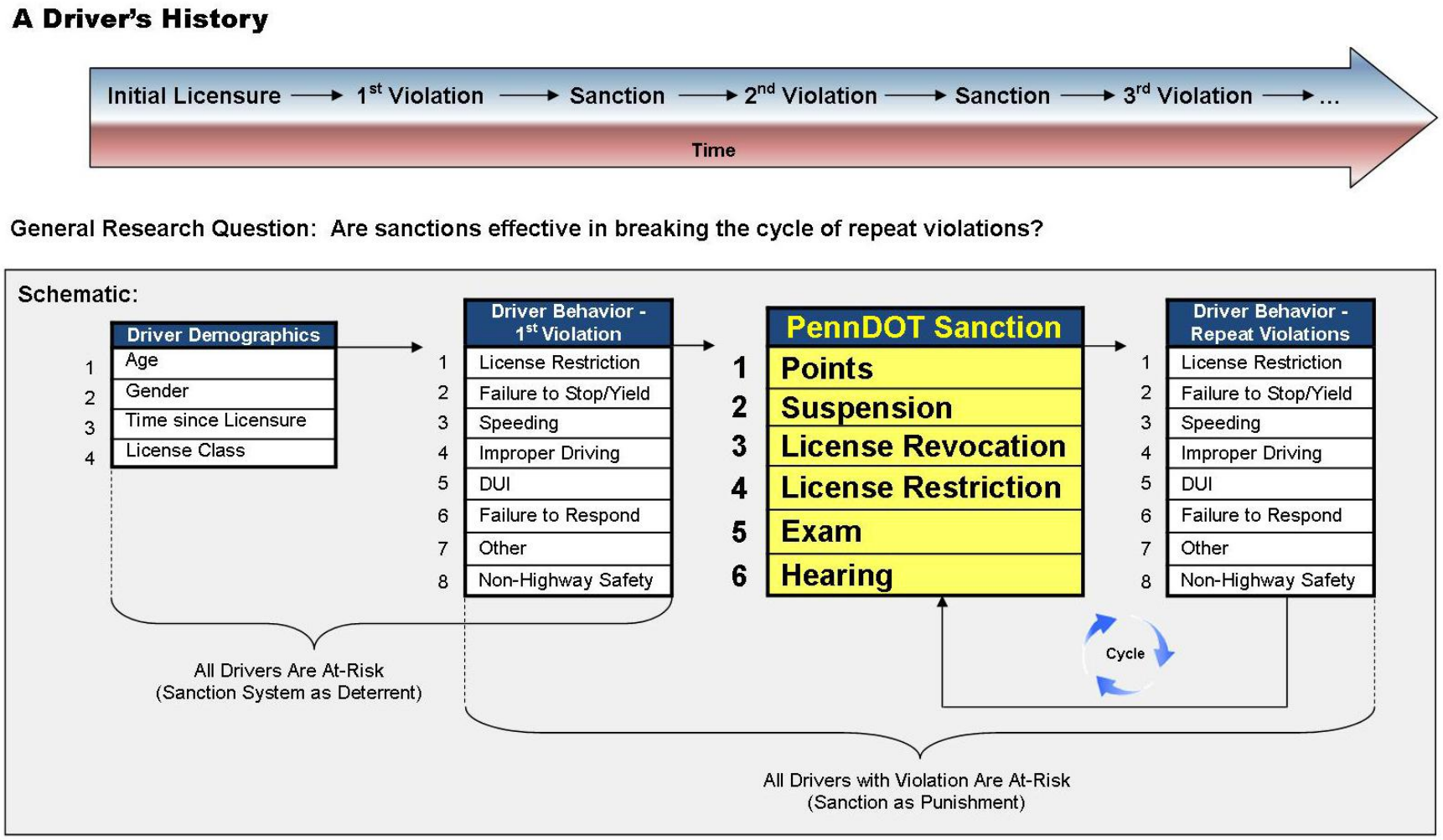

Sanction Process Goal: Safer Drivers
3 Dimensions of Driver Safety:
I. Society's Laws and Sanctions
Deterrence
Driver awareness of laws and consequences of violations
Driver Awareness
Sanctions
Sanction Applied
Punishment
Fines, suspensions, revocations
II. Driver x Society
Capable Driver
Knowledge, Skill, Awareness
Driver Capability
Impaired Driver
Physical, Cognitive, Perceptual, Temporary or Enduring
III. Driver Psychology
Driver
Personality, Maturity
Stable
Driver Psychology
Changeable
Driver Attitudes, Intentions, Decisions
Capable
Attitudes, Intentions, Decisions
Society
Psychology
Laws
Sanction
Deterrence
Punishment
Driver
Driver
Personality, Maturity
Impaired

Figure 3.


A Driver's History
Initial Licensure
1st Violation
Sanction
2nd Violation
Sanction
3rd Violation
…
Time
General Research Question: Are sanctions effective in breaking the cycle of repeat violations?
Schematic:
Driver Demographics
1 Age
2 Gender
3 Time since Licensure
4 License Class
Driver Behavior - 1st Violation
1 License Restriction
2 Failure to Stop/Yield
3 Speeding
4 Improper Driving
5 DUI
6 Failure to Respond
7 Other
8 Non-Highway Safety
PennDOT Sanction
1 Points
2 Suspension
3 License Revocation
4 License Restriction
5 Exam
6 Hearing
Driver Behavior - Repeat Violations
1 License Restriction
2 Failure to Stop/Yield
3 Speeding
4 Improper Driving
5 DUI
6 Failure to Respond
7 Other
8 Non-Highway Safety
Cycle
All Drivers Are At-Risk
(Sanction System as Deterrent)
All Drivers with Violation Are At-Risk
(Sanction as Punishment)

Task 1: Literature Search and Best Practices Review

Literature Review

A literature search on the effects of sanctions on subsequent driver behavior was conducted. This focused on a range of topics relating to this central issue, including:

- effects of sanctions on driver behavior
- design of driver point and sanction systems
- effects of crashes on subsequent safe driver behavior
- effectiveness of driver training programs
- effectiveness of driver safety education programs
- attitude change and safe driving behavior
- driver characteristics (age, gender, experience), propensity to engage in unsafe behavior

Published and unpublished studies were sought from such literature domains as psychology and human factors, safety and crash prevention, insurance, and law enforcement in domestic and international books and journals. Of particular importance were searches of transportation resources such as the Transportation Research Board's (TRB) TRIS database and for current research, the TRB Research-in-Progress database, and others such as the International Transport Research Documentation database.

Our literature search yielded 239 studies which we summarized in a Literature Review Report (printed as a separate stand-along document) organized into three sections:

I. Introduction
II. Synopsis of Findings: What the Literature Says about Factors Implicated in Risky Driving Behavior
III. Listing of References, Abstracts, and Relevant Topics of Articles and Reports Cited

Survey of Best Practices

A Survey of Best Practices was distributed via email to other state departments of transportation (DOTs) and departments of motor vehicles (DMVs). Survey topics included:

- driver sanctioning policies and practices
- research and evaluation studies of sanction process effectiveness
- recent improvements to driver sanctioning policies and practices
- the top three most successful practices in promoting driver safety

Eighteen states completed the survey, including: Arkansas, California, Georgia, Idaho, Iowa, Kentucky, Maryland, Minnesota, New Jersey, Nevada, Ohio, Oregon, South Carolina, Tennessee, Texas, Utah, Washington, and West Virginia. The survey and responses are included in Appendix A.

Task 2: Review of PennDOT Data

Stakeholder Interviews

A meeting was held on November 2, 2007 among the researchers, the project technical advisor (Scott Shenk, Manager, Driver Safety Division) and key stakeholders responsible for administering PennDOT's driver sanctioning system (including Janet Dolan, Director, Bureau of Driver Licensing; Diana Henning, Manager, License Control Division; Anne Titler, Manager, Driver Improvement and Evaluation; and Brenda Collins, Manager, Judicial/Information Sales). These individuals possess a wealth of knowledge, information, and insight concerning operation of the sanctioning system. By virtue of their "front line" observations and experience, they understand PennDOT's current practices, including types of sanctions, variations in their applications, their effectiveness, and ideas for improvements.

The focus of this discussion was an overview of operations of the Bureau of Driver Licensing. The researchers then met separately with each of these individuals, and also with Melanie Sterling (Manager, Hearings and Exams), Vita Youch (Manager, OLL/PL), and Harold Cramer (Assistant Chief Counsel). Stakeholder interviews addressed topics such as:

- role or roles in the sanctioning system and amount of experience in each role,
- duties and responsibilities in administering the system,
- perspective on how effectively and consistently the system is applied (over time, across localities/regions of the state, across individuals),
- views on what is working and what can be improved.

In addition to the formal stakeholder interviews, the researchers had numerous opportunities throughout the course of the project to ask questions of these and other PennDOT staff members as the need arose, share preliminary findings, and incorporate feedback into subsequent reports. Through these discussions we developed an understanding of the current sanction process and, particularly as we began to formulate improvement recommendations, were able to solicit their opinions concerning practical issues raised by specific recommendations.

Review of Documentation

We supplemented stakeholder interviews by reviewing documentation concerning the design, application, and effectiveness of PennDOT's sanctioning system. Documents included:

- Pennsylvania Vehicle Code
- Chapter 87 of the Pennsylvania Code
- The Pennsylvania Point System Fact Sheet
- Pennsylvania Driver's Manual
- What You Need to Know about Pennsylvania's Young Driver Law
- PennDOT Special Point Examination Driver's Handbook
- Release 1 Components of .*centric* system
- Release 2 Components of .*centric* system
- Release Roadmap V2 of .*centric* system

In addition, we were provided with samples of PennDOT's correspondence with drivers on topics including:

- Violations (letters informing drivers of points assessed due to particular violations)
- Special Point Exam Notification
- Hearing Notification
- 11-Point Notification
- Suspension Notification
- Failure to Respond Notification
- Young Driver Violation (letters to young drivers and parents)
- Driving without a License
- Occupational Limited License Recall
- License Restoration
- CDL Disqualification
- License Restoration Requirements Notification
- License Revocation

Our review of these documents led to several recommendations regarding PennDOT's communications with drivers, including improvements to handbooks, manuals, fact sheets, and driver correspondence.

Observations of Exams, Hearings, and Traffic Court

The research team conducted observations of Special Point Exam sessions (Harrisburg on December 10, 2007 and State College on December 20, 2007), Hearings (State College on December 20, 2007, Philadelphia on January 9, 2008, and Harrisburg on January 25, 2008), and Traffic Court/District Attorney Court (Philadelphia on March 28, 2008). More than 20 individual hearings were observed, including speed hearings, young driver hearings, Type II hearings, and Type III hearings. More than 20 individual court cases were observed. In addition, the researchers had opportunities to interview PennDOT's hearing examiners and Philadelphia's Traffic Court judges.

These observations afforded the researchers opportunities to witness first-hand typical interactions between the driver sanctioning system (in the persons of examiners and judges) and drivers who incur sanctions. We were impressed with the care and professionalism with which the examiners and judges approached their roles. Although their individual styles in dealing with drivers varied, all endeavored to communicate clearly with drivers, and to treat them respectfully. We believe they largely succeeded, often in the face of drivers who were openly dismissive and belligerent. They explained to drivers their predicaments, what they needed to do to comply, and how to avoid future problems. These observations contributed to improvement recommendations.

Driver Records Database

Vance & Renz, LLC received 1/10th of the driver records database in June, 2007. The data was provided by Scott Shenk via two DVDs, comprising 5 main tables, and over 47 million records. Upon receiving the data, it was converted from flat text tiles and imported into a SQL Server database and then also into a Microsoft Access database.

Initially, our main data concern was that all date fields within the data were stored as 6 digit integers (2 digit day, 2 digit month, and 2 digit year) – obviously meaning the system and data pre-dated the Y2K compliance factor. To solve this issue, PennDOT uses a second "century" field to flag which dates are in the 1900s and which are in the 2000s. We converted these dates to standard single field (mm/dd/yyyy) format.

The next step was to review the data to become familiar with coding and formatting. It soon became apparent that we did not have everything needed. Any coded field within the data was still in coded fashion, unable to be decoded without the related definition tables. Scott Shenk was contacted, and the 21 necessary code tables were provided in July, 2007.

Given the code tables, data, and detailed data definitions, the next review led to some new questions. We met with Scott Shenk and other expert system users to answer these questions and also review summary reports we created to ensure that the data were imported into our databases correctly. This meeting was very helpful to our understanding of how the system stores information and why/when particular data fields are used. Additional meetings and discussions were held throughout the project with appropriate PennDOT personnel as questions arose about data records and the sanctioning process. These communications were in person, by conference call, and via email.

One feature of the current PennDOT sanctioning system is the way points are assessed and stored within the system. When any driver's data within the sanctioning system database is retrieved at any given time, their point total is shown on screen. However, this point total is not necessarily their *current* point total – meaning if that particular driver hasn't had any points/sanctions for a few years since their last conviction, the point total isn't updated to reflect the automatic deduction of 3 points per year. Rather, their *actual* current point total must be hand calculated. This is not a safe data management practice. Human error (miscalculations, typographical errors, etc.) should not be a factor in determining a driver's current point total. Although not a hindrance to data analyses (we calculated point totals directly from violation records), this and other database issues prompted us to offer several recommendations concerning design of the new driver records database.

Task 3: Analyses of Driver Records

Although evidence-based decisions are central to achieving PennDOT's stated goal of determining "…whether or not drivers who have been subjected to special point exams, hearings and/or suspensions ultimately become safer drivers as a result of the penalties incurred" (RFQ 060801, p. 1), it is important to note the characteristics of the data available and their ability to support valid inferences about driver behavior. A driver record shows sanctions and points incurred for violations. Points and sanctions are actions of PennDOT's sanctioning system. Although these actions are responses to driving violations, they are not direct measures of driver behavior.

Indeed, it would be a mistake to assume that a driving record provides a complete picture of a driver's behavior. PennDOT's driver records database contains records for millions of drivers spanning many years. Analyzing these records to reach meaningful conclusions about sanction system effectiveness that support practical and useable improvement recommendations required a sophisticated analytic approach. A number of specific research questions were addressed in this research project that collectively elaborated the basic issue of sanction process effectiveness. Each specific question posed its own data requirements and analytic approach.

Analyses of driver records are presented in three sections: (1) descriptive summaries of violations including breakdowns by driver gender and type of violation, (2) analyses to determine whether and when drivers commit violations, and (3) analyses to determine the effects of sanctions on subsequent violations. Before presenting these results, we describe some of the complexities of driver records as these affect data requirements and interpretations of specific analyses.

Complexities of Driver Records

PennDOT's driver records databases contain records for millions of Pennsylvania drivers extending over many years. Records are stored in 10 databases corresponding to the last digit of a driver license number. Driver license numbers are assigned sequentially (each new license issued ends in 1, 2, 3, etc.), so each database contains a random sample of the driver population. PennDOT decided at the outset of this project to provide a copy of the database containing records of drivers whose license numbers end in '1' to the researchers for analysis. Personal identifiers such as names, addresses, and social security numbers were purged from the records by PennDOT prior to transfer of the database to the researchers. This database, created in June 2007, contains records for approximately 1.6 million drivers.

Most analyses reported in the following sections were conducted using a random sample of 100,000 driver records. Because many of the analyses planned were computationally intensive, very large samples (involving hundreds of thousands or millions of cases) would tax the resources of even today's powerful computer processors. A random sample of 100,000 records (the "100K sample") is (a) sufficient for statistical purposes, (b) representative of the population of Pennsylvania drivers, and (c) efficient in terms of data processing and computational resources.

Although preliminary analyses were conducted on the full sample of 100,000 driver records, some analyses required particular "cuts" or subsamples of the records. For example, *survival analyses* -- to test whether and when violations occurred in a driver's career -- require a "beginning of time," such as date of initial Pennsylvania licensure. Preliminary analyses revealed that, prior to 1980, the "date of initial license" (product issue date) field was updated each time a license was renewed, which precludes accurate determination of the initial licensure date. Therefore, survival analyses were conducted using only drivers whose dates of initial Pennsylvania licensure were 1980 or later. PennDOT's current driver sanction process of 6-point exams and hearings was instituted in October, 1990. Therefore, analyses testing the effectiveness of sanctions included only drivers whose date of initial Pennsylvania licensure was October 1, 1990 and later.

PennDOT's driver records are exceedingly complex. This is in part due to the multiple legacy database systems that preceded today's records databases, and also due to the fact that driver histories involve many transactions over many years. The researchers devoted a great deal of time to processing these records to create datasets suitable for analyses (and verifying the accuracy of each dataset created). Each major type of analysis (frequency, survival, and random coefficient modeling) presented in this report required creation of a separate dataset. Our objective was to conduct a series of analyses with an overall goal of understanding the effectiveness of sanction processes. Particular choices concerning which drivers to include in an analysis affected specific results; in their entirety, however, we believe that a clear picture emerges from these analyses.

Frequencies of Violations

As illustrated in Figure 3, a driver must commit (in fact, must be convicted of) one or more violations before a sanction is imposed. Preliminary analyses of driver records revealed a large number of specific violation codes (more than 800). To reduce these myriad codes to a manageable number of violation types, the researchers categorized them into eight categories: License Restriction, Failure to Stop/Yield, Speeding, Improper Driving, DUI, Failure to Respond, Other Violations, and Non-Highway Safety Violations. These categories are shown in Figure 3. To create these categories, the researchers discussed similarities and differences among violation codes and code descriptions, and identified a preliminary set of violation categories. Two of the researchers (Renz and Vance) independently categorized all violations, resolving coding discrepancies by discussion. An Excel® spreadsheet summarizing violation categories was then provided to Scott Shenk, the project's Technical Advisor, who reviewed and revised the categories and violation code assignments as needed. The final violation categories are shown in Figure 3; violation codes and descriptions are listed by category in Appendix B.

Violation categories 1 – 5 (License Restriction, Failure to Stop/Yield, Speeding, Improper Driving, and DUI) involve operating a vehicle in a prohibited manner. Violation categories 6 – 8 (Failure to Respond, Other Violations, Non-Highway Safety Violations) generally do not involve vehicle operation. Categories 6 – 8 include crimes and procedural offenses (e.g., underage alcohol possession or possession of marijuana). Some analyses presented next were conducted considering each violation category separately, whereas other analyses were conducted using only driving violations (Categories 1 – 5).

Figure 4 shows the proportions of male and female drivers with no driving violations, 1 or more violations, and 2 or more violations. These estimates are based on the 100K Sample, considering Category 1 – 5 violations only, over drivers' entire Pennsylvania driving careers. The earliest date of birth of any driver in this sample was May 1, 1900 and the latest date of birth was December 5, 1990 (drivers who are now deceased were included in analyses, with estimated date of death used in analyses as needed). Approximately 57% of drivers in this sample had no driving violations, 43% had one or more violations, and 24% had two or more violations. Males were more likely to commit violations than females, and gender differences increased with each successive violation. Approximately 35% of male and 65% of female drivers had no violations. Of drivers with 1 or more violations, 65% were males and 35% were females. Of drivers with 2 or more violations, 74% were males and 26% were females.

Figure 5 shows the proportions of drivers with 1 or more, 2 or more, and 3 or more driving violations by violation Categories 1 – 5. The pie charts of Figure 5 are roughly proportional in size to the number of drivers at each violation count (decreasing from 43% of drivers with 1 or more violations to 14% of drivers with 3 or more violations). It is apparent from these pie charts that the proportions of violations per category remain fairly constant as the number of violations increases. Speeding accounts for most of the violations (more that 50%), followed by Failure to Stop/Yield (16 – 20%), Improper Driving (10 - 14%), License Restriction (8 – 9%), and DUI (5 – 8%). Speeding may be the most common type of violation in part because police can passively monitor driver behavior (e.g., using radar), whereas other violation types are not as easily detected.

Whereas Figure 5 shows cumulative percentages of violation frequencies by categories (violations of drivers with 1 or more violations, 2 or more violations, and 3 or more violations), an alternative approach is to ask about the types of driving violations committed by drivers as their first, second, and third violations, considering only drivers whose maximum numbers of violations are specifically one, two, and three. This places the focus directly on violations that occur first, second, and third. Following that thinking, Figure 6 shows frequencies of violations for drivers with 1 through 10 violations. The percentages of drivers shown by the left-most bar for each violation category were calculated for drivers with one, and only one, violation. The second bar for each category was calculated for drivers with two, and only two, violations. The percentages shown were calculated considering only the *second* violations of these drivers. Thus, among 18,810 drivers with exactly 1 violation (out of 100,000 drivers total), approximate percentages of these 18,810 *first* violations were: 6% License Restriction, 20% Fail to Stop/Yield, 61% Speeding, 8% Improper Driving, and 5% DUI. Among 335 drivers with exactly 10 violations (out of 100,000 drivers total), approximate percentages of *tenth* violations were: 29% License Restriction, 10% Fail to Stop/Yield, 31% Speeding, 13% Improper Driving, and 17% DUI.

