EFFECTS OF DEFENSIVE VEHICLE HANDLING TRAINING ON NOVICE DRIVER SAFETY: *PHASE 3. DATA ANALYSIS AND RESULTS*

FHWA/MT-10-004/8183-003

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prepared for
THE STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION

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THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

September 2010

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RESEARCH PROGRAMS

MDT

Effects of Defensive Vehicle Handling Training on Novice Driver Safety: Phase 3. Data Analysis and Results

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15. Supplementary Notes **Research performed in cooperation with the Montana Department of Transportation and the US Department of Transportation, Federal Highway Administration. Project information can be found at http://www.mdt.mt.gov/research/projects/safety/defensive.shtml.**

16. Abstract This project evaluates the effectiveness of a multistage driver education program for Montana's young drivers. A total of 347 teenaged drivers who had completed high school driver education agreed to participate. These drivers were randomly split into two groups of approximately equal size, one of which received additional instruction in a defensive driving workshop (case group) and another that did not (control group). Self-reported and DMV data was collected over a four-year period (from 2006 to 2009) to determine the drivers' involvement in near-misses, single- and multiple-vehicle collisions and any citations received. In 2006 and 2007, there was a significantly lower number of self-reported citations in the case group compared to the control group. However, when adjusted for driving exposure the differences were found to be insignificant. When adjusting for driving exposure, near-miss and collision experience between the two groups was not significantly different during any of the survey years. It should be noted that other possible positive outcomes of the training, such as increased knowledge, increased skills, and increased driving adaptability, cannot be measured by analyzing the dependent variables collected in this study.

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1. INTRODUCTION

Young teenaged drivers have a considerably higher crash rate than any other age group, with new teenaged drivers having the highest crash rates of any group of drivers. While research has struggled to find clear evidence that traditional high school driver education programs have a positive impact on safe driving, the hope is that emerging and future driver education programs will build upon the lessons learned from the traditional approaches to driver education. As one example, some experts have recommended a multistage training approach in which the traditional training is supplemented by a carefully designed advanced training program. Such an approach is advocated by the American Driver and Traffic Safety Education Association (Robinson, 2001) as part of a graduated licensing system, in which "initial training of novice drivers will provide basic vehicle handling skills and the second training course will provide other safe driving skills, including enhanced decision making to reduce the risk of young drivers."

This project was a three-phase effort to evaluate the effectiveness of such a multistage program for Montana's young drivers. Phase 1 included selection and recruitment of participants and development of training materials. Phase 2 concentrated on three major tasks—final preparation for training, collection of driving experience data, and presentation of the training to the teen drivers. Phase 3 was a follow-up longitudinal study of the driving experiences and safety records of the Phase 2 participants.

During Phase 1, approximately 400 teenaged drivers who had completed high school driver education agreed to participate in the study. The drivers were randomly and evenly divided into a treatment group (case group) that received the defensive driving workshop and a control group that did not.

During Phase 2, the young drivers in the case group completed a detailed questionnaire developed by the Montana Office of Public Instruction (OPI) concerning their driving experience in the time since completion of driver education classes. They then completed approximately nine hours of instruction, both in a classroom setting and behind the wheel. These activities were conducted at a driver training facility in Lewistown, Montana. More detail about these activities can be found in Kelly and Stanley (2006). The half of the teen drivers who were not drawn to take part in the training workshops were mailed survey forms that were identical to those completed by the students at Lewistown. Approximately 350 usable responses to the questionnaire were received from the two groups.

During Phase 3, the driving experiences of the trained/case and non-trained/control drivers were followed for a period of four years. Using the OPI-developed written questionnaires mailed to each participant, reports of crash and violation histories of the participants were obtained. This report summarizes the work done on the project for the four-year period since the end of the defensive driving training workshops and includes analyses of safety-related data collected to date.

2. BACKGROUND

2.1. The Experience of Young Drivers

Each year, roadway crashes take the lives of approximately 40,000 people and seriously injure another three million in the United States (U. S. Department of Transportation, 2005). The cost of these crashes approaches $200 billion.

Teenaged drivers have a considerably higher crash rate than any other age group. Figure 1 shows that drivers under the age of 20 have a crash rate four times that of the general driving population (Williams, 2003). New teenaged drivers have the highest crash rates of any group of drivers. The highest crash rate is experienced within two years of receiving the driving license. As expected, the crash rate decreases with driving experience and increased maturity. Research is needed to determine how to safely equip novice drivers with the important elements of experience before they encounter a need for it in an actual driving situation. Many novice driver crashes involve improper reactions to skids, panic stops, run-off-pavement, and other unusual situations unfamiliar to the young driver. Other crashes can partially be attributed to lifestyle issues such as risk-taking, risk-seeking, peer pressure and approval, distraction, and substance abuse.

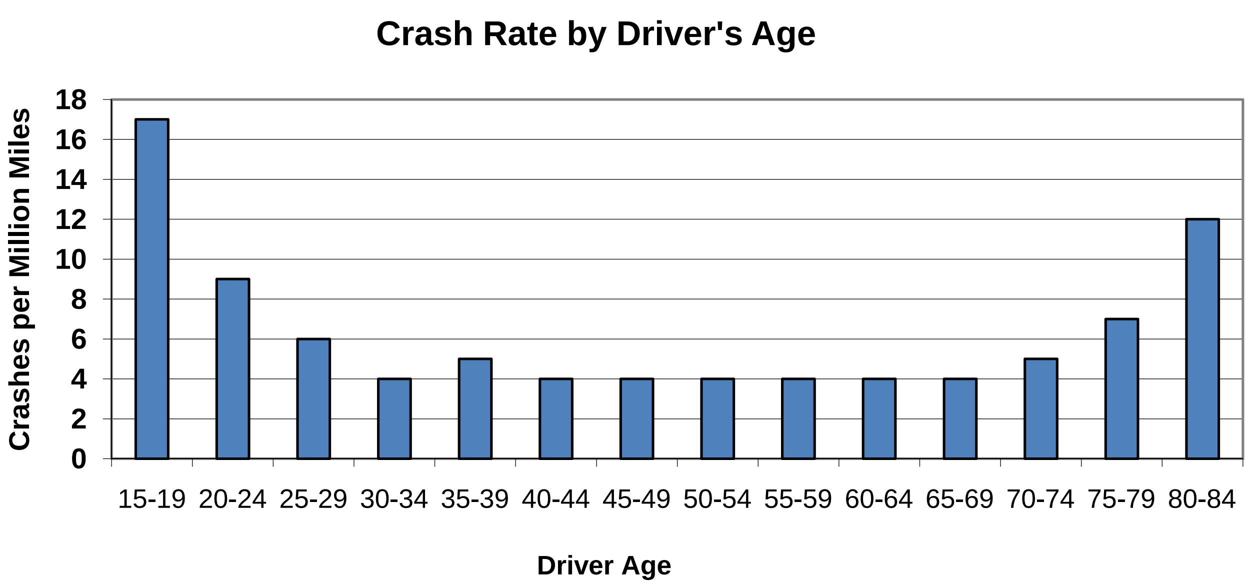

Figure 1. Crash Rate by Driver's Age (from Williams, 2003).

In the United States, most driving training is provided informally by parents or, more formally, in high-school-affiliated classes. These classes require numerous hours (typically 30) of classroom instruction on rules of the road, vehicle operation, and safety. The nascent drivers then spend several hours (typically six) behind the steering wheel driving in parking lots or in normal traffic on familiar streets. Only rarely do they experience circumstances in which the vehicle must be handled at its performance limits.

Driver education in European countries is much more rigorous than that in the United States. Classroom training is presented on vehicle operating principles and basic maintenance. Typically, behind-the-wheel training provides more emphasis on the advanced aspects of vehicle handling in potentially hazardous conditions. Classroom training provides more emphasis on cognitive factors such as risk perception. Also, the minimum age for driver licensing (typically 18 years) is usually higher than the ages mandated by the states in the United States (Siegrist, 2003).

Several organizations in the United States offer training in advanced vehicle handling for novice drivers (Car Control, n.d.a.). Such training is intended to supplement basic driving classes and typically includes vehicle control on skid pads, obstacle avoidance, rapid deceleration braking, and maneuvering near the vehicle performance limits. While there is considerable anecdotal evidence that such training creates a more skilled and capable novice driver when added to the standard driver instruction, few systematic studies of its effect on the safety of young drivers have been completed. Where such studies have been done, results are contradictory and subject to interpretation and controversy.

2.2. Research on Driver Training

Many questions have been raised concerning the effectiveness of conventional young driver education programs. A former researcher at the Insurance Institute for Highway Safety, Williams (2003) declared these short-term programs to be unrealistic approaches to increasing the safety of young drivers. Conversely, a study conducted by the Oregon Department of Transportation (ODOT) and the Center for Applied Research found "significantly lower rates of convictions, suspensions and crashes" for those taking the driver education course versus those who learned through 50 hours of informal, supervised training (Triplett, 2005).

International literature demonstrates little proof that formal driver instruction increases driver safety, yet arguably these programs have failed to adequately address age- and experience-related factors that contribute to a young driver's increased risk of crashes. It is believed that such programs can be more effective if they are more empirically based, addressing the age- and experience-related factors (Mayhew and Simpson, 2002). Mayhew and Simpson state the reasons why formal instruction fails to reduce crashes:

- Driver education/training fails to teach the knowledge and skills critical for safe driving.
- Driver education does teach safety skills but students are not motivated to use them.
- Driver education fosters overconfidence.
- Driver education fails to adequately address lifestyle issues.
- Driver education fails to tailor content to student needs.

The well-known DeKalb driver education study, conducted in suburban Atlanta, was one of the first attempts to systematically validate the benefits of driver education (Stock et al., 1983). A cohort of 16,000 high school students was examined. The participants were divided into three groups based on the training they received, i.e., no training at all, a minimal curriculum of 20 hours of training, or a Safe Performance Curriculum (SPC) of 70 hours of training. The SPC curriculum was based on a task analysis of required driver skills, but little information survives about how it was conducted. While there was some evidence that indicated training had a positive safety impact (e.g., increase in safety belt use) on teen driving during the first six months after receiving training, there was no statistically significant differences in driving safety between the groups after the six months. One observation was that drivers in the "no-training" group delayed obtaining their driver's licenses as compared to drivers in the other groups. The methodology has generated considerable subsequent debate, especially concerning the possible lack of equivalency of the three groups and the inadequacy of the statistical model to show differences between them. Despite its limitations, this classic study has widely been considered the definitive evaluation and used as evidence to support the subsequent defunding of many high school driver education programs.

Mayhew and Simpson (2002) completed a synthesis of research related to safety benefits of young driver training. They concluded that the major effect of traditional, school-affiliated driver education programs is to make licensing more readily available to younger drivers. They found no clear evidence that these traditional programs have a positive impact on safe driving. The authors recommended a multistage training approach in which the traditional training is later supplemented by a carefully designed advanced training program that:

- Is focused on psychomotor, cognitive, and perceptual skills shown to be associated with high collision rates among young drivers;
- Includes experiences demonstrating the value of safe driving practices;
- Incorporates experiences that make the drivers more aware of their own limitations;
- Uses techniques developed to address lifestyle and risk-taking behaviors; and
- Recognizes that there are individual differences in skill levels and addresses specific skill deficiencies of the individual participants.

Such an approach is advocated by the American Driver and Traffic Safety Education Association as part of a graduated licensing system in which, according to Robinson (2001), "Initial training of novice drivers will provide basic vehicle handling skills and the second training course will provide other safe driving skills, including enhanced decision making to reduce the risk of young drivers."

