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16. Abstract

This study used school-based survey data from 6,870 students, and Michigan State Police crash records and Michigan Secretary of State driver history records to identify crash types for which teen drivers are at excess risk, and to examine psychosocial and behavioral factors that predicted the crash types. Rates and rate ratios were used in combination to identify the crash types that represent the most serious threat to teen drivers, relative to adults. The crash types that represent the greatest risk to teenage men included: road departure/passenger; speeding/nighttime; single vehicle/road departure/speeding; weekend/nighttime/passenger; speeding/weather/nighttime; passenger/nighttime; improper lane use/passenger; single vehicle/road departure; single vehicle/driver action; speeding/weather; alcohol/passenger/speeding; alcohol/passenger/nighttime; alcohol/nighttime/speeding; alcohol/weekend/speeding; alcohol/passenger/weekend; alcohol/speeding; alcohol/speeding/casualty; casualty/passenger/nighttime; casualty/road departure/nighttime; casualty/speeding; casualty/overturn; casualty/road departure; and casualty/weekend/nighttime. For teenage women, weekend/nighttime/passenger, passenger/nighttime, road departure/passenger, speeding/nighttime, speeding/weather/nighttime, driver action/weather/nighttime, improper lane use/passenger, alcohol/passenger/speeding, alcohol/nighttime/speeding, alcohol/passenger/weekend, alcohol/weekend/speeding, alcohol/speeding/casualty, alcohol/passenger, alcohol/passenger/casualty, alcohol/passenger/nighttime, casualty/passenger/nighttime, casualty/overturn, casualty/road departure/nighttime, casualty/weekend/nighttime, casualty/weekend/nighttime, casualty/speeding, and casualty/passenger/alcohol. Crash risk declined rapidly with each additional year of age for teen drivers, and teen and adult women had higher rates than their male counterparts for all crash types, with the exception of alcohol-involved crashes. Implications for teen driver training, supervision, and graduated driver licensing programs were discussed.

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Executive Summary

- For general and casualty crashes, women, both teen and adult, had higher crash rates per 100,000 person miles driven (PMD) than teen and adult men.
- For alcohol-involved crashes, teen and adult men had higher crash rates per 100,000 PMD than women.
- The rate ratios for all crash types were generally smaller for women than for men, indicating that teen and adult women differed less in their crash rates than did teen and adult men.
- When crash elements (i.e., individual crash characteristics) were examined, crashes at intersections were the most frequent crash for men and women, both teen and adult.
- Crashes occurring when passengers were in the vehicle with the teen were the second most common crash element for teen men and women. This was followed by weather, weekend, single vehicle and nighttime for teen men, and by weather, weekend, driver action and failure to yield for teenage women.
- Crash elements that differed the most between teens and adults were speeding, road departure, passenger, nighttime, and failure to yield. This ordering was the same for teenage men and women.
- Considering general crash types, those occurring most frequently for teenage men were casualty/passenger, passenger/nighttime, single vehicle/road departure, single vehicle/passenger, and weekend/nighttime. For teenage women they were casualty/passenger, passenger/nighttime, weekend/nighttime, single vehicle/passenger, and single vehicle/road departure.
- Teenage and adult men differed most in road departure/passenger, speeding/nighttime, single vehicle/road departure/speeding, weekend/nighttime/passenger, speeding/weather/nighttime, and passenger/nighttime crash types. Teenage and adult women differed most in their rates of weekend/nighttime/passenger, passenger/nighttime, road departure/passenger, speeding/nighttime, speeding/weather/nighttime, and driver action/weather/nighttime crash types.
- The highest rates of alcohol-involved crashes for teenage men were alcohol/nighttime, alcohol/passenger, alcohol/weekend, alcohol/passenger/nighttime, alcohol/nighttime/casualty, and alcohol/weekend/nighttime. The alcohol-involved crash types with the highest rate for teenage women were alcohol/nighttime, alcohol/passenger, alcohol/weekend, alcohol/passenger/nighttime, alcohol/nighttime/casualty, and alcohol/passenger/casualty.
- Rate ratios of alcohol-related crashes for men were highest for alcohol/passenger/speeding, alcohol/passenger/nighttime, alcohol/nighttime/speeding, alcohol/weekend/speeding, alcohol/passenger/weekend, and alcohol/speeding crash types. For women the crash types with the highest rate ratios were alcohol/passenger/speeding, alcohol/nighttime/speeding, alcohol/passenger/weekend, alcohol/weekend/speeding, alcohol/speeding/casualty, and alcohol/passenger.

- Casualty crash types with the highest rates for teenage men were casualty/passenger, casualty/weekend, casualty/weather, casualty/nighttime, casualty/failure to yield, and casualty/weekend/passenger. These were also the highest rate casualty crash types for teenage women, and ranked in the same order as for teenage men.

- Rate ratios of casualty crash types for men were casualty/passenger/nighttime, casualty/road departure/nighttime, casualty/speeding, casualty/overturn, casualty/road departure, and casualty/weekend/nighttime. For women, the crash types with the highest rate rations were casualty/passenger/nighttime, casualty/overturn, casualty/road departure/nighttime, casualty/weekend/nighttime, casualty/speeding, and casualty/passenger/alcohol.

- Overall crash rates for teenage men and women decreased rapidly from age 16-19, for teenage men declining from 31.86 per 100,000 PMD to 9.88 per 100,000 PMD, and for women from 49.13 per 100,000 PMD to 15.40 per 100,000 PMD.

- Rate ratios for overall crashes for men decreased from 5.07 for 16-year-old teens to 1.57 for 19-year-old teens. For women, rate ratios decreased from 3.67 to 1.15.

- Regression analysis showed no differential patterns of association between teen psychosocial characteristics and involvement in specific crash types for teen drivers. Instead, general patterns of prediction were consistent with previous research by this group, which show an association between psychosocial characteristics and crash involvement.

- The prominence of passengers, and nighttime and weekend crash elements in the results of this study provide support for graduated driver licensing (GDL) programs that place restrictions on driving that involves these factors. Furthermore, these results indicate that just as crash elements combine to form high crash risk conditions, GDL should move toward policies and restrictions that take more than one driving condition or characteristic into account at a time.

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1 Introduction

1.1 Aims Addressed by this Study

<u>Aim 1</u>: Enhance understanding of the situational risk factors that increase crash risk more for teen than for adult drivers, including the role that older age at licensure plays in moderating the effects of those factors on teen crash risk.

Evidence suggests that situations that contribute to crash risk vary by the age of the driver. Some situations increase the risk of all drivers, while others are more detrimental for teen drivers than for adults, and some are completely unique to teens (Lam, 2003; Lam et al., 2003; Preusser, Ferguson, Williams, 1998; Rueda-Domingo et al., 2004; Ulmer, Williams, Preusser, 1997; Williams, 1993). Other evidence indicates that older novice teen drivers (i.e., those licensed at an older age, but before age 20) experience lower levels of crash risk than teens licensed at younger ages (Mayhew, Simpson, Pak, 2003). This study examined crash types and identified those that were associated with excess risk for involvement by teen drivers.

<u>Aim 2</u>: Identify adolescent psychosocial and behavioral risk and protective factors that predict fatal and non-fatal crashes including situational factors that increase crash risk for teen drivers, but not for adults (i.e., those identified in Aim 1).

Analyses addressing this aim built on the results of Aim 1 by identifying factors related to crashes for which teens were at excess risk. Aim 2 examined injury as well as non-injury crash types.

<u>Aim 3</u>: Synthesize the study results into practical guidelines for policy and intervention design and implementation, and disseminate the results to stakeholders in and outside of academia.

An integrated summary and program guidelines will be prepared for use in making policy decisions, designing interventions, and implementing programs to reduce the crash risk of teen drivers. These guidelines will be shared with stakeholders in and outside of academia (i.e., state injury prevention program staff, Department of Community Health, community groups, health and injury prevention practitioners.

1.2 The Problem

Motor vehicle crashes (crashes) are the greatest single health threat to teens. In 2004, crashes accounted for 38% of all deaths among 16-19-year-olds, making it the leading cause of death for this age-group. This is in stark contrast to the next three leading causes of death for teens: homicide at 15%; suicide at 13%; and unintentional injuries other than crashes at 12% (Web-based Injury Statistics Query and Reporting System, 2007).

Little or no positive change has occurred in teen crash numbers in the past decade to 15 years (Shope, Bingham, under review). In 2005, 7,460 15-20-year-old drivers were involved in fatal crashes, representing a 7% decrease from 1995; however, during the same decade teen driver fatalities increased by 4%. This resulted from a 5% increase in driver fatalities among young male drivers and a 1%, decrease in female driver fatalities. Teen drivers are over-represented in fatal crashes. Although teen drivers account for only 6.3% of all drivers, they represented

12.6% of drivers involved in fatal crashes (an over-representation of 2.0) and 16.0% of drivers in police-reported crashes (an over-representation of 2.5) (National Highway Traffic Safety Administration [NHTSA], 2006).

There is consensus in the fields of transportation safety and injury prevention regarding the urgent need to reduce the incidence of crashes involving teen drivers (16-19 years of age). The Centers for Disease Control (CDC) "Injury Research Agenda" item D (CDC, 2002, p. 43) calls for research to "identify the underlying behavioral and situational factors associated with crashes involving teens; and develop and evaluate appropriate interventions to address those factors." Healthy People 2010 (2004) agenda item 15-15a is to "Reduce deaths caused by motor vehicle crashes." Finally, the Institute of Medicine's "Reducing the Burden of Injury" (1999, p. 115) also highlights the need to reduce teen mortality and morbidity due to crashes. However, there needs to be greater understanding of teen crashes if effective interventions, driver training and licensure procedures, and public policy are to reduce the incidence of injury crashes in this age group of drivers.

1.2.1 Crash Characteristics and Risk

Characteristics of the teen driver, time of day, day of week, driver behavior, and the context within the vehicle have been found to increase crash involvement by teen drivers. Teen characteristics related to increased crash risk include being male, less experienced, licensed at a younger age, and fatigue (Ferguson, Leaf, Williams, Preusser, 1996; Mayhew, Simpson, Pak, 2003; McCartt, Shabanova, Leaf, 2003; Williams, Ulmer, Preusser, 1997; Williams, Preusser, Ulmer, Weinstein, 1995). Compared to older drivers, teen crashes occur more often at night and on the weekend (Doherty, Andrey, MacGregor, 1998; Lam, 2003; Mayhew et al., 2003; Preusser, Ferguson, Williams, 1998; Rice, Peek-Asa, Kraus, 2003; Williams, 2003; Ulmer, Williams, Preusser, 1997; Williams, et al., 1995), while speeding, driving in a risky manner, or using alcohol (Lam, 2003; Ferguson, 2003; McKnight, McKnight, 2003), and when passengers, especially teen passengers, are present (Cooper, Atkins, Gillen, 2005; Doherty et al., 1998; Gonzales, Dickinson, DiGuiseppi, Lowenstein, 2005; Lam, 2003; Lin, Fearn, 2003; Rice et al., 2003; Williams, 2001, 2003; Williams et al., 1995).

Inexperience, under-developed driving skills, and immaturity of teens together contribute to poor performance of driving tasks. Teen crashes are often attributable to the failure of basic vehicle control, inattention and distraction, insufficient or ineffective visual search, poor velocity control, improper space and distance management, and the poor execution of emergency maneuvers (Ferguson, 2003; Gonzales et al., 2005; Lam, 2003; McKnight, McKnight, 2003). Other crashes that are common among teen drivers include single vehicle, road departure, and rollover crashes (Gonzales et al., 2005; Mayhew et al., 2003; Ulmer, et al., 1997).

With some exceptions (Williams, 2003; Ferguson, 2003), crash risk has typically been examined one crash characteristic at a time. Few attempts have been made to define crash types in terms of combinations of crash characteristics, and to then examine the combinations for their effect on crash risk. Some combinations of characteristics would be expected to have more serious implications for safety than others. Knowing what these combinations are would provide direction for crash reduction efforts.

1.2.2 Psychosocial Characteristics and Crash Risk

A variety of psychosocial and behavioral characteristics are predictive of crash-related injury and death of teen drivers. For example, previous research by our group indicates that higher levels of parental monitoring of teen behavior in general, is associated with a lower incidence of teen involvement in high-risk driving, offenses, and crashes (Bingham, Shope, 2004a, 2004b, 2005, 2006; Lang, Waller, Shope, 1996; Shope, Raghunathan, Patil, 2003; Shope, Waller, Lang, 1996; Shope, Waller, Raghunathan, Patil, 2001). In addition, more integration into conventional society, as indicated by greater orientation to parents than peers, higher marks in school, and decreased tolerance of deviant behavior are all associated with fewer high-risk driving behaviors and outcomes (Bingham & Shope, 2004a, 2004b, 2005, 2006; Pelz & Shuman, 1973; Shope, Waller, Lang, 1996; Shope et al., 2003). Involvement in socially proscribed behaviors such as substance use is consistently related to poorer driving outcomes, including higher rates of high risk driving, offenses and crashes (Arnett, 1994; Bingham, Shope, 2004a, 2004b, 2005, 2006; Copeland, Shope, Waller, 1996; Donovan 1993; Gregersen, Berg, 1994; Jessor, 1987; Murray, 1998; Shope, Bingham, 2002; Shope et al, 2003).