Considering the overall picture of frequencies of violations by categories reveals some noteworthy trends as the number of violations per driver increases. Speeding violations predominate regardless of total number of violations, although the proportion of violations that are Speeding decreases as drivers accumulate more violations. Proportions of License Restriction violations increase with successive violations, perhaps due to driving under

suspension for prior violations. Proportions of violations that are Failure to Stop/Yield decrease somewhat with increasing numbers of violations. Proportions of violations that are Improper Driving and DUI increase somewhat with increasing numbers of violations.

Figures 7 and 8 present the proportions of driving violations by categories separately for female (Figure 7) and male (Figure 8) drivers. Compared to males, somewhat greater proportions of first, second, and third violations of females are Speeding. Males have slightly greater proportions of Improper Driving and DUI violations at each violation count. Although males commit (or are convicted of) more violations than females, comparison of these figures reveals substantial similarities in their proportions of violations by categories.

One can also ask whether drivers tend to be consistent in the types of violations they commit from one violation to the next. Table 1 shows cross-tabulations of consecutive violations by violation categories. Tabled values are the percentages of drivers whose next violation fell into the same (value shown in **bold**) or different category as the previous violation. Thus, for example, reading across the first row of data in Table 1, of 2,589 drivers whose first violation was License Restriction, second violations were: 34% License Restriction, 18% Failure to Stop/Yield, 30% Speeding, 11% Improper Driving, and 7% DUI. Reading down the full columns of Table 1 reveals that, for each subsequent violation, the preceding violation was most likely to fall into the same category – that is, if the second violation was License Restriction, the first violation was more likely to be License Restriction than anything else; if the third violation was Failure to Stop/Yield, the second violation was more likely to be Failure to Stop/Yield than anything else; if the fourth violation was Speeding, the third violation was more likely to be Speeding than anything else; if the fifth violation was Improper Driving, the fourth violation was more likely to be Improper Driving than anything else. Thus, there is a distinct tendency for drivers to repeat the same type of violation from one violation to the next (for drivers who commit another violation). This tendency is strongest for License Restriction and Speeding violations (as shown by the comparatively high repeat-violation percentages for these types of violations).

In summary, we learn from Figures 5 through 8 that most drivers (57%) commit (or are convicted of) no violations, and a substantial minority (19%) commit only one violation during their driving careers. By far the most common type of violation is speeding, although the preponderance of this category diminishes somewhat as drivers accumulate more violations. The category that increases the most with multiple violations is license restriction, perhaps because many drivers continue to drive under suspension (for previous violations). Males commit far more violations than females, but the relative frequency of violation types is approximately equal across genders. Finally, there is a tendency for drivers with multiple violations to repeat the same type of violation.

Figure 4. Proportions of Male and Female Drivers with Violations

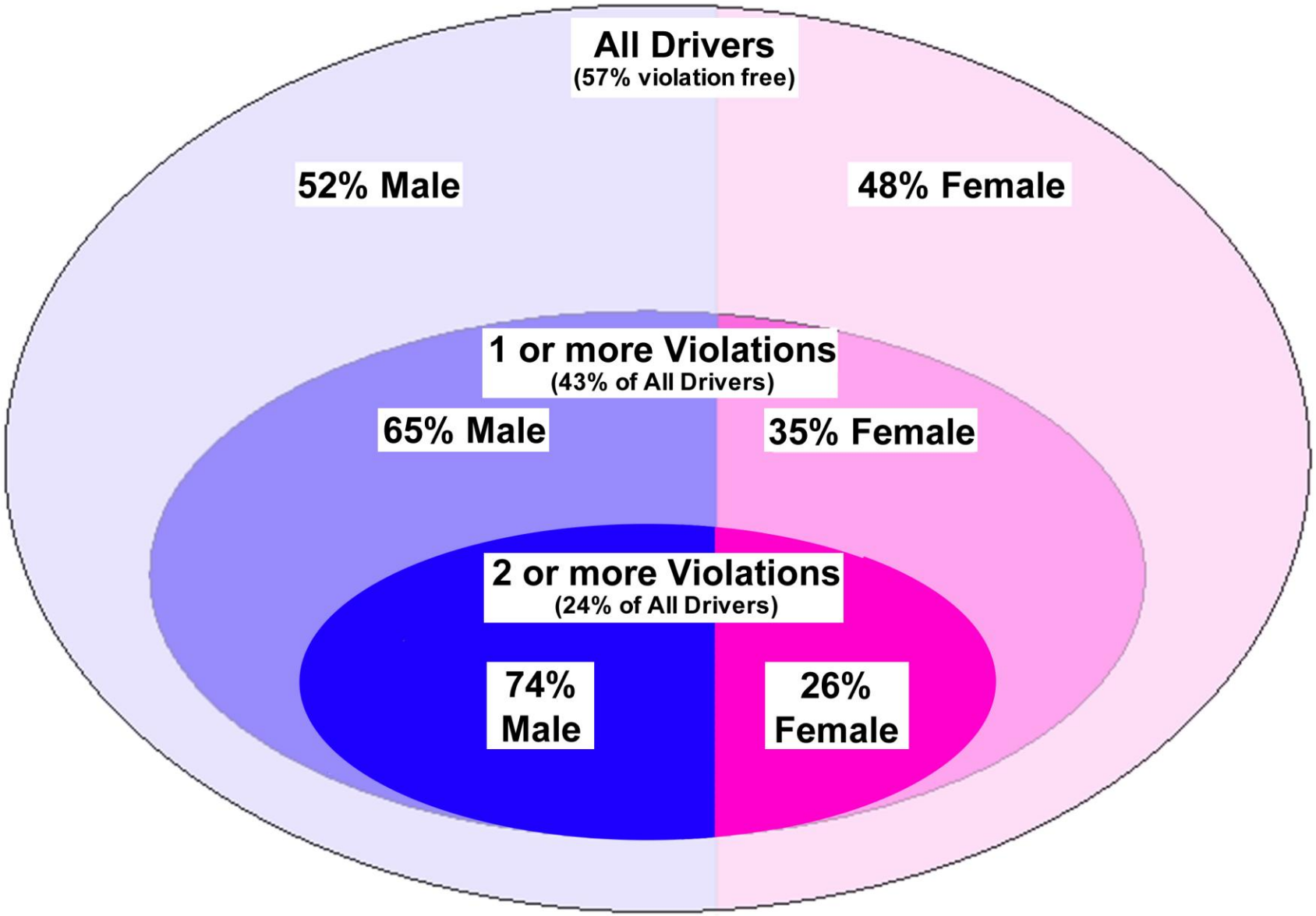


Figure 5. Proportions of Violations by Categories

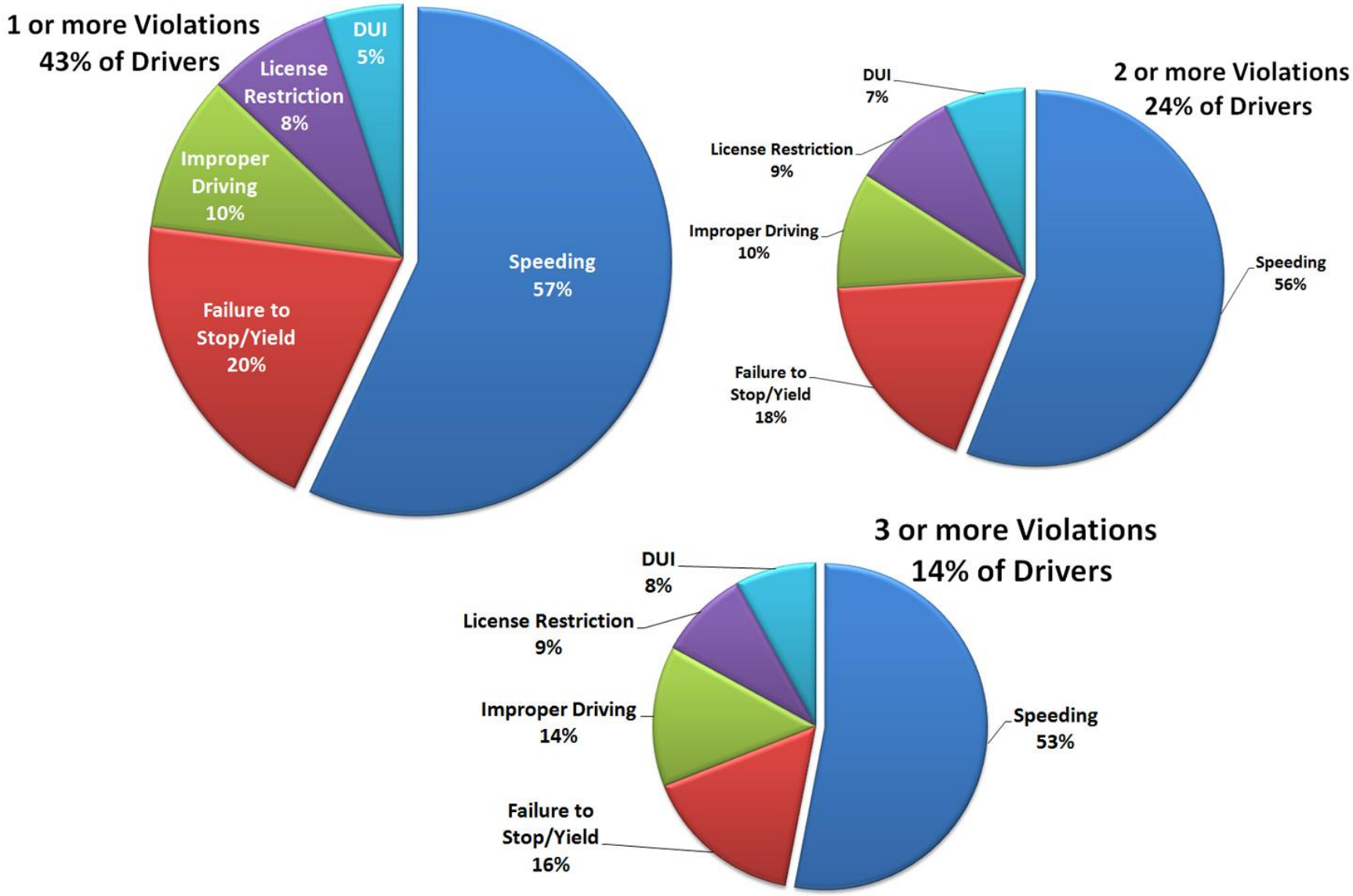


Figure 6.

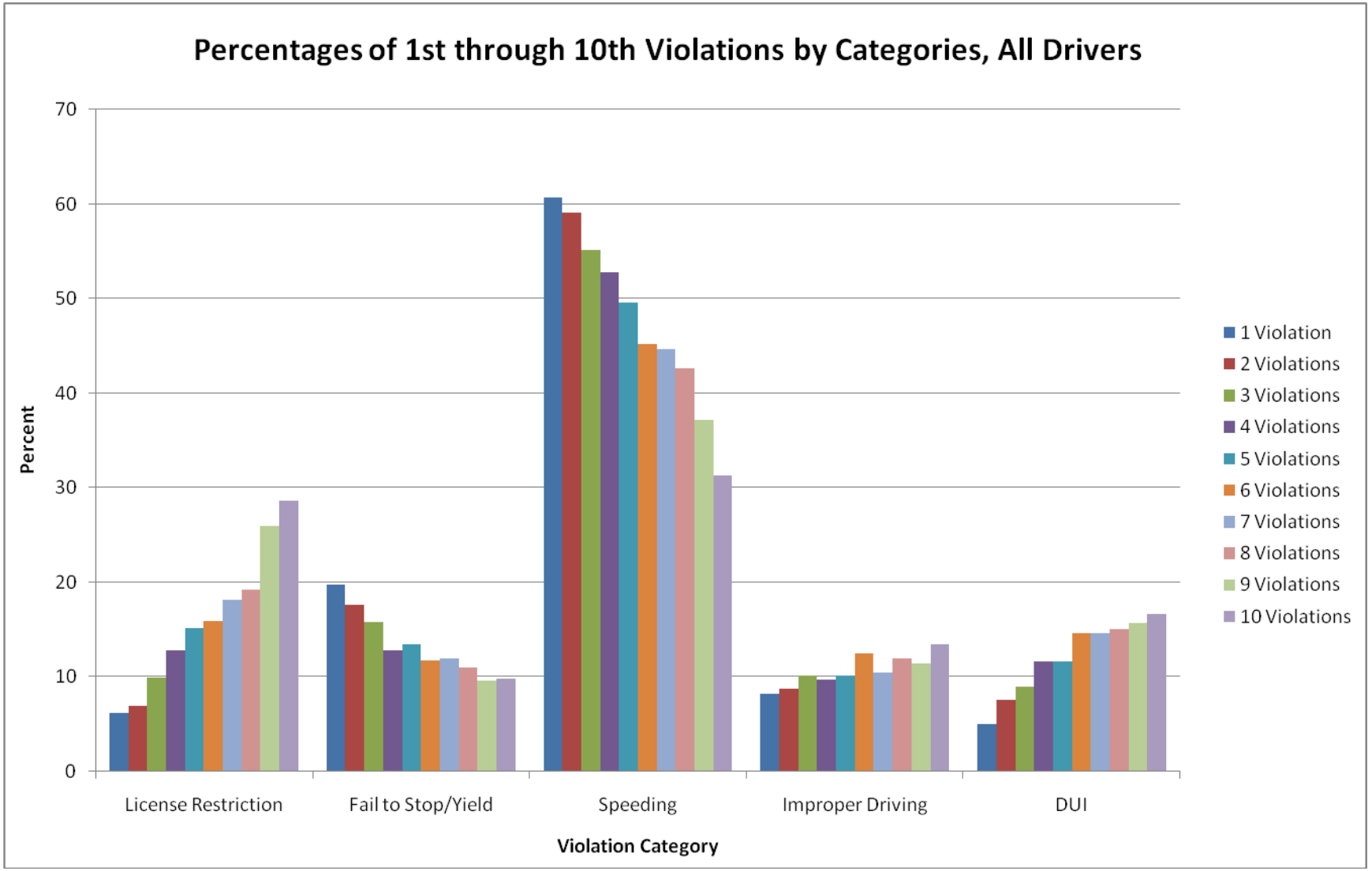

Percentages of 1st through 10th Violations by Categories, All Drivers
Percent
70
60
50
40
30
20
10
0
License Restriction
Fail to Stop/Yield
Speeding
Improper Driving
DUI
Violation Category
1 Violation
2 Violations
3 Violations
4 Violations
5 Violations
6 Violations
7 Violations
8 Violations
9 Violations
10 Violations

Figure 7.

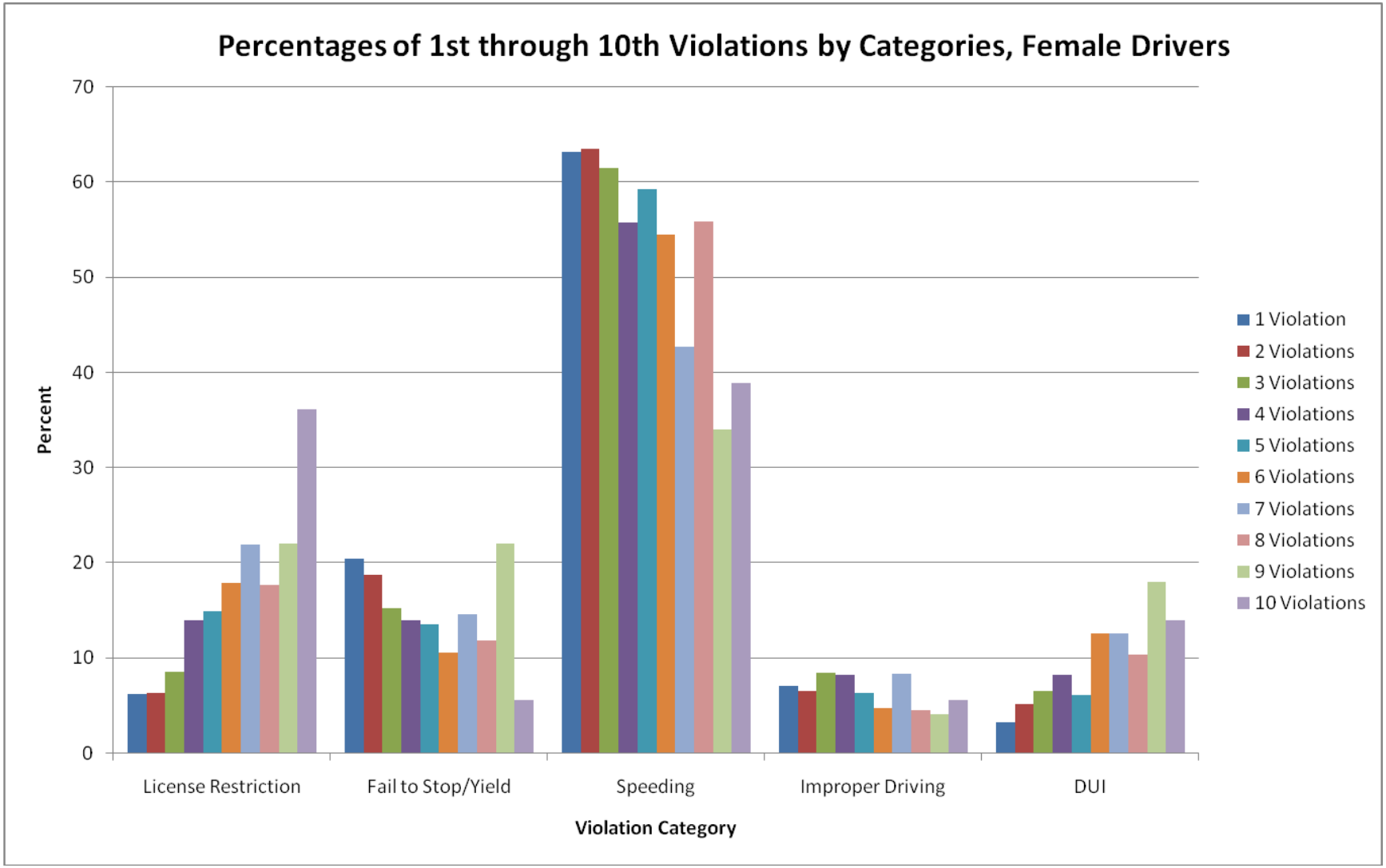

Percentages of 1st through 10th Violations by Categories, Female Drivers
Percent
70
60
50
40
30
20
10
0
License Restriction
Fail to Stop/Yield
Speeding
Improper Driving
DUI
Violation Category
1 Violation
2 Violations
3 Violations
4 Violations
5 Violations
6 Violations
7 Violations
8 Violations
9 Violations
10 Violations

Figure 8.