A study of over 400 graduates of an urban, East Coast course for young, previously licensed drivers reported that the graduates had 77 percent fewer crashes than their peers (Car Control, n.d.b.). That number, however, was probably inflated by a weak research design in which the more careful and highly motivated teens were self-selected into the training classes. A more carefully designed and controlled study was needed to validate those striking results.

Skill-based training has created much discussion among driver education experts. Research has shown that skill-based strategies may produce overconfidence toward one's own skills (Gregersen, 1996a). For example, Glad (1988) found that those taking part in skid training as a mandatory part of the training had an increase in slippery road crashes. Another study found that after the introduction of skid training into the education curriculum, higher rates of crashes occurred in slippery road conditions (Keskinene et al., 1992). It is believed that many skid training courses were based on maneuvering skills, leading to overconfidence. To counter this effect, it has been suggested that a distinction be made between training of skills and training of risk-awareness. Skill-based training concerns understanding vehicle control and maneuvering, while risk awareness is designed to increase knowledge, experience and recognition of dangers (Gregersen, 1996b; Sanders, 2003). A study on the effectiveness of skid-car training for teenage novice drivers in Oregon found that females who received skid-car training had no change in crash rates, while the males appeared to have higher rates in the two years after training. However, it did appear that those receiving the training had relatively fewer slick-surface and rear-end collisions (Jones, 1995).

The EU (European Union) ADVANCED Project (Sanders, 2003) developed several recommendations for post-license driver training. These recommendations were not objectively based but were based on the consensus of the researchers and investigators working in the area. The general recommendations include:

- Courses should focus on the specific needs of participants and encourage them to improve their driving style and behavior.
- Track-based driver courses should focus more on risk awareness than on maneuvering skills.
- Comprehensive feedback and discussion sessions should be conducted after each on-road exercise.
- To maintain individual attention, group size should not exceed 10 participants per instructor during track-based courses.
- Training must be relevant to real-life situations and exercises and discussion should be related to real-life scenarios.
- Overconfidence should be avoided; this is done by allowing students to fail (i.e., hit obstacles, or lose full or temporary control of the vehicle).
- Good client–trainer relations should be established to have the greatest influence on the participant throughout the course.

Graduated licensing programs have been shown to significantly reduce young driver crashes and fatalities (McKnight and Peck, 2002). While these programs don't necessarily improve the skills of young drivers, they do reduce their miles of driving and their exposure to peer pressure and hazardous driving conditions during their early driving years (Fohr et al., 2005). During the 2005 legislative session, a form of graduated licensing was instituted for Montana. Since implementation only began in 2006, it is too early to determine whether the expected benefits will materialize.

3. METHODOLOGY

Approximately 400 teenaged drivers who had completed high school driver education were approached to participate in this study; a total of 347 agreed to participate. These drivers were randomly split into two groups of approximately equal size. One group received additional instruction in a defensive driving workshop, and the other group did not. Their subsequent driving safety experience over the following four-year period was tracked to assess whether the additional driver training has an impact on their safety. The large size of the sample and random assignment of the participants to the control and case groups allowed for this assessment of cause and effect to be more confidently made.

3.1. Overview of Training

The Montana OPI scheduled Lewistown Driver In-Vehicle Education (D.R.I.V.E.) facilities and instructors for 18 one-day sessions during the summer of 2005. Each day, 12 young drivers were scheduled to take the training workshops in Lewistown. The Western Transportation Institute (WTI) contracted with school bus providers for the Great Falls and Billings school districts to provide transportation to and from Lewistown. Students from Harlem were bused by their high school, which does not contract out its transportation services. Students from Lewistown and the surrounding communities provided their own transportation to the training facility.

At the training facility, the young drivers completed a participant consent form and a detailed survey concerning their driving experience since completion of driver education classes. They then completed approximately nine hours of instruction in the classroom setting and behind the wheel. At the completion of the day's training, each student received a tailored “report card” concerning his or her driving performance, and exercises they could do on their own to improve it. The training is presented in more detail in Kelly and Stanley (2006).

The half of the teen drivers who were not drawn to take part in the training workshops were mailed survey forms that were identical to those completed by the students at Lewistown, and they were asked to complete and return them to WTI.

3.2. Driving History

Students participated in a pretraining exercise in which, with no prior instruction, they were required to navigate two separate instructor-initiated skids in a specially equipped SkidMonster vehicle, and to demonstrate their vehicle positioning to the front and sides. After all students completed this exercise, they proceeded to the classroom where they filled out a human participant consent form. A detailed young driver survey (see Appendix A) completed by the participants on their driving experience since completing their driver education class was developed by the Montana OPI. The questionnaire was tailored to ask those questions that correlate highly to teen crash involvement, as determined from teen crash data. Information solicited by the survey included:

- The number of hours per week they usually drive;
- The number of passengers (and age classification) usually in the vehicle and how often they have passengers in their car;
- Type of vehicle driven;

- Time of day they usually drive;
- History of traffic citations and warnings;
- History of near-miss crashes;
- History of single-vehicle crashes; and
- History of multiple-vehicle crashes.

3.3. Classroom Instruction

Upon completing the young driver survey and receiving the student folder of instructional materials the students who received the defensive driving workshop were taken to the Montana D.R.I.V.E. classroom training facility. Training is described in detail by Kelly and Stanley (2006). Here training was done in two classroom periods (morning and afternoon) led by a classroom instructor. Both the morning and afternoon classroom instruction included PowerPoint presentations. The purpose of these presentations was to inform the students of driver readiness with reference to seat adjustment, mirrors, driver position, use of the ”dead pedal,” seat belts, balanced hand position on the wheel, and windows up.

Brief overviews of the material presented in the classroom sessions are provided below.

- Morning Classroom: “Montana Teen Class Phase I” presentation was provided to facilitate the lecture. Further demonstrations were provided on the effects of high speeds on losing control of the vehicle. This included using a small “Frisbee-type” saucer and matchbox cars to demonstrate the effects of speed on friction of the vehicle’s wheels. A slide-by-slide explanation of the Montana Teen Class Phase I PowerPoint presentation as lectured to the students was previously provided to MDT in the Training Materials.
- Afternoon Classroom: “Montana Teen Class Phase II” presentation was provided to facilitate the lecture. No further demonstrations were provided. A slide-by-slide explanation of the Montana Teen Class Phase II PowerPoint presentation as lectured to the students was previously provided to MDT in the Training Materials.

Integrated with the PowerPoint presentations were two interactive sessions using E-book activities, one in the morning and the other in the afternoon. Within the two E-book periods were embedded video clips demonstrating principles discussed. Provided in the E-book were interactive grids where students were to mark their answers to questions that were posed to them on principles discussed. Upon completion, students could check their answers with the provided answer sheets.

A picture of the classroom instruction portion at the Montana D.R.I.V.E. training facility is provided in Figure 2. The classroom is a retired driver simulator trailer about 12 ft wide and 40 ft long. Three computers were set up to deliver the E-book training. A fourth computer was used to deliver the PowerPoint. Students sat in inactive simulator stations during the classroom instruction.

Figure 2. Instructional Classroom at Montana D.R.I.V.E. Training Facility.

Additional classroom instruction was completed out-of-doors at the Montana D.R.I.V.E. training facility to allow students more arm and leg room to practice maneuvers as instructed.

3.4. Behind-the-Wheel Instruction

Behind-the-wheel instruction was done using three sedans equipped with SkidMonsters, a proprietary device used to teach vehicle control and skid recoveries. Two other sedans were equipped with levers to activate rear brakes. An additional regular sedan and a mid-1990s sport utility vehicle were used to teach reference points and off-road recovery. Figure 3 shows a vehicle equipped with the SkidMonster technology.

Figure 3. Student Participating in SkidMonster Behind-the-Wheel Instruction.

The two lever-equipped skid sedans were used in pre- and post-instruction skid assessments. The three SkidMonster vehicles were used to teach behaviors and skills related to 10 safe driving habits documented by Mottola (2003). The driving track used was a paved "Monster Pad" that is 200 ft by 600 ft.

At the conclusion of the behind-the-wheel instruction and the post test on the wet skid pad, instructors took the students to the Monster pad and divided the group into two teams. They then had a "road rally" with each team member driving a SkidMonster-equipped car through the course in a timed event that included all aspects of training covered throughout the day. Rules and separate grade sheets were given beforehand so the drivers would know what to expect.

Anecdotal reports from students who went through the workshop indicated that they felt more relaxed and confident about their driving ability. Instructors reported "they made great strides, showing improvement in the post-test of front/side limitations and skids; and, they also understood the importance of controlling the four-second danger zone and keeping the vehicle in balance." Overall, the students gained valuable knowledge and skills with regard to driving, and became more confident in their ability to handle various driving situations. Analysis of the vehicle-handling scores, especially skid recovery, showed significant improvement in vehicle handling between the pre-testing and the post-testing.

Using a paired t-test, an analysis of the students' skid-car performance both before and after training was conducted to assess if the students improved according to the instructors scoring criteria.

3.5. Collection of Driving-Related Data

Figure 4 provides a timeline of the project's data collection periods for Phase 3.

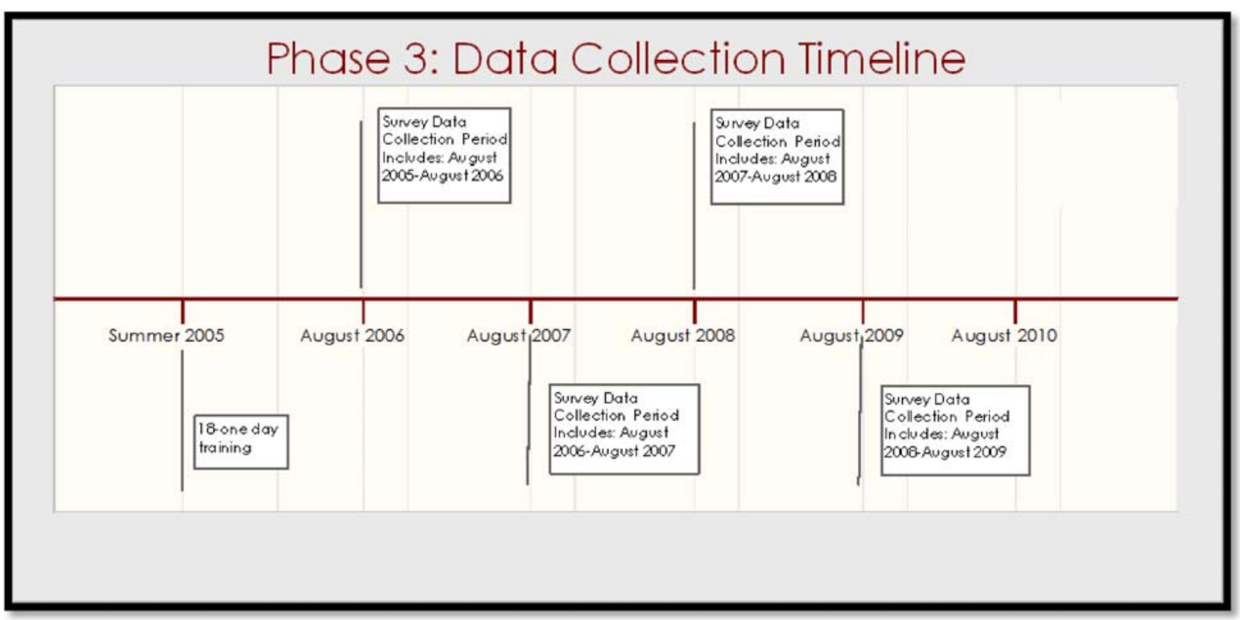

Figure 4. Project Timeline.