While research shows a general association between psychosocial and behavioral characteristics of teens and their driving behaviors and outcomes, it is plausible that information about psychosocial characteristics that serve as risk and protective factors for teen involvement in specific types of crashes would make it possible to more finely tune intervention and prevention efforts to the characteristics of individual teens. Research yielding this type of information would need to go beyond epidemiological investigation of high-risk groups, and instead focus on individual environmental, psychosocial and behavioral variables, to identify individual characteristics that either increase teen drivers' risk of crash and related injury, or protect them from these outcomes.

1.2.3 Measuring Teen Crash Risk

Two methods often used to gauge crash risk are rate ratios (RRs) and crash rates. RRs provide statistical comparisons of two rates, such as the rates of two groups of people. Crash rates reflect the frequency of crashes in terms of some constant amount of driving exposure. Because miles driven or hours spent driving are difficult to measure in large samples of drivers, crash rates are not typically calculated using these units of exposure. Denominators that are commonly used in transportation research are total vehicle miles traveled (VMT), and per capita (i.e., licensed drivers, total population). VMT is an estimate of the number of miles driven by an entire population or a specific sample. Per capita estimates use population size as the measure of exposure. This paper presents a method for estimating person miles driven (PMD). While VMT provides an estimate of how frequently crashes occur per mile traveled by vehicles in the population, PMD is an estimate of the number of crashes per mile driven by a single driver.

When used together, rates and RRs provide a more complete characterization of the degree of risk than either indicator by itself. For example, if teen and adult drivers are compared, crashes that have a high rate but a low RR would be better targeted on a population level, because they occur at the same rate for teens and adults, but the rate is high. Alternatively, a crash with a high rate and a large RR would be in urgent need of being addressed among teen drivers, because of its high rate and because it occurs much more often in teens than adults.

Many factors that contribute to high crash risk among teen drivers are not easily addressed directly, and are only resolved by time, greater experience, skill acquisition, and increased

neurological and psychological maturity. Inexperience has been targeted by a number of intervention approaches, most notably, graduated driver licensing. Immaturity and its consequences, such as high-risk driving behaviors, are more difficult to directly target with interventions, and yet it is a significant contributor to teen drivers' risk of being involved in a crash. Greater understanding of the multiple characteristics of crashes that combine to place teens at greatest risk would provide essential guidance in developing approaches to reducing teen crashes that result from immaturity or other causes.

1.2.4 Predicting Teen Crash Risk

Problem Behavior Theory (PBT) (Jessor, 1987) provides a framework for examining environmental, personality, and behavioral variables that predict high-risk driving and its outcomes. PBT classifies behavior as conventional (i.e., socially *prescribed/ encouraged*) or problem behavior (i.e., socially *proscribed/ prohibited* behavior), and recognizes that problem behaviors tend to co-occur within individuals, resulting in a "problem behavior syndrome." During adolescence, problem behavior includes both age-graded (i.e., proscribed for adolescents but not adults) and generally prohibited behaviors (i.e., socially inappropriate and illegal behaviors).

PBT recognizes three systems of variables that were used to identify, and organize variables for this study: Behavior system, perceived environment system, and the personality system. *The Behavior System* includes both conventional and problem behaviors. Conventional behavior involvement is hypothesized to be associated with lower rates of high-risk driving and poor driving outcomes, while involvement in problem behaviors is indicative of increased likelihood of high-risk driving and poor driving outcomes. Research has demonstrated the association between adolescent problem behavior and motor vehicle offense and crash involvement, and drink/driving behavior (Bingham, Shope, 2004a, 2005; Bingham, Elliott, Shope, 2007; Donovan, 1993; Jessor et al., 1997; Shope, Bingham, 2002). Adolescents who are involved in more substance use, including cigarette smoking, and smokeless tobacco, alcohol, and marijuana use (Farrow, 1985) are more likely to experience higher rates of drink/driving, traffic offenses, and motor vehicle crashes (Bingham, Shope, 2004a, 2004b, 2005, 2006, 2007; Donovan, 1993; Jessor 1987; Jessor et al., 1991; Shope, Bingham, 2002; Shope et al., 2001a; Wilson, Jonah, 1988).

*T*he *perceived environment and personality systems* provide motivation for involvement in, or avoidance of problem behaviors, including high-risk driving (Beirness, Simpson, 1988; Jessor, Jessor, 1977; Donovan, 1993; Jessor, 1987; Jessor et al., 1997; Klepp et al., 1991; Swisher, 1988). The personality system includes perceptions of society, others, and self, and attachment to, or alliance with conventional social institutions (i.e., family, school, religion, the legal system, social expectations) and the values they represent (Hirschi, 1969; Jessor et al., 1983), which are related to increased or decreased levels of conventional and problem behavior. Research supports the role of the personality system in high-risk driving, showing an association with hostility, alienation from the educational system (Bingham et al, 2007; Pelz, Schuman, 1973), low school grades, and poor educational achievement (Murray, 1998).

The perceived environment system includes influences from the social and physical environment, such as parental attitudes, parenting behaviors, and peer influences. Research has shown consistent associations between poor driving outcomes and parental factors. Low parental monitoring and unrestricted driving are associated with more drink/driving (Beck, Lockhart, 1992; Williams et al., 1986), and higher rates of adolescent high-risk driving (Dishion,

Loeber, 1985; Hartos et al., 2000; Reid, Patterson, 1989; Shope et al., 2001a; Shope et al., 2001b; Smith, Krohn, 1995; Steinberg, 1987; Stice, Barrera, 1995; Stice et al., 1993). Greater parental permissiveness predicts more offenses and crashes (Jackson et al., 1997; Shope 1997; Shope et al., 1996b; Shope et al., 2001a; Windle, 1996; Zhang et al., 1997, 1999).

1.3 Summary

Teen drivers are at very high risk of crash-related injury, making crashes the leading cause of morbidity and mortality in this population. Clearly, current measures aimed at curbing teen drivers' involvement in crashes are not sufficient. More information about the characteristics of crashes for which teens are at elevated risk, and a better understanding of the individual-level factors related to elevated crash risk are needed to effectively reduce the crash risk of teen drivers.

2 Methods

2.1 Data Sources and Collection

The data for this study were from three sources: school-based surveys, Michigan State Police (MSP) crash records, and Michigan Secretary of State (SoS) driver history records.

2.1.1 School Survey Participants

The Alcohol Misuse Prevention Study (AMPS) was funded in 1984 by NIAAA to develop, implement and evaluate an alcohol intervention. At least one of the six AMPS school-based surveys was completed by 10,729 students in six school districts located in southeast Michigan. The student participants represented two age cohorts referred to here as the "Class of 1991" and the "Class of 1992." At the first survey the Class of 1991 was in 6th grade, and the Class of 1992 was in 5th grade. Subsequently post-test evaluations were administered in grades 6/5, 7/6, 7/8, and in 10th and 12th grades. The intervention was effective in reducing alcohol misuse, especially in participants with the highest initial misuse rates. Subsequent analyses identified some remaining effects relating to the number of serious offenses.

NIAAA initially funded the driving follow-up of the AMPS participants from 1991 to 1996. At that time the driving careers of subjects who had previously participated in AMPS were compiled from crash history data obtained from the MSP and the driver history records from the Michigan SoS dating from each participant's initial Michigan driver licensure. These data were linked to the school survey data of each of the AMPS participants.

The sample for this study included AMPS participants who obtained a Michigan driver license prior to age 20 (n=6,870, 77%). The remaining 23% of the AMPS participants either never obtained a Michigan driver license or were first licensed at age 20 or older. The sample for the proposed study averaged age 17.8 $\pm$ 0.7 in 12th grade, were 48% female, 11% African American, 84% white, and 5% other races. African Americans were not over-sampled, and the racial distribution of this sample is typical of the schools where the surveys were administered. Due to the small proportion of African American compared to white AMPS participants, race differences in crash risk could not be examined.

2.1.2 Michigan-Wide Crash History Data

MSP crash data were obtained for each calendar year by the Transportation Data Center at UMTRI for all Michigan crashes. These crash data were the center piece of this study, because they include details of all police-reported crashes in Michigan. For this study, two sets of Michigan crash data were used. One set was matched to the AMPS data, as previously noted. The other included data on all crashes occurring from 1989 through 1996 for drivers who were either between the ages of 16 and 20 (n=634,359; 44% male), or 45 and 65 (n=1,420,828; 56% male) at the time of the crash.

2.2 Measures

2.2.1 School Survey

The school survey measures were calculated from three longitudinal follow-ups: 10th Grade, fall; 10th Grade, spring; and 12th Grade, spring. Each scale was calculated for each of the three follow-ups, yielding three scores for each scale. These three scores were then averaged together to provide a mean teenage measure of each construct.

2.2.2 Parenting Factors

The Perceived Environment System was assessed in the 10th and 12th grade surveys using three measures: parental behavioral monitoring, permissiveness, and nurturance.

Parental Monitoring. Parental behavioral monitoring (McAlister, 1983) was measured by four items that asked the participants: how often their parents knew when they were not in school; how often they obeyed their parents' teachings; how often they did what their parents told them to do; and if their parents felt it was important to know where the participant was all the time. Responses to the first three items were 0=never, 1=rarely, 2=sometimes, 3=often, and the responses for the last item were 1=no and 2=yes. The items were summed to form a composite score, with higher scores representing more monitoring. The items of this scale demonstrate adequate internal consistency (α=.63) (Cattell, 1982) and the scale has been used successfully in past research predicting adolescent and young adult outcomes (Bingham & Shope, 2004a).

Parental Permissiveness: Global. Parental permissiveness was a scaled variable ranging from 0 (not permissive) to 12 (very permissive). This variable was constructed by summing the scores of four items (White, Johnson, Horwitz, 1986): 'How often do your parents allow you to go out when you want to?' 'How often do your parents let you get away without doing work you've been told to do?' 'How often do your parents let you off easy when you have done something wrong?' 'How often do your parents let you spend money you have earned on whatever you wish?' Item responses were 0=never, 1=rarely, 2=sometimes, 3=often. This scale has been found in past research to be predictive of adolescent and young adult behavioral outcomes (Bingham, Shope, 2004a, 2004b, 2006, 2007), and has adequate internal consistency (α=.54) (Cattell, 1982).

Parental Nurturance. Parental nurturance was a scaled variable ranging from 0 (no nurturance) to 30 (high nurturance). This variable was created using seven survey items (Dishion, Loeber, 1985; White et al., 1985; Barnes, Windle, 1987) — 'How often do you share thoughts or feelings with your parents?' 'How often do you spend time with your parents?' 'When you do something well, how often do your parents give you praise or encouragement for what you do?' 'How often do your parents give you a hug, kiss, or a pat on the shoulder?' 'How often do you and your parents do things together that you all enjoy?' 'How often do your parents enjoy talking things over with you?' 'How often do your parents cheer you up when you're sad?' Internal consistency for this scale was α=.88

2.2.3 Attachment to Conventional Society

The personality system was assessed in the 10th and 12th grade surveys using three measures of participants' connectedness with the conventional social institutions of family and school, and to social norms regarding deviant behavior (Hirschi, 1969). The measures were parent-orientedness, marks in school, and tolerance of deviance.

Parent versus Peer Orientation. Parent vs. peer-orientedness was measured by three items that asked the adolescents: who they usually went to for help when they had a problem (1=usually my parents, 2=usually someone else, 3=my parents and someone else, and 4=neither my parents nor someone else); whether they generally felt more comfortable with their family or their friends (1=family, 2=friends, 3=both family and friends, and 4=neither family nor friends); and, how much they relied on their parents for advice and guidance (0=none, 1=a little, 2=some, 3=a lot). The first two items were recoded (1, 3)=2 and (2, 4)=1, and all three items were summed to form a composite measure that was centered on a value of 1.5, with a higher score representing greater parent-orientedness (α=.72).

Tolerance of Deviance. Tolerance of deviance was assessed by a modified version of the measure developed by Rachal and associates (1975). This five-item Likert-type scale asked participants to rate the moral wrongness of specific deviant behaviors on a scale of 1=not wrong, 2=a little bit wrong, 3=wrong, and 4=very wrong. The items were reverse coded and summed so that higher scores represented greater tolerance of deviance (α=.80).

Marks in School. A single item that asked adolescents to report their typical grades in school classes measured marks in school. Responses were coded as 1=mostly F's, 2=mostly D's and F's, 3=mostly D's, 4=mostly C's and D's, 5=mostly C's, 6=mostly B's and C's, 7=mostly B's, 8=mostly A's and B's, and 9=mostly A's.