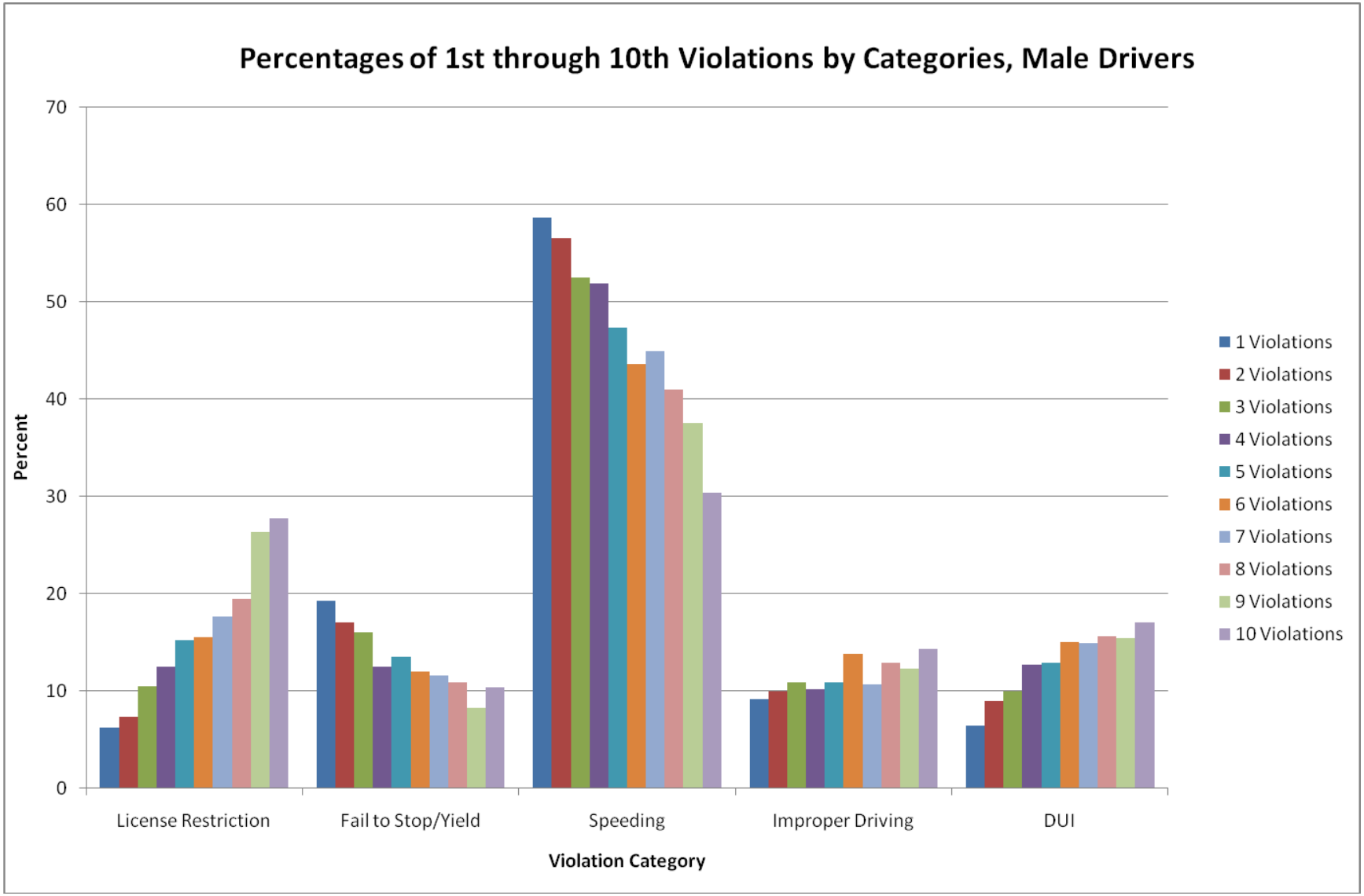

Percentages of 1st through 10th Violations by Categories, Male Drivers
Percent
70
60
50
40
30
20
10
0
License Restriction
Fail to Stop/Yield
Speeding
Improper Driving
DUI
Violation Category
1 Violations
2 Violations
3 Violations
4 Violations
5 Violations
6 Violations
7 Violations
8 Violations
9 Violations
10 Violations

Table 1.

Cross-Tabulations of Consecutive Violations by Violation Categories

		Second Violation				
First Violation	***N***	License Restriction	Failure to Stop/Yield	Speeding	Improper Driving	DUI
License Restriction	2,589	**34%**	18%	30%	11%	7%
Failure to Stop/Yield	4,936	8%	**24%**	51%	11%	5%
Speeding	13,409	5%	16%	**65%**	9%	5%
Improper Driving	2,619	10%	18%	48%	**16%**	9%
DUI	1,248	14%	14%	33%	14%	**25%**

		Third Violation				
Second Violation	***N***	License Restriction	Failure to Stop/Yield	Speeding	Improper Driving	DUI
License Restriction	1,699	**44%**	16%	25%	9%	7%
Failure to Stop/Yield	2,746	12%	**22%**	47%	11%	7%
Speeding	8,036	8%	14%	**63%**	10%	6%
Improper Driving	1,769	13%	17%	42%	**17%**	12%
DUI	949	13%	14%	35%	14%	**24%**

		Fourth Violation				
Third Violation	***N***	License Restriction	Failure to Stop/Yield	Speeding	Improper Driving	DUI
License Restriction	1,513	**46%**	14%	24%	10%	7%
Failure to Stop/Yield	1,629	15%	**19%**	44%	13%	9%
Speeding	4,914	9%	13%	**62%**	10%	7%
Improper Driving	1,101	14%	13%	42%	**17%**	13%
DUI	753	17%	12%	31%	14%	**27%**

		Fifth Violation				
Fourth Violation	***N***	License Restriction	Failure to Stop/Yield	Speeding	Improper Driving	DUI
License Restriction	1,255	**47%**	13%	22%	10%	9%
Failure to Stop/Yield	990	19%	**17%**	44%	12%	8%
Speeding	3,146	11%	13%	**59%**	10%	7%
Improper Driving	796	18%	13%	38%	**17%**	14%
DUI	591	19%	11%	32%	16%	**21%**

Survival Analyses

Analyses summarized in the preceding section documented the types of violations that drivers committed and the proportions of drivers who committed them. *Survival analyses* presented in this section address the question of *whether* and *when* violations occurred. Survival analyses are particularly well-suited to studies of events that unfold over time. A typical question addressed by a survival analysis could be: What proportion of drivers committed at least one violation, and when did it occur? To provide a proper answer one must consider the time frame. A violation within the first year of Pennsylvania licensure? First ten years of Pennsylvania licensure? Ever? Considering that some drivers have been licensed for many years whereas others were newly licensed, how should license tenure factor into the answer?

Initial Licensure to First Violation

Survival analyses require a beginning of time, a measure of time, and an event (such as a violation). The first set of survival analyses examined elapsed time (in years) from date of initial Pennsylvania licensure (beginning of time) to first driving violation (event). An advantage of survival analysis in examining whether and when an event occurs is that it accounts for drivers for whom the event does not occur. We know, for example, that some drivers never commit (are never convicted of) a violation. Survival analyses properly include them in calculations of whether and when events occur.

Table 2 summarizes results of survival analyses from initial licensure to first driving violation. Separate analyses addressed time from Pennsylvania licensure to first violation (any Category 1 – 8 violation) for all drivers, and by gender and license class (C, CDL, M) breakdowns. In addition, analyses were conducted for elapsed time to first violation for each violation category (1-License Restriction, 2-Failure to Stop/Yield, 3-Speeding, 4-Improper Driving, 5-DUI, 6-Failure to Respond, 7-Other Violations, and 8-Non-Highway Safety), also with gender and license class breakdowns.

Table 2 shows the proportions of drivers who "survived" each interval since Pennsylvania licensure (1, 3, 5, 10, and 20 years) without committing a driving violation. For example, 94% of female drivers committed no driving violations by the end of their first year of licensure (they survived without a violation); conversely, 6% of female drivers committed a driving violation during their first year of licensure. Comparable values for male drivers are: 85% survived their first year without a driving violation, and 15% committed a driving violation during their first year of licensure. At 20 years since licensure, 57% of female drivers and 39% of male drivers are predicted to survive violation-free. Therefore, to answer a question concerning the proportion of drivers who will ever commit a driving violation, we can state that about 43% of females and 61% of males are predicted to eventually commit a driving violation. We can further summarize the predicted proportions of violation-free drivers (or the converse) at any given interval.

It is useful to plot the results of survival analyses in the form of a survival function. Figure 9 shows a continuous curve of the probability of surviving without a first violation from the beginning of time (time 0 = date of Pennsylvania licensure) through a 27-year observation

period. (As previously noted, date of initial Pennsylvania licensure was not reliably recorded until 1980. Therefore, the earliest date of licensure for drivers included in this first set of survival analyses was 1980. The observation period extended for 27 years, until 2007 when the driver records were provided to the researchers. Note that year 1 of license tenure corresponds to 1980 only for drivers licensed in 1980; for other drivers, year 1 is first year of licensure, which could have been any year from 1980 to 2006. Similarly, only drivers licensed in 1980 could have been observed for the entire 27 year study period for other drivers in the sample, the duration of observation was shorter. The observation period for each driver extended from licensure until a first violation was committed, until 2007 [end of time], or until approximate date of death [if available in the records provided]. As will be explained in more detail below, survival analysis builds upon available data.)

Two important conclusions can be drawn from Figure 9. First, survival rate dropped precipitously during the first few years after Pennsylvania licensure. The curve became more gradual with increasing years after licensure until it leveled off after about 25 years. Thus, drivers were most likely to commit a first driving violation within a few years of licensure. Second, approximately 46% of drivers are predicted to survive 27 years without committing a driving violation. The longer a driver survived without a violation, the less likely he or she was to ever commit a violation.

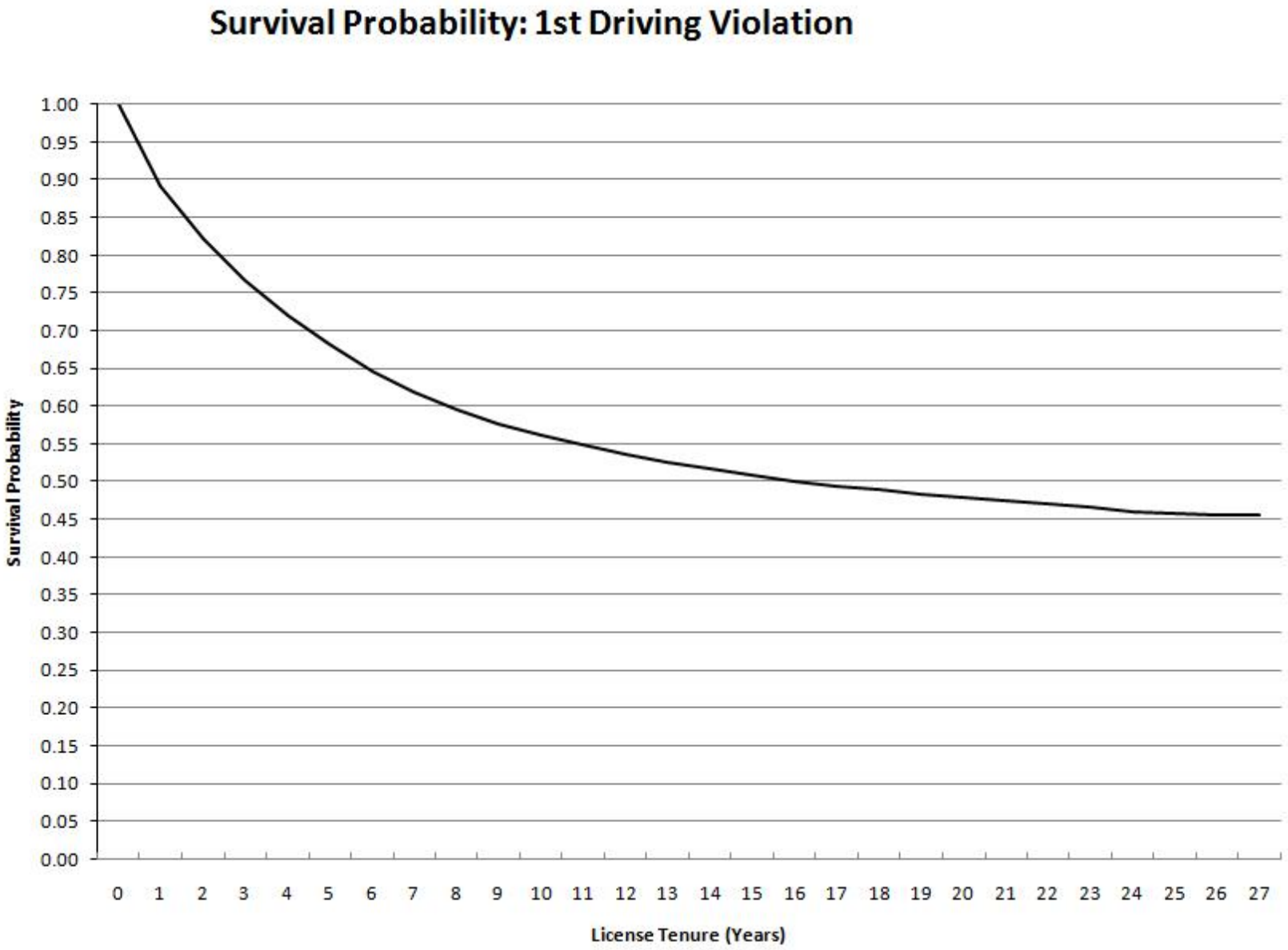
Results of a survival analysis can be examined in greater detail. A *life table* (the primary tool for describing event occurrence data) for the survival function depicted in Figure 9 is presented in Table 3. This analysis included 72,035 drivers who received a license between 1980 and 2007, a period of 27 years (out of the 100,000 drivers in the full sample that covered a much longer period). Reading across the first line of data, at year 1 (column 1, the beginning of time) all 72,035 drivers entered the analysis (column 2). No drivers had yet been *censored* (explained below) at the beginning of year 1 (column 3). All 72,035 drivers were *at risk* of a violation at the outset (column 4); that is, all drivers could potentially have committed a violation at any time after licensure. During this first year of licensure 7,750 drivers committed a violation (column 5). The proportion of drivers committing a violation during year 1 was 0.107 (*hazard rate* = 7,750 / 72,035, column 6). The proportion of drivers who survived year 1 violation-free is shown in column 7 (0.892; i.e., 1 – hazard rate). The *cumulative proportion* of drivers who survived each interval violation-free is shown in column 8 (0.892); this column provides the values of the *survival function* plotted in Figure 9.

All 72,035 drivers included in this analysis (i.e., all drivers in the original sample of 100,000 who received a license from 1980 to 2007) were not observed for 27 years. Only drivers licensed in 1980 could have been observed for 27 years. Drivers licensed in 1981 could have been observed for 26 years. Drivers licensed in 2006 could have been observed for 1 year. Thus, the potential observation period for a given driver depended on year of licensure. Drivers who were licensed in 1981 or later were *censored* from the analysis beginning in year 2; that is, they did not contribute data to observation periods longer than their license tenure. Therefore, the number of drivers who entered a time interval decreased with each successive year (Table 3, column 2, year 2 and later). In year 2, 2,520 drivers were censored (Table 3, column 3, year 2).

Table 2. Proportions of Drivers without First Violations

Type of Violation	Years since Licensure	Driver Characteristics				
		Female	Male	Class C	CDL	Class M
Any Driving (Category 1-5)	1	94	85	90	81	86
	3	85	69	77	62	69
	5	77	59	69	51	59
	10	66	47	57	38	43
	20	57	39	49	28	35
License Restriction	1	99	97	98	97	98
	3	98	94	96	95	96
	5	97	92	95	93	95
	10	96	89	93	90	93
	20	95	86	91	87	91
Fail to Stop/Yield	1	98	96	97	96	96
	3	96	91	93	89	91
	5	94	87	90	85	87
	10	91	81	86	79	82
	20	88	76	82	73	77
Speeding	1	96	92	94	90	90
	3	88	79	84	74	76
	5	83	71	77	64	66
	10	74	58	66	49	52
	20	67	48	58	40	42
Improper Driving	1	99	97	98	95	96
	3	98	93	96	88	92
	5	97	91	94	84	89
	10	96	87	92	78	85
	20	95	83	89	71	80
DUI	1	100	99	99	99	99
	3	99	97	98	97	98
	5	99	95	97	95	96
	10	98	91	94	91	93
	20	97	87	92	87	90
Failure to Respond	1	98	96	97	96	97
	3	95	91	93	91	94
	5	93	87	90	88	92
	10	90	82	86	82	89
	20	87	77	82	77	85
Other	1	100	99	99	97	99
	3	99	98	99	93	98
	5	99	96	98	90	97
	10	98	94	97	84	95
	20	97	92	96	79	92
Non-Highway Safety	1	99	96	97	97	98
	3	97	93	95	95	96
	5	97	92	94	94	95
	10	97	91	94	94	95
	20	96	90	93	93	94

Figure 9.


Survival Probability: 1st Driving Violation
Survival Probability
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
License Tenure (Years)

The number of drivers at risk of a violation in a given year was equal to the number of drivers who were at risk in the previous year minus the number of drivers who committed a violation in the previous year, minus the number of censored drivers. Statistics shown for a given interval in Table 3 were calculated from data for drivers who were available at that interval. In this way, hazard rates and survival function values were calculated from the available data, thereby maximizing its information value.

It is important to note here that there is a fundamental difference between an estimate of proportion of violators from survival analysis and a direct calculation of proportion of violators. Figures 4 and 5 showed that 43% of drivers committed one or more violations, and 24% of drivers committed two or more violations. These proportions were calculated directly (proportion of violators = [number of violators / number of drivers]). In comparison, the survival analysis estimate of proportion of violators is *greater* than the directly calculated proportion at every period with censored cases.

In accounting for censoring, survival analysis estimates the proportion of violators that would have occurred *if all cases were observed throughout the entire study period*. Accounting for censoring is an important benefit of survival analysis. Consider two extreme (but actual) cases. A driver licensed in 1980 who drove violation-free throughout the entire 27-year observation period contributes more information to the analysis than a driver licensed in 2006 who drove violation-free for one year (the latter case was censored after one year). Survival analysis properly accounts for censored cases (those whose license tenure was less than 27 years). Survival analysis estimates proportions of violators according to the number of violators *at each interval* relative to the number of drivers at risk of a violation at that interval (see hazard rates, Table 3, column 6). In contrast, direct calculation of proportion of violators ignores the fact that the durations of opportunities to observe drivers vary dramatically across drivers. Thus, direct calculation of proportion of violators *underestimates* the proportion of violators that would have been observed if all drivers in the sample had been observed for a full 27-year period. Estimates of proportions of violators obtained from survival analyses are superior to direct calculations because survival analyses account for censoring in the data.

Two important conclusions can be reached from the data presented in Table 3. First, the survival graph presented in Figure 9 is based on a very large sample of drivers. Although the sample diminishes in size when extended to 27 years, over this long period a smooth trend is evident. Second, the survival function provides another way to answer the question concerning the proportion of drivers who committed a violation. The *median lifetime* is the point in the survival function when 50% of the sample has committed a violation. As can be seen in column 8 of Table 3, a value of .50 occurred at year 16. This indicates that 50% of drivers who were at risk committed a first driving violation by about year 16 of their driving careers. Of the 50% of drivers who were at risk and were violation-free at year 16, most (92%, or .46 / .50) will probably never commit a driving violation. This is shown in Figure 8, where the survival function plateaus at 46% of drivers surviving indefinitely without a driving violation.

Table 3. Life Table: First Driving Violation after Licensure

Year	Number Entering	Number Censored	Number at Risk	Number Violating	Proportion Violating (Hazard Rate)	Proportion Surviving Violation-Free	Cumulative Proportion Surviving (Survival Function)
1	72,035	0	72,035	7,750	0.107587	0.892413	0.892413
2	64,285	2,520	61,765	4,823	0.078086	0.921914	0.822728
3	56,942	2,473	54,469	3,721	0.068314	0.931686	0.766524
4	50,748	2,563	48,185	2,898	0.060143	0.939857	0.720423
5	45,287	2,715	42,572	2,290	0.053791	0.946209	0.681671
6	40,282	2,442	37,840	1,974	0.052167	0.947833	0.64611
7	35,866	2,328	33,538	1,423	0.042429	0.957571	0.618696
8	32,115	1,881	30,234	1,136	0.037574	0.962426	0.595449
9	29,098	2,044	27,054	865	0.031973	0.968027	0.576411
10	26,189	2,053	24,136	653	0.027055	0.972945	0.560816
11	23,483	1,929	21,554	479	0.022223	0.977777	0.548353
12	21,075	1,885	19,190	401	0.020896	0.979104	0.536894
13	18,789	1,563	17,226	339	0.01968	0.98032	0.526328
14	16,887	1,435	15,452	260	0.016826	0.983174	0.517472
15	15,192	1,448	13,744	223	0.016225	0.983775	0.509076
16	13,521	1,296	12,225	199	0.016278	0.983722	0.500789
17	12,026	1,331	10,695	130	0.012155	0.987845	0.494702
18	10,565	967	9,598	116	0.012086	0.987914	0.488723
19	9,482	1,023	8,459	78	0.009221	0.990779	0.484217
20	8,381	1,085	7,296	83	0.011376	0.988624	0.478708
21	7,213	1,028	6,185	55	0.008892	0.991108	0.474451
22	6,130	1,004	5,126	47	0.009169	0.990831	0.470101
23	5,079	1,059	4,020	42	0.010448	0.989552	0.46519
24	3,978	1,065	2,913	29	0.009955	0.990045	0.460558
25	2,884	1,045	1,839	12	0.006525	0.993475	0.457553
26	1,827	925	902	3	0.003326	0.996674	0.456031
27	899	756	143	0	0	1	0.456031

Explanation of Life Table Columns:

Year = number of years since a driver's license was issued ("license tenure")
Number Entering = number of drivers at each interval who are still driving and who have not yet committed a violation
Number Censored = number of drivers whose license tenure ends during an interval and who must be dropped from further consideration
Number at Risk = Number Entering – Number Censored (indicates true number of drivers who are at risk of a violation at each interval)
Number Committing Violation = number of drivers who commit a violation during an interval
Proportion Committing Violation = Number Committing Violation / Number at Risk (indicates within-interval violation rate)
Proportion Surviving Violation-Free = 1 – (Number Committing Violation / Number at Risk) (indicates within-interval *survival* rate)
Cumulative Proportion Surviving = the percentage of drivers who remain violation-free through the end of each interval

As summarized in Table 2, survival analyses from date of initial Pennsylvania licensure to first violation were conducted for each violation type and for gender and license class breakdowns. Survival graphs and life tables for these analyses are included in Appendix C. To briefly summarize these findings, (a) male drivers were more likely to commit first violations and commit them sooner after licensure than female drivers, especially Speeding and Improper Driving violations; and (b) CDL license holders were somewhat more likely than Class C and M license holders to commit first violations. Considering that CDL holders drive for a living, they probably have greater exposure than typical Class C and M license holders.