As previously discussed, during the initial year of the study, while training was being conducted, participants completed a written survey (Appendix A) regarding their driving experience that was developed by the Montana OPI. Participants who did not take part in the training were mailed the questionnaire during the same timeframe and reimbursed for their time in completing it. Following the morning classroom and in-vehicle sessions, instructors assessed the students regarding their performance in the 10 safe driving behaviors emphasized throughout the training. Each category was rated by the instructor according to the student's performance of specific actions. The ratings were scored by the instructor according to whether or not the specified safe driving behaviors were not followed, not always followed, or always followed. The behaviors and scoring metrics are shown in Table 1.

Table 1. Instructor Report Card Scoring Metrics.

Driving Behavior	Instructor Scoring Metrics
Shows Driver-Vehicle Readiness	Always use safety belts and headlights
	Show correct seating position
	Show correction position and use of steering wheel
	Stay focused on driving task
Accurately Positions Vehicle	Position right side to road edge with accuracy
	Position front bumper to intersection with accuracy
	Use lane positions effectively
Keeps Car in Balance	Make smooth and effective starts and stops
	Get speed control before turning steering wheel
	Use controlled braking
	Use "transition pegs" while braking or accelerating
Establishes Clear Path	Search the "Target area"
	Evaluate intended path of travel
	See open space before accelerating
	Turn head before turning steering wheel
Handles "LOS/POT Blockages"	Detect LOS-POT blockages
	Check for escape/alternate path
	Get best speed control and lane position
	Control four-second danger zone
Controls Intersections	Search left, front, and right zones for "open" zones
	Detect LOS-POT blockages
	Control four-second danger zone
	Control two-second "Point of No Return"
Controls Rear Zone	Check mirrors when braking
	Check blind spots before moving into another lane
Controls Curves	Use lane positions correctly
	Reduce speed within four-second danger zone
	Use "transition peg" to determine when to accelerate
	Look through curve for "Open/Closed POT"
Controls Vehicle in Front	"Close in" on slower moving vehicles gradually
	Keep four-second following time
	Stop behind vehicle to see rear tires
Controls Emergency Situations	Detect "off target" skid conditions
	Take corrective actions without delay
	Point head and eyes toward target area
	Effectively use "vehicle controls"

At the end of the first year after the defensive driver training was conducted, and each year thereafter, a survey covering the prior year was mailed to the study participants. These surveys were identical to the one they were asked to complete prior to the training course. They were reimbursed with a $10 payment for their time in completing and returning the survey. Of the 347 surveys mailed out for the first survey period (2006), 284 participants returned the surveys (82 percent return rate). For the second survey period (2007), 347 surveys were mailed again; 270 participants returned the surveys (78 percent return rate). In September 2008, surveys were sent to the 347 participants using the addresses provided during their training. Ninety-nine participants responded to the initial mailing, and an additional 63 responded following a reminder/secondary mailing. Of the 161 that responded (47 percent response rate), 23 participants chose to use the online survey response option. Of the 347 original project participants, mailings to 38 participants were returned as undeliverable. Specific response data is shown in Table 2 for both the case and control groups.

Table 2. Survey Response Rates.

Survey Response Rates				
	Case Group		Control Group	
	N=165		N=182	
	n	%	n	%
Year 1	146	88%	138	76%
Year 2	125	76%	145	80%
Year 3	76	46%	85	47%
Year 4	82	50%	85	47%

In addition to the survey, participants' Department of Motor Vehicle (DMV) records were obtained using the Montana Department of Justice Motor Vehicle Division's online driver history record service (https://app.mt.gov/dojdrs/). The analysis of the participants' driving records in the study serves the purpose of providing a more objective form of data collection compared to that of the self-reported survey data. Data collected through both methods were analyzed, as studies have indicated that DMV data may slightly under-represent driver behaviors since the records do not contain information regarding unreported incidents or all unsafe driving behaviors (Schultheis et al., 2002). DMV records were available for 295 participants. The other 52 participants were not found in the DMV database, either because the participants never listed their Montana driver's license number on their surveys or because they had since moved out of state. DMV data availability is shown in Table 3. When the DMV data was reexamined in 2009, records were available for 309 participants. The increase was due to the participants including information on returned surveys that was required to search the DMV records, but that was previously missing or illegible on handwritten surveys (e.g., correct date of birth, drivers license numbers).

Table 3. DMV Data Availability.

DMV Data Availability				
	Case Group		Control Group	
	N=165		N=182	
	n	%	n	%
Year 1	138	84%	157	86%
Year 2	138	84%	157	86%
Year 3	138	84%	157	86%
Year 4	144	87%	165	91%

3.6. Develop Database for Archiving and Analysis

During Year One, all survey data were obtained in written form on paper. In order to support archiving and analyzing the data, a database was developed to record all of the data obtained in 2005 through 2009.

Data provided by the participants during Year One (August 2005–August 2006) and subsequent years were transferred from their paper forms into a database. The database contained names and updated mailing addresses of all participants and the driving experience data they reported each year. It was suitable for preparing mailing labels for contacting participants as well as archiving and analyzing data. As written forms were received from participants, the data they submitted was entered for analysis.

3.7. Test and Control Group Baseline

Selected information collected from the participants on their pre-program driving history was analyzed to document their experiences in their first months after high school driver training and to further ensure that the Case Group (those who had received the training) and the Control Group were equivalent on traffic-safety-relevant attributes before the defensive training workshops were presented. During the initial driving period, approximately 18 percent of the drivers in both groups reported experiencing crashes. Approximately 17 percent of the Case Group and 19 percent of the Control Group were given traffic citations or warnings. These data suggest that by using a random group assignment, the groups were equivalent before the training workshops.

3.8. Post-intervention Data and Methods

Descriptive statistics were summarized for 2006 through 2009 on safety-relevant data. The dependent variables, termed "incidents," reported by each driver were classified into five main categories: citations, near-miss collisions, single-vehicle collisions, multiple-vehicle collisions, and total collisions. Citations included moving warnings, moving violations, parking tickets, and minors in possession (MIP). Near-miss collisions were incidents that did not involve an actual collision; rather the collision was avoided by a narrow margin. Single-vehicle incidents were events that involved only the driver's vehicle, whereas multiple-vehicle incidents involved two or more vehicles. The total number of collisions included both single- and multiple-vehicle incidents. Detailed descriptions of the dependent variables collected in this study are presented in Table 4.

Table 4. Description of Dependent Variables (shaded variables are survey based).

Survey Citations	The number of moving warnings, moving violations, parking tickets, and minors in possession (MIP)
DMV Citations	The number of citations each participant received according to the Montana DMV
DMV Driving-Related Citations	The number of driving-behavior-related citations each participant received according to the Montana DMV
Survey Near-Miss Incidents	The number of incidents that did not occur but were avoided by a narrow margin
Survey Single-Vehicle Incidents	The number of incidents that involved only the driver's vehicle
Survey Multiple-Vehicle Incidents	The number of incidents that involved two or more vehicles
Survey Total Collisions	The sum of single-vehicle incidents and multiple-vehicle incidents (see above).
Exposure	The number of hours per week each participant reported driving
Adjusted Citations Received	Citations Received/Number of Hours Driven/Month
Adjusted DMV Citations Received	DMV Citations/Number of Hours Driven/Month
Adjusted DMV Citations, Driving Related	DMV Citations—Driving Related/Number of Hours Driven/Month
Adjusted Near-Miss Incidents	Near-Miss Incidents/Number of Hours Driven/Month
Adjusted Single-Vehicle Incidents	Single-Vehicle Incidents/Number of Hours Driven/Month
Adjusted Multiple-Vehicle Incidents	Multiple-Vehicle Incidents/Number of Hours Driven/Month
Adjusted Total Collisions	Total Collisions/Number of Hours Driven/Month.
Pre-training Score	Instructor scores (for Case Group only) on defensive maneuvers prior to being trained on the skid cars
Post-training Score	Instructor scores (for Case Group only) on defensive maneuvers after being trained on the skid cars

3.9. Statistical Methods Used for Data Analysis

In order to determine the effectiveness of the training program, inferential statistics were used to test for the statistical significance of group membership and performance year. Due to the non-parametric nature of count data, a Chi-squared analysis on frequency counts was used to determine statistically significant relationships for each incident type (citation, near miss, single vehicle, multiple vehicle, and total collisions) within each group over time, as well as within each time period between each group. When a statistically significant difference was calculated the respective Chi-square and p-values were reported. For the parametric data, e.g., exposure-based data, an Analysis of Variance (ANOVA) was used to determine where statistically significant ($p<0.05$) differences were present. When a statistically significant difference was calculated the respective F-value and p-values were reported.

To determine the effect size of the Case Group versus the Control Group an odds ratio was calculated. The odds ratio is defined as the ratio of the odds of an incident occurring in one group to the odds of it occurring in another group, or a sample-based estimate of that ratio. In this case, the odds ratio was generated to represent the odds of an incident, e.g., receiving a citation, in the Control Group to the odds of receiving a citation in the Case Group. The odds ratio calculation is shown in Equation 1.

$$\frac{p/(1-p)}{q/(1-q)} = \frac{p(1-q)}{q(1-p)} \qquad \textbf{Equation 1}$$

Where:

p = probability of the event in each of the groups (untrained, or control group)
q = probability of the event in each of the groups (trained, or case group)

An odds ratio of one indicates that the incident under question is equally likely to occur in both the Case and Control Group. When the odds ratio is greater than one, this indicates that the incident under question is more likely to occur in the Control Group. If the odds ratio is less than one, this indicates that the incident is less likely to occur in the Control Group.

The data provided through surveys were evaluated within each group (Case or Control) over time, as well as within each survey collection period (2005–2006, 2006–2007, 2007–2008, and 2008–2009). The metrics that were evaluated independently of exposure were tested using Chi-squared analysis between groups using counts of participants who reported at least one incident, or who reported no incidents for each category. This method is preferred as the Case and Control Groups have unequal sample sizes of survey responses in every survey period. While testing the survey data to observe change over time, Chi-squared analysis was again used because there were unequal sample sizes from each group responding in each year.

An exposure analysis was conducted to determine if those participants who drove more hours per week experienced more incidents. In addition, this parametric data was analyzed using a repeated measures ANOVA to determine the main effects of time. In other words, over time does the number of incidents significantly increase or decrease? Only those participants who responded to the survey for all four response periods were used in the repeated measures ANOVA. There were 51 participants in the Control Group and 53 in the Case Group who consistently responded to the survey in years 2006 through 2009.

4. RESULTS

4.1. Survey Data

4.1.1. Summary Statistics by Year

The descriptive statistics and calculated odds ratio for the number of incidents for the Case and Control Groups in 2006 through 2009 for each dependent variable are provided in Table 5. In reference to the 2006 data, citations, multiple collisions, and total collisions are more likely to occur in the Control Group, whereas near misses are more likely to occur in the Case Group. In 2007, the Control Group is more likely to receive citations, be involved in near misses, and experience multiple collisions, while those in the Case Group are more likely to be involved in single collisions and total collisions. In 2008, the Control Group is more likely to be involved in a near miss, while those in the Case Group are more likely to be involved in single, multiple and total collisions. Viewed through time, the only consistent apparent trend is a shift in the relative likelihood of a collision away from the Control Group in 2006 toward the Case Group in 2009. Clearly, when viewed in this manner, the results are mixed in terms of the training program's effectiveness, and thus a more thorough statistical analysis was conducted, with the results presented below.