2.2.4 Contextual Alcohol Influences

Peer Alcohol Use. Peer alcohol use was constructed from nine items measuring peers' alcohol use behaviors (e.g., who they drank with), outcomes (e.g., get into trouble), attitudes (e.g., is it okay for teens to drink alcohol), and overt peer pressure to drink. The nine items were scored on different scales (e.g., 0=never, 1=rarely, 2=sometimes, 3=often; 0=none, 1=a few, 2=some, 3=a lot, all; 1=a very good idea, 2=a good idea, 3=neither a good not bad idea, 4=a bad idea, 5=a very bad idea); hence, they were standardized to a mean of zero and a standard deviation of 1, summed together, and then the absolute value of the lowest score was added to each participant's score so that the lowest scale score was zero. Internal consistency for this measure is α=0.84.

Sibling Alcohol Use. Sibling alcohol use was the sum of three items about brothers' and three items about sisters' drinking behavior (e.g., who they drink with) and outcomes, (e.g., trouble because of drinking). The responses were 1=yes and 0=no. A summary scale score was created by summing the six items together. The internal consistency for this scale was α=0.75.

Parental Permissiveness: Teen Alcohol Use. Parents' attitudes toward young people's drinking were measured by a scaled variable that ranged from low, 0 (not permissive) to high, 6 (very permissive) permissiveness. This variable was created from four separate survey items: 'How do your parents feel about kids your age drinking beer, wine, or hard liquor?' 'How do your parents feel about kids your age getting drunk?' 'Do your parents allow you to drink alcohol at

parties when they are present?' 'Do your parents allow you to drink alcohol at parties when they are not present?' Internal consistency for this scale was α=0.75.

2.2.5 Psycho-Emotional Factors

Susceptibility to Peer Pressure. This measure included 13 items, that were scored as 0=no, 1=probably not, 2=probably, and 3=yes. The items asked the participant to say how likely it would be for him/her to do specific socially unacceptable behaviors (e.g., drink, skip school, smoke) it they were encouraged to do so by a friend. The scale had high internal consistency (α=0.90).

Self-Esteem. Eight items were used to measure self-esteem with responses of 1=yes and 0=no. The items were summed together to obtain an overall scale score. Internal consistency was α=0.74.

Reasons to Drink and to Abstain. Reasons to drink was the sum of seven items and reasons to abstain a sum of eight items to which teens responded 1=yes or 0=no. The items listed reasons to either drink (e.g., to have a good time, forget problems, calm down) or abstain (e.g., too young, doesn't really solve problems, because of risk of getting into trouble) (reasons to drink, α=0.78; reasons to abstain, α=0.81).

Health Locus of Control. This scale consisted of 21 items with responses of 1=yes, and 0=no. Items asked the participant if they believed they were able or unable to do things to take care of their health. Items asking about the inability to care for one's health were reverse-scored, and a scale score was calculated by summing across the times. Internal consistency was α=0.71.

2.2.6 Alcohol Misuse

Alcohol misuse during the previous 12 months was assessed by a 10-item scale that measured overindulgence in alcohol (i.e., drink more than planned, sick after drinking, and get drunk), trouble resulting from alcohol use (i.e., trouble in school, with friends, parents and police), and alcohol use leading to complaints from others (i.e., same and opposite sex friends, and dating partners) (α=.82). Item responses were 0=never, 1=once, 2=two times, and 3=three or more times (Shope, Copeland, Dielman, 1994). Higher summed scores reflected greater alcohol misuse.

2.3 Crash Types

Crashes types were formed using combinations of crash elements. Crash elements were single characteristics of the crash, such as occurring at night or in bad weather conditions. The crash elements were selected by the research team based on four criteria: 1) represented drivers' behaviors well enough to identify likely causes of the crash (e.g., speeding); 2) known from prior research to be a threat to teens (e.g., driving with passengers); 3) provided information about the surrounding context of the crash (e.g., bad weather conditions); and, 4) casualties (i.e., fatal and non-fatal injuries) were used to indicate a crash outcome of particular interest and as an indicator of crash severity. Table 1 lists all of the crash elements used in this study and a brief description of each.

Table 1. Crash elements used to construct crash types.

Crash Elements	Description
Alcohol	Crashes in which the driver had been drinking.
Casualty	At least one casualty in any vehicle involved in the crash.
Driver action	Driver was either backing, turning, or passing when the crash occurred.
Failure to yield	Driver did not yield.
Intersection	The crash occurred at an intersection.
Nighttime	The crash occurred after dark.
Overall	Includes all crashes, and was used to calculate total crash rates and rate ratios, and was also used as a baseline to which the rate ratios for other crash elements and types were compared to identify excess risk.
Overturn	The driver's vehicle overturned during the crash.
Passenger	There was at least one passenger in the driver's car at the time of the crash.
Road departure	The crash involved or resulted in a road departure.
Single vehicle	Only one vehicle was involved in the crash.
Speeding	The driver was speeding at the time of the crash.
Weather	The crash occurred when it was raining, snowing, foggy, the roads were wet, or the roads were snowy/icy.
Weekend	The crash occurred on the weekend.

2.3.1 General Crash Types

The general crash types consisted of combinations of single crash elements. In this way, crash types allowed the contribution of multiple elements to the rates and rate ratios of crash types to be examined. General crash types and their descriptions are listed in Table 2.

Table 2. General crash types.

Crash Types	Description
Driver action/Weather	Resulted from driver action in poor weather conditions.
Driver action/ Weather/Nighttime	Resulted from driver action, in poor weather, at night.
Lane use/Passenger	Resulted from improper lane use with at least one passenger in the driver's vehicle.
Night/Weather	Occurred at night in poor weather conditions.
Passenger/Nighttime	Occurred with at least one passenger on board at night.
Road departure/ Passenger	Target vehicle departed the road as a result or cause of the crash, and there was at least one passenger.
Single vehicle/Driver action	Only one vehicle was involved in the crash, which resulted from driver action.
Single vehicle/ Passenger	A crash involving one vehicle only, in which there was at least one passenger.
Single vehicle/Road departure	A crash involving only one vehicle, which departed the road, either causing or resulting from the crash.
Single vehicle/Road departure/Speed	A crash involving one vehicle only that departed the road, either causing or resulting from the crash, and involved speeding.
Speed/Nighttime	Involved speeding and it occurred at night.
Speed/Weather	Involved speeding and the weather conditions were poor.
Speed/Weather/ Nighttime	Involved speeding in poor weather conditions at night.
Weekend/Nighttime	Occurred on the weekend at night.
Weekend/Nighttime/ Passenger	Occurred on the weekend, at night, with at least one passenger present.

2.3.2 Alcohol-Involved Crash Types

The alcohol crash types examined in this study included combinations of crash elements that represented times of the day or week and circumstances that would be expected to commonly co-occur with alcohol use. These crash types are listed in Table 3, along with a brief description of each.

Table 3. Alcohol crash types.

Crash Types	Description
Alcohol:	
Nighttime	At night.
Nighttime/Speeding	At night and involved speeding.
Passenger	At least one passenger on board.
Passenger/Nighttime	At night with at least one passenger.
Passenger/Speeding	At least one passenger and involved speeding.
Passenger/Weekend	At least one passenger and occurred on the weekend.
Speeding	Involved speeding.
Weekend	Occurred on the weekend.
Weekend/Nighttime	Occurred on the weekend at night.
Weekend/Speeding	Occurred on the weekend and involved speeding.

2.3.3 Casualty Crash Types

The elements that made up the casualty crash types were selected for their representation of conditions that are high-risk to teen drivers (see Table 4).

Table 4. Casualty crash types.

Crash Types	Description
Casualty:	
Driver action	Resulted from driver action.
Failure to Yield	Resulted from failure to yield.
Nighttime	Occurred at night.
Overturn	The vehicle overturned.
Passenger	At least one passenger was onboard.
Passenger/Nighttime	At least one passenger and occurred at night.
Road departure	Crash in which the vehicle left the road.
Road departure/ Nighttime	Occurred at night and the vehicle left the road.
Speeding	Involved speeding.
Weather	Occurred in poor weather conditions.
Weather/Nighttime	Occurred in poor weather conditions at night.
Weekend	Occurred on the weekend.
Weekend/Nighttime	Occurred at night on the weekend.
Weekend/Passenger	Occurred on the weekend with at least one passenger on board.

2.3.4 Age at Licensure

A similar concept to driving inexperience is age at licensure. Evidence does suggest that older age at licensure is related to lower offense and crash rates (Elliott et al., 2002; Maycock et al., 1991). Age at licensure will be included as a covariate in the regression analyses.

2.4 Data Analysis

2.4.1 Missing Data Imputation

Multiple imputation was used to replace missing data for AMPS participants who had completed any of the surveys using the IMPUTE module of IVEware, which is SAS-based software developed by the University of Michigan Institute for Social Research (Raghunathan, Solenberger, Van Hoewyk, 2002). The primary outcome of imputation is increased power to detect effects, which results from increased sample size and the predictive variation that is restored to the measures. IVEware utilizes all of the observed data to estimate the missing data values using a sequential regression approach (Raghunathan et al., 2001). Five imputations were completed. The quality of the imputations was monitored by comparing the observed and imputed variable distributions to ensure that the estimation did not result in aberrations.

Multiple imputation generates valid estimates if the data are missing at random; however, the assumption that the data are missing at random is not empirically verifiable. Nevertheless, it is reasonable to assume data are missing-at-random provided that the number of observed covariates is large. Given the large amount of complete data, in combination with the numerous covariates included in the imputation for the proposed study, it is likely that the missing at random assumption was met.

Data from the crash history were not be imputed, as they are assumed to be complete. Therefore, if participants in the school survey did not have crash records it was assumed that they had never been a driver in a police reported crash.

2.4.2 Estimating Person Miles Driven

PMD was estimated using data from the 1990 and 1995 National Personal Travel Survey (NPTS), and the 2001 National Household Travel Survey (NHTS). This was achieved in a multi-step process. First, data for the northern mid-west region (i.e., Wisconsin, Illinois, Indiana, Ohio, and Michigan) were recoded and reformatted as necessary, and respondents of the correct age ranges were selected (i.e., 15-19 and 45-65 years of age). Next, total annual miles driven were calculated by applying the appropriate weights and summing within each state by household, respondent, year of age, and sex group. Those totals were next further collapsed to provide total annual miles traveled for each year of age, sex, and state.

Population totals were calculated next by obtaining participant counts for each year of age by sex by state group, weighting these frequencies and then summing them to obtain total population estimates. Then the two data sets, annual miles traveled and population, were merged. This process was repeated for each of the three survey years.

The resulting three datasets representing the three survey years were appended into a single file. Raw person miles were calculated for each year of age by sex by state group by dividing total annual miles driven by the population for that group. A mixed model approach was used to

produce final estimates of PMD using raw person miles driven as the outcome, and all main effects and interactions of year of age, sex, state, and survey year as random effects. The model was weighted by the square root of the population size for each group. The predicted values from this model provided the estimates by year of age and sex of annual PMD that were used to calculate rates and rate ratios. At this point, the data for all states other than Michigan were dropped, and only Michigan data were used in rate and rate ratio estimation.

In the final step of data preparation, the change in PMD between surveys, from 1990 to 1995 and from 1995 to 2001, was divided by the number of intervening years and summed with the PMD for each previous year to general linear approximations of year-by-year changes in PMD for each year from 1989 to 1996, which is the time interval examined for this study.

2.4.3 Calculating Rates and Rate Ratios

Generalized linear modeling was used to estimate rates and rate ratios using a loglinear approach to predict the occurrence (0/1) of each crash type, with the log of annual PMD used as the offset variable. The models took the following form.

$$\log \mu = \lambda_0 + \lambda_1 x ,$$

where x is 1=teen and 0=adult. Application of the values of x to the equation listed above resulted in the following two equations:

$$\log \mu_T = \lambda_0 + \lambda_1 \text{ (teens), and}$$

$$\log \mu_A = \lambda_0 \text{ (adults);}$$

therefore the rate (r_T) for teens was

$$r_T = 100{,}000 \times \left(e^{\lambda_0 + \lambda_1}\right), \text{ and}$$

the rate for adults was

$$r_A = 100{,}000 \times \left(e^{\lambda_0}\right).$$

The rate ratio (r.r.) was calculated as:

$$r.r. = \frac{\Pr(crash\ \ for\ T)}{\Pr(crash\ \ for\ A)}, \text{ so}$$

$$\log\ \ r.r. = \log \frac{\Pr(T)}{\Pr(A)}$$

$$= \log \frac{\mu_T}{\mu_A}$$

$$= \log \mu_T - \log \mu_A$$

$$= (\lambda_0 + \lambda_1) - \lambda_0$$

$$= \lambda_1;\ \ therefore\ \ r.r. = e^{\lambda_1}$$

Because the rates and rate ratios were estimated and not calculated directly, the rate ratios reported from this study are not a simple ratio of the rates for teens to adults.

2.4.4 Prediction Model Estimation

Logistic regression models were estimated using generalized linear models and, because multiply imputed data sets were analyzed, the models were calculated using the SASMOD module of IVEWare (Raghunathan, Solenberger, Van Hoewyk, 2002). Separate models were estimated using parental influences, attachment to conventional society, contextual alcohol influences, psycho-emotional factors, and alcohol use. Next, each model was re-estimated while adjusting for age at driver licensure.