First to Second Violation

The second set of survival analyses examined elapsed time (in years) from date of first violation (beginning of time) to second violation (event). Table 4 summarizes results of these analyses. Separate analyses addressed time from first to second driving violation (any Category 1 – 5 violation) for all drivers, and by gender and license class (C, CDL, M) breakdowns. In addition, analyses were conducted for elapsed time to second violation for each violation category (1-License Restriction, 2-Failure to Stop/Yield, 3-Speeding, 4-Improper Driving, 5-DUI, 6-Failure to Respond, 7-Other Violations, and 8-Non-Highway Safety), also with gender and license class breakdowns.

Table 4 shows the proportions of drivers who survived each interval since first driving violation (1, 3, 5, 10, and 20 years) without committing a second driving violation. For example, 86% of female drivers committed no additional violations by the end of their first year after first violation (they survived without a violation); conversely, 14% of female drivers committed a second driving violation during the year following their first violation. Comparable values for male drivers are: 77% survived their first year without another violation, and 23% committed a second driving violation within a year after their first. At 20 years after first driving violation, 47% of female drivers and 25% of male drivers are predicted to survive violation-free. Therefore, to answer a question concerning the proportion of drivers who will ever commit a second driving violation, we can state that about 53% of females and 75% of males who commit a first violation are expected to eventually commit a second violation. We can further summarize the proportions of drivers with and without a second violation at any given interval.

Figure 10 shows a continuous curve of the probability of surviving without a second driving violation from the beginning of time (time 0 = date of first driving violation) through a 25-year observation period. Two important conclusions can be drawn from Figure 10. First, survival rate dropped precipitously during the early years after first violation. The curve became more gradual with increasing years. Thus, drivers were most likely to commit a second driving violation within a few years of a first violation. Second, approximately 29% of drivers are expected to survive 25 years without committing a second driving violation. The longer a driver survived without a second violation, the less likely he or she was to commit a second violation.

The life table for the survival function depicted in Figure 10 is presented in Table 5. This analysis included 42,793 drivers who committed a first driving violation. Although this large initial sample diminished in size when extended to 25 years, over this long period a smooth trend is evident. The median lifetime indicates that 50% of drivers committed a second driving

violation by about year 6 after their first violation. By 25 years, 29% of drivers survived without a second violation, and 71% had committed another violation. (Note that this compares to a direct calculation of second violation percentage of 56% [.24 / .43]. As explained above, survival analysis accounts for censoring of cases, and therefore provides a better estimate of violation percentage than a direct calculation.)

As summarized in Table 4, survival analyses from first to second violation were conducted for each violation type and for gender and license class breakdowns. Survival graphs and life tables for these analyses are included in Appendix C. To briefly summarize these findings, (a) male drivers were more likely to commit second violations and commit them sooner after first violations than female drivers, especially License Restriction, Speeding, and Improper Driving violations; and (b) CDL license holders were somewhat more likely than Class C and M license holders to commit second violations. As noted previously, considering that CDL holders drive for a living, they probably have greater exposure than typical Class C and M license holders.

Young Driver Violations

The third set of survival analyses examined elapsed time (in months) from date of Pennsylvania licensure (beginning of time) to first violation (event) for male and female drivers who were 16 or 17 years old at time of licensure. Table 6 summarizes results of these analyses. Separate analyses addressed time from licensure to first violation (any Category 1 – 8 violation) and for each violation category (1-License Restriction, 2-Failure to Stop/Yield, 3-Speeding, 4-Improper Driving, 5-DUI, 6-Failure to Respond, 7-Other Violations, and 8-Non-Highway Safety).

Table 6 shows the proportions of drivers who survived each interval since Pennsylvania licensure (6, 12, 18, 24, and 36 months, until young drivers were 19 or 20 years old) without committing a violation (Categories 1-8). For example, 97% of female drivers committed no violations by six months after licensure (they survived without a violation); conversely, 3% of female drivers committed a violation of some type during this period. Comparable values for male drivers are: 93% survived their first six months without a violation, and 7% committed a violation during this period.

Figure 11 shows a continuous curve of the probability of surviving without a violation from the beginning of time (time 0 = date of Pennsylvania licensure) through a 36-month observation period. Two important conclusions can be drawn from Figure 11. First, survival rate dropped gradually and continuously for both genders throughout the observation period. Thus, young drivers accumulated violations at a steady pace. Second, the rate at which violations were committed was greater for males than females. By 36 months since licensure, proportionally twice as many males as females committed violations (38% vs. 19%).

The life tables for the survival functions depicted in Figure 11 are presented in Tables 7 and 8. These analyses included 21,160 female (Table 7) and 24,427 male drivers (Table 8). Because of the short time-frame of these analyses (compared to the analyses presented in the preceding sections), very few cases were censored during the 36-month observation period. For both genders the median lifetime (the point at which 50% of drivers survived without a violation) was

Table 4. Proportions of Drivers without Second Violations

Type of Violation	Years since Licensure	Driver Characteristics				
		Female	Male	Class C	CDL	Class M
Any Driving (Category 1-5)	1	86	77	81	75	77
	3	72	55	61	53	55
	5	64	45	52	43	45
	10	55	33	42	31	34
	20	47	25	33	23	28
License Restriction	1	87	79	81	83	86
	3	79	67	70	73	77
	5	75	61	64	67	72
	10	70	54	57	61	67
	20	66	49	52	57	63
Fail to Stop/Yield	1	96	92	93	92	93
	3	91	84	86	84	85
	5	89	80	83	80	81
	10	85	73	77	73	75
	20	81	66	71	66	70
Speeding	1	90	85	87	84	84
	3	78	68	72	65	66
	5	72	59	64	56	57
	10	64	48	54	45	46
	20	57	40	46	37	38
Improper Driving	1	98	93	95	91	94
	3	95	86	89	83	87
	5	94	82	85	78	83
	10	91	76	80	70	77
	20	88	67	73	60	69
DUI	1	95	93	94	95	88
	3	90	85	86	89	83
	5	86	80	80	85	79
	10	77	68	69	76	71
	20	68	57	58	66	63
Failure to Respond	1	78	72	74	76	79
	3	65	56	59	62	66
	5	59	48	52	55	60
	10	52	40	43	47	52
	20	44	32	35	42	45
Other	1	95	90	94	81	89
	3	92	84	90	71	82
	5	91	81	88	65	78
	10	88	76	84	57	73
	20	86	73	82	51	69
Non-Highway Safety	1	94	87	88	90	90
	3	89	77	80	83	83
	5	87	74	77	81	81
	10	85	71	74	78	78
	20	84	68	72	76	76

Figure 10.

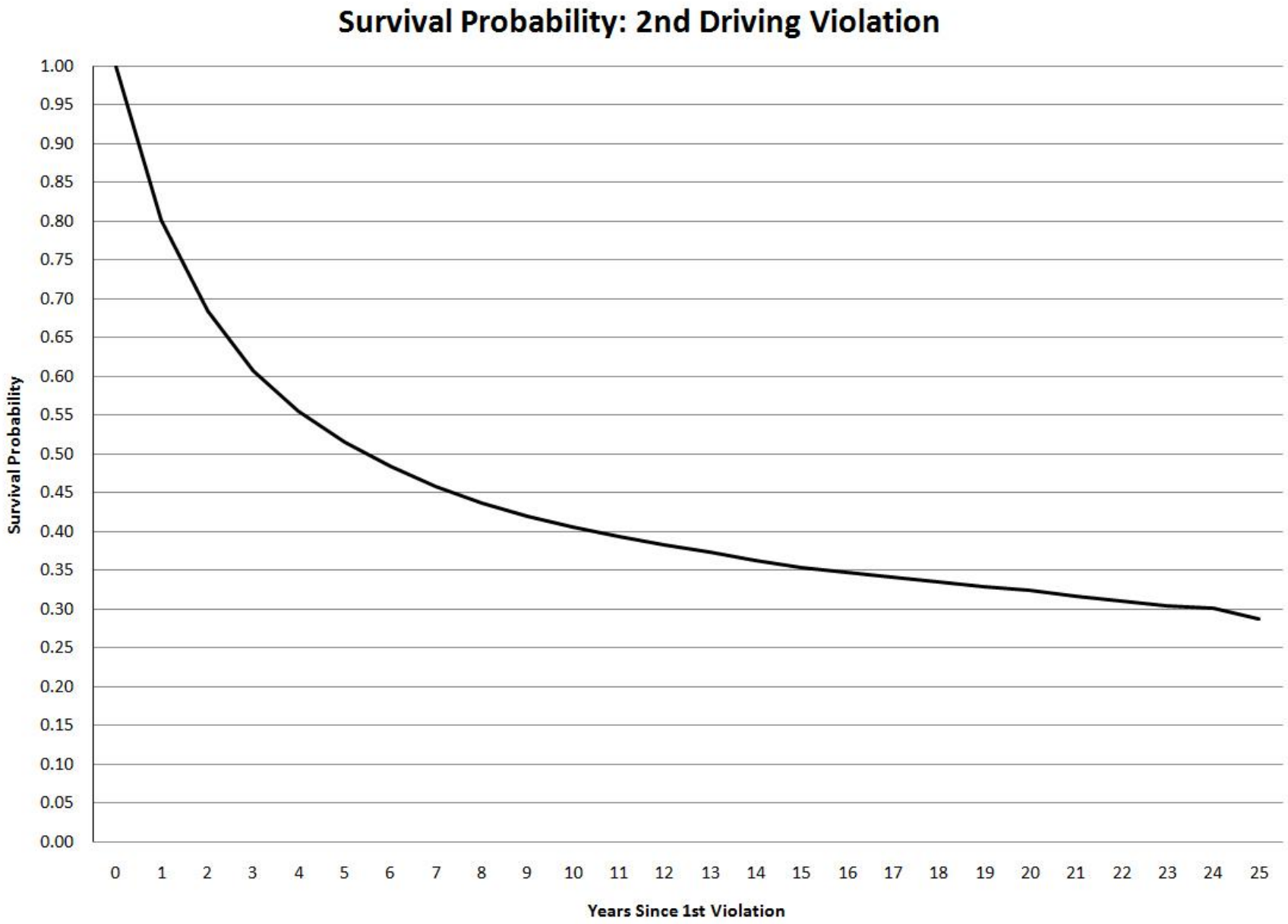

Survival Probability: 2nd Driving Violation
Survival Probability
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Years Since 1st Violation

Table 5. Life Table: Second Violations over 25 Years after First Violations (Categories 1-5)

Year	Number Entering	Number Censored	Number at Risk	Number Violating	Proportion Violating (Hazard Rate)	Proportion Surviving Violation-Free	Cumulative Proportion Surviving (Survival Function)
1	42,793	0	42,793	8,492	0.198444	0.801556	0.801556
2	34,301	1,182	33,119	4,882	0.147408	0.852592	0.683401
3	28,237	1,422	26,815	2,999	0.11184	0.88816	0.606969
4	23,816	1,336	22,480	1,933	0.085988	0.914012	0.554777
5	20,547	1,253	19,294	1,377	0.071369	0.928631	0.515183
6	17,917	1,233	16,684	1,030	0.061736	0.938264	0.483378
7	15,654	1,165	14,489	770	0.053144	0.946856	0.457689
8	13,719	1,103	12,616	580	0.045973	0.954027	0.436648
9	12,036	1,023	11,013	416	0.037774	0.962226	0.420154
10	10,597	1,045	9,552	315	0.032977	0.967023	0.406298
11	9,237	893	8,344	255	0.030561	0.969439	0.393882
12	8,089	783	7,306	211	0.02888	0.97112	0.382506
13	7,095	711	6,384	159	0.024906	0.975094	0.372979
14	6,225	858	5,367	148	0.027576	0.972424	0.362694
15	5,219	699	4,520	115	0.025442	0.974558	0.353466
16	4,405	744	3,661	61	0.016662	0.983338	0.347577
17	3,600	739	2,861	49	0.017127	0.982873	0.341624
18	2,812	680	2,132	36	0.016886	0.983114	0.335855
19	2,096	612	1,484	26	0.01752	0.98248	0.329971
20	1,458	492	966	15	0.015528	0.984472	0.324847
21	951	259	692	16	0.023121	0.976879	0.317336
22	676	179	497	11	0.022133	0.977867	0.310313
23	486	136	350	6	0.017143	0.982857	0.304993
24	344	108	236	3	0.012712	0.987288	0.301116
25	233	78	155	5	0.032258	0.967742	0.291403

Explanation of Columns: See Table 3 note.

beyond the period studied: 81% of females and 62% of males survived for 36 months since licensure without a violation.

As summarized in Table 6, survival analyses for young male and female drivers from licensure to first violation were conducted for each violation type (Categories 1-8). Inspection of Table 6 reveals that speeding was by far the most common type of violation committed by young drivers, especially males. Figure 12 shows a continuous curve of the probability of surviving without a Speeding violation from the beginning of time (time 0 = date of Pennsylvania licensure) through a 36-month observation period. Proportionally twice as many males as females committed Speeding violations (25% vs. 12%) by the end of this period. The life tables for the survival functions depicted in Figure 12 are presented in Tables 9 and 10.

As summarized in Table 6, survival analyses for young drivers from Pennsylvania licensure to first violation were conducted for samples of drivers licensed during *four years before* and *four years after* the Young Driver Law (YDL) took effect on August 24, 1999. Significant differences in survival rates were found for three violation categories. As might be expected, because of the restrictions the law placed on young drivers, License Restriction violations increased somewhat comparing before to after violation rates, from 1% pre-YDL to 3% post-YDL. Speeding violations decreased somewhat after the law took effect, from 24% pre-YDL to 22% post-YDL.

Figure 13 shows a continuous curve of the probability of surviving without a Speeding violation from the beginning of time (time 0 = date of licensure) through a 36-month observation period for the before- and after-YDL samples. The life tables for the survival functions depicted in Figure 13 are presented in Tables 11 and 12. It is possible that the small reduction in speeding violations among young drivers documented in these tables was at least partially attributable to the effects of the Young Driver Law.

Table 6. Proportions of Young Drivers without First Violations

Type of Violation	Months since Licensure	Driver Characteristics			
		Female	Male	Before Young Driver Law	After Young Driver Law
Any Violation (Category 1-8)	6	97	93	No significant differences	
	12	93	86		
	18	90	79		
	24	87	73		
	36	81	62		
License Restriction	6	100	100	100	100
	12	100	99	99	99
	18	100	99	99	98
	24	100	98	99	98
	36	99	98	99	97
Fail to Stop/Yield	6	99	98	No significant differences	
	12	98	96		
	18	98	95		
	24	97	93		
	36	96	90		
Speeding	6	98	96	96	96
	12	96	92	92	93
	18	94	88	88	89
	24	92	83	84	85
	36	88	75	76	78
Improper Driving	6	100	98	No significant differences	
	12	99	97		
	18	99	96		
	24	99	94		
	36	98	92		
DUI	6	100	100	No significant differences	
	12	100	100		
	18	100	100		
	24	100	99		
	36	100	98		
Failure to Respond	6	100	100	No significant differences	
	12	100	100		
	18	100	100		
	24	100	99		
	36	100	98		
Other	6	100	100	No significant differences	
	12	100	100		
	18	100	99		
	24	100	99		
	36	100	99		
Non-Highway Safety	6	100	99	100	99
	12	99	99	99	99
	18	99	98	98	98
	24	99	97	97	96
	36	98	94	95	94

Figure 11.

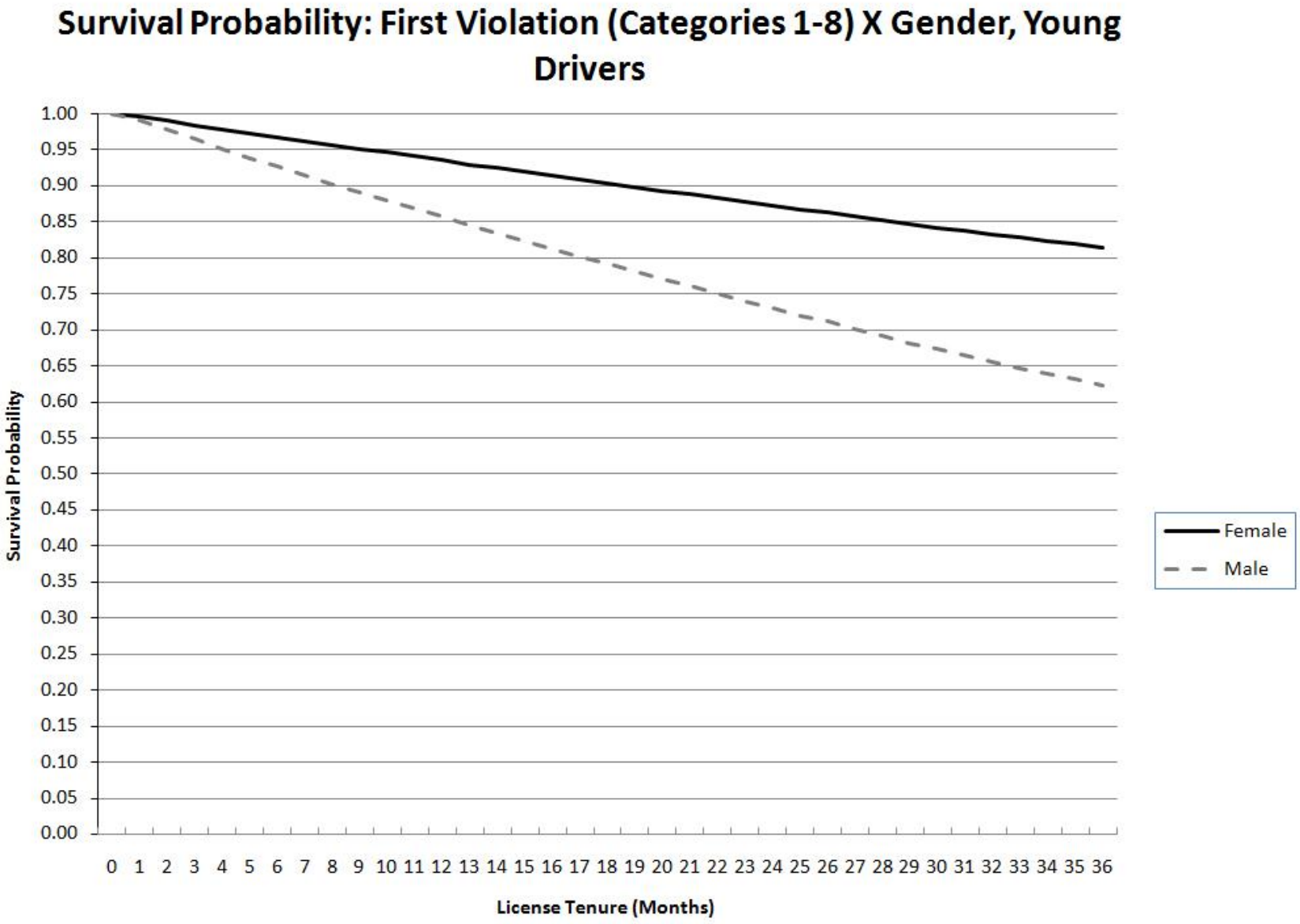

Survival Probability: First Violation (Categories 1-8) X Gender, Young Drivers
Survival Probability
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
License Tenure (Months)
Female
Male

Table 7. Life Table: First Violations over 36 Months of Licensure for Young Female Drivers

Month	Number Entering	Number Censored	Number at Risk	Number Committing Violation	Proportion Committing Violation (Hazard Rate)	Proportion Surviving Violation-Free	Cumulative Proportion Surviving (Survival Function)
1	21,160	0	21,160	72	0.003403	0.996597	0.996597
2	21,088	8	21,080	114	0.005408	0.994592	0.991208
3	20,966	69	20,897	102	0.004881	0.995119	0.98637
4	20,795	59	20,736	120	0.005787	0.994213	0.980661
5	20,616	69	20,547	124	0.006035	0.993965	0.974743
6	20,423	49	20,374	118	0.005792	0.994208	0.969098
7	20,256	56	20,200	119	0.005891	0.994109	0.963389
8	20,081	64	20,017	103	0.005146	0.994854	0.958432
9	19,914	59	19,855	103	0.005188	0.994812	0.95346
10	19,752	56	19,696	93	0.004722	0.995278	0.948958
11	19,603	66	19,537	101	0.00517	0.99483	0.944052
12	19,436	83	19,353	114	0.005891	0.994109	0.938491
13	19,239	52	19,187	109	0.005681	0.994319	0.933159
14	19,078	67	19,011	103	0.005418	0.994582	0.928103
15	18,908	58	18,850	114	0.006048	0.993952	0.922491
16	18,736	61	18,675	114	0.006104	0.993896	0.916859
17	18,561	55	18,506	102	0.005512	0.994488	0.911806
18	18,404	64	18,340	103	0.005616	0.994384	0.906685
19	18,237	41	18,196	107	0.00588	0.99412	0.901353
20	18,089	46	18,043	104	0.005764	0.994236	0.896158
21	17,939	42	17,897	115	0.006426	0.993574	0.890399
22	17,782	51	17,731	111	0.00626	0.99374	0.884825
23	17,620	68	17,552	125	0.007122	0.992878	0.878524
24	17,427	62	17,365	97	0.005586	0.994414	0.873617
25	17,268	58	17,210	102	0.005927	0.994073	0.868439
26	17,108	80	17,028	93	0.005462	0.994538	0.863696
27	16,935	58	16,877	107	0.00634	0.99366	0.85822
28	16,770	61	16,709	102	0.006104	0.993896	0.852981
29	16,607	55	16,552	108	0.006525	0.993475	0.847415
30	16,444	41	16,403	90	0.005487	0.994513	0.842766
31	16,313	48	16,265	114	0.007009	0.992991	0.836859
32	16,151	41	16,110	100	0.006207	0.993793	0.831664
33	16,010	38	15,972	96	0.006011	0.993989	0.826665
34	15,876	49	15,827	85	0.005371	0.994629	0.822226
35	15,742	43	15,699	86	0.005478	0.994522	0.817722
36	15,613	61	15,552	102	0.006559	0.993441	0.812358

Explanation of Columns: See Table 3 note.