Table 5. Summary of Survey Data.

2006 Survey Data

	Case Participants		Control Participants					
	No Incident	Incident	No Incident	Incident	Case	Control	Difference	Odds
Citations	118	29	97	41	20%	30%	-10%	1.7
Near Miss	84	63	89	49	43%	36%	7%	0.7
Single Vehicle	128	19	120	18	13%	13%	0%	1
Multiple Vehicle	126	21	112	26	14%	19%	-5%	1.4
Total	112	35	101	37	24%	27%	-3%	1.2

2007 Survey Data

	Case Participants		Control Participants					
	No Incident	Incident	No Incident	Incident	Case	Control	Difference	Odds
Citations	86	39	80	65	31%	45%	-14%	1.8
Near Miss	89	36	95	50	29%	34%	-6%	1.3
Single Vehicle	109	16	132	13	13%	9%	4%	0.7
Multiple Vehicle	99	26	107	38	21%	26%	-5%	1.4
Total	85	40	102	43	32%	30%	2%	0.9

2008 Survey Data

	Case Participants		Control Participants					
	No Incident	Incident	No Incident	Incident	Case	Control	Difference	Odds
Citations	86	39	80	65	31%	45%	-14%	1.8
Near Miss	89	36	95	50	29%	34%	-6%	1.3
Single Vehicle	109	16	132	13	13%	9%	4%	0.7
Multiple Vehicle	99	26	107	38	21%	26%	-5%	1.4
Total	85	40	102	43	32%	30%	2%	0.9

2009 Survey Data

	Case Participants		Control Participants					
	No Incident	Incident	No Incident	Incident	Case	Control	Difference	Odds
Citations	65	17	70	15	21%	18%	3%	0.8
Near Miss	66	16	67	18	20%	21%	-1%	1.1
Single Vehicle	75	6	82	3	7%	4%	3%	0.5
Multiple Vehicle	73	9	75	10	11%	12%	-1%	1.1
Total	68	14	72	13	17%	15%	2%	0.9

4.1.2. Exposure – Number of Hours Driven per Week

Figure 5 provides the self-reported number of hours driven per week by the participants. In year 2006 and 2007, the number of hours exposed to driving (hours driven/week) was not significantly different between the Case and the Control Group. In 2008, the Case Group reported spending significantly ($p=0.019$) more time behind the wheel per week than the Control Group—the Case Group reported spending roughly 8.5 hours per week and the Control Group reported 6.4 hours per week. One may assume the more exposure to driving the greater likelihood of a safety breach. Therefore, subsequent data analysis was conducted to account for driving exposure during that time period. No significant difference between the Case and Control Groups was found for 2009 driving exposure.

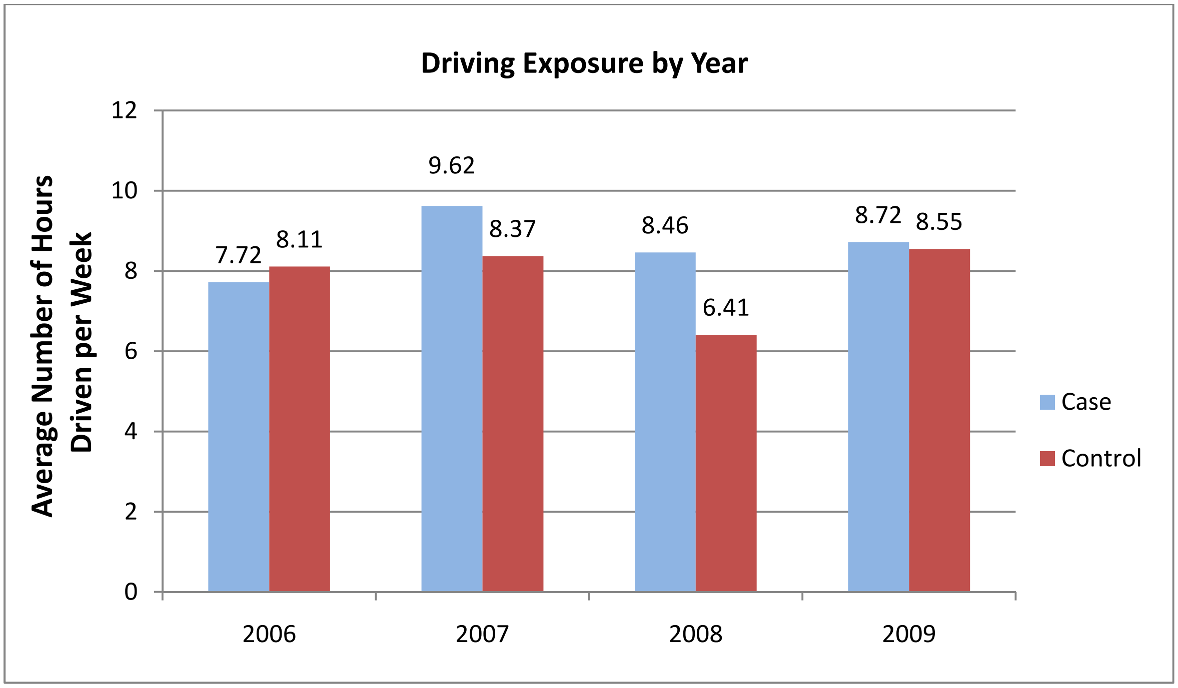

Figure 5. Hours Driven per Week.

4.1.3. Citations

A summary of the number of self-reported citations for each year is provided in Table 6. Analysis of the 2006 survey data indicated that there was a statistically significant difference (χ^2=3.828, p=0.05) in the number of citations between the Case and Control Group. Those in the Case Group reported fewer citations (20 percent) than those in the Control Group (30 percent). Similarly, in 2007 a statistically significant difference (χ^2=5.33, p=0.02) was determined between the Case and Control group. Those in the Case Group reported receiving fewer citations (31 percent) than those in the Control Group (45 percent). However, in 2008 the number of citations is almost identical between the groups, with an odds ratio of one. There is additionally no significant difference in reported citations between the groups in 2009. This result may indicate that the effects of the training are no longer noticeable three years beyond training.

Table 6. Reported Citations.

	Case Participants		Control Participants					
	None	Incidents	None	Incidents	Case	Control	Difference	Odds
2006	118	29	97	41	20%	30%	-10%	1.7
2007	86	39	80	65	31%	45%	-14%	1.8
2008	53	22	62	25	30%	29%	1%	1.0
2009	65	17	70	15	21%	18%	3%	0.8

From 2006 to 2007, the number of students who received one or more citations increased (Figure 6) for both the Case and Control Groups. In the Case Group, 20 percent reported receiving one or more citations in 2006, increasing significantly (χ^2=4.742, p=0.029) to 31 percent in 2007. The Control Group demonstrated significantly (χ^2=6.898, p=0.009) higher percentages of citations in

2007 than in 2006—30 percent reported one or more citations in 2006, and 45 percent in 2007. Following a peak in 2007, the 2008 and 2009 data demonstrate a downward trend for both Case and Control Groups. The Case Group shows a marginally significant decrease from 2007 to 2009 (χ^2=2.75, p=0.097). The Control Group shows a significant decrease in citation percentage from 2007 to 2008 (χ^2=5.93, p=0.015), and a marginally significant decrease from 2008 to 2009 (χ^2=2.96, p=0.085).

Overall, in terms of the number of citations, it appears the training is more effective than no training from 2006 to 2007. However, both groups witnessed an increase in the number of citations from 2006 to 2007, but both decreased to their lowest levels in the fourth year. When adjusted for driving exposure, the number of reported citations was not significantly different between the groups during any survey year.

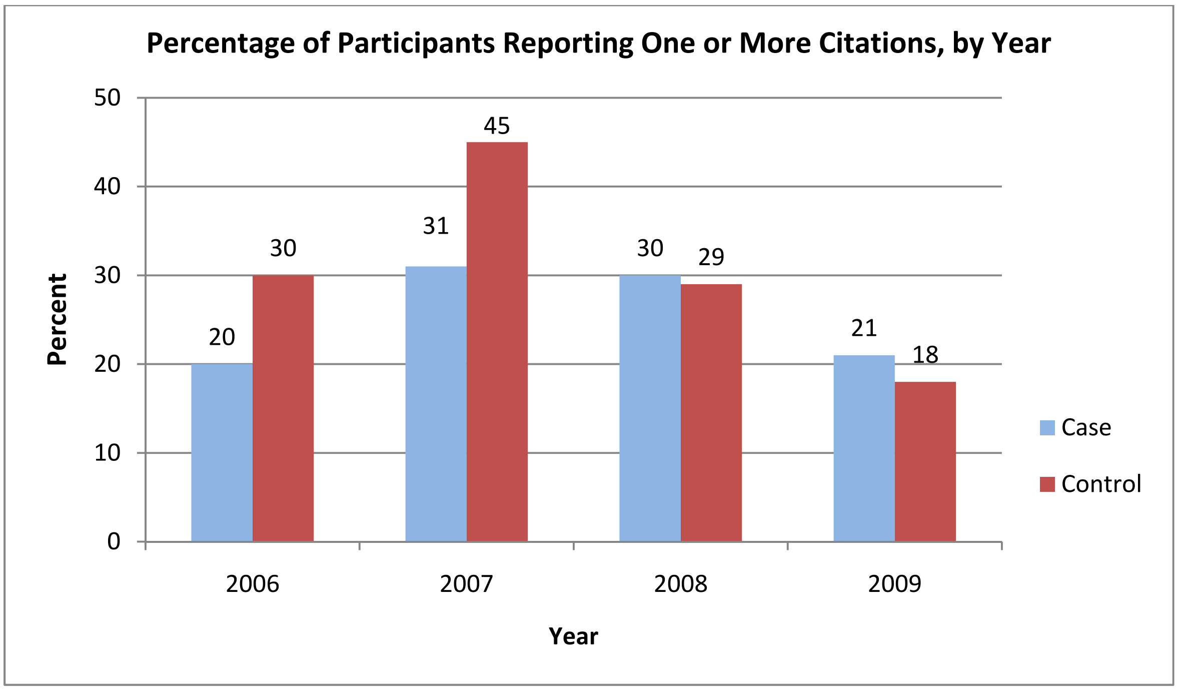

Figure 6. Percent Reporting Citations by Year.

4.1.4. Near-Miss Incidents

The survey data on near misses is summarized in Table 7 and Figure 7. In terms of the number of one or more near-miss incidents, no significant differences were found between the Case Group and the Control Group in any year. Moreover, when adjusting for driving exposure, the number of near-miss incidents was not significantly different between the groups during any survey year. Examining each group over time demonstrated a statistical significance with the Case Group having fewer participants reporting near-miss incidents each year (χ^2=27.4, p<0.0001). The Control Group also showed a downward trend, showing significant differences between years 2006 and 2009 (χ^2=5.14, p=0.023). Near-miss incidents for 2007 and 2008 support the downward trend, but the near miss involvement for years 2007 and 2008 was not large enough to show a statistically significant decline.

Table 7. Reported Near-Miss Incidents.