3 Results

3.1 Descriptive Statistics

3.1.1 Statewide Crash Elements and Types

Frequencies and percents of Michigan drivers, ages 15-19 and 45-65 years who were included in this study are listed in Table 5. These frequencies represent the number of drivers who were involved in a crash with a particular element at least once between 1989 and 1996. The counts are not mutually exclusive, with drivers who were involved in a crash with two of the elements listed in the table being counted once for each element. The total listed at the bottom of Table 5 represents the total number of drivers in the age groups over the time interval studied who were involved in at least one crash. A higher percentage of teen than adult drivers are involved all of the crashes listed in Table 2.

The element that was experienced by the largest proportion of drivers was an intersection crash. This was true for men and women, both teen and adult, while the crash element that was experienced by the fewest drivers was an overturned vehicle. This was also true of both sexes and age-groups. A higher proportion of teens than adults experienced all of the crash elements except alcohol-involvement. The proportion of teens who experienced a crash element was more than 30% greater than that of adults for failure to yield (boys only), improper lane use (boys only), nighttime, overturn, passenger, road departure and speeding.

Table 5. Frequencies and percentages of the Michigan population ages 16-19 and 45-65 who experienced a crash element at least once between 1989 and 1996.

	Men				Women			
	Teens		Adults		Teens		Adults	
Crash Elements	n	%	n	%	n	%	n	%
Alcohol-Involved	20380	5.45	28431	6.06	7524	2.97	7953	2.59
Casualty	103112	27.59	117922	25.13	78816	31.07	87997	28.65
Driver Action	79668	21.32	81443	17.35	58493	23.06	59541	19.38
Failure to Yield	55235	14.78	47433	10.11	46153	18.19	41899	13.64
Improper Lane Use	17089	4.57	15359	3.27	9371	3.69	8833	2.88
Intersection	243598	65.18	288290	61.43	174885	68.94	207025	67.39
Nighttime	81551	21.82	64962	13.84	43307	17.07	28585	9.31
Overturn	10440	2.82	4461	0.96	5799	2.31	2231	0.74
Passenger	159081	42.56	124585	26.55	110298	43.48	72222	23.51
Road Departure	39987	10.70	19698	4.20	19669	7.75	12635	4.11
Single Vehicle	87913	23.52	96252	20.51	44332	17.48	50228	16.35
Speeding	43421	11.62	16894	3.60	20662	8.14	10736	3.49
Weather	135258	36.19	162286	34.58	89988	35.47	102830	33.47
Weekend	128837	34.47	150071	31.98	84030	33.12	92278	30.04
Total	373742	100.00	469306	100.00	253679	100.00	307197	100.00

The frequencies and percentage of involvement in the crash types by Michigan teens and adults are shown in Table 6. Involvement in each of the crash types was greater for teens than adults. The proportion of teens who experienced a crash type was more than 30% greater than adults for all crash types with the exception of driver action in poor weather conditions. The largest

Table 6. Frequencies and percentages of the Michigan population ages 16-19 and 45-65 who experienced a crash type at least once between 1989 and 1996.

Crash Types				
	Teens		**Adults**	
Men	**n**	**%**	**n**	**%**
Driver Action, Weather	24810	6.64	25752	5.49
Driver Action, Weather, Nighttime	4657	1.25	2405	0.51
Nighttime, Weather	28372	7.59	22107	4.71
Passenger, Casualty	48801	13.06	35923	7.65
Passenger, Improper Lane Use	7634	2.04	3641	0.78
Passenger, Nighttime	40909	10.95	18005	3.84
Passenger, Road Departure	18006	4.82	4173	0.89
Passenger, Single Vehicle	37216	9.96	28070	5.98
Single Vehicle, Driver Action	9718	2.60	4691	1.00
Single Vehicle, Road Departure	37683	10.08	17595	3.75
Single Vehicle, Road Departure, Speeding	17609	4.71	5753	1.23
Speeding, Nighttime	14131	3.78	4001	0.85
Speeding, Weather	24345	6.51	11893	2.53
Speeding, Weather, Nighttime	6896	1.85	2674	0.57
Weekend, Nighttime	35608	9.53	23609	5.03
Weekend, Nighttime, Passenger	19609	5.25	7654	1.63
Women	**Teens**		**Adults**	
	n	**%**	**n**	**%**
Driver Action, Weather	17210	6.78	17689	5.76
Driver Action, Weather, Nighttime	2585	1.02	1189	0.39
Nighttime, Weather	15317	6.04	9621	3.13
Passenger, Casualty	37302	14.70	23264	7.57
Passenger, Improper Lane Use	4326	1.71	2063	0.67
Passenger, Nighttime	23121	9.11	7641	2.49
Passenger, Road Departure	8503	3.35	2624	0.85
Passenger, Single Vehicle	18438	7.27	11707	3.81
Single Vehicle, Driver Action	4386	1.73	2825	0.92
Single Vehicle, Road Departure	18422	7.26	11325	3.69
Single Vehicle, Road Departure, Speeding	7944	3.13	4225	1.38
Speeding, Nighttime	4928	1.94	1611	0.52
Speeding, Weather	13444	5.30	8475	2.76
Speeding, Weather, Nighttime	2974	1.17	1224	0.40
Weekend, Nighttime	18990	7.49	9608	3.13
Weekend, Nighttime, Passenger	11432	4.51	2988	0.97

3.2 differences for men were Passenger/Road Departure (442% greater for teens), Speeding/Nighttime (teens 345% greater), Single Vehicle/Road Departure/Speeding (teens 283% higher), Speeding/Weather/Nighttime (teens 225% greater), and Weekend/Nighttime/Passenger (teens 222% greater). For women the largest differences were for somewhat different crash types: Weekend/Nighttime/Passenger (teens 365% greater), Passenger/Road Departure (teens 294% greater), Speeding/Nighttime (teens 273% greater), and Passenger/Nighttime (teens 266% greater).

3.3 Longitudinal Sample

3.3.1 Crash Elements and Types

The number of crashes experienced by the participants in the longitudinal sample is shown in Table 7. Only 44% of the participants had no crashes between the ages of 16 and 19 years. This varied for men and women, with 37% of men and 51% of women reporting no crashes. The range in number of crashes for the entire sample was from none to nine. The numbers of crashes for men also extended from none to nine, but for women the largest number of crashes for one person was seven.

Table 7. The number of crashes per person in the AMPS sample

	Total		Men		Women	
Number of Crashes	**n**	**%**	**n**	**%**	**n**	**%**
0	2993	43.57	1312	36.99	1676	50.51
1	2157	31.40	1148	32.37	1009	30.41
2	1056	15.37	634	17.87	422	12.72
3	418	6.08	271	7.64	147	4.43
4	164	2.39	118	3.33	46	1.39
5	52	0.76	38	1.07	14	0.42
6	18	0.26	16	0.45	2	0.06
7	8	0.12	6	0.17	2	0.06
8	3	0.04	3	0.08	0	0.00
9	1	0.01	1	0.03	0	0.00
Total	6870		3547		3318	

As for the Michigan-wide sample, the most commonly occurring crash element for participants in the longitudinal study was an intersection crash, with 1844 of men and 1330 of women experiencing a crash with this element (Table 8). The least common crash element was overturn, with only 60 for men and 21 for women. Crash elements that are more common in crashes involving women compared to men drivers included casualty, driver action, failure to yield, intersection, passenger, and weekend. Men had more crashes than women that involved alcohol, improper lane use, nighttime driving, overturned vehicles, road departure, a single vehicle, speeding, and weather.

Table 8. Numbers and percentages of crash elements experienced by the men and women in the AMPS study.

	Men		Women	
Crash Elements	**n**	**%**	**n**	**%**
Alcohol-Involved	234	2.42	97	1.52
Casualty	960	9.91	662	10.37
Driver Action	713	7.36	514	8.05
Failure to Yield	517	5.34	409	6.41
Improper Lane Use	130	1.34	84	1.32
Intersection	1844	19.03	1330	20.83
Nighttime	704	7.27	385	6.03
Overturn	60	0.62	21	0.33
Passenger	1164	12.01	861	13.49
Road Departure	293	3.02	171	2.68
Single Vehicle	543	5.60	289	4.53
Speeding	280	2.89	127	1.99
Weather	1162	11.99	706	11.06
Weekend	1084	11.19	728	11.40

The most commonly occurring crash types were passenger/casualty crashes for both men and women (Table 9). The least common were passenger/improper lane use for men and speeding/weather/nighttime for women. Comparing men and women, driver action/weather, passenger/casualty, passenger/nighttime, passenger/road departure, and single vehicle/road departure, were more common for women. Men and women were essentially equal in their rates of passenger/single vehicle crashes.

Table 9. The numbers and percentages of men and women in the AMPS study who experienced each of the crash types.

	Men		Women	
Crash Types	**n**	**%**	**n**	**%**
Driver Action, Weather	403	9.10	239	10.07
Driver Action, Weather, Nighttime	169	3.82	84	3.54
Nighttime, Weather	428	9.67	194	8.18
Passenger, Casualty	585	13.21	410	17.28
Passenger, Improper Lane Use	86	1.94	44	1.85
Passenger, Nighttime	456	10.30	271	11.42
Passenger, Road Departure	191	4.31	104	4.38
Passenger, Single Vehicle	319	7.20	171	7.21
Single Vehicle, Driver Action	197	4.45	94	3.96
Single Vehicle, Road Departure	276	6.23	155	6.53
Single Vehicle, Road Departure, Speeding	127	2.87	66	2.78
Speeding, Nighttime	153	3.46	46	1.94
Speeding, Weather	201	4.54	86	3.62
Speeding, Weather, Nighttime	113	2.55	32	1.35
Weekend, Nighttime	424	9.58	217	9.14
Weekend, Nighttime, Passenger	300	6.78	160	6.74

3.3.2 Predictor Variables

Table 10 shows the univariate descriptive statistics for the psychosocial covariates that were used to predict teens' involvement in specific types of crashes. For most of the measures, men and women were quite similar, with the only noticeable differences being for parental monitoring, which was higher for women; tolerance of deviance, which was higher for men; marks in school, which was higher for women; and age at licensure, with women being licensed at a slightly older average age than men.

Table 10. Univariate descriptive statistics for the covariates used to predict crashes in the AMPS sample.

	Men (n=3547)		Women (n=3318)	
Covariates	**Mean**	**Std Dev**	**Mean**	**Std Dev**
Parental Monitoring	2.16	0.45	2.28	0.43
Global Parental Permissiveness	2.19	0.33	2.19	0.34
Parental Nurturance	1.93	0.44	2.00	0.48
Parent versus Peer Orientation	1.68	0.34	1.70	0.37
Past Year Alcohol Use	0.25	0.28	0.24	0.26
Peer Alcohol Use	0.10	0.45	0.09	0.46
Sibling Alcohol Use	0.20	0.22	0.23	0.24
Parental Permissiveness toward Teens Drinking	1.38	0.32	1.37	0.32
Susceptibility to Peer Pressure	0.97	0.47	0.90	0.44
Self-Esteem	0.80	0.17	0.77	0.19
Tolerance of Deviance	2.31	0.46	2.26	0.44
Reasons to Drink	0.49	0.25	0.46	0.25
Reasons to Abstain	0.61	0.22	0.63	0.20
Health Locus of Control	0.90	0.10	0.93	0.08
Marks in School	6.86	1.20	7.12	1.13
Age at Licensure	16.51	1.27	16.72	1.43

3.4 Total Michigan Population: Rates and Rate Ratios

In this section rates and rate ratios are presented for the crash elements, general crash types, alcohol crash types, and casualty crash types. High rates are defined relative to the range of observed rates for the crash elements, and general, alcohol and fatal crash types. Excess crash risk is defined as rate ratios that are significantly greater for teen than adult drivers of the same sex. When the combined risk based on rates and rate ratios is considered, these criteria are used to identify crash elements and types that have medium to high rates and rate ratios.

3.4.1 Crash Elements - Men

Rates of the crash elements for teen and adult men are displayed in Table 11a. The crash elements with the highest rates for teenage men were intersection, passenger, weather, weekend, single vehicle, nighttime, and driver action crashes. Improper lane use was the least frequent crash element for teen and adult men, and surprisingly given the high risk that is usually associated with it, speeding had next to the lowest rate for both age groups.

Table 11a. Crash element rates for teen and adult men.

	Rate[1]	
Crash Elements	**Teens**	**Adults**
Overall	14.92	6.19
Intersection	9.73	3.79
Passenger	6.35	1.64
Weather	5.40	2.15
Weekend	5.15	1.98
Single vehicle	3.51	1.28
Nighttime	3.26	0.87
Driver action	3.18	1.07
Failure to yield	2.21	0.62
Road departure	1.60	0.26
Speeding	1.73	0.23
Improper lane use	0.68	0.20

1- Rates are based on 100,000 PMD.