Table 8. Life Table: First Violations over 36 Months of Licensure for Young Male Drivers

Month	Number Entering	Number Censored	Number at Risk	Number Committing Violation	Proportion Committing Violation (Hazard Rate)	Proportion Surviving Violation-Free	Cumulative Proportion Surviving (Survival Function)
1	24,427	0	24,427	223	0.009129	0.990871	0.990871
2	24,204	15	24,189	350	0.014469	0.985531	0.976533
3	23,839	70	23,769	334	0.014052	0.985948	0.962811
4	23,435	77	23,358	316	0.013529	0.986471	0.949786
5	23,042	73	22,969	322	0.014019	0.985981	0.936471
6	22,647	48	22,599	272	0.012036	0.987964	0.9252
7	22,327	65	22,262	308	0.013835	0.986165	0.912399
8	21,954	79	21,875	294	0.01344	0.98656	0.900137
9	21,581	70	21,511	274	0.012738	0.987262	0.888671
10	21,237	71	21,166	263	0.012426	0.987574	0.877629
11	20,903	60	20,843	276	0.013242	0.986758	0.866007
12	20,567	66	20,501	287	0.013999	0.986001	0.853884
13	20,214	66	20,148	284	0.014096	0.985904	0.841848
14	19,864	50	19,814	265	0.013374	0.986626	0.830588
15	19,549	50	19,499	248	0.012719	0.987281	0.820025
16	19,251	53	19,198	253	0.013178	0.986822	0.809218
17	18,945	64	18,881	244	0.012923	0.987077	0.79876
18	18,637	48	18,589	243	0.013072	0.986928	0.788319
19	18,346	55	18,291	250	0.013668	0.986332	0.777544
20	18,041	51	17,990	236	0.013118	0.986882	0.767344
21	17,754	66	17,688	223	0.012607	0.987393	0.75767
22	17,465	71	17,394	210	0.012073	0.987927	0.748522
23	17,184	61	17,123	259	0.015126	0.984874	0.7372
24	16,864	56	16,808	231	0.013743	0.986257	0.727069
25	16,577	54	16,523	205	0.012407	0.987593	0.718048
26	16,318	50	16,268	204	0.01254	0.98746	0.709044
27	16,064	49	16,015	205	0.0128	0.9872	0.699967
28	15,810	65	15,745	237	0.015052	0.984948	0.689431
29	15,508	68	15,440	218	0.014119	0.985881	0.679697
30	15,222	55	15,167	182	0.012	0.988	0.671541
31	14,985	37	14,948	178	0.011908	0.988092	0.663544
32	14,770	48	14,722	169	0.011479	0.988521	0.655927
33	14,553	36	14,517	201	0.013846	0.986154	0.646845
34	14,316	44	14,272	191	0.013383	0.986617	0.638189
35	14,081	43	14,038	159	0.011326	0.988674	0.63096
36	13,879	40	13,839	182	0.013151	0.986849	0.622662

Explanation of Columns: See Table 3 note.

Figure 12.

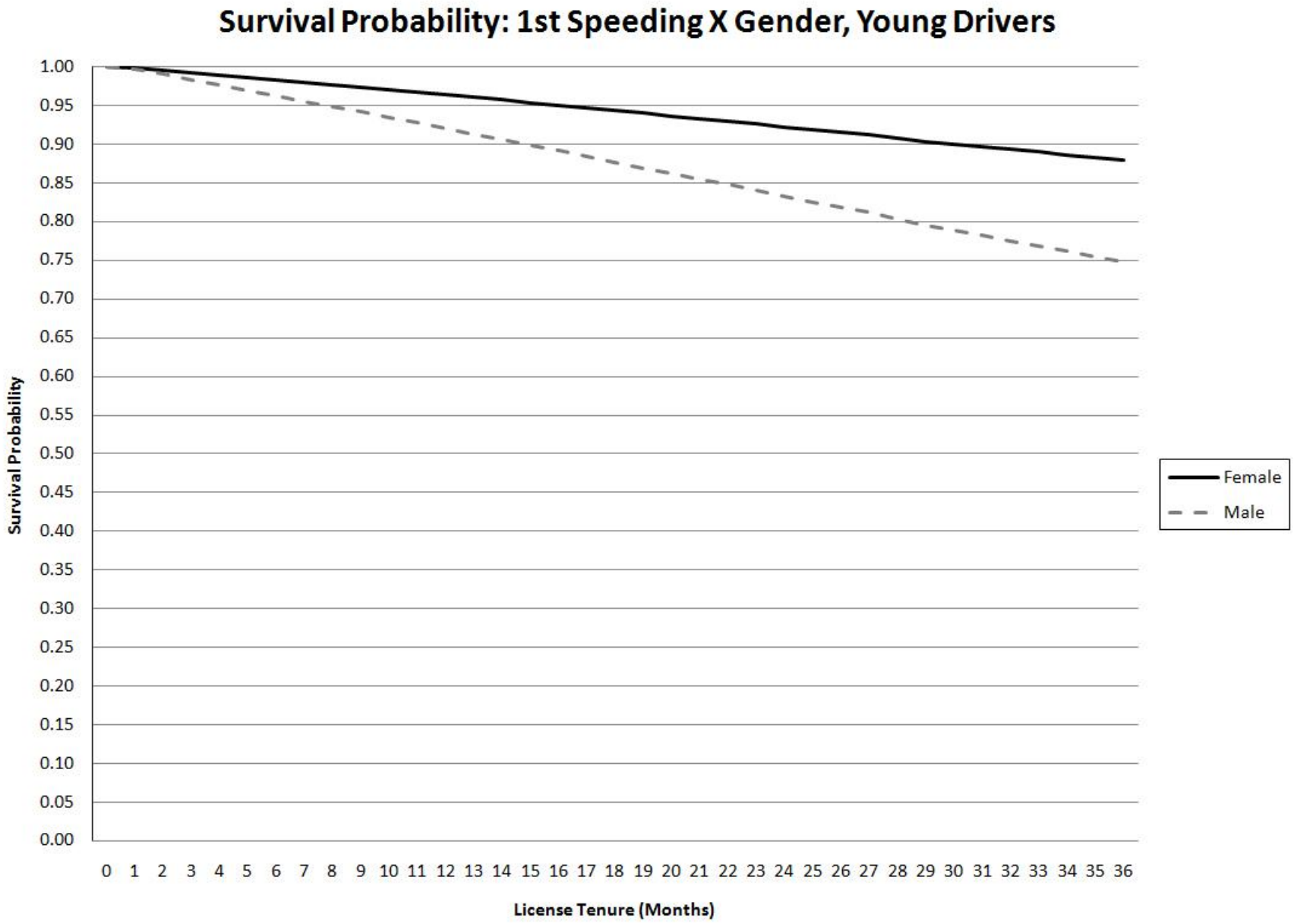

Survival Probability: 1st Speeding X Gender, Young Drivers
Survival Probability
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
License Tenure (Months)
Female
Male

Table 9. Life Table: 1st Speeding Violation over 36 Months after Licensure, Young Female Drivers

Month	Number Entering	Number Censored	Number at Risk	Number Violating	Proportion Violating (Hazard Rate)	Proportion Surviving Violation-Free	Cumulative Proportion Surviving (Survival Function)
1	21,160	0	21,160	20	0.000945	0.999055	0.999055
2	21,140	8	21,132	49	0.002319	0.997681	0.996738
3	21,083	69	21,014	55	0.002617	0.997383	0.994129
4	20,959	59	20,900	62	0.002967	0.997033	0.99118
5	20,838	69	20,769	67	0.003226	0.996774	0.987983
6	20,702	49	20,653	63	0.00305	0.99695	0.984969
7	20,590	57	20,533	69	0.00336	0.99664	0.981659
8	20,464	64	20,400	55	0.002696	0.997304	0.979013
9	20,345	59	20,286	57	0.00281	0.99719	0.976262
10	20,229	57	20,172	56	0.002776	0.997224	0.973552
11	20,116	66	20,050	65	0.003242	0.996758	0.970395
12	19,985	85	19,900	67	0.003367	0.996633	0.967128
13	19,833	53	19,780	63	0.003185	0.996815	0.964048
14	19,717	69	19,648	58	0.002952	0.997048	0.961202
15	19,590	62	19,528	76	0.003892	0.996108	0.957461
16	19,452	63	19,389	74	0.003817	0.996183	0.953807
17	19,315	55	19,260	61	0.003167	0.996833	0.950786
18	19,199	69	19,130	75	0.003921	0.996079	0.947058
19	19,055	47	19,008	73	0.00384	0.99616	0.943421
20	18,935	47	18,888	65	0.003441	0.996559	0.940175
21	18,823	45	18,778	74	0.003941	0.996059	0.93647
22	18,704	58	18,646	78	0.004183	0.995817	0.932552
23	18,568	75	18,493	92	0.004975	0.995025	0.927913
24	18,401	67	18,334	63	0.003436	0.996564	0.924724
25	18,271	61	18,210	78	0.004283	0.995717	0.920763
26	18,132	84	18,048	63	0.003491	0.996509	0.917549
27	17,985	59	17,926	78	0.004351	0.995649	0.913557
28	17,848	65	17,783	77	0.00433	0.99567	0.909601
29	17,706	59	17,647	81	0.00459	0.99541	0.905426
30	17,566	44	17,522	69	0.003938	0.996062	0.901861
31	17,453	51	17,402	82	0.004712	0.995288	0.897611
32	17,320	47	17,273	86	0.004979	0.995021	0.893142
33	17,187	44	17,143	71	0.004142	0.995858	0.889443
34	17,072	52	17,020	64	0.00376	0.99624	0.886098
35	16,956	50	16,906	71	0.0042	0.9958	0.882377
36	16,835	66	16,769	84	0.005009	0.994991	0.877957

Explanation of Columns: See Table 3 note.

Table 10. Life Table: 1st Speeding Violation over 36 Months after Licensure, Young Male Drivers

Month	Number Entering	Number Censored	Number at Risk	Number Violating	Proportion Violating (Hazard Rate)	Proportion Surviving Violation-Free	Cumulative Proportion Surviving (Survival Function)
1	24,427	0	24,427	104	0.004258	0.995742	0.995742
2	24,323	15	24,308	165	0.006788	0.993212	0.988983
3	24,143	70	24,073	176	0.007311	0.992689	0.981753
4	23,897	77	23,820	170	0.007137	0.992863	0.974746
5	23,650	73	23,577	164	0.006956	0.993044	0.967966
6	23,413	51	23,362	163	0.006977	0.993023	0.961212
7	23,199	66	23,133	179	0.007738	0.992262	0.953775
8	22,954	83	22,871	174	0.007608	0.992392	0.946518
9	22,697	73	22,624	173	0.007647	0.992353	0.939281
10	22,451	79	22,372	182	0.008135	0.991865	0.931639
11	22,190	64	22,126	174	0.007864	0.992136	0.924313
12	21,952	66	21,886	168	0.007676	0.992324	0.917218
13	21,718	73	21,645	178	0.008224	0.991776	0.909675
14	21,467	53	21,414	174	0.008126	0.991874	0.902283
15	21,240	59	21,181	170	0.008026	0.991974	0.895042
16	21,011	57	20,954	160	0.007636	0.992364	0.888207
17	20,794	73	20,721	169	0.008156	0.991844	0.880963
18	20,552	51	20,501	164	0.008	0.992	0.873916
19	20,337	60	20,277	185	0.009124	0.990876	0.865942
20	20,092	57	20,035	166	0.008286	0.991714	0.858768
21	19,869	73	19,796	170	0.008588	0.991412	0.851393
22	19,626	87	19,539	142	0.007268	0.992732	0.845205
23	19,397	67	19,330	175	0.009053	0.990947	0.837553
24	19,155	64	19,091	163	0.008538	0.991462	0.830402
25	18,928	65	18,863	161	0.008535	0.991465	0.823315
26	18,702	61	18,641	149	0.007993	0.992007	0.816734
27	18,492	61	18,431	158	0.008573	0.991427	0.809732
28	18,273	75	18,198	197	0.010825	0.989175	0.800967
29	18,001	77	17,924	173	0.009652	0.990348	0.793236
30	17,751	70	17,681	133	0.007522	0.992478	0.787269
31	17,548	51	17,497	128	0.007316	0.992684	0.78151
32	17,369	56	17,313	149	0.008606	0.991394	0.774784
33	17,164	46	17,118	161	0.009405	0.990595	0.767497
34	16,957	59	16,898	141	0.008344	0.991656	0.761093
35	16,757	54	16,703	138	0.008262	0.991738	0.754805
36	16,565	52	16,513	132	0.007994	0.992006	0.748771

Explanation of Columns: See Table 3 note.

Figure 13.

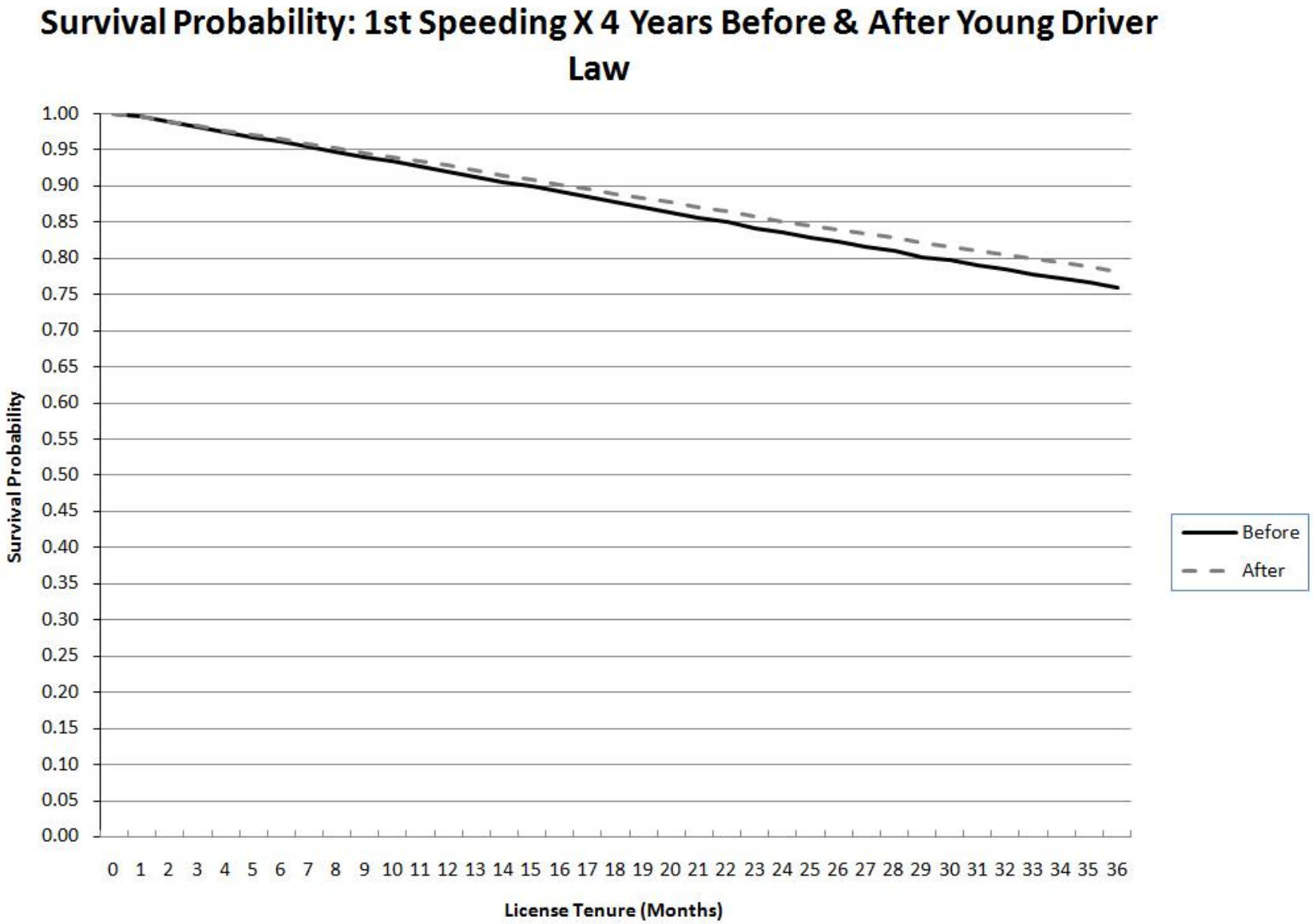

Survival Probability: 1st Speeding X 4 Years Before & After Young Driver Law
Survival Probability
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
License Tenure (Months)
Before
After

Table 11. Life Table: 1st Speeding Violation over 36 Months after Licensure, Before Young Driver Law

Month	Number Entering	Number Censored	Number at Risk	Number Violating	Proportion Violating (Hazard Rate)	Proportion Surviving Violation-Free	Cumulative Proportion Surviving (Survival Function)
1	6,472	0	6,472	24	0.003708	0.996292	0.996292
2	6,448	0	6,448	47	0.007289	0.992711	0.98903
3	6,401	0	6,401	48	0.007499	0.992501	0.981613
4	6,353	0	6,353	47	0.007398	0.992602	0.974351
5	6,306	0	6,306	40	0.006343	0.993657	0.968171
6	6,266	1	6,265	45	0.007183	0.992817	0.961216
7	6,220	0	6,220	45	0.007235	0.992765	0.954262
8	6,175	0	6,175	42	0.006802	0.993198	0.947772
9	6,133	0	6,133	44	0.007174	0.992826	0.940972
10	6,089	0	6,089	34	0.005584	0.994416	0.935718
11	6,055	0	6,055	50	0.008258	0.991742	0.927991
12	6,005	0	6,005	37	0.006162	0.993838	0.922273
13	5,968	1	5,967	45	0.007541	0.992459	0.915318
14	5,922	0	5,922	49	0.008274	0.991726	0.907744
15	5,873	0	5,873	32	0.005449	0.994551	0.902798
16	5,841	0	5,841	56	0.009587	0.990413	0.894143
17	5,785	0	5,785	48	0.008297	0.991703	0.886724
18	5,737	0	5,737	45	0.007844	0.992156	0.879769
19	5,692	0	5,692	47	0.008257	0.991743	0.872504
20	5,645	0	5,645	41	0.007263	0.992737	0.866167
21	5,604	0	5,604	47	0.008387	0.991613	0.858903
22	5,557	0	5,557	45	0.008098	0.991902	0.851947
23	5,512	0	5,512	52	0.009434	0.990566	0.84391
24	5,460	1	5,459	40	0.007327	0.992673	0.837727
25	5,419	0	5,419	34	0.006274	0.993726	0.83247
26	5,385	0	5,385	43	0.007985	0.992015	0.825823
27	5,342	0	5,342	44	0.008237	0.991763	0.819021
28	5,298	0	5,298	35	0.006606	0.993394	0.81361
29	5,263	1	5,262	57	0.010832	0.989168	0.804797
30	5,205	0	5,205	29	0.005572	0.994428	0.800313
31	5,176	0	5,176	44	0.008501	0.991499	0.79351
32	5,132	0	5,132	42	0.008184	0.991816	0.787016
33	5,090	0	5,090	46	0.009037	0.990963	0.779903
34	5,044	1	5,043	38	0.007535	0.992465	0.774027
35	5,005	0	5,005	45	0.008991	0.991009	0.767067
36	4,960	0	4,960	54	0.010887	0.989113	0.758716

Explanation of Columns: See Table 3 note.