	Case Participants		Control Participants					
	None	Incidents	None	Incidents	Case	Control	Difference	Odds
2006	64	63	89	49	43%	36%	7%	0.7
2007	89	36	95	50	39%	34%	-6%	1.3
2008	58	17	62	24	23%	28%	-5%	1.3
2009	66	16	67	18	20%	21%	-1%	1.1

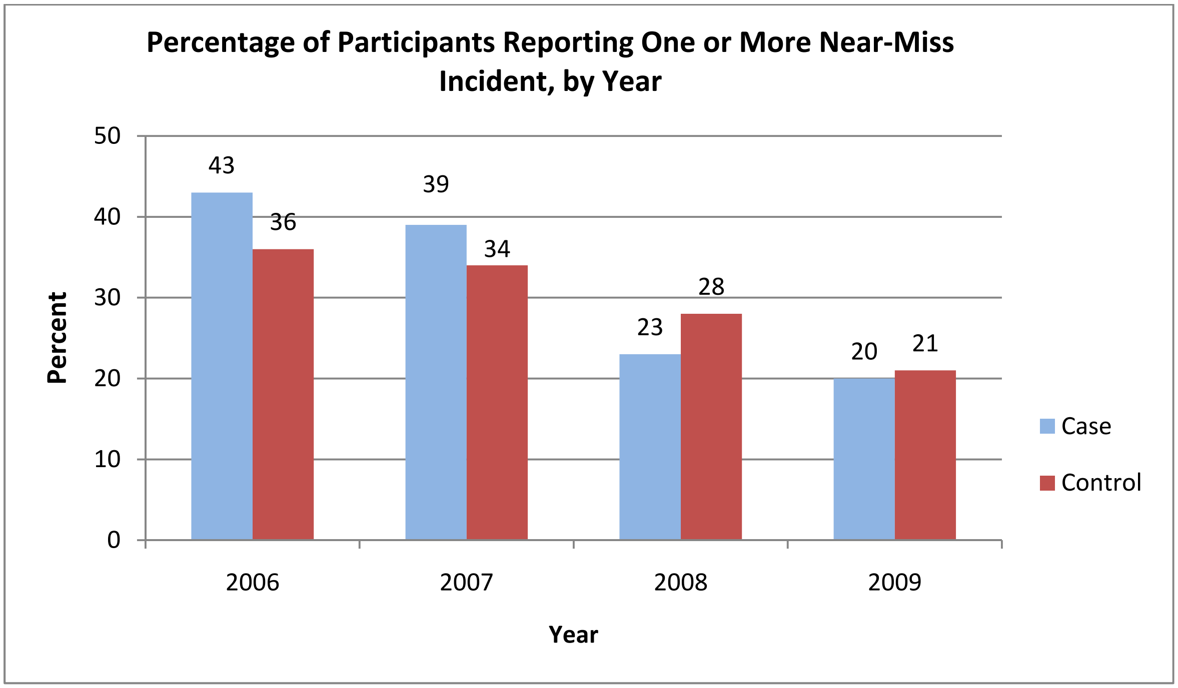

Figure 7. Percentage of Participants Reporting One or More Near-Miss Incident.

4.1.5. Single-Vehicle Collisions

Table 8 and Figure 8 provide the single-vehicle collision data reported for each survey period. The difference between Case and Control Groups for participants reporting one or more single-vehicle collisions was found to be significant (X^2=3.89, p=0.049) during the 2008 period. The Case Group reported significantly more single-vehicle collisions (14 percent) than the Control Group (5 percent). However, when adjusted for driving exposure, the number of single-vehicle collisions was not significantly different between the groups during any survey year. The Control Group experienced a statistically significant (X^2=8.22, p=0.042) decrease in the number of reported single-vehicle collisions from 2006 to 2009. The Case Group showed a decrease in the number of reported single-vehicle collisions from 2008 to 2009, although this decrease was not statistically significant.

Table 8. Reported Single-Vehicle Collisions

	Case Participants		Control Participants					
	None	Incidents	None	Incidents	Case	Control	Difference	Odds
2006	128	19	120	18	13%	13%	0%	1.0
2007	109	16	132	13	13%	9%	4%	0.7
2008	65	10	83	4	14%	5%	9%	0.3
2009	75	6	82	3	7%	4%	3%	0.5

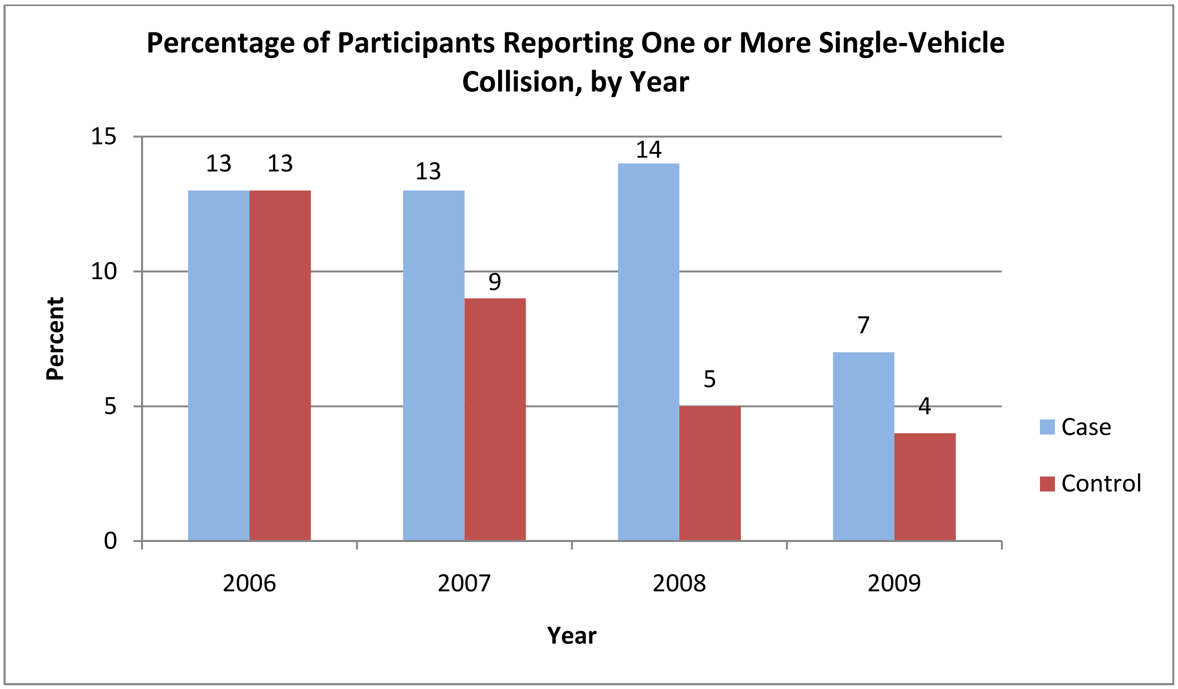

Figure 8. Percentage of Participants Reporting One or More Single-Vehicle Collision.

4.1.6. Multiple-Vehicle Collisions

The difference between Case and Control Groups in the self-reported number of one or more multiple-vehicle collisions was determined to be statistically insignificant over the four-year survey period. Moreover, when adjusting for driving exposure, the number of reported multiple-vehicle collisions was not significantly different between the groups during any survey year. Observing the data from 2006 to 2007, similar to the citation findings, those in the Case Group were involved in consistently fewer multiple-vehicle collisions than the Control Group. However, in 2008 the case participants reported having more multiple-vehicle collisions (12 percent) than the Control Group (8 percent). The change over time for the Case Group showed a marginally significant decrease in the number of participants reporting multiple-vehicle collisions between 2007 and 2009 (X^2=4.64, p=0.098). Although the change over time for the Case Group was not large enough to be statistically significant, the Control Group showed significant variability (X^2=15.3, p=0.002) from 2006 to 2009. The summarized findings are presented in Table 9 and Figure 9.

Table 9. Reported Multiple-Vehicle Collisions.

	Case Participants		Control Participants					
	None	Incidents	None	Incidents	Case	Control	Difference	Odds
2006	126	21	112	26	14%	19%	-5%	1.4
2007	99	26	107	38	21%	26%	-5%	1.4
2008	66	9	80	7	12%	8%	4%	0.6
2009	73	9	75	10	11%	12%	-1%	1.1

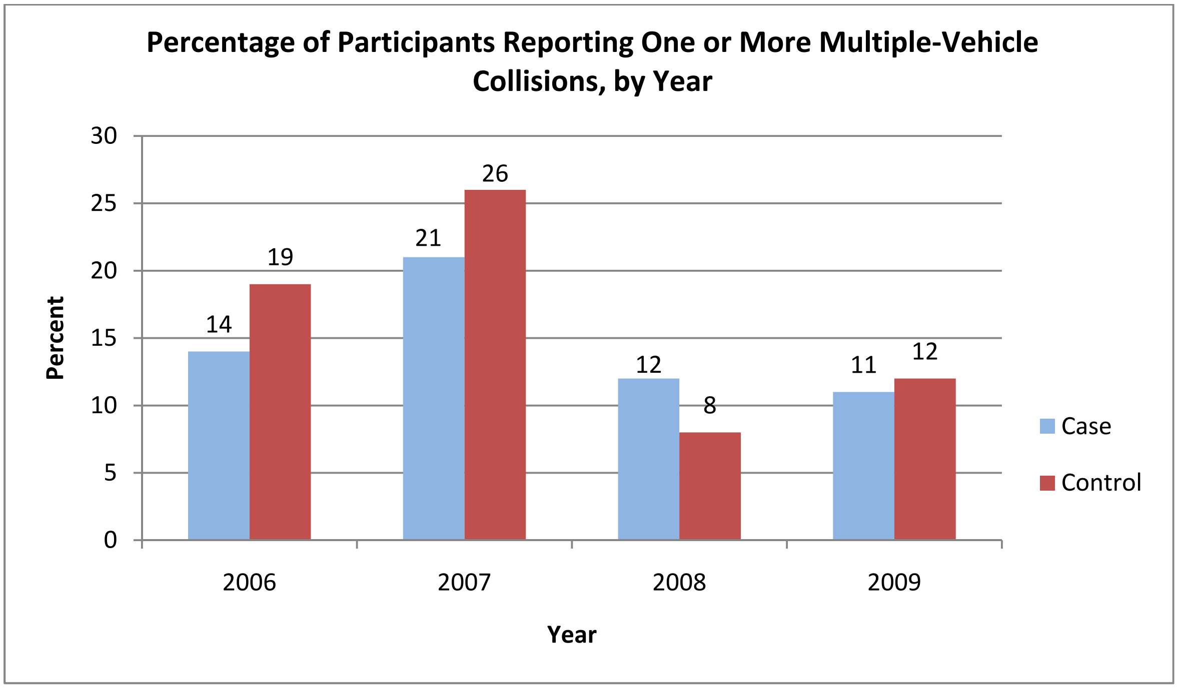

Figure 9. Percentage of Participants Reporting One or More Multiple-Vehicle Collisions.

4.1.7. Total Vehicle Collisions

The summarized data for total vehicle collisions is shown in Table 10 and Figure 10. The number of study participants who were involved in a collision, either single-vehicle or multiple-vehicle, was significantly (X^2=4.54, p=0.033) different between the Case and Control Groups for the 2008 period. The Case Group reported significantly more total vehicle collisions (21 percent) compared to the Control Group (11 percent). However, when adjusted for driving exposure, the total number of vehicle collisions was not significantly different between the groups during any survey year. Examining the change over time, both groups showed an increase in the number of total vehicle collisions between 2006 and 2007. The Case Group showed a significant decrease from 2007 to 2009 (X^2=6.58, p=0.037). The Control Group showed a decrease from 2007 to 2008 (X^2=10.2, p=0.001) followed by an insignificant increase from 2008 to 2009.

Table 10. Reported Total Vehicle Collisions.