Rate ratios (RR), and 95% confidence intervals (CI) comparing teen and adult men on crash elements are displayed in Table 11b. The RR for all crashes was 2.41 (Table 11b). Using this as a baseline RR for comparison, crash elements that are significantly greater than 2.41 represent excess risk. As can be seen from Table 11b, teenage men were at excess risk for all of the elements listed. The crash elements with the highest RR values included speeding, road departure, passenger, nighttime, failure to yield, and improper lane use. The crash element with the lowest level of excess risk was weather. Crash elements that had high crash rates and rate ratios represent the greatest interest from the perspective of increasing teen driver safety. Those crash elements that fell into this category included intersection, passenger, weather, weekend single vehicle, nighttime and driver action.

Table 11b. Crash element rate ratios and 95% confidence intervals for teen and adult men.

Crash Elements	Rate Ratios	95% CI	
		Lower	Upper
Overall	2.41	2.40	2.42
Speeding	7.64	7.51	7.77
Road departure	6.08	5.98	6.18
Passenger	3.87	3.84	3.90
Nighttime	3.74	3.71	3.78
Failure to yield	3.57	3.53	3.61
Improper lane use	3.38	3.31	3.45
Driver action	2.98	2.95	3.01
Single vehicle	2.74	2.72	2.77
Weekend	2.59	2.58	2.61
Intersection	2.56	2.55	2.58
Weather	2.52	2.50	2.53

3.4.2 Crash Elements – Women

Rates of crash elements for teenaged and adult women are listed in Table 12a. The overall crash rate was 22.49 for teenage women. As with teenage men, teenage women also experienced the highest rate of crashes at intersections, with the second highest rate due to driving with a passenger in the car, in poor weather, and on the weekend, but driver action ranks higher for teenage women than for their male counterparts. Teenage women also experienced high rates of crashes resulting from failure to yield, single vehicle crashes, and nighttime crashes. Similar to teenage men, teenage women experience the lowest rate of crashes as a result of improper lane use. Overall, teenage and adult women had higher crash rates than their male counterparts on the basis of PMD.

Table 12a. Crash element rates for teen and adult women.

	Rate[1]	
Crash Elements	**Teens**	**Adults**
Overall	22.49	12.84
Intersection	15.51	8.62
Passenger	9.78	3.06
Weather	7.98	4.33
Weekend	7.45	3.86
Driver action	5.19	2.46
Failure to yield	4.09	1.72
Single vehicle	3.93	2.11
Nighttime	3.84	1.21
Speeding	1.83	0.46
Road departure	1.74	0.53
Improper lane use	0.83	0.37

1- Rates are based on 100,000 PMD.

RR values, and CIs comparing the crash elements for teen and adult women are in Table 12b. The RR for all crashes was 1.75 for women. Using this baseline value to define excess risk, as with men, all of the crash elements being examined represented excess risk to female teen drivers. The highest RR values were associated with speeding, road departure, passengers, and nighttime driving. The lowest level of excess risk was for intersection crashes. Crash elements with high rates and rate ratios, and therefore key targets for increasing the driver safety of teenage women, were intersection, passenger, weather, weekend, driver action, failure to yield, single vehicle, and nighttime.

Table 12b. Crash element rate ratios and 95% confidence intervals for teen and adult women.

Crash Elements	Rate Ratios	95% CI	
		Lower	Upper
Overall	1.75	1.74	1.76
Speeding	4.02	3.93	4.12
Road departure	3.27	3.20	3.34
Passenger	3.20	3.17	3.23
Nighttime	3.18	3.13	3.22
Failure to yield	2.38	2.34	2.41
Improper lane use	2.27	2.21	2.33
Driver action	2.10	2.08	2.13
Weekend	1.93	1.91	1.95
Single vehicle	1.86	1.84	1.88
Weather	1.84	1.83	1.86
Intersection	1.80	1.79	1.81

3.4.3 General Crash Types – Men

Table 13a shows the rates of general crash types for teen and adult men. The highest rate crash type for the teenage men was casualty/passenger, with a rate of 1.95 per 100,000 PMD. The second highest rate is for passenger/nighttime crash types, followed by single vehicle/road departure, single vehicle/passenger, weekend/nighttime and nighttime/weather. The lowest rate crash type was driver action/weather/nighttime.

Table 13a. General crash type rates for teen and adult men.

Crash Types	Rate[1]	
	Teens	Adults
Overall	**14.92**	**6.19**
Casualty/Passenger	1.95	0.47
Passenger/Nighttime	1.63	0.24
Single vehicle/Road departure	1.50	0.24
Single vehicle/Passenger	1.49	0.37
Weekend/Nighttime	1.42	0.32
Nighttime/Weather	1.13	0.30
Driver action/Weather	0.99	0.34
Speeding/Weather	0.97	0.16
Weekend/Nighttime/Passenger	0.78	0.10
Road departure/Passenger	0.72	0.06
Single vehicle/Road departure/Speeding	0.70	0.08
Speeding/Nighttime	0.56	0.05
Single vehicle/Driver action	0.39	0.06
Improper lane use/Passenger	0.30	0.05
Speeding/Weather/Nighttime	0.28	0.04
Driver action/Weather/Nighttime	0.19	0.03

1- Rates are based on 100,000 PMD.

RR values and CIs for general crash types for teen and adult men are displayed in Table 13b. The overall RR value was 2.41, indicating that teens were at excess risk for all the general crash types. Teens were at the highest level of excess risk for road departure/passenger, speeding/nighttime, single vehicle/road departure/speeding, weekend/nighttime/passenger, speeding/weather/nighttime, passenger/nighttime, improper lane use/passenger, single vehicle/road departure, single vehicle/driver action, and speeding/weather. Teens had the lowest level of excess risk for driver action/weather. The crash types that combined elevated rates and rate ratios included passenger/nighttime, single vehicle/road departure, single vehicle/passenger, weekend/nighttime and nighttime/weather.

Table 13b. General crash type rate ratios and 95% confidence intervals for teen and adult men.

Crash Types	Rate Ratio	95% CI	
		Lower	Upper
Overall	**2.41**	**2.40**	**2.42**
Road departure/Passenger	13.04	12.62	13.47
Speeding/Nighttime	10.35	10.01	10.71
Single vehicle/Road departure/Speeding	9.10	8.85	9.37
Weekend/Nighttime/Passenger	7.65	7.46	7.85
Speeding/Weather/Nighttime	7.58	7.27	7.92
Passenger/Nighttime	6.80	6.68	6.91
Improper lane use/Passenger	6.42	6.18	6.67
Single vehicle/Road departure	6.40	6.29	6.51
Single vehicle/Driver action	6.25	6.04	6.47
Speeding/Weather	6.08	5.95	6.21
Driver action/Weather/Nighttime	5.79	5.52	6.07
Weekend/Nighttime	4.49	4.42	4.56
Casualty/Passenger	4.12	4.06	4.17
Single vehicle/Passenger	4.01	3.95	4.07
Nighttime/Weather	3.82	3.76	3.89
Driver action/Weather	2.93	2.88	2.98

3.4.4 General Crash Types – Women

The rates of general crash types for teen and adult women are found in Table 14a. As with men, casualty/passenger crashes are the most frequently occurring type for teenage women, followed by passenger/nighttime. Teenage women also had high rates of weekend/nighttime, single vehicle/passenger, single vehicle/road departure, driver action/weather, nighttime/weather, speeding/weather, and weekend/nighttime/passenger crash types. They had the lowest crash rates for driver action/weather/nighttime. Teenage and adult women both had higher rates of general crash types than their male counterparts.

Table 14a. General crash type rates for teen and adult women.

	Rate[1]	
Crash Types	**Teens**	**Adults**
Overall	**22.49**	**12.84**
Casualty/Passenger	3.31	0.98
Passenger/Nighttime	2.05	0.33
Weekend/Nighttime	1.68	0.41
Single vehicle/Passenger	1.63	0.50
Single vehicle/Road departure	1.63	0.48
Driver action/Weather	1.53	0.74
Nighttime/Weather	1.36	0.41
Speeding/Weather	1.19	0.36
Weekend/Nighttime/Passenger	1.01	0.13
Road departure/Passenger	0.75	0.11
Single vehicle/Road departure/Speeding	0.70	0.18
Speeding/Nighttime	0.44	0.07
Single vehicle/Driver action	0.39	0.12
Improper lane use/Passenger	0.38	0.09
Speeding/Weather/Nighttime	0.26	0.05
Driver action/Weather/Nighttime	0.23	0.05

1- Rates are based on 100,000 PMD.

Table 14b displays the RRs and CIs of crash types for teen and adult women. With an overall RR=1.75, teenage women were at excess risk for all of the crash types examined. The crash types for which teens were at the highest level of excess risk included: weekend/nighttime/ passenger; passenger/nighttime; road departure/passenger; speeding/ nighttime, speeding/ weather/nighttime; driver action/weather/nighttime; and improper lane use/passenger, but they were at excess risk for all crash types examined. Teens were at the lowest level of excess risk for driver action/weather crash types. The crash types that represented the greatest combined risk when rates and RRs are considered together were casualty/passenger, passenger/nighttime, weekend/nighttime, single vehicle/passenger, single vehicle/road departure, driver action/weather, nighttime/weather, speeding/weather, and weekend/nighttime/passenger.

Table 14b. General crash type rate ratios and 95% confidence intervals for teen and adult women.

Crash Types	Rate Ratio	95% CI	
		Lower	Upper
Overall	**1.75**	**1.74**	**1.76**
Weekend/Nighttime/Passenger	7.94	7.64	8.25
Passenger/Nighttime	6.80	6.68	6.91
Road departure/Passenger	6.69	6.42	6.98
Speeding/Nighttime	6.28	5.95	6.63
Speeding/Weather/Nighttime	4.99	4.68	5.32
Driver action/Weather/Nighttime	4.56	4.26	4.87
Improper lane use/Passenger	4.39	4.18	4.62
Single vehicle/Road departure/Speeding	3.93	3.79	4.07
Single vehicle/Road departure	3.42	3.34	3.49
Casualty/Passenger	3.36	3.31	3.42
Single vehicle/Driver action	3.33	3.17	3.48
Speeding/Weather	3.32	3.23	3.41
Nighttime/Weather	3.32	3.24	3.41
Weekend/Nighttime	3.32	4.03	4.23
Single vehicle/Passenger	3.29	3.21	3.36
Driver action/Weather	2.07	2.03	2.11

3.4.5 Alcohol Crashes – Men

Table 15a shows the rates of alcohol crashes for teen and adult men. The alcohol crash type with the highest rate was alcohol/nighttime, followed by alcohol/passenger, alcohol/weekend, alcohol/passenger/nighttime, alcohol/nighttime/casualty, and alcohol/weekend/nighttime. Overall, rates for alcohol crashes were low compared to general crash types, and this was similar for teenage and adult men. Unlike overall crash types, men had higher rates than women for all of the alcohol crash types.

Table 15a. Alcohol crash rates for teen and adult men.

	Rate[1]	
Crash Types	**Teens**	**Adults**
Overall	**14.92**	**6.19**
Overall Alcohol	**0.81**	**0.38**
Alcohol/Nighttime	0.59	0.16
Alcohol/Passenger	0.44	0.09
Alcohol/Weekend	0.37	0.15
Alcohol/Passenger/Nighttime	0.32	0.04
Alcohol/Nighttime/Casualty	0.29	0.08
Alcohol/Weekend/Nighttime	0.28	0.07
Alcohol/Passenger/Casualty	0.22	0.05
Alcohol/Passenger/Weekend	0.20	0.04
Alcohol/Speeding	0.19	0.04
Alcohol/Weekend/Casualty	0.18	0.07
Alcohol/Nighttime/Speeding	0.15	0.02
Alcohol/Speeding/Casualty	0.10	0.02
Alcohol/Passenger/Speeding	0.10	0.01
Alcohol/Weekend/Speeding	0.08	0.02

1- Rates are based on 100,000 PMD.

Table 15b shows the RR values, and CIs for alcohol crashes for teen and adult men. Teens were at excess risk for all alcohol crash types with an overall RR=2.41, and an overall alcohol RR of 2.13. Alcohol crash types with the highest levels of excess risk included alcohol/passenger/speeding, alcohol//passenger/nighttime, alcohol/nighttime/speeding, alcohol/weekend/speeding, alcohol/passenger/weekend, alcohol/speeding, and alcohol/speeding/casualty. Excess risk was the least for alcohol/weekend. The crash types of greatest combined risk when rates and RRs were considered together were alcohol/nighttime, alcohol/passenger, alcohol/weekend, alcohol/passenger/nighttime, alcohol/nighttime/casualty, and alcohol/weekend/nighttime.

Table 15b. Alcohol crash type rate ratios and 95% confidence intervals for teen and adult men.