Table 12. Life Table: 1st Speeding Violation over 36 Months after Licensure, After Young Driver Law

Month	Number Entering	Number Censored	Number at Risk	Number Violating	Proportion Violating (Hazard Rate)	Proportion Surviving Violation-Free	Cumulative Proportion Surviving (Survival Function)
1	6,141	0	6,141	23	0.003745	0.996255	0.996255
2	6,118	0	6,118	44	0.007192	0.992808	0.98909
3	6,074	0	6,074	41	0.00675	0.99325	0.982413
4	6,033	0	6,033	36	0.005967	0.994033	0.976551
5	5,997	0	5,997	36	0.006003	0.993997	0.970689
6	5,961	0	5,961	39	0.006543	0.993457	0.964338
7	5,922	0	5,922	43	0.007261	0.992739	0.957336
8	5,879	0	5,879	42	0.007144	0.992856	0.950497
9	5,837	0	5,837	40	0.006853	0.993147	0.943983
10	5,797	1	5,796	38	0.006556	0.993444	0.937794
11	5,758	0	5,758	35	0.006078	0.993922	0.932094
12	5,723	1	5,722	37	0.006466	0.993534	0.926067
13	5,685	0	5,685	44	0.00774	0.99226	0.918899
14	5,641	1	5,640	38	0.006738	0.993262	0.912708
15	5,602	0	5,602	47	0.00839	0.99161	0.90505
16	5,555	1	5,554	37	0.006662	0.993338	0.899021
17	5,517	0	5,517	35	0.006344	0.993656	0.893318
18	5,482	0	5,482	44	0.008026	0.991974	0.886148
19	5,438	0	5,438	43	0.007907	0.992093	0.879141
20	5,395	0	5,395	32	0.005931	0.994069	0.873926
21	5,363	1	5,362	43	0.008019	0.991981	0.866918
22	5,319	0	5,319	35	0.00658	0.99342	0.861213
23	5,284	0	5,284	43	0.008138	0.991862	0.854205
24	5,241	1	5,240	44	0.008397	0.991603	0.847032
25	5,196	1	5,195	34	0.006545	0.993455	0.841489
26	5,161	0	5,161	28	0.005425	0.994575	0.836923
27	5,133	0	5,133	45	0.008767	0.991233	0.829586
28	5,088	0	5,088	39	0.007665	0.992335	0.823227
29	5,049	0	5,049	41	0.00812	0.99188	0.816542
30	5,008	1	5,007	26	0.005193	0.994807	0.812302
31	4,981	0	4,981	35	0.007027	0.992973	0.806594
32	4,946	0	4,946	35	0.007076	0.992924	0.800887
33	4,911	0	4,911	32	0.006516	0.993484	0.795668
34	4,879	0	4,879	29	0.005944	0.994056	0.790939
35	4,850	0	4,850	26	0.005361	0.994639	0.786699
36	4,824	1	4,823	37	0.007672	0.992328	0.780663

Explanation of Columns: See Table 3 note.

Random Coefficient Modeling

Whereas survival analysis addresses the question of *whether* and *when* violations occur, random coefficient modeling tests the effects of sanctions on future driving behavior. Because points are assigned to drivers based on the specific violations committed, the cumulative point total for each driver serves as a reasonable indicator of driving safety over time.

On the day of licensure, each driver begins with zero points (excluding those with pre-licensure violations). As we know from analyses reported earlier, some drivers will not be convicted of any violations; this yields a flat trajectory indicating a lifetime point total of zero for this subset of the driving population. In contrast, for a driver convicted of multiple points-earning violations the trajectory has a positive slope, indicating that he or she is earning points at a non-zero rate over time (e.g., 2 points per year). As the violation data show, some drivers accrue dozens of points. The question that random coefficient modeling addresses is: What are the effects of sanctions on drivers' future point accumulation rates? If sanctions are effective, they should "break the trend" in drivers' point accumulation rates. If sanctions are ineffective, point accumulation rates should continue to follow the trends established before the sanctions were applied.

The type of random coefficient modeling employed here (i.e., modeling *discontinuous individual change*) requires specification of the variable to be modeled (accumulated point totals), a metric for time (years since Pennsylvania licensure), event dates (date of each points-earning violation), sanction dates (date when a given sanction was triggered), and an index of the end of time (June, 2007 or whenever the driver stopped driving). The first part of the analysis provides the estimated average accumulated point trajectory for drivers *before* a sanction was applied. The second part of the analysis provides the estimated average accumulated point trajectory for drivers *after* a sanction was applied. The difference between these two trajectories provides an estimate of the effectiveness of the sanctions.

To be included in this analysis and to properly construct a point trajectory, a driver must have committed two or more points-earning violations *and* received one of six types of sanctions: (1) Special Written Exam, (2) Type II Hearing, (3) Type III Hearing, (4) Suspension, (5) Speed Hearing, and (6) Young Driver Hearing. These analyses included only first-time applications of each type of sanction to a driver. The current sanction process was instituted by PennDOT in October, 1990. To evaluate the effectiveness of this sanction process, drivers who were licensed prior to October 1, 1990 (and therefore subject to the previous sanction process) were excluded. As we know from analyses reported earlier, most drivers are convicted of less than two violations during their driving careers. To ensure a sample of sufficient size, all drivers who met the above criteria were drawn from the full database of approximately 1.6 million drivers provided to the researchers.

A total of 48,749 drivers who met the above criteria were included in this data set. Among them, they accumulated 138,459 violations and 464,351 points. Table 13 summarizes results of random coefficient modeling to test the effectiveness of the six types of sanctions. These results are described in greater detail below.

Table 13. Summary of Random Coefficient Modeling Analyses

Number Of Drivers In The Analysis	Pre-Sanction Point Accumulation Rate (Points Per Year)	Sanction Type	Post-Sanction Point Accum. Rate (Points Per Year)	Effect Of Sanction On Point Accum. Rate	Percent Reduction In Point Accum. Rate	Annual Reduction In Points & 3-Point Violations		
						Points	=	Violations
21,350	0.79	Written 6-pt Exam	0.71	-0.08	10%	17,080	=	5,693
5,423	2.35	Type II Hearing	0.79	-1.56	66%	84,600	=	28,200
1,281	2.94	Type III Hearing	0.61	-2.33	79%	29,850	=	9,950
20,692	1.08	Suspension	0.52	-0.56	52%	115,880	=	38,627
2,265	1.43	Speed Hearing	0.71	-0.72	50%	16,310	=	5,437
246	3.35	Young Driver Hearing	1.08	-2.27	68%	5,580	=	1,860
					TOTAL :	269,280	=	89,760

Note. Analysis is based on an original data set of 10% of driver records including 48,749 drivers, 138,459 violations, and 464,351 points. Annual reductions in points and violations shown in columns 7 and 8 are extrapolated from the 10% driver records sample to the full population.

Males:

Number Of Drivers In The Analysis	Pre-Sanction Point Accumulation Rate (Points Per Year)	Sanction Type	Post-Sanction Point Accum. Rate (Points Per Year)	Esimated Effect Of Sanction On Point Accum. Rate	Estimated Percent Reduction In Point Accum. Rate
15,862	0.86	Written 6-pt Exam	0.74	-0.12	14%
4,429	2.38	Type II Hearing	0.80	-1.58	66%
1,114	2.95	Type III Hearing	0.62	-2.33	79%
15,651	1.20	Suspension	0.53	-0.67	56%
1,834	1.55	Speed Hearing	0.73	-0.82	53%
217	3.55	Young Driver Hearing	1.08	-2.47	70%

Females:

Number Of Drivers In The Analysis	Pre-Sanction Point Accumulation Rate (Points Per Year)	Sanction Type	Post-Sanction Point Accum. Rate (Points Per Year)	Esimated Effect Of Sanction On Point Accum. Rate	Estimated Percent Reduction In Point Accum. Rate	
5,488	0.61	Written 6-pt Exam	0.60	-0.01	2%	{ value not statistically significant
994	2.19	Type II Hearing	0.68	-1.51	69%	
167	2.86	Type III Hearing	0.52	-2.34	82%	
5,041	0.74	Suspension	0.49	-0.25	25%	
431	0.89	Speed Hearing	0.62	-0.27	30%	
29	1.33	Young Driver Hearing	1.05	-0.28	21%	{ value not statistically significant

Effectiveness of Special Written Exams, Type II Hearings, and Type III Hearings

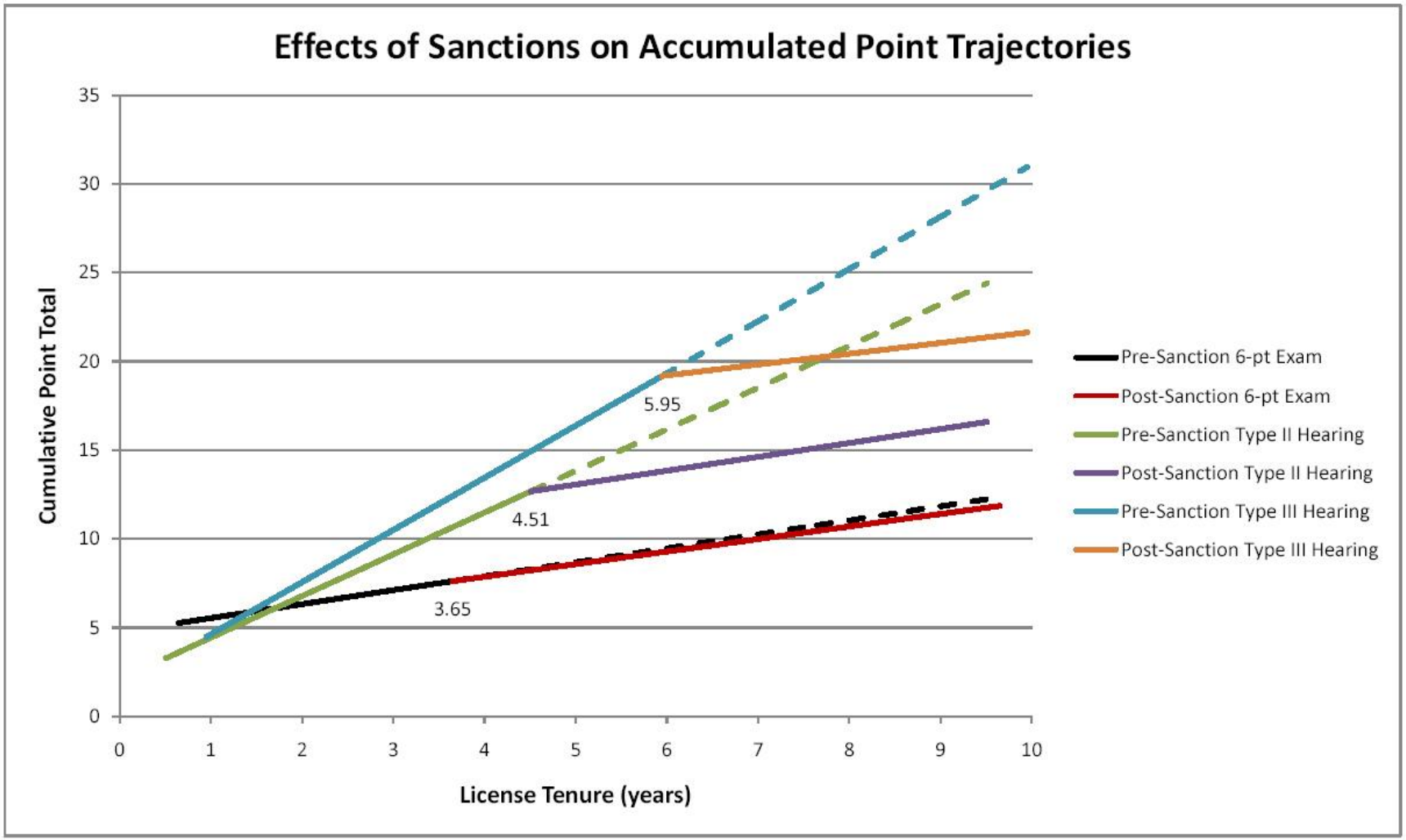
As shown in Table 13, 21,350 drivers took a Special Written Exam (triggered when a driver's point total reaches 6 or more). The accumulated point trajectory before the Exam (pre-sanction) was 0.79, which means that on average, drivers accumulated less than one point per year before taking the Exam. The accumulated point trajectory following the Exam (post-sanction) was 0.71. The difference between these two values is 0.08, and shows that there was a modest reduction (10%) in the average rate at which drivers continued earning points after taking the Exam. The practical implications of this reduction become more evident when considering the high number of drivers who took the Exam relative to other sanctions. As shown in Table 13, when the .08 reduction is multiplied by the 21,350 drivers with license numbers ending in '1' who took the Exam, and adjusting for the fact that this sample was $1/10^{th}$ of the total population, drivers earned an estimated 17,080 *fewer points per year* (or are convicted of what would be equivalent to 5,693 fewer 3-point violations per year) following the sanction. However, as we show below, even when considered against the relatively high volume of drivers who take the Exam, the practical effect is modest when compared with other sanction types.

Table 13 also shows that 5,423 drivers attended a Type II Hearing (generally triggered when a driver's point total reaches 6 or more for the second time). The pre-sanction accumulated point trajectory was 2.35, which means that on average, drivers accumulated more than two points per year before attending a Type II Hearing. The post-sanction accumulated point trajectory was 0.79, which indicates that on average, drivers accumulated less than one point per year after a Type II Hearing. The difference of 1.56 between these two values is a 66% reduction in the rate at which drivers continued earning points after a Type II Hearing. Considering the practical implications of this reduction (multiplying the 1.56 reduction by the 5,423 drivers who attended a Type II Hearing and extrapolating to the full population), Table 13 shows that drivers earned an estimated 84,600 *fewer points per year* (or are convicted of what would be equivalent to 28,200 fewer 3-point violations per year) following the sanction.

Table 13 shows that 1,281 drivers attended a Type III Hearing (generally triggered when a driver's point total reaches 6 or more for the third time). The pre-sanction accumulated point trajectory of 2.94 means that on average, drivers accumulated almost three points per year before attending a Type III Hearing. The post-sanction accumulated point trajectory of 0.61 indicates that, on average, drivers accumulated less than one point per year after a Type III Hearing. The difference of 2.33 is a 79% reduction in the rate at which drivers continued earning points after a Type III Hearing. In practical terms, multiplying the 2.33 reduction by the 1,281 drivers who attended a Type III Hearing and extrapolating to the full population reveals that drivers earned an estimated 29,850 *fewer points per year* (or are convicted of what would be equivalent to 9,950 fewer 3-point violations per year) following the sanction.

The results of these analyses are illustrated in Figure 14. The trajectory of an average driver is shown for each of the three sanction types (Special Written Exam, Type II Hearing, Type III Hearing), beginning with the date of initial licensure. The point at which the sanction is applied to the average driver (i.e., average elapsed time in years since licensure) is found where the initial trajectory breaks into two separate lines. The dashed line shows (hypothetically) how the

Figure 14.


Effects of Sanctions on Accumulated Point Trajectories
Cumulative Point Total
License Tenure (years)
0
5
10
15
20
25
30
35
0
1
2
3
4
5
6
7
8
9
10
3.65
4.51
5.95
Pre-Sanction 6-pt Exam
Post-Sanction 6-pt Exam
Pre-Sanction Type II Hearing
Post-Sanction Type II Hearing
Pre-Sanction Type III Hearing
Post-Sanction Type III Hearing

pre-sanction trajectory would have evolved had the driver continued earning points at the pre-sanction rate. The second line (shown in a different color), indicates the actual point trajectory for the average driver following the sanction. The differences in slope between the pre- and post-sanction trajectories illustrate sanction effectiveness. The conclusion from Figure 14 is that the three sanction types reduce the rate of future violations and point accumulations.

Effectiveness of Suspensions

As shown in Table 13, driving privileges of 20,692 drivers were suspended for points-earning violations. (Note that drivers who incurred suspensions for DUI violations were not included in these analyses, as suspensions but not points are imposed for DUI convictions.) The pre-sanction accumulated point trajectory was 1.08, meaning that on average, drivers accumulated about one point per year before receiving a suspension. The post-sanction accumulated point trajectory was 0.52, which indicates that on average, drivers accumulated about one-half point per year after suspension. The difference of 0.56 between these two values is a 52% reduction in the rate at which drivers continued earning points after a suspension. Considering the practical implications of this reduction (multiplying the .56 reduction by the 20,692 suspended drivers and extrapolating to the full population), these drivers earned an estimated 115,880 *fewer points per year* (or are convicted of what would be equivalent to 38,627 fewer 3-point violations per year) following the sanction.

Because a variety of factors determine the length of a suspension (e.g., type of violation, driving record), we tested whether the effects of suspensions depend on their durations. The results of this analysis are shown in Figure 15 for suspension durations of 15, 90, 180, and 365 days. As shown, the slope of the post-sanction point trajectory is less steep (i.e., shows a greater reduction in rate of accumulation of points) as the suspension duration increases. Note that the post-365-day trajectory is flat for the first year after the suspension is applied, consistent with the fact that drivers do not have driving privileges during this period (and presumably are not driving); also, drivers who commit driving violations while suspended receive additional suspensions, not additional points. The conclusion from Figure 15 is that suspensions of any duration are effective; longer duration suspensions are somewhat more effective in reducing the rate of future violations and point accumulations.

Effectiveness of Speed Hearings and Young Driver Hearings

As shown in Table 13, 2,265 drivers attended a Speed Hearing. The pre-sanction accumulated point trajectory was 1.43, which means that on average, drivers accumulated nearly one and a half points per year before attending a Speed Hearing. The post-sanction accumulated point trajectory was 0.71, which indicates that on average, drivers accumulated less than one point per year after a Speed Hearing. The difference of 0.72 between these two values shows a 50% reduction in the rate at which drivers continued earning points after a Speed Hearing. The practical implications of this reduction (multiplying the .72 reduction by the 2,265 drivers who attended a Type II Hearing and extrapolating to the full population) are that drivers earned an estimated 16,310 *fewer points per year* (or are convicted of what would be equivalent to 5,437 fewer 3-point violations per year) following the sanction.

Figure 15.