	Case Participants		Control Participants					
	None	Incidents	None	Incidents	Case	Control	Difference	Odds
2006	112	35	101	37	24%	27%	-3%	1.2
2007	85	40	102	43	32%	30%	2%	0.9
2008	59	16	77	10	21%	11%	10%	0.4
2009	68	14	72	13	17%	15%	2%	0.9

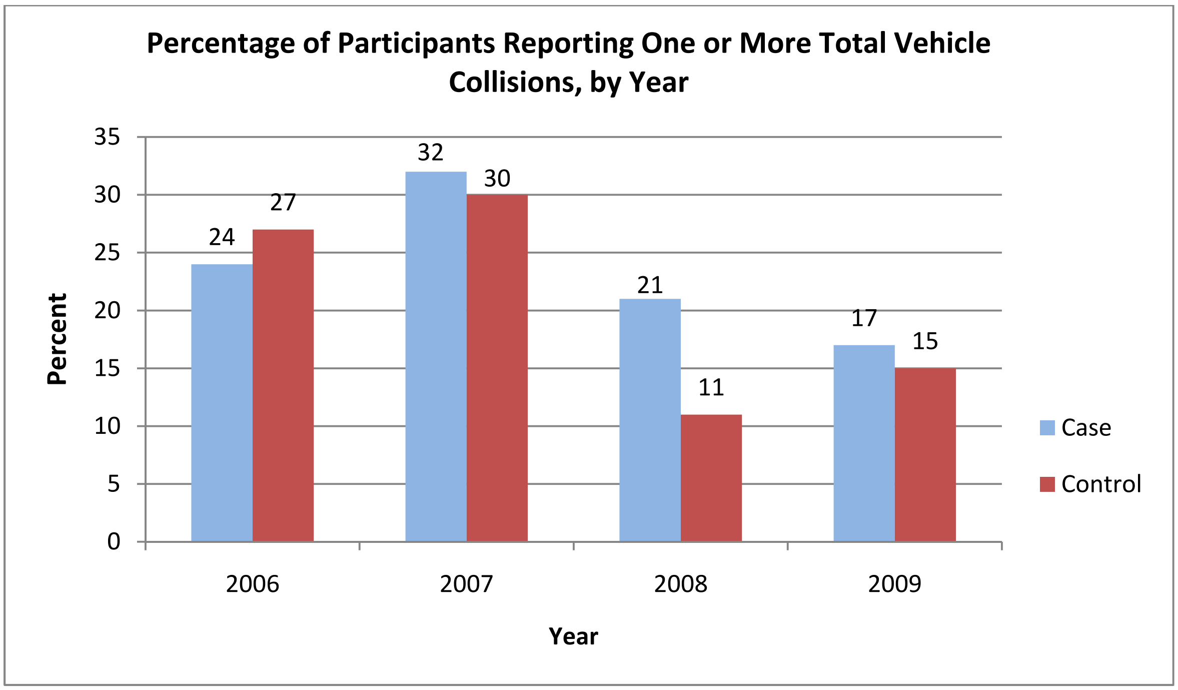

Figure 10. Percentage of Participants Reporting One or More Total Vehicle Collisions.

4.1.8. Limitations of Aggregating Survey Data by Collision and Near-Miss Type

It should be noted that this analysis by specific types of collisions and near misses relied on self-reported survey information that lacked a consistent reporting format for the young drivers to follow. Collision and near-miss descriptions were often vague and seldom included adequate information to determine collision type, region of impact, striking vehicle, or the at-fault driver. Therefore, results of that analysis may not be sufficient to draw prescriptive conclusions.

It should also be noted that in 2004 the National Highway Traffic Safety Administration's (NHTSA) Fatality Accident Reporting System (FARS) reported that 75 percent of fatal crashes among drivers between the ages of 16 and 19 were due to driver error, 35 percent involved the driver speeding, and nearly 50 percent of the incidents involved single-vehicle collisions. In the participants' self-reported crash descriptions, few definitively identified the at-fault driver or admitted to driver error, and the posted or actual traveling speed at the location of the incident was not given.

Specific to the near-miss information in this study, only 20 percent of near-miss reports in 2006 provided enough information to determine what would have been the striking vehicle if the crash occurred, 23 percent in 2007, 19 percent in 2008, and 20 percent of near-miss reports in 2009. The lack of consistent data regarding each crash or near-miss event negates meaningful statistical analysis by crash type. Because of these stated limitations, future studies seeking to utilize survey data should consider using a consistent categorical measure based upon standardized vehicle crash databases, such as the FARS and/or NHTSA's General Estimates System.

4.2. DMV Data

The DMV records provided every official citation received (in Montana) by participants within the survey response periods. The citation codes were classified into "driving related" or "other" offenses, as shown in Table 11. Driving-related citations were grouped together so that their analysis could provide insight about driving performance, and the non-driving-related citations were grouped to demonstrate an indication of driver attitude or general driver safety culture. The citation groups were evaluated in each year between groups (Case and Control) and again within each group over time. No participants were cited for being involved in a crash and only the codes listed in Table 11 were found among the participant records. Thus, there appear to be some discrepancies between the self-reported and DMV-based assessment of participant driving experiences. It was discovered that the discrepancy was due to the reporting of parking tickets in the self-reported citations, which is not reported within the DMV database of citations.

Table 11. Montana DMV Citation Codes Reported from Participants' Records.

Driving-Related Citation Codes	
Code No.	Description
M15	Stop Sign Violation
M16	Failure to Obey Red (Stop) Traffic Signal
M18	Flashing Signal Violation (Red or Yellow)
M25	Stop Violation: Emerging From Alley, Private Road, Building, or Driveway
M34	Following too Closely
M42	Changing Lanes when Unsafe To Do So
M81	Careless Driving
M84	Reckless Driving
N01	Failure to Yield When Entering Hwy From Private Road or Driveway
N25	Failure to Yield to Vehicle on Right
N31	Failure to Yield to Vehicle Making Left Turn
N53	Unsafe Left Turn Across Lane Marked With Two Yellow Lines
N54	Improper Approach When Making Right Turn
N82	Interfering With Traffic While Backing
S92	Speeding Interstate Urban - Exceed Night Limit Of 65

Other Citation Codes	
Code No.	Description
A08	Driving With BAC > 0.08
A21	Driving Under Influence of Alcohol
B08	Failure to Notify Owner Following Unattended Vehicle Damage
B61	Failure to Report Accident
B91	No Motorcycle Endorsement
D07	Driving Without a License
D36	Failure to Carry Proof of Insurance
E70	Improper Use of Amber Light - Use Only For Funeral
S94	Basic Rule - Reasonable And Prudent
Other	Leaving Unattended Vehicle Without Setting Brake
Other	Operating an Improperly Registered Vehicle
Other	Operating a Vehicle with License Plates Obstructed to View

4.2.1. DMV Driving-Related Citations

A summary of the DMV driving-related citation data is found in Table 12. The number of driving-related citations was not significantly different between the Case Group and the Control Group during any survey year. Additionally, when adjusted for driving exposure, differences between the number of DMV driving-related citations were also found to be insignificant between the groups during any survey year.

Table 12. Number of DMV Driving-Related Citations

	Case Participants		**Control Participants**					
	None	Incidents	None	Incidents	Case	Control	Difference	Odds
2006	117	21	133	24	15%	15%	0%	1.0
2007	123	15	147	10	18%	6%	12%	0.6
2008	128	10	140	17	7%	10%	-3%	1.6
2009	125	19	146	19	13%	12%	1%	1.2

4.2.2. DMV Non-Driving-Related Citations

Table 13 summarizes the findings for the non-driving-related citations. No significant differences were found between the Case Group and the Control Group in the number of non-driving-related citations reported. Additionally, when adjusted for driving exposure, differences in the number of DMV non-driving-related citations were also found to be insignificant between the groups during any survey year.

Table 13. Number of DMV Non-Driving-Related Citations.

	Case Participants		Control Participants					
	None	Incidents	None	Incidents	Case	Control	Differences	Odds
2006	133	5	153	4	4%	3%	1%	0.7
2007	133	5	147	10	4%	6%	-2%	1.8
2008	133	5	152	5	4%	3%	1%	0.9
2009	136	8	152	13	6%	8%	-2%	1.4

4.3. Gender Effects

The data was also studied examining the difference in response variables between groups consisting of male and female participants to look for potential gender effects on driver behavior and history. Males showed higher exposure in number of hours driven per week in all years, and a higher percentage of males reported one or more citation (both self-reported and DMV-reported) in all years. Males also have higher DMV-reported citations than females after adjusting for driving exposure. Males show higher percentage of involvement in single-vehicle collisions than females in any year. Females show higher percentage of involvement in multiple-vehicle collisions than males in any year. A summary of this data is shown Table 14 and more thorough data analysis is presented below.

Table 14. Male and Female Response.

2006 Survey Data

	Male		Female					
	No Incident	Incident	No Incident	Incident	M	F	Difference	Odds
Citations	98	44	116	26	31%	18%	13%	2.0
DMV Citations	113	37	129	16	25%	11%	14%	2.6
Near Miss	83	59	89	53	42%	37%	5%	1.2
Single Vehicle	117	25	130	12	18%	8%	10%	2.3
Multiple Vehicle	120	22	117	25	16%	17%	1%	0.9
Total	101	41	108	34	29%	24%	5%	1.3

2007 Survey Data

	Male		Female					
	No Incident	Incident	No Incident	Incident	M	F	Difference	Odds
Citations	72	63	94	41	47%	30%	17%	2.0
DMV Citations	132	18	130	15	12%	10%	2%	1.2
Near Miss	95	40	89	46	30%	34%	-4%	0.8
Single Vehicle	117	18	124	11	13%	8%	5%	1.7
Multiple Vehicle	104	31	103	32	23%	24%	-1%	1.0
Total	87	48	94	42	36%	31%	5%	1.2

2008 Survey Data

	Male		Female					
	No Incident	Incident	No Incident	Incident	M	F	Difference	Odds
Citations	57	26	56	22	31%	28%	3%	1.1
DMV Citations	127	23	133	12	15%	8%	7%	2.0
Near Miss	66	17	57	21	21%	27%	-6%	0.7
Single Vehicle	75	8	72	6	10%	8%	2%	1.3
Multiple Vehicle	75	8	70	8	10%	10%	0%	0.9
Total	70	16	65	13	19%	17%	2%	1.1

2009 Survey Data

	Male		Female					
	No Incident	Incident	No Incident	Incident	M	F	Difference	Odds
Citations	58	15	77	17	21%	18%	3%	1.1
DMV Citations	124	32	132	21	21%	14%	7%	1.6
Near Miss	57	16	76	18	22%	19%	3%	1.1
Single Vehicle	66	6	91	3	8%	3%	5%	2.8
Multiple Vehicle	66	7	82	12	10%	13%	-3%	0.7
Total	60	15	79	15	20%	16%	4%	1.3

Males show higher exposure for driving time than females in all years; the higher male exposure is significant in 2006 ($t=4.33$, $p=0.0001$), 2008 ($t=3.86$, $p=0.0002$), and 2009 ($t=5.63$, $p=0.0001$). A summary of this data is shown in Table 15.

Table 15. Driving Exposure by Gender.

	Male		Female	
	Number	Average (hours driven per week)	Number	Average (hours driven per week)
Year 1	145	8.31	143	7.10
Year 2	136	9.19	135	8.82
Year 3	83	8.08	79	6.63
Year 4	73	9.84	94	7.63

Males show a higher percentage of one or more self-reported citations than females in all years, significant only in 2006 ($X^2=6.14$, $p=0.013$) and 2007 ($X^2=7.57$, $p=0.006$).