Crash Types	Rate Ratio	95% CI	
		Lower	Upper
Overall	**2.41**	**2.40**	**2.42**
Overall Alcohol	**2.13**	**2.10**	**2.16**
Alcohol/Passenger/Speeding	18.16	16.45	20.04
Alcohol/Passenger/Nighttime	9.08	8.70	9.47
Alcohol/Nighttime/Speeding	8.03	7.57	8.52
Alcohol/Weekend/Speeding	5.44	5.08	5.84
Alcohol/Passenger/Weekend	5.12	4.90	5.35
Alcohol/Speeding	5.10	4.87	5.33
Alcohol/Speeding/Casualty	5.07	4.76	5.40
Alcohol/Passenger	4.89	4.75	5.04
Alcohol/Passenger/Casualty	4.62	4.44	4.82
Alcohol/Weekend/Nighttime	4.16	4.02	4.31
Alcohol/Nighttime	3.71	3.62	3.79
Alcohol/Nighttime/Casualty	3.66	3.53	3.78
Alcohol/Weekend/Casualty	2.41	2.32	2.50
Alcohol/Weekend	2.40	2.34	2.47

3.4.6 Alcohol Crashes – Women

Table 16a shows the rates of alcohol crash types for teen and adult women. As with teenage men, the highest rates of crash were for alcohol/nighttime, followed by alcohol/passenger, alcohol/weekend, alcohol/passenger/nighttime, alcohol/nighttime/casualty, and alcohol/weekend/nighttime.

Table 16b. Alcohol crash type rates for teen and adult women.

Crash Types	Rate[1]	
	Teens	**Adults**
Overall	**22.49**	**12.84**
Overall Alcohol	**0.67**	**0.38**
Alcohol/Nighttime	0.43	0.14
Alcohol/Passenger	0.38	0.09
Alcohol/Weekend	0.30	0.13
Alcohol/Passenger/Nighttime	0.26	0.04
Alcohol/Nighttime/Casualty	0.24	0.07
Alcohol/Passenger/Casualty	0.21	0.05
Alcohol/Weekend/Nighttime	0.20	0.06
Alcohol/Passenger/Weekend	0.19	0.04
Alcohol/Weekend/Casualty	0.16	0.07
Alcohol/Speeding	0.07	0.02
Alcohol/Nighttime/Speeding	0.06	0.01
Alcohol/Speeding/Casualty	0.04	0.01
Alcohol/Passenger/Speeding	0.04	0.00
Alcohol/Weekend/Speeding	0.03	0.01

1- Rates are based on 100,000 PMD.

Table 16b shows the RRs, and CIs of alcohol crash types for teen and adult women. Teens were at excess risk for alcohol crashes with an overall RR=1.75 and an RR for all alcohol-involved crashes of 1.97. The highest RR values were for alcohol/passenger/speeding, alcohol/nighttime/speeding, alcohol/passenger/weekend, alcohol/weekend/speeding, alcohol/speeding/casualty, alcohol/passenger, alcohol/passenger/casualty, and alcohol/passenger/nighttime. The lowest level of excess risk was for alcohol/weekend crashes. The alcohol crash types with combined rates and rate ratios resulting in a high level of risk include alcohol/nighttime, alcohol/passenger, alcohol/weekend, alcohol/passenger/nighttime, alcohol/nighttime/casualty, and alcohol/weekend/nighttime.

Table 16b. Alcohol crash type rate ratios and 95% confidence intervals for teen and adult women.

Crash Types	Rate Ratio	95% CI	
		Lower	Upper
Overall	**1.75**	**1.74**	**1.76**
Overall Alcohol	**1.97**	**1.91**	**2.03**
Alcohol/Passenger/Speeding	10.87	8.73	13.53
Alcohol/Nighttime/Speeding	5.47	4.74	6.30
Alcohol/Passenger/Weekend	4.62	4.29	4.98
Alcohol/Weekend/Speeding	4.38	3.67	5.24
Alcohol/Speeding/Casualty	4.13	3.55	4.80
Alcohol/Passenger	4.10	3.90	4.31
Alcohol/Passenger/Casualty	4.01	3.75	4.28
Alcohol/Passenger/Nighttime	4.01	6.23	7.18
Alcohol/Speeding	3.68	3.29	4.11
Alcohol/Weekend/Nighttime	3.63	3.40	3.87
Alcohol/Nighttime/Casualty	3.41	3.21	3.61
Alcohol/Nighttime	3.20	3.06	3.34
Alcohol/Weekend	2.40	2.34	2.47
Alcohol/Weekend/Casualty	2.33	2.18	2.49

3.4.7 Casualty Crashes – Men

Rates, of casualty crashes for teen and adult men are found in Table 17a. The most frequently occurring casualty crash type for teenage men was with passengers. This was followed by casualty/weekend, casualty/weather, casualty/nighttime, casualty/failure to yield, casualty/weekend/passenger, and casualty/driver action.

Table 17a. Casualty crash rates for teen and adult men.

Crash Types	Rate[1]	
	Teens	**Adults**
Overall	**14.92**	**6.19**
Overall Casualty	**4.12**	**1.55**
Casualty/Passenger	1.95	0.47
Casualty/Weekend	1.43	0.51
Casualty/Weather	1.37	0.53
Casualty/Nighttime	0.96	0.20
Casualty/Failure to Yield	0.76	0.20
Casualty/Weekend/Passenger	0.73	0.18
Casualty/Driver Action	0.72	0.22
Casualty/Speeding	0.59	0.07
Casualty/Road Departure	0.55	0.09
Casualty/Passenger/Nighttime	0.53	0.06
Casualty/Weekend/Nighttime	0.42	0.08
Casualty/Alcohol	0.39	0.18
Casualty/Weather/Nighttime	0.31	0.08
Casualty/Road Departure/Nighttime	0.25	0.03
Casualty/Passenger/Alcohol	0.22	0.05
Casualty/Overturn	0.21	0.03

1- Rates are based on 100,000 PMD.

RR values, and CIs of casualty crashes for teen and adult men are found in Table 17b. Teens were at excess risk for casualty crashes with an overall RR=2.41 and a rate ratio for all casualty crashes of 2.65. Excess risk for casualty crashes was greatest for casualty/passenger/ nighttime, casualty/road departure/nighttime, casualty/speeding, casualty/overturn, casualty/road departure, and casualty/weekend/nighttime. Excess risk was lowest for casualty/weather. Crash types with high crash risk due to a combination of rates and RR values were casualty/passenger, casualty/weekend, casualty/weather, casualty/nighttime, casualty/failure to yield, casualty/weekend/passenger, and casualty/driver action.

Table 17b. Casualty crash type rate ratios and 95% confidence intervals for teen and adult men.

Crash Types	Rate Ratio	95% CI	
		Lower	Upper
Overall	**2.41**	**2.40**	**2.42**
Overall Casualty	**2.65**	**2.63**	**2.67**
Casualty/Passenger/Nighttime	8.98	8.69	9.28
Casualty/Road Departure/Nighttime	8.98	8.56	9.42
Casualty/Speeding	8.07	7.83	8.32
Casualty/Overturn	7.10	6.76	7.45
Casualty/Road Departure	6.20	6.03	6.38
Casualty/Weekend/Nighttime	5.26	5.10	5.43
Casualty/Nighttime	4.71	4.62	4.80
Casualty/Passenger/Alcohol	4.62	4.44	4.82
Casualty/Passenger	4.12	4.06	4.17
Casualty/Weather/Nighttime	4.12	3.98	4.26
Casualty/Weekend/Passenger	4.04	3.95	4.13
Casualty/Failure to Yield	3.84	3.76	3.92
Casualty/Weekend	2.81	2.77	2.85
Casualty/Weather	2.56	2.52	2.60
Casualty/Alcohol	2.16	2.10	2.21

3.4.8 Casualty Crashes – Women

The rates of casualty crashes for teen and adult women are found in Table 18a. The three casualty crash types with the highest rates for teenage women were casualty/passenger, casualty/weather, and casualty/weekend, casualty/driver action, casualty/nighttime, and casualty/weekend/passenger.

Table 18a. Casualty crash rates for teen and adult women.

Crash Types	Rate[1]	
	Teens	**Adults**
Overall	**22.49**	**12.84**
Overall Casualty	**6.99**	**3.67**
Casualty/Passenger	3.31	0.98
Casualty/Weather	2.37	1.24
Casualty/Weekend	2.29	1.11
Casualty/Driver Action	1.36	0.60
Casualty/Nighttime	1.26	0.30
Casualty/Weekend/Passenger	1.19	0.34
Casualty/Road Departure	0.73	0.19
Casualty/Passenger/Nighttime	0.72	0.09
Casualty/Speeding	0.71	0.15
Casualty/Weekend/Nighttime	0.55	0.11
Casualty/Weather/Nighttime	0.43	0.12
Casualty/Alcohol	0.36	0.18
Casualty/Road Departure/Nighttime	0.23	0.04
Casualty/Passenger/Alcohol	0.22	0.05
Casualty/Passenger/Alcohol	0.21	0.03
Casualty/Failure to Yield	0.20	0.06

1- Rates are based on 100,000 PMD.

The RR values and CIs of casualty crashes for teen and adult women are found in Table 18b. With an overall RR=1.75 and a RR for all casualty crashes of 1.90, teens were at excess risk for all of the casualty crash types examined in this study. The greatest excess risk was associated with the following crash types: casualty/passenger/nighttime, casualty/overturn, casualty/road, departure/nighttime, casualty/weekend/nighttime, casualty/weekend/nighttime, casualty/speeding, and casualty/passenger/alcohol. The casualty crash type with the lowest level of excess risk was casualty/alcohol. The casualty crash types with the highest combined risk when both the rate and RR are taken into account were casualty/passenger, casualty/weather, and casualty/weekend, casualty/driver action, casualty/nighttime, and casualty/weekend/passenger.

Table 18b. Casualty crash type rate ratios and 95% confidence intervals for teen and adult women.

Crash Types	Rate Ratio	95% CI	
		Lower	Upper
Overall	**1.75**	**1.74**	**1.76**
Overall Casualty	**1.90**	**1.89**	**1.92**
Casualty/Passenger/Nighttime	7.86	7.51	8.22
Casualty/Overturn	7.10	6.76	7.45
Casualty/Road Departure/Nighttime	6.06	5.63	6.52
Casualty/Weekend/Nighttime	5.07	4.85	5.30
Casualty/Speeding	4.67	4.50	4.85
Casualty/Passenger/Alcohol	4.62	4.44	4.82
Casualty/Road Departure	3.76	3.63	3.89
Casualty/Weather/Nighttime	3.68	3.52	3.85
Casualty/Failure to Yield	3.63	3.40	3.87
Casualty/Weekend/Passenger	3.54	3.44	3.63
Casualty/Passenger	3.36	3.31	3.42
Casualty/Weather	2.56	2.52	2.60
Casualty/Driver Action	2.26	2.21	2.31
Casualty/Nighttime	2.26	4.07	4.30
Casualty/Weekend	2.06	2.03	2.10
Casualty/Alcohol	2.06	1.98	2.15

3.4.9 Overall Crash Rates by Age and Sex

Rates were estimated for teen and adult men by the teens' year of age (see Table 19a). Crash rates are highest for teens at age 16, and decline with each subsequent year of age. This is consistent with other research showing that the first year of driving is the most dangerous. These rates also reflect the rapid rate of decline in crash rates during the early months of licensure. Teens' crash rates decline 44% from age 16 to 17. Rates for teens continue to decline with another decrease of an additional 45% from ages 17 to 19.

Table 19a. Overall crash rates by age for teen and adult men.

Crash Types	Rate[1]	
	Teens	Adults
Overall 16	31.86	6.29
Overall 17	18.00	6.29
Overall 18	13.86	6.29
Overall 19	9.88	6.29

RR and 95% CIs are displayed in Table 19b, and reflect what was observed in the rates in table 19a. From age 16 to 17 the RR drops from 5.07 to 2.86. From age 17 to 19 the RR declines to 1.57, demonstrating a narrowing of the difference in crash risk for teen and adult men.

Table 19b. Overall crash rate ratios and 95% confidence intervals for teen and adult men.

Crash Types	Rate Ratio	95% CI	
		Lower	Upper
Overall 16	5.07	5.05	5.08
Overall 17	2.86	2.85	2.87
Overall 18	2.20	2.20	2.21
Overall 19	1.57	1.57	1.58

Rates for teen and adult women by the teens' year of age are displayed in Table 20a. As with the teenage men, teenage women experience a rapid decrease in crash rates between ages 16 and 19; however, the rates are higher for teenage women than their male age mates, and they decline more slowly. By age 19 the crash rate for teenage women is roughly equal to that of teenage men at age 17.

Table 20a. Overall crash rates for teen and adult women.

Crash Types	Rate[1]	
	Teens	Adults
Overall 16	49.13	13.40
Overall 17	30.69	13.40
Overall 18	16.96	13.40
Overall 19	15.40	13.40

Table 20b displays RR and 95% CI values comparing teenage and adult women. The difference between teenage and adult women's crash risk is smaller than for teen and adult men at each year of age. The difference in crash risk between teen and adult women when teens are 18 is already less than the difference between adult men and teenage men who are age 19, and the difference is even smaller for teenage women who are 19 years of age.

Table 20b. Overall crash rate ratios and 95% confidence intervals for teen and adult women.