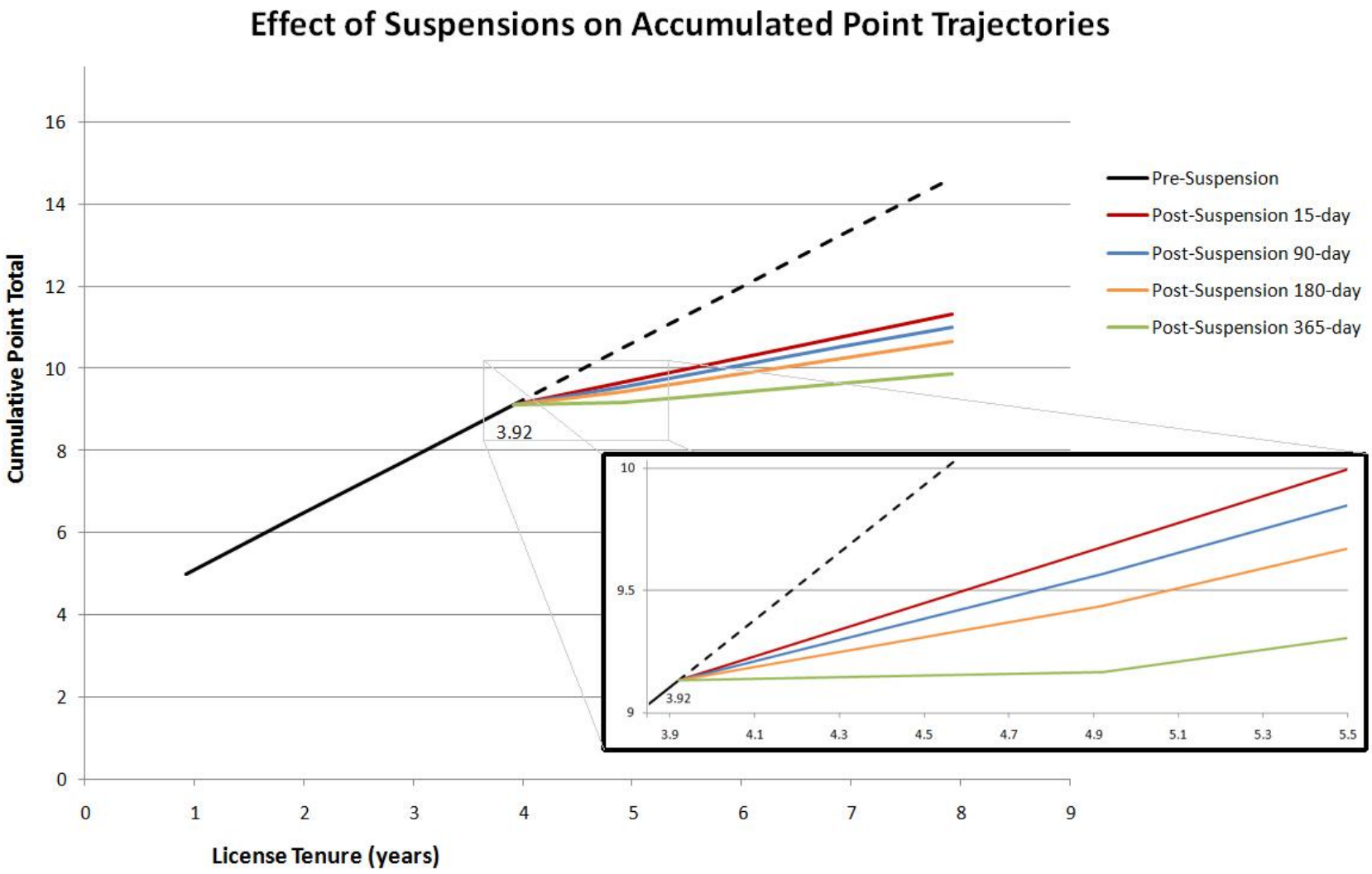

Effect of Suspensions on Accumulated Point Trajectories
Cumulative Point Total
License Tenure (years)
3.92
Pre-Suspension
Post-Suspension 15-day
Post-Suspension 90-day
Post-Suspension 180-day
Post-Suspension 365-day

Table 13 shows that 246 drivers attended a Young Driver Hearing. The pre-sanction accumulated point trajectory of 3.35 means that, on average, drivers accumulated more than three points per year before attending a Young Driver Hearing. The post-sanction accumulated point trajectory of 1.08 indicates that, on average, drivers accumulated just over one point per year after a Young Driver Hearing. The difference of 2.27 yields a 68% reduction in the rate at which drivers continued earning points after a Young Driver Hearing. In practical terms, multiplying the 2.27 reduction by the 246 drivers who attended a Young Driver Hearing, and extrapolating to the full population, reveals that drivers earned an estimated 5,580 *fewer points per year* (or are convicted of what would be equivalent to 1,860 fewer 3-point violations per year) following the sanction.

Figure 16 illustrates the accumulated point trajectory of an average driver for both sanction types (Speed Hearing, Young Driver Hearing) beginning with the date of initial Pennsylvania licensure. As before, the point at which the sanction was applied to the average driver is found where the initial trajectory breaks into two separate lines. The dashed line shows how the pre-sanction trajectory would evolve had the driver continued earning points at his/her pre-sanction rate, and the second line (shown in a different color) indicates the actual point trajectory for the average driver following the sanction. The differences in slope between the pre- and post-sanction trajectories illustrate sanction effectiveness. The conclusion from Figure 16 is that the two sanctions reduce the rate of future violations and point accumulations.

Gender Differences in Effectiveness of Sanctions

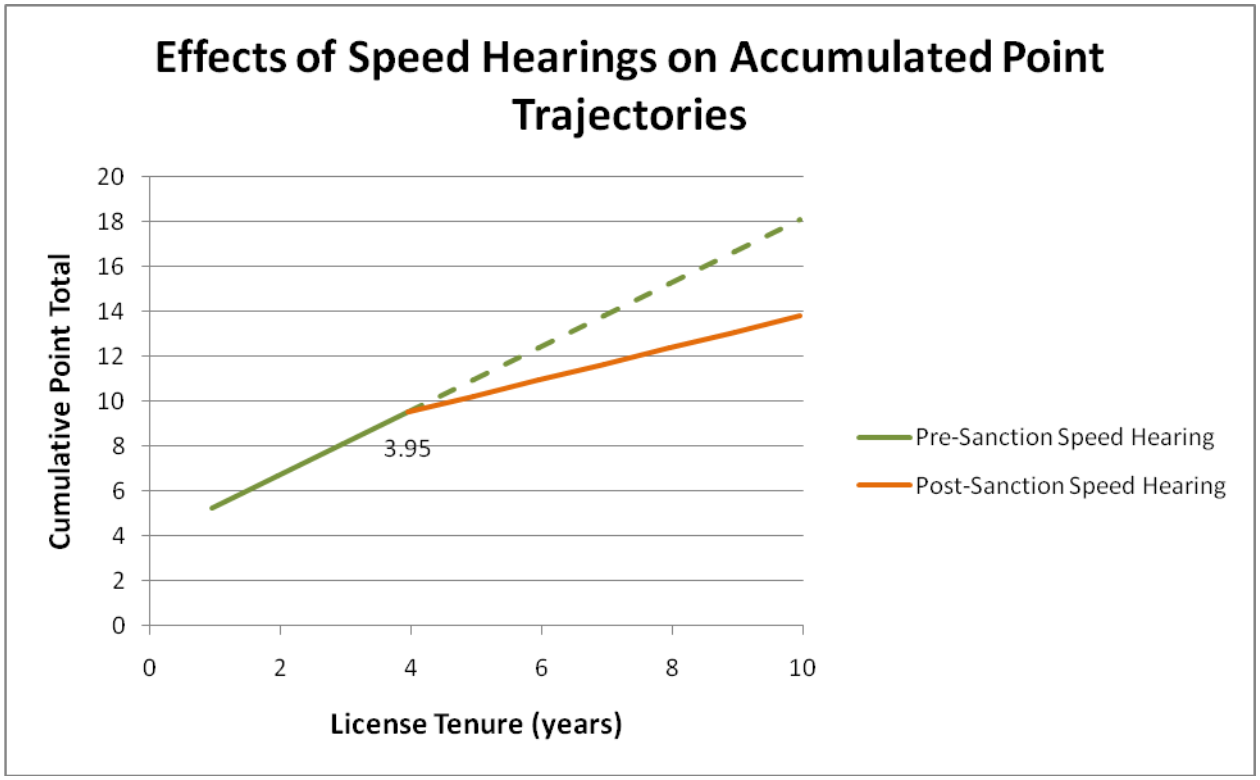
The analyses discussed above were conducted separately for male and female drivers to test whether the effects of sanctions on post-sanction point trajectories differed based on gender. As shown in Table 13, some gender differences were found. Notably, the estimated effect of the sanction on the point accumulation rate was stronger for males than females for Special Written Exams, Suspensions, Speed Hearings, and Young Driver Hearings. The analyses for Young Driver Hearings should be interpreted cautiously, as this analysis is based on a very small number of female drivers ($N = 29$). There were no gender differences for Type II or Type III Hearings. Is sum, sanctions are more effective for males than females for four of six sanction types. For the remaining two types, sanctions are equally effective for males and females.

Violations and Sanctions

The overarching goal of PennDOT's sanction process is to encourage safer driving. Recommendations for improvements should build on the successes of the current process. As reported in previous sections, most drivers commit (or are convicted of) fewer than two violations during their driving careers and are not subject to most sanctions that PennDOT applies. Improvement recommendations should therefore (a) focus on changing the behavior of that segment of the driving population likely to commit multiple violations (i.e., problem drivers), and (b) enhance the deterrent effects of the sanction process for all drivers.

Figure 17 shows the average time since Pennsylvania licensure when drivers incurred each type of sanction for the first time. Most sanctions are applied to drivers who have committed two or

Figure 16.


Effects of Speed Hearings on Accumulated Point Trajectories
Cumulative Point Total
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
3.95
License Tenure (years)
Pre-Sanction Speed Hearing
Post-Sanction Speed Hearing

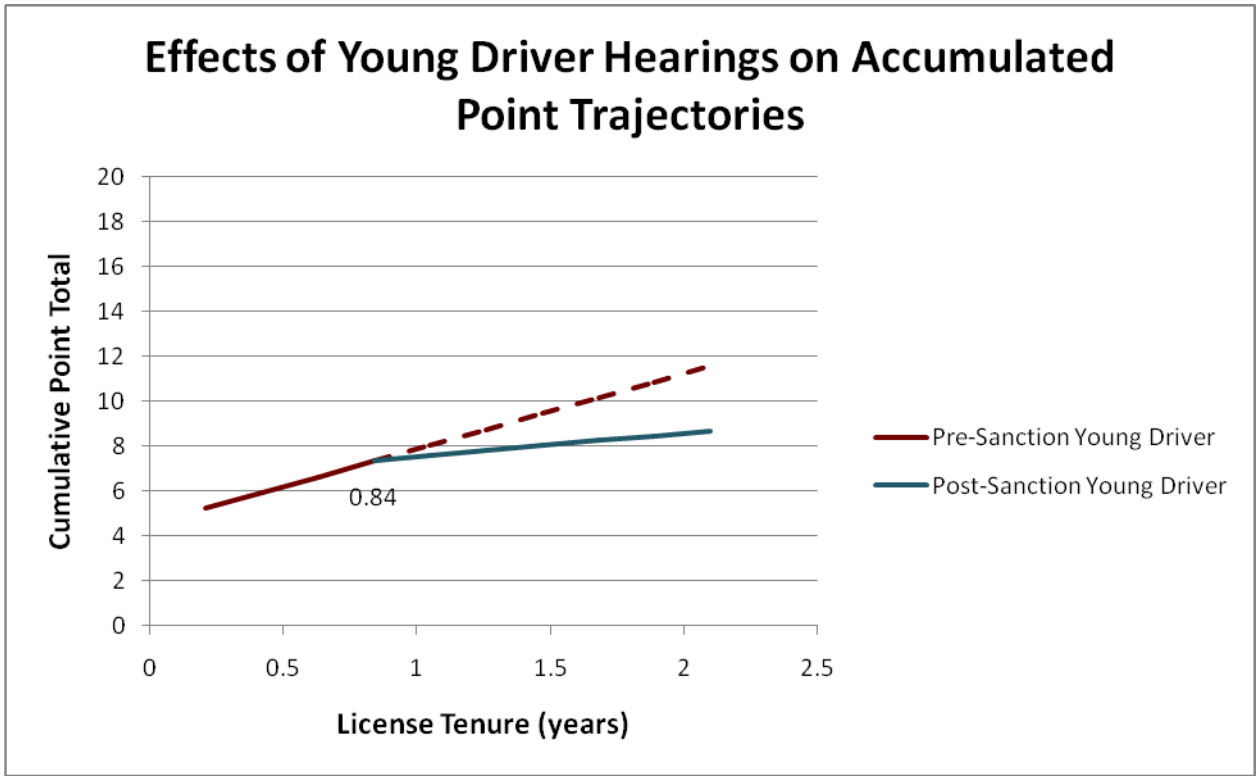
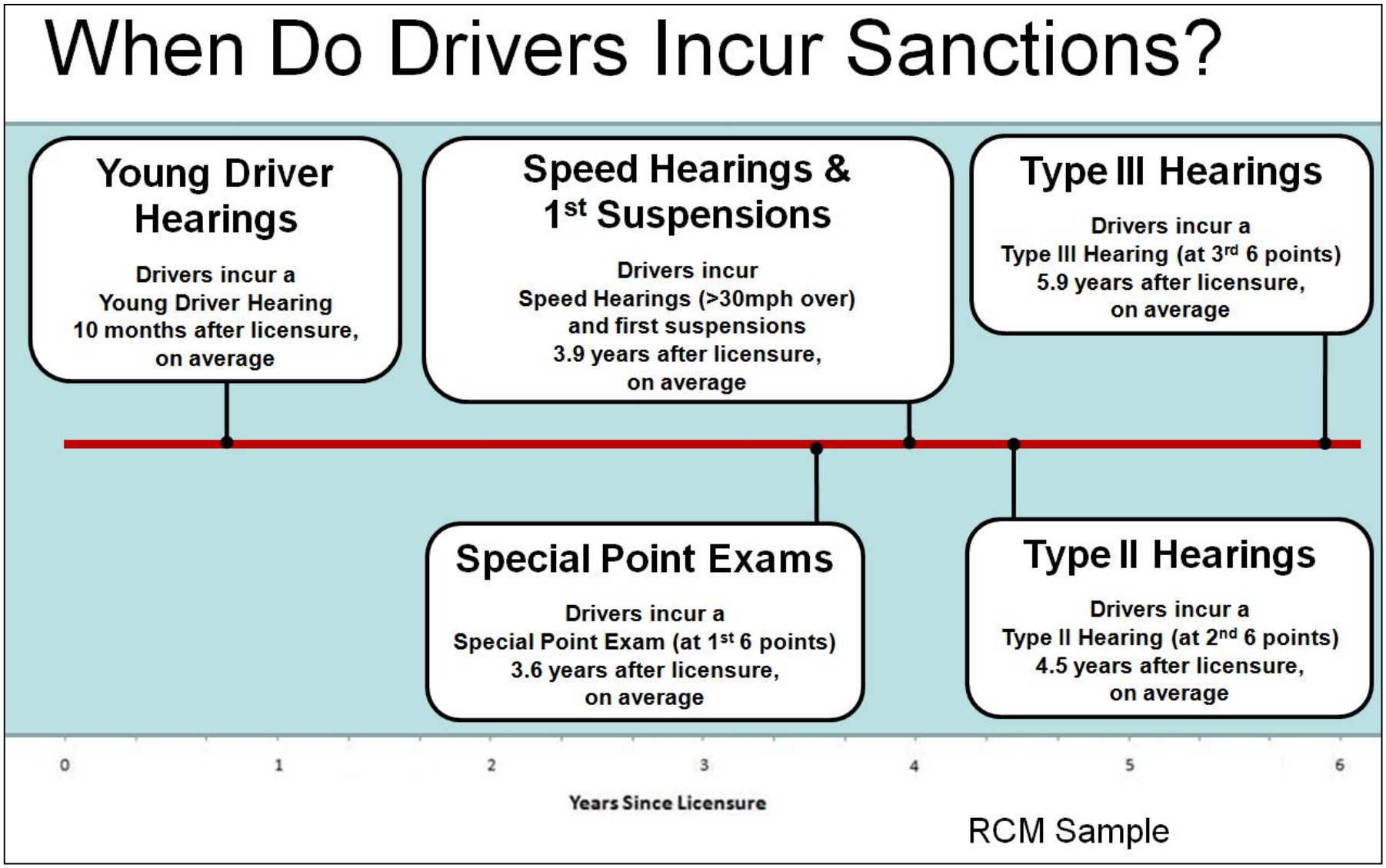

Effects of Young Driver Hearings on Accumulated Point Trajectories
Cumulative Point Total
20
18
16
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
0.84
License Tenure (years)
Pre-Sanction Young Driver
Post-Sanction Young Driver

Figure 17.


When Do Drivers Incur Sanctions?
Young Driver Hearings
Drivers incur a Young Driver Hearing 10 months after licensure, on average
Speed Hearings & 1st Suspensions
Drivers incur Speed Hearings (>30mph over) and first suspensions 3.9 years after licensure, on average
Type III Hearings
Drivers incur a Type III Hearing (at 3rd 6 points) 5.9 years after licensure, on average
Special Point Exams
Drivers incur a Special Point Exam (at 1st 6 points) 3.6 years after licensure, on average
Type II Hearings
Drivers incur a Type II Hearing (at 2nd 6 points) 4.5 years after licensure, on average
0
1
2
3
4
5
6
Years Since Licensure
RCM Sample

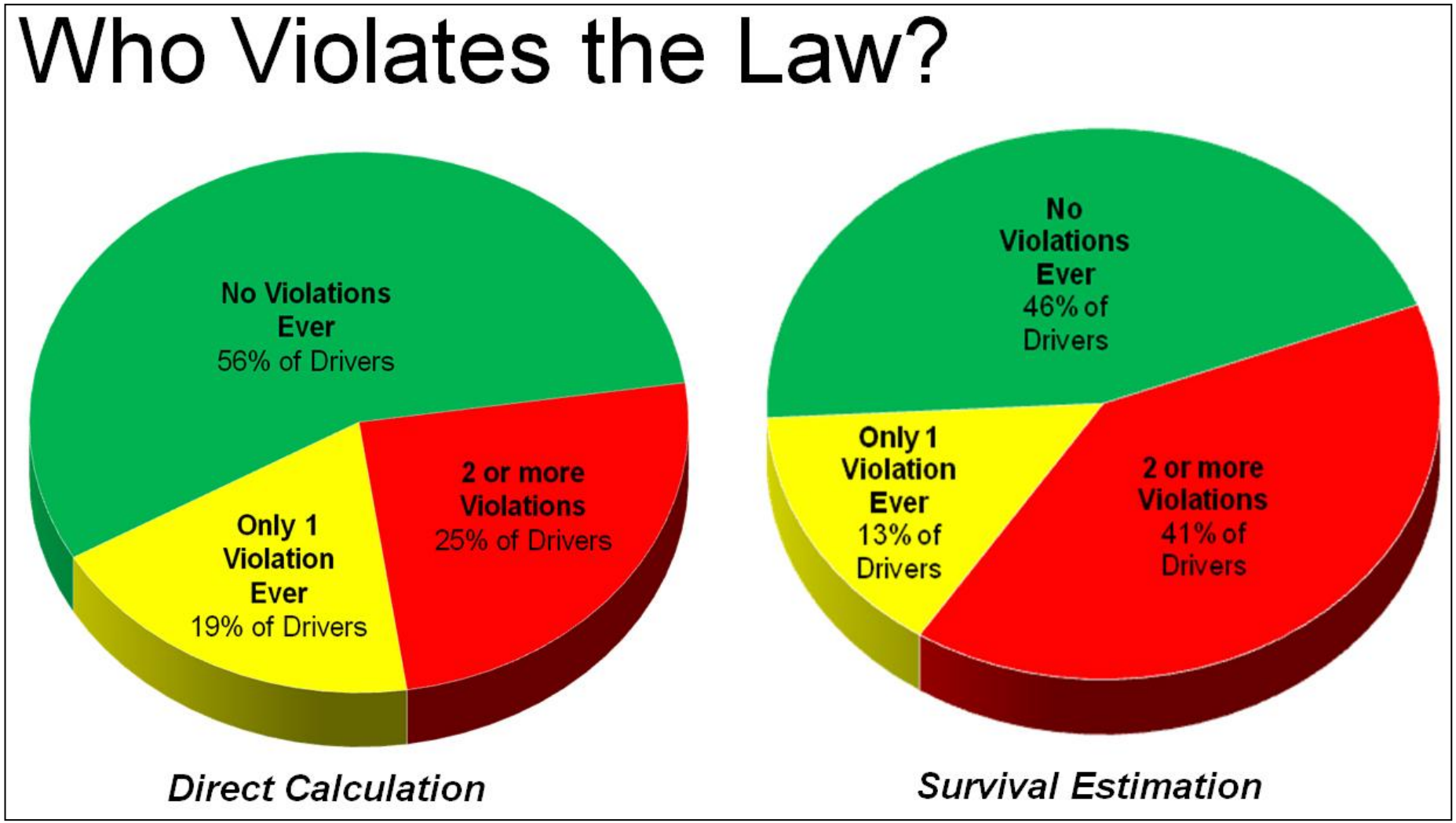
more violations. Survival analyses described above reveal a strong tendency for drivers with violations to commit a first violation soon after licensure, and a second violation soon after the first. Figure 17 complements these findings – on average, drivers incur first sanctions within six years of licensure, including the sequential sanctions of Special Point Exams, Type II Hearings, and Type III Hearings. Problem drivers appear to be a distinctly different subpopulation than drivers who are sanction-free, committing more violations sooner after licensure. Implications of these findings for sanction process improvement recommendations will be discussed in the next section.

Figure 18 shows the proportions with zero, one, and two or more violations among drivers who obtained a license since 1980. The pie chart on the left is based on direct calculations, whereas the pie chart on the right shows survival estimates. As explained earlier (p. 26), direct calculations do not take into account the fact that some drivers were observed for much longer periods than others, as determined by date of licensure. They therefore *underestimate* the proportions of drivers with two or more violations that would be obtained if all drivers were observed for their entire careers. Survival analysis estimates of drivers with two or more violations are greater than estimates derived from direct calculations because they adjust for differences among drivers in observation periods – in effect, they produce estimates of violations that drivers will have across their entire driving careers.

By either calculation, fewer than half of all drivers are expected to be convicted of two or more violations during their driving careers. In contemplating ways to improve the current driver sanctioning process, it is important to keep in mind that the current process appears to effectively deter most drivers from committing multiple violations. The goals of improvement recommendations should be to enhance the effectiveness of the current process as applied to problem drivers *and* to enhance its effectiveness as a deterrent against unsafe driving for all drivers.