A higher percentage of males have one or more DMV-reported citations than females in all years, significant in 2006 ($X^2=9.3$, $p=0.002$), and marginally significant in 2008 ($X^2=3.51$, $p=0.061$). The average number of DMV citations per male ($\mu=0.32$) is significantly higher than the average number of DMV citations per female ($\mu=0.11$) in 2006 ($t=2.63$, $p=0.009$) and marginally significant in 2008 ($\mu_{male}=0.25$, $\mu_{female}=0.09$, $t=1.85$, $p=0.064$). When examined adjusting for exposure, males still have a higher number of DMV citations per subject, although the significance is not achieved.

Males show a higher percentage of involvement in one or more single-vehicle collisions and total vehicle collisions in each year, although this higher rate of involvement is insignificant in any year. Females show higher percentage of involvement in one or more multiple-vehicle collisions, insignificant in any year.

4.4. Evaluation of Specific Elements of the Training Program

While not envisioned as part of the original project, some preliminary analyses were also completed at the end of this study on two specific elements of the training program, namely, the skid car training and the report card exercise. These analyses and their results are described below.

4.4.1. Skid Car Training Scores

Each trainee participated in two skid-car trials at 30 mph, with no instruction given. The ratings were based on a scale of 1 to 5 (1 = Failure, wrong actions, no actions; 2 = Poor, correct action too late; 3 = Fair, corrected with difficulty; 4 = Good, slight delay, correct action; 5 = Excellent, no delay, correct action). Two trials were measured and scored for each pre- and post-training test. The analysis of the instructor's evaluation of the participant's skid car pre- and post-training exercises found that students received significantly ($p<0.0001$) higher scores post-training than pre-training (Figure 11).

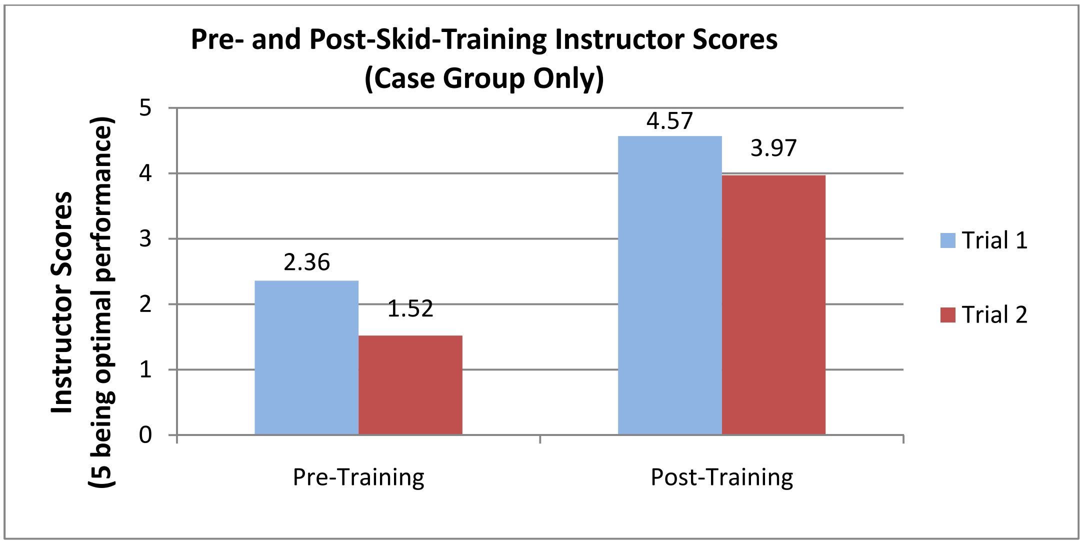

Figure 11. Pre- and Post-Skid-Training Instructor Scores.

4.4.2. Report Card Data

Immediately upon completion of the training provided at the beginning of this program to the participants in the Case Group, these participants each received a tailored "report card" evaluating his or her driving performance. An analysis was done of the subsequent self-reported driving history for these participants during the first year of this study in the context of their report card scores. The specific categories of evaluation used for the report card are summarized in Table 16.

Table 16. Report Card Evaluation Categories.

Category	Description
A	Shows driver-vehicle readiness
B	Keeps car in balance
C	Accurately positions vehicle
D	Establishes clear path
E	Handles “LOS/POT” blockage
F	Controls intersections
G	Controls rear zone
H	Controls curve
I	Controls vehicle in front
J	Controls emergency situation

Instructors rated the participants in each category on a scale of 1 to 3, with 1 representing satisfactory performance and 3 representing a need for improvement. The distribution of report card scores is shown in Figure 12.

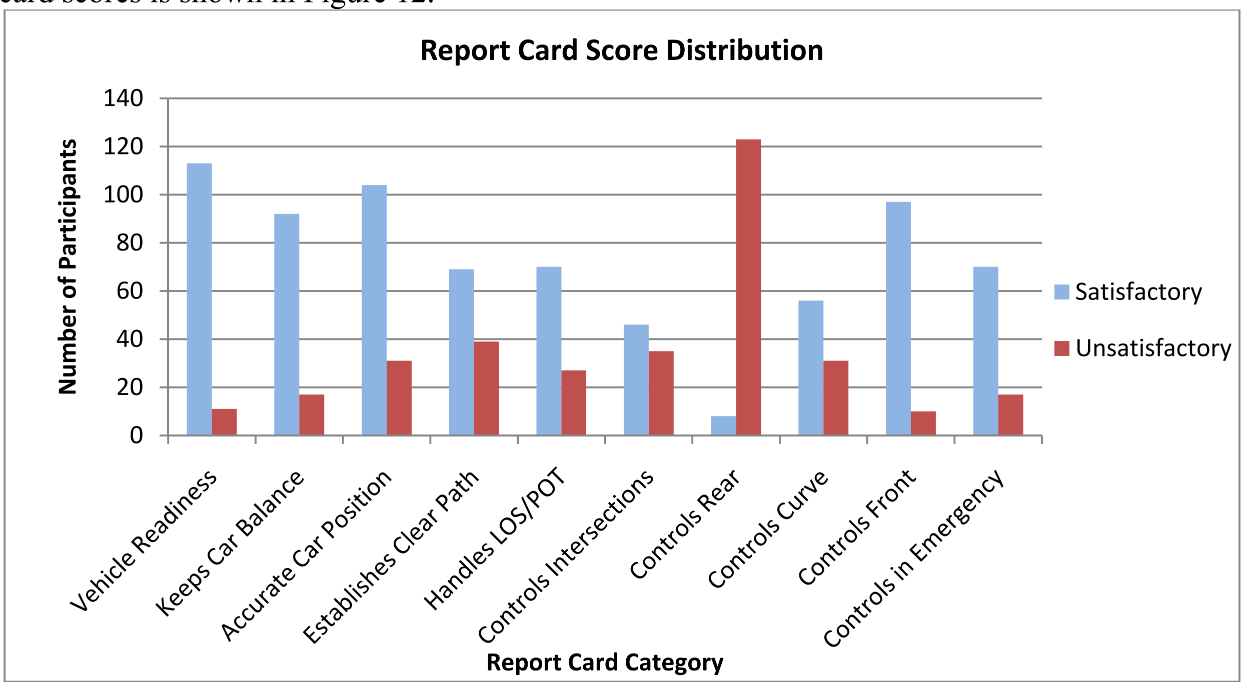

Figure 12. Report Card Score Distribution.

A Poisson regression approach was taken to determine possible relationships between response and explanatory variables (note again that only data from 2006 was analyzed). The goal in fitting these models was to identify those report card categories that did a good job of predicting how a young driver would perform a year after training. This provided insight into whether different predictors worked better for some responses than others, and what combination of predictors worked the best overall. Poisson regression is a standard generalized linear model approach that models a count response variable as a function of several explanatory variables. By assuming that the response variable is Poisson, the probability of a given value of the response variable can effectively be expressed as follows:

$$P(Y = y) = \frac{e^{-\mu}\mu^{y}}{y!}$$ **Equation 2**

Where:

$Y = \{0, 1, 2, ...\}$
μ = the parameter of the Poisson process

A unique and important property of Poisson random variables is that the mean response value should be equal to the variance of the responses. Since the response variables examined here are all Poisson, in order to model the responses as linear functions of the explanatory variables, the model follows the following equation:

$$\log(\mu(y)) = \beta 0 + \beta 1\ x1 + \beta 2\ x2 + ... + \beta k\ xk$$ **Equation 3**

Where:

μ = mean response value
$y = \{0, 1, 2, ...\}$
β = coefficient estimates
x = observed covariate values for a particular case

The implication of this model is that the response variable has the following distribution:

$$Yi \sim Poi(\exp(\beta 0 + \beta 1\ x1 + \beta 2\ x2 + ... + \beta k\ xk\ ))$$ **Equation 4**

Where:

$Y = \{0, 1, 2, ...\}$
β = coefficient estimates
x = observed covariate values for a particular case

The explanatory variables are considered to be ordinal in this case, and thus representative of a continuous latent variable representing performance. Further, it was assumed that an increase of a point at one region of the report card has the same effect on the response as an increase of a point at a different region of the report card. Parameters are estimated via the maximum likelihood method, yielding estimates that are approximately unbiased for large sample sizes, and standard error estimates rely on sufficient sample size.

A preliminary fit done with this model revealed some over dispersion of each of the Poisson models (which is to say, the mean response value was somewhat lower than the variance of responses in the data). This problem was accounted for by fitting a zero-inflated Poisson model to the data. A zero-inflated model recognizes that some subset of the population of interest is never "at risk"; that is, for example, they never receive a traffic citation. Individuals are "at risk" or not, and can be thought of as being separated by some binomial process. Individuals who are not "at risk" get response values of 0. The number of traffic citations received by the remainder of the population draws from a Poisson random variable. These two processes (the "risk" process, which is binary, and the citation counts process, which is Poisson) are modeled in tandem, both as functions of the predictor variables (in this case, the score report cards). The models used here were fit in the statistical computing environment *R* (Institute for Statistics and Mathematics).

The following four count response variables were modeled separately: Near Misses, DMV Citations, Single-Vehicle Crashes and Multiple-Vehicle Crashes. The explanatory variable suite consisted of the 10 different score reports, labeled A through J as shown in Table 16. Preliminary models were fit that included all explanatory variables as predictors for the Poisson processes. Certain covariates were excluded based on insignificance in either process. Each response and the covariates used to model its Poisson process are listed in Table 17.

Table 17. Response Variables and Corresponding Reduced Models.

Response	**Model Fit**
Near Miss	$\log(\mu\text{Near Miss}) = \beta 0 + \beta 1\ B + \beta 3\ G + \beta 4\ I$
DMV Citations	$\log(\mu\text{DMV Citations}) = \beta 0 + \beta 2\ B + \beta 8\ H$
Single	$\log(\mu\text{Single}) = \beta 0 + \beta 1\ A + \beta 2\ B + \beta 3\ D + \beta 4\ E + \beta 5\ I$
Multiple	$\log(\mu\text{Multiple}) = \beta 0 + \beta 4\ F$
Where the *Response* is each particular event type response variable found in Table 16 and *Model Fit* is the statistical model containing those predictors found to be significant.	

Over dispersion was problematic in all of these options (see

Table 18 for means and variances for each response variable below). Model fit was much improved by fitting zero-inflated models.

Table 18. Means and Variances for each Response Variable.