Crash Types	Rate Ratio	95% CI	
		Lower	Upper
Overall 16	3.67	3.65	3.68
Overall 17	2.29	2.28	2.30
Overall 18	1.27	1.26	1.27
Overall 19	1.15	1.15	1.15

3.5

3.6 Regression Models

3.6.1 Odds Ratios

The odds ratios (OR) for teenage males for involvement in the various crash types are found in Table 21. For teenage men the variables that most often predicted the likelihood of being involved in a crash were marks in school, peer alcohol use, susceptibility to peer pressure, health locus of control, and past year alcohol use. Past year alcohol use was the variable predictive of the most crash types. Looking at overall crashes for men, with significant odds ratios of 1.12 and 1.17, the greater the susceptibility to peer pressure and the greater the past year alcohol misuse the more likely it was for teens to be involved in a crash. High health locus of control was associated with a 43% decrease in the risk that teens would be involved in a crash.

When the models were adjusted for age at first licensure, the strength of the effects tended to decline for most of the predictors, in most of the models. However, the effects of some of the predictors consistently increased when the models were adjusted. The variables that tended to show increased effects were: parental permissiveness toward alcohol use by teens, peer alcohol use, susceptibility to peer pressure, and past year alcohol misuse.

Age at licensure was a highly significant predictor in nearly all of the models, and was never non-significant. The odds ratio of age at licensure for overall crashes was 0.88 ($p<.000$), indicating that older age at licensure was significantly associated with lower crash risk.

The odds ratios (OR) for teenaged females' involvement in various crash types are found in Table 22. The variables that most often predicted the likelihood of a crash for teen women were global parental permissiveness, parental nurturance, parent vs. peer orientation, tolerance of deviance, peer alcohol use, parental permissiveness toward teen alcohol use, susceptibility to peer pressure, and past year alcohol misuse, with increased parental nurturance and increased parent vs. peer orientation predicting a reduced risk for crash involvement. The variable showing prediction for the greatest number of crash types for teen women was susceptibility to peer pressure. Health locus of control was significant for speeding crashes with an odds ratio of 22.95; however, health locus of control appears to be an anomalous variable for women with the odds ratios varying greatly across crash type with a range of 0.54 to 52.10. Changes in the models for women when they were adjusted for age at first licensure were the same as those noted for men.

3.6.2 Patterns of Prediction

The results of the regression models were closely examined for evidence of some specificity in prediction, with some psychosocial characteristics predicting some crash types more than others. No evidence of differential prediction could be found. Overall, the results of these analyses mirror the results of other analyses conducted on this sample examining the association between psychosocial characteristics and overall crash occurrence (Bingham, Shope, 2005).

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Overall	0.92+ (0.91+)	0.93 (0.89*)	0.94 (0.94)	0.90+ (0.91+)	1.04 (1.02)	0.96 (0.95+)	1.03 (1.02)	0.96 (0.98)	1.01 (1.03)	1.12* (1.10*)	0.88 (0.84)	0.96 (0.95)	1.15 (1.16+)	0.57*** (0.51***)	1.17** (1.15**)
Alcohol-Involved	0.91 (0.83)	1.42- (1.32-)	0.91 (0.89)	0.81 (0.80-)	1.16 (1.21-)	0.93 (0.88*)	1.68** (1.77**)	1.10 (0.96-)	0.94 (1.10)	1.47* (1.64*)	1.38- (1.19)	1.65- (1.48-)	0.65- (0.70-)	0.47- (0.25+)	2.89*** (3.04***)
Casualty	1.00 (0.96)	0.96 (0.87)	0.86 (0.87)	0.90 (0.93)	0.89 (0.96)	0.92+ (0.88+)	1.01 (1.06)	0.88 (0.79-)	1.05 (1.19)	1.20+ (1.29+)	1.01 (0.86)	1.10 (0.98)	1.49+ (1.44-)	0.47+ (0.26**)	1.44** (1.48*)
Driver Action	0.97 (0.94)	1.14 (1.04)	0.93 (0.94)	0.86 (0.89)	1.07 (1.11)	0.95 (0.90*)	0.98 (1.04)	1.05 (0.92)	1.10 (1.24-)	1.02 (1.16)	1.00 (0.89)	1.10 (0.98)	1.03 (1.15)	0.48+ (0.25**)	1.02 (1.19)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Speed	0.98 (0.93)	1.52+ (1.33-)	0.87 (0.87)	1.08 (1.05)	1.03 (1.07)	0.93 (0.87*)	1.53** (1.58**)	1.02 (0.88)	0.86 (1.03)	1.23- (1.37-)	0.91 (0.80-)	0.98 (0.89)	1.08 (1.18)	0.89 (0.39-)	1.40- (1.60+)
Failure to Yield	0.90 (0.86)	0.99 (0.91)	1.13 (1.14)	1.15 (1.14)	1.11 (1.16)	0.99 (0.92)	1.00 (1.06)	0.99 (0.87)	1.03 (1.20-)	1.13 (1.27-)	1.34- (1.13)	1.08 (0.98)	1.06 (1.16)	1.29- (0.56-)	0.98 (1.14)
Lane Use	0.76- (0.73-)	0.90 (0.82)	0.79- (0.80-)	0.82 (0.82)	1.21- (1.26-)	0.90 (0.85*)	1.25- (1.33-)	0.61 (0.54-)	1.09 (1.26-)	1.34- (1.48-)	0.76- (0.71-)	0.71- (0.68-)	0.94 (1.01)	0.61- (0.32-)	1.40- (1.59-)
Road Departure	0.87 (0.84)	0.93 (0.86)	0.72+ (0.73+)	0.73- (0.73-)	0.87 (0.93)	0.88** (0.83**)	1.32+ (1.39*)	1.30- (1.09)	0.96 (1.10)	1.04 (1.17)	0.66- (0.63-)	1.26- (1.15)	0.72- (0.79-)	0.49- (0.27+)	1.59* (1.80**)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Intersection	0.94 (0.91)	1.02 (0.94)	0.94 (0.96)	0.94 (0.98)	1.07 (1.09)	0.93 (0.90+)	1.07 (1.08)	0.81 (0.80-)	1.03 (1.14)	1.17 (1.20-)	1.05 (0.89)	1.01 (0.94)	1.21- (1.22-)	0.45* (0.31**)	1.35* (1.32*)
Weekend	0.96 (0.93)	1.02 (0.92)	0.90 (0.91)	1.00 (1.02)	1.04 (1.08)	0.96 (0.91+)	1.00 (1.05)	1.04 (0.91)	0.94 (1.10)	1.09 (1.20-)	0.85 (0.78-)	0.80- (0.78-)	0.90 (1.05)	0.54 (0.30**)	0.98+ (1.11)
Weather	0.88 (0.85)	1.04 (0.95)	0.95 (0.97)	0.93 (0.97)	1.08 (1.11)	0.97 (0.92)	0.93 (1.00)	0.84 (0.79-)	1.16 (1.27-)	1.05 (1.15)	0.85 (0.78-)	1.15 (1.01)	1.04 (1.14)	0.52- (0.28**)	1.08 (1.22-)
Nighttime	0.90 (0.86)	1.08 (1.00)	0.89 (0.90)	0.87 (0.89)	1.09 (1.13)	0.93+ (0.88*)	1.17 (1.20-)	1.19 (1.01)	0.97 (1.12)	1.25 (1.35*)	1.17 (0.98)	1.26- (1.08)	1.01 (1.12)	0.36* (0.20**)	1.83*** (1.85***)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Passenger	0.81+ (0.78*)	1.07 (0.99)	0.96 (0.97)	0.90 (0.93)	1.06 (1.09)	0.94 (0.90)	1.12 (1.13)	0.94 (0.85)	1.13 (1.24-)	1.16 (1.25-)	0.94 (0.86)	1.13 (0.99)	1.18 (1.25-)	0.33** (0.21***)	1.45** (1.46*)
Single Vehicle	0.85 (0.81)	0.97 (0.88)	0.73* (0.73*)	0.81 (0.81)	1.18 (1.20-)	0.91** (0.86**)	1.49*** (1.51**)	1.05 (0.90)	1.15 (1.32-)	1.38* (1.50**)	0.60+ (0.58-)	1.01 (0.91)	0.90 (0.96)	0.91 (0.44-)	1.50* (1.64**)
Passenger \ Nighttime	0.80 (0.77+)	1.06 (0.98)	0.89 (0.89)	0.84 (0.85)	1.06 (1.11)	0.94 (0.88+)	1.17 (1.22-)	1.25- (1.05)	1.01 (1.16)	1.15 (1.28-)	1.32- (1.08)	1.45- (1.26-)	1.06 (1.18)	0.32* (0.17**)	2.02*** (2.11***)
Weekend\ Nighttime	0.90 (0.85)	1.21- (1.08)	0.83 (0.84)	0.81 (0.82)	1.10 (1.14)	0.91+ (0.86*)	1.12 (1.18)	1.29- (1.08)	1.04 (1.23-)	1.32* (1.44*)	0.96 (0.82)	1.14 (1.01)	0.87 (0.98)	0.59- (0.27*)	1.84*** (1.90***)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Single Vehicle| Driver Action	0.89 (0.84)	1.48- (1.33-)	0.74- (0.75-)	0.79- (0.80-)	1.27- (1.24-)	0.89* (0.85**)	1.40- (1.39-)	1.21- (1.23-)	1.45- (1.53-)	1.30- (1.28-)	1.05 (0.95)	1.23- (1.19)	1.01 (1.04)	0.49- (0.36-)	1.62+ (1.57+)
Weekend\Nighttime \ Passenger	0.75- (0.72+)	1.16 (1.03)	0.85 (0.85)	0.77- (0.78-)	1.17 (1.12)	0.89 (0.86+)	1.23 (1.23-)	1.00 (1.01)	1.17 (1.25-)	1.36+ (1.33-)	1.09 (0.97)	1.22- (1.17)	0.94 (0.99)	0.26* (0.18**)	2.19*** (2.09***)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Single Vehicle\ Road Departure	0.88 (0.85)	1.01 (0.94)	0.70* (0.71+)	0.73- (0.73-)	0.97 (0.95)	0.87* (0.85**)	1.47* (1.47*)	1.14 (1.16)	1.08 (1.11)	1.23- (1.21-)	0.71- (0.67-)	1.15 (1.13)	0.74- (0.76-)	0.41- (0.35-)	1.88** (1.84**)
Single Vehicle\ Passenger	0.75+ (0.72+)	1.06 (0.96)	0.69* (0.69*)	0.78- (0.79-)	1.22- (1.18)	0.90+ (0.87*)	1.49* (1.48*)	0.93 (0.95)	1.36- (1.43-)	1.57* (1.54*)	0.72- (0.67-)	0.87 (0.84)	1.07 (1.09)	0.59- (0.43-)	1.96** (1.90**)
Nighttime\ Weather	0.89 (0.85)	1.04 (0.93)	0.87 (0.87)	0.87 (0.88)	1.23- (1.20-)	0.91 (0.88*)	1.07 (1.06)	0.93 (0.98)	1.19 (1.27-)	1.35* (1.33+)	1.29- (1.12)	1.29- (1.24-)	1.23- (1.29-)	0.25* (0.18*)	1.68** (1.61*)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Speeding/ Weather	0.97 (0.92)	1.77* (1.56-)	0.88 (0.88)	1.05 (1.07)	1.22- (1.18)	0.91 (0.87*)	1.61* (1.57*)	0.88 (0.92)	0.77- (0.81)	1.40- (1.37-)	1.06 (0.94)	0.98 (0.95)	1.13 (1.19)	0.82 (0.56-)	1.46- (1.41-)
Speeding\ Weather\ Nighttime	1.01 (0.96)	1.83- (1.65-)	1.12 (1.12)	1.27- (1.27-)	1.32- (1.29-)	0.87 (0.84*)	1.77* (1.73*)	1.39- (1.43-)	0.69- (0.74-)	1.71+ (1.70+)	3.21- (2.83-)	1.03 (1.00)	1.61- (1.67-)	1.44- (1.06)	1.61- (1.57-)
Speeding/ Nighttime	1.03 (0.98)	1.56- (1.41-)	0.91 (0.91)	1.04 (1.05)	1.10 (1.08)	0.88+ (0.85*)	1.03 (1.56*)	0.57- (1.29-)	0.51- (1.02)	1.51- (1.50-)	1.59- (1.44-)	0.84 (0.81)	1.22- (1.27-)	0.64- (0.49-)	1.79+ (1.74+)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Driver Action\ Weather	0.98 (0.94)	1.07 (0.95)	0.93 (0.94)	0.89 (0.91)	1.06 (1.04)	0.91* (0.88**)	0.97 (0.96)	0.87 (0.91)	1.17 (1.23-)	1.09 (1.05)	1.08 (0.97)	1.13 (1.12)	0.99 (1.04)	0.19** (0.14***)	1.14 (1.09)
Driver Action\ Weather\ Nighttime	1.15 (1.10)	1.06 (0.91)	0.89 (0.89)	1.00 (1.01)	1.05 (1.02)	0.87* (0.83**)	1.30- (1.27-)	0.87 (0.91)	1.09 (1.17)	1.32- (1.28-)	2.08- (1.77-)	1.56- (1.51-)	1.45- (1.52-)	0.26- (0.18*)	1.74* (1.65+)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Lane Use\ Passenger	0.74- (0.71-)	1.05 (0.95)	0.72- (0.73-)	0.63- (0.64-)	1.18 (1.15)	0.84 (0.82)	1.49- (1.48-)	0.64- (0.65-)	1.29- (1.34-)	1.31- (1.29-)	0.81 (0.76-)	0.94 (0.92)	0.74- (0.77-)	0.39- (0.32-)	2.14* (2.08*)
Road Departure/ Passenger	0.86 (0.82)	0.97 (0.90)	0.67* (0.68+)	0.67- (0.68-)	0.93 (0.92)	0.86* (0.84**)	1.39+ (1.38+)	1.11 (1.13)	0.98 (1.02)	1.32- (1.30-)	0.65- (0.62-)	0.98 (0.95)	0.91 (0.95)	0.75- (0.62-)	1.97** (1.92*)
Casualty/ Passenger	0.92 (0.88)	0.92 (0.84)	0.87 (0.87)	0.91 (0.92)	0.98 (0.95)	0.89 (0.86+)	1.10 (1.10)	0.85 (0.87)	1.20- (1.25-)	1.27- (1.25-)	0.97 (0.87)	1.18 (1.14)	1.35- (1.41-)	0.25** (0.18***)	1.62** (1.57*)