Survival analysis assumes that censored drivers (i.e., drivers whose license tenure was less than the full observation period) do not differ in any important way from non-censored drivers (i.e., drivers who were observed for the entire period), except for having obtained their licenses more recently. We believe this assumption to be valid, and survival analyses provide better estimates of proportions of violators than direct calculations. However, factors such as improvements to the driver sanction process can threaten this assumption. For example, if awareness of the importance of safe driving increases among drivers, and if sanctions become even more effective, then survival analysis estimates of proportions of violators will prove to be overestimates. That is the goal of the recommendations for sanction process improvements offered in the next section.

Figure 18.


Who Violates the Law?
No Violations Ever
56% of Drivers
Only 1 Violation Ever
19% of Drivers
2 or more Violations
25% of Drivers
Direct Calculation
No Violations Ever
46% of Drivers
Only 1 Violation Ever
13% of Drivers
2 or more Violations
41% of Drivers
Survival Estimation

Task 4: Recommendations

As previously stated, the overarching goal of PennDOT's driver sanctioning process is to encourage safer driving. Recommendations for improvements should build on the successes of the current process. As reported in previous sections, most drivers commit (or are convicted of) fewer than two violations during their driving careers and are not subject to most sanctions that PennDOT applies. Improvement recommendations should therefore (a) focus on changing the behavior of that segment of the driving population likely to commit multiple violations, and (b) enhance the deterrent effects of the sanction process for all drivers.

Drivers who are sanctioned at some point during their driving careers appear to be a distinctly different subpopulation than drivers who remain sanction-free. Sanctioned drivers commit more violations sooner after licensure. However, sanctions are effective in improving their driving behavior; after a first sanction, the rate of accumulation of points for violations decreased by amounts ranging from 10% for Special Point Exams to 79% for Type III Hearings.

Note that alternative explanations attributing post-sanction reductions to causes other than sanctions cannot be entirely ruled out. It is possible, for instance, that with increasing age and maturity drivers naturally commit fewer violations. Drivers incur their first sanctions at different ages, however, and it is unlikely that age or any variable other than actual sanctions would coincide with the observed reductions in rates of point accumulations. We therefore conclude that sanctions have their intended effects – they encourage safer driving.

Some unsafe drivers, of course, do not respond to sanctions and continue to drive unsafely. Others require multiple sanctions before they improve. For example, drivers who incur a Type III Hearing have previously been subjected to one or more Special Point Exams and Type II Hearings. At the time of their first Type III Hearing, on average, drivers have been licensed for just under six years, accumulating violations and points at a rapid pace. The rate of post-sanction improvement for these drivers is the most dramatic of any sanction we studied. Most sanctioned drivers improve, although some drivers require multiple sanctions before they reform.

Estimates of proportions of drivers who commit two or more violations provided in previous sections vary depending on the sample studied and the type of estimate, either direct calculation from the data (24%) or survival analysis predictions (41%). We regard direct calculations as underestimates because they fail to adjust for differences among drivers in observation periods – in effect, many drivers in the sample who would eventually commit two or more violations have simply not had sufficient time to do so by the time the data were analyzed. On the other hand, survival analysis predictions assume that the future will be like the past – nothing will intervene in the future to influence driving behavior that wasn't also operating during the data gathering period. The goal of the recommendations presented next is to suggest changes to the sanction process that will improve their effectiveness. Once these improvements take effect, survival

predictions of multiple violators may prove to be overestimates. However, barring any such improvements, survival estimates better predict future rates of violations than direct calculations.

To drive safely and responsibly, drivers must (a) know the laws that regulate driving, (b) understand that driving is a privilege and that PennDOT administers driving privileges through its licensing and sanctioning processes, and (c) understand the linkages among unsafe driving, violations, points, and sanctions. Several major themes that underlie our recommendations follow from these points.

- First, we believe that many (indeed, probably most) drivers do not have a clear understanding of Pennsylvania's point and sanction system. Several recommendations address the need to make drivers more aware of the linkages among unsafe driving, violations, points, and sanctions. This is especially true for drivers with multiple violations and suspensions.
- Second, PennDOT's role as administrator of the driving privilege system should be more salient to drivers. Drivers should understand that PennDOT keeps records of all convictions for driving violations, even for those drivers who have never possessed a Pennsylvania driver's license, and that these records are shared with law enforcement agencies, the courts, and insurance companies. PennDOT can and does suspend or revoke driving privileges. We believe that greater understanding of the penalties for unsafe driving as well as PennDOT's authority to intervene by imposing sanctions will enhance the deterrent value of the sanction process and help drivers make better driving decisions.
- Third, the sanction process should distinguish among drivers who incur few if any convictions during their driving careers and those who commit violations early and often after licensure. Sanctions are effective in reducing violations – they should be applied sooner to drivers whose patterns of violations reveal a likelihood of becoming repeat or habitual offenders.
- Fourth, we endorse PennDOT's work in creating a new driver records database system that will make information from driving records more accessible to authorized personnel so that important trends in driving safety can be monitored and evaluated. Adjustments to the sanction process should be evidence-based, and this new database will support future decision makers.

RECOMMENDATIONS

A. Sanctions and the Sanctioning Process

A1: Type II Hearing within 3 Years after Licensure

Drivers who trigger a Type II Hearing (i.e., who reach six [6] points for a second time) within three (3) years after initial licensure should receive a 30-day suspension.

A2: Six Points within First 18 Months after Licensure

Drivers who accumulate six (6) or more points within their first 18 months after initial licensure should incur a Special Point Examination *and* a Departmental Hearing. The outcome of this hearing should be biased toward a suspension of at least 30 days. The hearing should immediately follow the Special Point Examination.

A3: Six Points within First 18 Months after Licensure for Young Drivers

Young drivers (16 – 17 years old) who accumulate six (6) or more points should incur a Special Point Examination *and* a Departmental Hearing. The outcome of this hearing should be a suspension of at least 90 days. The hearing should immediately follow the Special Point Examination. Enforce Section 1503(c3), Jr License of the Vehicle Code.

A4: The Special Point Examination

A4a. <u>Review and update the contents of the Special Point Examination.</u>
Review and revise for clarity items on the Special Point Examination. Expand the content coverage of items on the Special Point Examination to test knowledge of violations, points, and sanctions, in conjunction with expansion of content coverage of the Special Point Examination Driver's Handbook (see Recommendation A4b).

A4b. <u>Review and update the contents of the Special Point Examination Driver's Handbook.</u>
The Special Point Examination Driver's Handbook focuses on DUI and suspensions in Part 1. The safe driving section, Part 2, doesn't have any wording on the sanctions that may accompany unsafe driving, it really only focuses on how to avoid an accident. What is missing is information on what to expect if the driver doesn't change behavior -- more points, hearings, etc. Material that addresses points, sanctions, and the likelihood that past bad driving patterns will lead to further sanctions should be included. Understanding of this material should be assessed with questions added to the Special Point Examination.

**Note: See Appendix D for Supporting Materials relating to A4, Special Point Examination.*

B. Violations and Points

B1. Violation-free Drivers

Acknowledge drivers whose driving records remain violation-free. In the current system, there is no positive reinforcement for drivers who maintain violation-free driving records. There is only the absence of punishment that comes with sanctions. PennDOT should occasionally compliment violation-free drivers and remind them of the importance of safe driving, perhaps in license renewal letters. This would both reinforce safer driving practices and subtly remind drivers that PennDOT keeps records.

B2. Points and Sanction System Details

Make details of the points and sanction system more readily available to learners, drivers, and especially violators. Revise the Special Point Examination and Driver's Handbook (Publication 248) as follows:

B2a. Add the point system details to the Driver's Handbook. Express in an easy to understand format. Include in Part 1 of the Handbook, not as an appendix.

B2b. Include questions in the Sample Test Items (Part 1)
Regarding point values for specific violations and other relevant violation/sanction issues.

B2c. Include questions on the Special Point Examination
That determine working knowledge of the point system and sanctions for violations.

B2d. Add narrative to the Driver's Handbook
Perhaps in the form of short scenarios that describe common situations seen that lead to points, special exams, hearings and license revocation. See Appendix D for examples and illustrations.

B2e. Add information to the Driver's Handbook, Part 1
Regarding sanctions for non-driving offenses that exacerbate the impact of driving behavior violations.

B2f. Add an additional reference to the *Pennsylvania Point System Fact Sheet* in Chapter 6 of the Pennsylvania Driver's Manual (Publication 95).

B3. Frequently Asked Questions about Driving Privileges

Prepare FAQ sheet that describes the point system in a more user-friendly manner, like has been done with insurance documents – using personal pronouns and other readily identifiable language. Some of this language could be used in the Driver's

Handbook as described above. Include an FAQ as an insert with each letter informing drivers of violations and points.

Rationale:
Drivers do not appear to understand how easily they can trigger a Type II Hearing in the year following a Special Point Exam – one more violation is all it takes. The Exam appears to be an annoyance to drivers and little else; having passed it, they lose 2 points and think they're done with it. Drivers should be encouraged to contemplate their driving habits and realistically consider what they need to do to improve, and avoid another sanction. What we're after here is to increase the deterrence value of the Special Point Exam by making them realize that they could soon face more serious punishments; this increased awareness/salience will lead to better driving decisions and behavior.

C. Communications with Drivers

From the documents received in the course of the study, we grouped the various correspondences with motorists into categories and present recommendations for seven of the categories that deal most directly with sanctioning actions.

- General Violation (letters informing drivers of points due to a violation but no further action, e.g., speeding, careless driving)
- Special Point Exam Notification
- Hearing Notification
- 11 Point Notification
- Suspension Notification
- Failure to Respond Notification
- Young Driver Violation (driver and driver's parents)

C1. Letters to Violators

C1a. Write bolder, clearer, and more informative letters to violators.
Correspondence with motorists conveys the basic information regarding the violation and sanction as well as what is needed to be done resulting from the sanction. Yet, many of the letters can be written using more "plain English," and minimizing language that is clear to PennDOT, but potentially not clear to the typical motorist. Some of the wording currently used in letters to violators that could be clarified includes:

- In some instances, references to forms or publications are by number only; references to forms and publications should include number, title, and how to obtain a copy (if a copy is not included with the letter).
- In some instances, violations are referred to by abbreviations; the full violation name/description should be used.
- In some instances, the word *sanction* is used as a general term; use a specific term (such as suspension, hearing, special point examination) when that is what is meant. For example, an 11-point suspension letter states that "… a sanction of 55 DAY(S) is hereby imposed…".
- General statements such as having "6 or more points" should be replaced by statements citing the precise number of points on the person's record.

C1b. Include a subject line.
In general, letters could be more readily understood if there was a subject line including the significant sanction with date, such as "Suspension of license for 55 days effective February 29, 2008 12:01 a.m." or "Special Written Examination required by March 15, 2008" or some short description.

C1c. Organize information in letters using a consistent format.
A number of the letters reviewed showed a need for organization that groups together each of the basic elements to be communicated, e.g., all information

about the consequences of the sanction should be grouped together. Many letters have the consequence information described in one paragraph with a reference to more details about the sanction elsewhere in the letter. Letters can be organized in the following 5-step fashion – fully discussing each element:

1. Explanation of the violation
2. What sanction is imposed and why
    - Include list of violations for motorists having more than one violation
    - Include a reference to an enclosed *Pennsylvania Point System Fact Sheet*
3. What this means to the motorist
    - Warn that due to this history a more serious sanction, such as examination, hearing and/or loss of license, will likely be imposed at the next violation
4. What the motorist needs to do next and what happens if motorist does not comply and what may be the future
    - The consequences of not responding
    - How the motorist risks making things worse by failure to comply/respond
5. Recap of forms or attachments (with website references as well) and how to get relevant forms or publications if not enclosed with the letter

C1d. <u>Emphasize key messages.</u>

Specific messages should be emphasized appropriate to the reason for the letter. For example, it should be clearly stated in a *suspension* letter that, **"No credit toward serving the suspension or revocation shall be earned until the driver's license/learner's permit is surrendered to PennDOT" (PA Driver's Manual, p. 56).** The distinction between suspension period and credit for suspension should be clearly explained; it should be clear to the driver that a license must be surrendered or a suspension must be acknowledged, and that credit for a suspension period does not begin until the date of receipt of the license or acknowledgement by PennDOT.

C1e. <u>Address the issue of non-response/non-compliance.</u>

"What happens if I don't do what this letter says," is a question that a number of the letters do not address. Review each type of letter to determine if it provides a full and clear explanation of what will happen if the motorist does not comply within the timeframe specified. For example, a notification of the requirement to take and pass a special points examination states that no extensions will be granted, but there is no discussion of further sanctions or consequences if the motorist does not comply or if the motorist fails the examination. The letter refers the motorist to the Special Point Examination Driver's Handbook, which states in the first and last paragraphs of the document what the consequence is – license suspension, but this should be clearly stated in the body of the letter.

C1f. Enclose a copy of a driver's record.
Enclose a copy of a driving record with correspondence to violators having *more than one violation*. The list of the person's violations, whether they still are affecting the point total or not, provides a degree of personalization to the letter and conveys additional accountability to PennDOT. Having such information shows motorists their driving behavior history and reminds them they may have to "clean up their act."

C1g. Enclose a copy of the *Pennsylvania Point System Fact Sheet*.
Enclose a copy of the *Pennsylvania Point System Fact Sheet* with every letter, so that motorists can review what another violation will do to their driving privileges. Explain why this document is enclosed. Such addition is an expense for PennDOT, yet it can help motorists understand what is potentially in store for them if they do not change behavior, and it can make them generally more aware that consequences exist.

C1h. Enclose a copy of *Frequently Asked Questions about Driving Privileges*.
See Recommendation B3 for a description of this document.

C1i. Add Webpage(s) to PennDOT DMV website to describe the point system.
Each of the letters has contact information at the end. If people have questions by the time they read the whole letter, they can call for clarification. However, better direction to materials on the website and easier access to and more website information on the points system may reduce telephone calls.

**Note: See Appendix D for Supporting Materials relating to C1, Letters to Violators.*

C2. Letter Formats

Reformat letters, print on better quality stationery (including envelopes), with professional letterhead, an official seal or logo, better font, etc. Include authoritative statement on the outside of the envelope such as "Important Driver License Communication from PennDOT." The appearance and feel of the letter should convey authority and command attention – it should not be easily overlooked, forgotten, or inadvertently discarded as junk mail.

C3. No-Action Correspondence

When the decision following a hearing is to take no action, inform the driver of this via a letter that reminds the driver of the number of points currently on the driving record.

C4. Video Cameras in Examination/Hearing Rooms

A ceiling-mounted video camera should be clearly visible in each room used for examinations and hearings. Whether these are actually operational or not, drivers should have the impression that they are being monitored.

C5. Sanctioning Project Results

Make selected results of study available to driving public to inform drivers regarding risks and probability of violations and sanctions.

- Prepare a fact sheet or a FAQs sheet that discusses the risks associated with patterns of violations and their consequences that have been brought out by the study. Discuss findings about the timeframe and number of violations and the history of what has happened in the future to others having been in the same position.
- Incorporate these risks in Chapter 4 of the driver's manual.

C6. Media Coverage

At completion of the study, get media coverage on selected results to assist in communicating messages to Pennsylvania drivers. Message might focus on

- Lack of awareness of points and consequences.
- Issues surrounding revocation of license not well understood
- Hearings and exams promote better driving behavior
- Potential risks associated with age/number of violations

Rationale for Recommendations:

Most drivers appear to be only somewhat familiar with Pennsylvania's points and sanction process. They probably don't know how many points are assigned for violations, and lack specific understanding that some violations trigger hearings and/or suspensions, that accumulation of points leads to various sanctions, and so on. A goal of these recommendations is to increase driver awareness of the sanction process, thereby enhancing its deterrence value. The expectation is that informed drivers will make better choices in their driving behavior, leading ultimately to safer driving habits.

D. PennDOT Staff

D1. Share Study Findings

Use results of this study to encourage the workforce and to facilitate successful practices. Provide a synthesis of findings for distribution to PennDOT field hearing and examiner staff that shows benefit of their activities.

- Prepare briefing materials and a presentation for PennDOT executives
- Prepare handout information for staff

D2. Facilitate Staff Development

Have annual meetings of PennDOT staff involved in driver licensing and sanctioning to surface issues in need of attention, to share successful practices, to offer advice on dealing with difficult or irate drivers, and so on.

E. Database

E1. Violation Records

Store each violation for each driver as a single record, with an identifying "ViolationID". The ViolationID would serve as a key to link all information and transactions pertaining to a given violation. A report of violation records could easily assemble all data pertaining to a violation for a given driver. Currently, violation information is duplicated with every transaction related to that violation. Storing redundant data unnecessarily complicates the task of compiling a complete violation record. Proper database design would simplify the task of quickly identifying and sorting pertinent violation data.

E2. Point Histories

Point totals should be automatically updated by programming and applying the rules for adding and subtracting points. Currently, a driver could have 0 actual points but show many points. The point tally for any given driver is only updated as the record is accessed by PennDOT staff, whereupon it is updated by hand. This requires time and attention of PennDOT staff that could be directed to more productive activities, and leaves room for human error.

E3. Data Integrity Checks

Data errors should be corrected by running integrity checks periodically. This could also uncover any potential system errors causing data problems. Some data errors are due to the data being imported over many legacy systems, some are from human error. Simple things like mis-keyed dates should be fixed prior to importing data into a new database system. Other checks for unmatched codes (invalid codes not found in code tables), improper violation codes, etc., should also be run periodically.

E4. Legacy Data Flags

Because the driver records system has been updated many times since its inception, drivers who have been in the database for a long time may have incomplete, missing, or misleading data. For instance, the Original Issue Date for drivers receiving their licenses prior to 1980 is generally not an *original* issue date. Until 1980, the database only had a single field for "issue date." After a first renewal, a driver's record lost the actual original issue date (it was overwritten with the more recent issue date). A mechanism is needed to flag data fields for drivers whose data values were imported from legacy systems when the specific codes are no long used or their meaning has changed.

E5. Code Table Glossary

There are many code tables used in conjunction with the driver records system. A glossary/help area in the system would be very useful for quickly interpreting code values and selecting proper codes when entering data. The glossary should define cryptic code labels (e.g., "ISSUE INVITATION TO RECERT HM"). This would be helpful to PennDOT staff in entering data and when answering driver's questions

about their records, and to researchers and administrators who analyze and interpret the data.

E6. Reporting

Good reporting capabilities are very helpful, and essential for answering most questions anyone could have about data within the system. Some useful features of reporting from the driver records database could be:

E6a. Overall Driver Reports

1. Dynamic Reporting
   - allow selectable criteria to build a report on the fly
   - save the criteria to rerun later/with different parameters
2. Assess how many Speeding/DUI/etc., violations between selectable date ranges
3. Other dynamic reports to view current suspended drivers, OLLs, PLLs, revocations, etc.

E6b. Single Driver Reports

1. Lifetime totals (points, suspensions, number of violations, violation types, etc)
2. Current Violations on record, accounting for only the points currently on record
3. Lifetime Violations on record, showing every violation ever received
4. Exam/Hearing Report
   - Showing violations that triggered an exam or hearing
   - To be reviewed by PennDOT staff, and a copy given to the driver at the exam or hearing

E6c. Violation Reports

Statistics of driver demographics, day of week, time of day, etc., based on a selected type of violation

E6d. Sanction Reports

Ability to get synopsis of who is getting sanctions based on violation types, driver demographics, location, driver age, license class, etc.

F. Visibility Recommendations

Document the results of the study in the appropriate literature.

F1. TRB

Prepare a paper documenting the results of the study for the Transportation Research Board Annual Meeting, January 2009. Paper due August 1, 2008.

F2. Press Release

Prepare press release for the driving public to inform regarding risks and probability of violations and sanctions.

F3. AAMVA

Share study results at the American Association of Motor Vehicle Administrators international and/or regional conference in 2008 or 2009.

Task 5: Final Report

A final report oral presentation with Powerpoint briefing slides was held at PennDOT's Riverfront Office Center on April 7, 2008. A copy of the Powerpoint slides, printed as a handout with briefing notes, is included in Appendix E.

Implementation of some of the recommendations provided in this report will require additions and modifications to existing documents and communications such as the Special Point Examination, Driver's Handbook, and correspondence letters to drivers, plus creation of new documents such as Frequently Asked Questions about Driving Privileges. Assistance with implementation can be provided by the Research and Innovation Implementation Program of PennDOT's Bureau of Planning and Research, Research Division. In addition to help in preparing these documents, the Implementation Program can help with field testing of these materials. Samples of drivers and learners can be recruited to review these communications to determine: (1) reading level, (2) drivers' understanding of messages and instructions from PennDOT, (3) drivers' understanding of their responsibilities to respond to instructions and complete next steps, and (4) drivers' reactions to the content and tone of these communications from PennDOT. These field tests and evaluations will help to ensure that PennDOT's documents and communications achieve their goals of promoting driver safety.