Variable	Mean	Response
Near Misses	0.6713	1.039
DMV Citations	0.2344	0.2911
Single-Vehicle Crashes	0.1748	0.2720
Multiple-Vehicle Crashes	0.1888	0.2387

Table 19 contains response variable, significant predictors for the Poisson process, predictor coefficient estimates, and p-values from Wald’s tests.

Table 19. Estimates and P-Values for Significant Predictors in Models for Each Response.

Response	Significant Predictors	β Estimate	eβ	P-value
Near Misses	Intercept	3.505	6.3281	.000456
	Keeps Car Balance	-.3713	0.689768	0.035854
	Controls Rear	-.3947	0.6738822	0.031907
	Controls Front	-.5138	0.598218	0.020991
DMV Citations	Keeps Car Balance	-.9262	0.3960559	0.0153
	Controls Curve	.6712	1.956584	0.0180
Single-Vehicle Crashes	Intercept	-9.5484	7.131528e-05	< .00001
	Vehicle Readiness	1.6904	5.421649	0.00637
	Keeps Car Balance	1.3997	4.053984	0.00048
	Clear Path	-.7203	0.4866063	0.03003
	Handles LOS/POT	1.0782	2.939384	0.00671
	Controls Front	1.7990	6.043601	< .00001
Multiple-Vehicle Crashes	Controls Intersections	0.74628	2.109139	0.045

Where *Response* is the event type response variable found in Table 16, *Significant Predictors* is the list of all predictors found to be significant in the model, *β Estimate* is the predictor coefficient estimates, *eβ* is the predictor coefficient estimate multiplied with e, and *P-value* is the level of significance (all p-values reported here are significant with an $\alpha < 0.05$.

Coefficient interpretation is contingent on all other covariates being included in the model. The interpretation of the coefficients is that for each one-unit increase in score report, the response value is expected to multiple by eβ. Thus, for a one-unit increase in score report Keeps Car in Balance, we expect the number of near misses to be 0.69 times the number of near misses at the lower score on score report Keeps Car in Balance. In summary, for Near Misses, Keeps Car in Balance, Controls Rear Zone, and Controls Front are significant predictors. For DMV Citations, after controlling for Zero-inflation, Keeps Car in Balance and Controls Curve are significant. For Single Vehicle Crashes after controlling for Zero-inflation Vehicle Readiness, Keeps Car in Balance, Clear Path, Handles LOS/POT, and Controls Front are all significant predictors. For Multiple Vehicle Crashes, Controls Intersections is a significant predictor in the Zero-inflated model.

4.5. Summary of Results

A summary of the key results from each of the dependent variables measured over the entire study period is presented in Table 20.

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Table 20. Summary of Results over All Survey Years

Summary of Differences: Case versus Control Groups		
Survey Year	**Adjusted for Exposure**	**Unadjusted for Exposure**
2006	No Significant Differences, Case Versus Control Group	Case group has significantly lower self-reported citation rates than control group
2007		Case group has significantly lower self-reported citation rates than control group
2008		Case group has significantly higher involvement in single-vehicle crashes
2009		No significant differences between groups
Summary of Differences: Changes Within Each Group, Over Time		
Group	**Adjusted for Exposure**	**Unadjusted for Exposure**
Case Group	No Significant Differences within Case Group Over Time	Self-reported citations significantly increased 2006–2007.
		Self-reported citations marginally significantly decreased 2007—2009.
		Near miss involvement significantly reduced every year.
		Single-vehicle crashes reduced 2008–2009, not significant.
		Multiple-vehicle crash involvement significantly decreased 2007–2009.
Control Group	No Significant Differences within Control Group Over Time	Self-reported citations significantly increased 2006–2007, significantly decreased 2007–2009.
		Near miss incident involvement significantly reduced between 2006 and 2009, reductions are shown in 2007 and 2008 as well but significance is not shown.
		Self-reported citations significantly increased 2006–2007.
		Single-vehicle crash involvement significantly reduced from 2008-2009.
		Multiple-vehicle crashes show significant reduction from 2007–2008, than an insignificant increase 2008–2009.

Summary of Gender Effects		
Category	**Adjusted for Exposure**	**Unadjusted for Exposure**
Exposure	No Significant Effect of Gender	Males have higher exposure than females in all years, significant only in 2006, 2007, and 2009.
Self-reported citations	No Significant Effect of Gender	Males have higher involvement in self-reported citations in all years, significant only in 2006 and 2007.
DMV Citations	Males have higher DMV citations than females in all years, but not significant	Males have higher involvement in DMV citations in all years, significant in 2006, marginally significant in 2008.
Single-vehicle Crashes	No Significant Effect of Gender	Males show higher involvement in single-vehicle crashes in all years, however not significant.
Multiple-vehicle crashes	No Significant Effect of Gender	Females show higher involvement in multiple-vehicle crashes in all years, however not significant.
Total crashes	No Significant Effect of Gender	Males show higher involvement in total crashes in all years, however not significant.

Skid Car Training Scores
Post-training instructor scores were significantly higher than pre-training scores.

Report Card Scores	
Response Variable	**Significant Predictors**
Near Miss	Keeps Car Balance, Controls Rear, Controls Front
DMV Citation	Keeps Car Balance, Controls Curve
Single-Vehicle Crash Involvement	Vehicle Readiness, Keeps Car Balance, Clear Path, Handles LOS/POT , Controls Front
Multiple-Vehicle Crash Involvement	Controls Intersections

5. DISCUSSION AND CONCLUSIONS

This report summarizes the descriptive statistics and statistical analysis for the self-reported and DMV records pertaining to safety-relevant driving performance of one group of teen drivers that received additional driving training (Case Group) compared to a second group that did not experience any supplemental training (Control Group). Aggregating the 2006, 2007, 2008, and 2009 data, the following are the statistically significant findings relating to the Case Group versus the Control Group:

- In 2006 and 2007, there was a significantly lower number of self-reported citations in the Case Group compared to the Control Group; however, when adjusted for driving exposure the differences were not found to be significant.
- When adjusted for driving exposure, the citation, near-miss and collision experience between the two groups was not significantly different during any of the survey years.
- The participants' DMV records for non-driving and driving-related citations did not correlate with the self-reported citation data. This was discovered to be due to counting of parking citations in the self-reported data, which were not considered reportable in the DMV database.
- The report card data was demonstrated to be a worthy instrument to predict "at risk" drivers, in that:
    - for near misses, Keeps car in balance, Controls rear zone, and Controls vehicle in front are significant predictors;
    - for DMV citations, Keeps car in balance and Controls curve is significant;
    - for single-vehicle collisions, Shows driver-vehicle readiness, Keeps car in balance, Establishes clear path, Handles "LOS/POT" blockage, and Controls vehicle in front are all significant predictors;
    - for multiple-vehicle collisions, Controls intersections is a significant predictor; and
    - for likelihood of receiving a citation and involvement in near misses and single-vehicle collisions, considered collectively, the factor Keeps car in balance appears to be the most reliable predictor.

The statistical finding that the Case Group recorded fewer citations in 2006 and 2007 does suggest some potential safety benefits for the supplemental driver-training course evaluated in this study. However, the absence of a significant difference in the collision experience of the two groups during this same period makes it unclear whether the training resulted in an immediate safety benefit. Furthermore, once exposure to driving was accounted for, the differences between the Case and Control Groups were no longer significant. It should be noted that other possible positive outcomes of the training, such as increased knowledge, increased skills, and increased driving adaptability, cannot be measured by analyzing the dependent variables collected in the driver survey. The short-term effects of the training were observable in the analysis of the pre-training and post-training test scores, indicating an immediate transfer of skills from instruction received regarding vehicle dynamics, balance, and control. Relative to the longer term impact of the training, the absence of a statistical difference in self-reported citations for the two groups in

2008 may indicate that the effects of the training are no longer noticeable three years after the training takes place.

The inconsistencies between the subjective self-reported citations and the objective numbers of DMV citations were discovered to be due to the inclusion of parking citations in the self-reported data, which were not considered reportable in the DMV database. Notably in this case, the differences in the two datasets affect the conclusion reached regarding differences in citation experience between the Case and Control Groups. This outcome supports the need to incorporate both types of data collection methods. By way of example, similar to the findings in research by Schultheis et al. (2002), the DMV records under represent driving behaviors and experiences because these records do not contain information on unsafe driving behaviors. Furthermore, the participants' understanding of citations may have included what they felt were unsafe driving behaviors associated with the incident for which they were cited. Also, they may have simply lost track of the year in which they received the citation.

Future research efforts of this type could benefit from certain variations in the study design. An ideal method of measuring training effectiveness is through naturalistic driver observation; this approach allows for direct observation of the driver's ability to, for example, handle a vehicle safely when the vehicle is skidding. Alternative future design suggestions include phone interviews, which permit the collection of detailed information necessary to complete a more comprehensive analysis. Conducting surveys at six-month intervals, at least initially, instead of using a one-year data collection period may help to better capture the length of time before the training benefit is no longer discernable. This six-month interval would coincide better with the well documented issue of higher fatality rates within six months of licensure. If surveys are to be used, a redesigned survey in a more standardized format similar to crash databases would be desirable. By way of example, using an exposure metric such as Vehicle Miles Traveled (VMT) may be more useful than a categorical "hours driven per week." Additionally, the surveys used in this research included a request that the participant briefly describe each encountered event. Responses ranged from complex discussions with diagrams and costs associated with repair, to less informative descriptions that avoided any discussion of severity, fault, or type of collision. Redesigning the survey to ensure collection of severity (e.g., vehicle damage only, injury, fatality) and crash type (e.g., angular, rear end, head on, sideswipe) information may aid in analysis of training effects and observing participant recollection and application of driving behaviors. A follow-up study using police crash reports that record specific crash information for each participant would be beneficial, and could achieve the same effect as a better designed survey.

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APPENDIX A: YOUNG DRIVER SURVEY

YOUNG DRIVER SURVEY

Name (as appears on driver license) ________________________ Driver License # ________________________

Address ____ City/State _____________________ Zip _____________

Gender: M F Date of Birth ____________ How long have you been driving? Years______ Months________

1. What city/school did you receive driver education? ____

2. How many hours a week do you usually drive? Check one: Under 2__ 3-5___ 6-10___ 11-15____
16-20____; more than 20____

3. How often do you have passengers in your vehicle?
Check one: Daily____ Weekly_____ Seldom_______
Are passengers usually (check all that apply)
family____ non-family____ teens____ adults ____
On average how many passengers each trip? ______

4. What type(s) of vehicles do you usually drive? Check ones that apply:
Car: Small___ Medium___ Large___
SUV: Small___ Medium___ Large___
Pickup: Small___ Medium___ Large___
Other_____ Describe___________________________________

5. What hours of the day do you usually drive? Check ones that apply: 6am – noon ___;
Noon – 6 pm___; 6 pm – 9 pm___; 9 pm – mid-night___; Mid-night- 6am___

6. In the past year have you received any of the following legal citations; if so how many?
Moving violations (tickets) ______; Moving warnings ___________; MIPs_________
DUIs __________; Suspended license____________
Other_____Describe___________________________________

7. In the past year, have you had any near miss crashes; if so how many? ____________
Describe your near misses, if any.____
____
____
____

8. In the past year have you had any single vehicle crashes (yours was the only vehicle involved), such as running off the road? If so, how many? _____________
Briefly describe: ____
____
____

9. In the past year have you had any multiple vehicle crashes (yours was not the only vehicle involved); if so how many? ______
List and briefly describe the crashes, if any ____
____
____

Please complete and return this survey by August 15, 2006 and we will send you $20.

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