Table 21. Regression results for men: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)

	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Single Vehicle/Road Departure/Speeding	1.04 (1.00)	1.01 (0.93)	0.82 (0.83)	1.08 (1.09)	0.95 (0.94)	0.88+ (0.85*)	1.49+ (1.48+)	1.21- (1.23-)	0.70- (0.73-)	1.10 (1.09)	1.21- (1.12)	1.22- (1.20-)	1.10 (1.15)	0.30- (0.25-)	1.25- (1.23-)

+<1.0, *<.05; **≤.01; ***≤.001, - not significant, however, 20% increase or decrease in odds and confidence interval is not especially large

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Overall	0.94 (0.92)	1.19** (1.12+)	0.86** (0.86**)	0.85* (0.85*)	1.20*** (1.15**)	0.98 (0.95)	1.18*** (1.15**)	1.04 (1.08)	1.22* (1.23*)	1.40*** (1.35***)	0.96 (0.91)	0.95 (0.96)	1.06 (1.06)	1.34 (1.01)	1.39*** (1.35***)
Alcohol-Involved	0.77- (0.66-)	1.33- (1.37-)	0.92 (0.89)	0.92 (0.84)	1.57+ (1.73*)	0.96 (0.91)	1.12 (1.22-)	2.05- (2.40+)	2.00- (2.21+)	2.02* (2.58**)	0.98 (1.07)	1.00 (0.95)	0.69- (0.77-)	6.08- (3.47-)	3.00*** (3.50***)
Casualty	0.90 (0.82)	1.32* (1.30+)	0.81* (0.79*)	0.74+ (0.73*)	1.15 (1.26*)	0.94 (0.91)	1.27* (1.33*)	1.02 (1.18)	1.33+ (1.38+)	1.61*** (1.88***)	0.75- (0.85)	0.95 (0.91)	1.07 (1.11)	1.07 (0.76-)	1.86*** (2.11***)
Driver Action	0.97 (0.86)	1.36+ (1.35+)	0.92 (0.88)	0.85 (0.80-)	1.15 (1.23-)	0.93 (0.89)	1.38** (1.44**)	0.93 (1.12)	0.85 (0.97)	1.42* (1.71***)	1.24- (1.23-)	1.16 (1.04)	1.17 (1.18)	3.60- (2.06-)	1.55* (1.80**)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Speed	0.81 (0.71-)	1.16 (1.22-)	1.39- (1.29-)	1.14 (1.03)	1.41 (1.55+)	1.01 (0.96)	1.22- (1.33-)	0.75- (0.87)	1.45- (1.62-)	1.08 (1.38-)	0.97 (1.03)	1.02 (0.96)	1.08 (1.17)	22.95* (13.67-)	0.92 (1.17)
Failure to Yield	0.74+ (0.68*)	1.18 (1.20-)	1.00 (0.94)	0.82- (0.76+)	1.18 (1.27+)	0.99 (0.95)	1.25+ (1.33*)	0.72- (0.88)	0.87 (0.98)	1.44* (1.75**)	1.19 (1.22-)	1.22- (1.10)	1.04 (1.09)	2.43- (1.41-)	2.06*** (2.25***)
Lane Use	1.15 (1.02)	0.69- (0.72-)	0.75- (0.71-)	0.65- (0.60-)	1.00 (1.11)	0.84 (0.80-)	1.13 (1.25-)	0.52- (0.58-)	1.02 (1.14)	0.77- (1.01)	0.40- (0.44-)	0.74- (0.70-)	0.69- (0.73-)	0.54- (0.42-)	1.32- (1.64-)
Road Departure	0.98 (0.86)	1.04 (1.08)	0.74- (0.72-)	0.64+ (0.61*)	0.95 (1.06)	0.93 (0.88*)	1.26- (1.37-)	0.88 (1.00)	1.94* (2.07*)	1.34- (1.67*)	0.29** (0.35*)	0.85 (0.80-)	0.99 (1.06)	3.54- (2.32-)	1.45- (1.74+)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Intersection	0.88 (0.83+)	1.38** (1.27*)	0.84* (0.85+)	0.83+ (0.82+)	1.36*** (1.32**)	0.98 (0.94)	1.25* (1.25*)	1.00 (1.17)	1.18 (1.21-)	1.68*** (1.68***)	1.13 (1.09)	0.92 (0.90)	0.99 (1.03)	1.24- (0.79-)	1.81*** (1.76***)
Weekend	0.95 (0.85)	1.17 (1.18)	0.90 (0.87)	0.74* (0.74*)	1.02 (1.12)	0.95 (0.91)	1.03 (1.13)	1.29- (1.44+)	1.23- (1.29)	1.42** (1.68***)	0.95 (1.03)	0.94 (0.89)	1.27- (1.27-)	1.78- (1.16)	1.48* (1.70**)
Weather	1.08 (0.93)	1.13 (1.14)	0.79* (0.79*)	0.88 (0.84)	1.13 (1.22+)	1.01 (0.96)	1.12 (1.20-)	0.76- (0.93)	1.36* (1.41*)	1.32* (1.57**)	0.69- (0.78-)	0.91 (0.86)	1.51- (1.46-)	1.17 (0.76-)	1.16 (1.40+)
Nighttime	0.94 (0.83)	1.43* (1.48*)	0.86 (0.83)	0.80- (0.75+)	1.32* (1.45**)	0.93 (0.89)	1.37* (1.45*)	1.57+ (1.70*)	1.38- (1.47+)	1.51* (1.92***)	1.09 (1.13)	1.12 (1.04)	1.04 (1.12)	2.25- (1.42-)	2.14*** (2.53***)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Passenger	0.88 (0.80+)	1.27+ (1.24-)	0.82* (0.82+)	0.89 (0.85)	1.19+ (1.24+)	0.91 (0.88)	1.49*** (1.46***)	0.94 (1.10)	1.21- (1.27-)	1.55*** (1.74***)	0.98 (1.05)	0.89 (0.89)	0.93 (1.01)	0.87 (0.58-)	1.69*** (1.81***)
Single Vehicle	0.94 (0.83)	1.00 (1.05)	0.79- (0.77-)	0.71+ (0.68*)	1.03 (1.14)	0.92+ (0.89*)	1.30+ (1.42*)	0.85 (0.96)	1.88* (2.01*)	1.35- (1.70**)	0.50+ (0.59-)	0.76- (0.73-)	0.97 (1.05)	2.32- (1.50-)	1.43- (1.73*)
Passenger \ Nighttime	0.97 (0.84)	1.51* (1.57*)	0.79- (0.77+)	0.85 (0.78-)	1.40* (1.54**)	0.91+ (0.88+)	1.58** (1.68**)	1.15 (1.29-)	1.52+ (1.63+)	1.43+ (1.84**)	1.09 (1.17)	1.26- (1.18)	0.85 (0.93)	2.16- (1.36-)	2.20*** (2.62***)
Weekend\ Nighttime	0.71+ (0.63*)	1.60* (1.72*)	0.98 (0.93)	0.61* (0.58*)	1.21- (1.37+)	0.91 (0.88+)	1.31- (1.43*)	2.11* (2.29**)	1.41- (1.54-)	1.73** (2.25***)	0.91 (1.02)	1.12 (1.05)	1.51- (1.56-)	3.97- (2.85-)	2.52*** (3.00***)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Single Vehicle\ Driver Action	0.82 (0.77-)	1.93+ (1.76-)	0.98 (1.00)	0.76- (0.75-)	1.46- (1.36-)	0.89 (0.84+)	1.47- (1.42-)	0.46- (0.50-)	1.65- (1.68-)	1.88+ (1.82+)	1.04 (0.97)	0.95 (0.95)	1.82- (1.85-)	3.90- (2.30-)	2.01+ (1.97+)
Weekend\Nighttime \ Passenger	0.62* (0.59*)	2.04* (1.90*)	0.86 (0.87)	0.57* (0.56*)	1.63* (1.54*)	0.89+ (0.85*)	1.84** (1.77**)	1.65- (1.78-)	1.67- (1.70-)	2.34*** (2.27**)	1.04 (0.99)	1.16 (1.16)	1.60- (1.62-)	4.56- (3.09-)	3.31*** (3.25***)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Single Vehicle\ Road Departure	0.88 (0.82)	1.13 (1.04)	0.72- (0.74-)	0.66- (0.65+)	1.16 (1.08)	0.91 (0.87*)	1.49+ (1.43+)	0.89 (0.98)	2.32* (2.36**)	1.75* (1.68*)	0.37* (0.36*)	0.91 (0.92)	1.11 (1.13)	3.70- (2.27-)	1.73+ (1.68+)
Single Vehicle\ Passenger	0.98 (0.91)	1.32- (1.22-)	0.53** (0.54**)	0.56* (0.55*)	1.30- (1.20-)	0.86* (0.82**)	1.77** (1.70**)	0.81 (0.89)	1.97* (2.01*)	1.96** (1.89**)	0.36* (0.34*)	0.63- (0.63-)	1.06 (1.09)	2.63- (1.56-)	1.89* (1.84*)
Nighttime\ Weather	0.97 (0.91)	1.66* (1.54+)	0.62** (0.63*)	0.60* (0.59*)	1.45+ (1.37-)	0.94 (0.90+)	1.42+ (1.37-)	1.06 (1.15)	1.83* (1.87*)	1.96* (1.89*)	0.60- (0.56-)	0.75- (0.75-)	1.41- (1.43-)	3.63 (2.26-)	1.81+ (1.77+)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Speeding/ Weather	0.71- (0.66-)	1.63- (1.45-)	1.37- (1.38-)	1.28- (1.24-)	1.75+ (1.60-)	0.99 (0.94)	1.28- (1.22-)	1.11 (1.25-)	1.69- (1.76-)	1.27- (1.21-)	0.99 (0.91)	0.92 (0.93)	0.93 (0.96)	52.10- (24.82-)	1.00 (0.96)
Speeding\ Weather\ Nighttime	0.51- (0.48-)	3.56+ (3.18+)	1.23- (1.24-)	1.32- (1.27-)	2.88* (2.68*)	0.97 (0.93)	1.37- (1.30-)	1.24- (1.42-)	3.93* (4.08*)	1.48- (1.43-)	0.89 (0.83)	0.72- (0.73-)	0.47- (0.49-)	13.60- (7.53-)	0.71- (0.69-)
Speeding/ Nighttime	0.57- (0.54-)	2.88+ (2.69+)	1.11 (1.12)	0.91 (0.89)	2.46* (2.34*)	0.93 (0.90)	1.42- (1.38-)	1.58- (1.72-)	2.25+ (2.30+)	1.73- (1.69-)	0.81- (0.78-)	0.75- (0.76-)	0.57- (0.58-)	7.60- (5.26-)	1.09 (1.08)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Driver Action\ Weather	1.07 (1.00)	1.62+ (1.46-)	0.82 (0.83)	0.86 (0.84)	1.38+ (1.28-)	0.96 (0.91)	1.50* (1.44*)	0.65- (0.72-)	1.36- (1.39-)	1.84** (1.76**)	0.86 (0.79-)	0.96 (0.95)	1.43- (1.46-)	3.21- (1.75-)	1.61+ (1.55-)
Driver Action\ Weather\ Nighttime	1.22- (1.14)	2.23+ (2.04+)	0.66- (0.67-)	0.81 (0.79-)	1.88* (1.75*)	0.91 (0.86)	1.58- (1.52-)	0.76- (0.84)	1.89+ (1.93+)	2.28* (2.20*)	1.12 (1.05)	1.28- (1.27-)	1.57- (1.59-)	9.21- (5.42-)	2.18+ (2.12+)
Lane Use\ Passenger	0.98 (0.90)	0.62- (0.56-)	0.62- (0.65-)	0.72- (0.69-)	1.36- (1.24-)	0.79- (0.74+)	1.76- (1.68-)	0.87 (0.96)	1.00 (1.03)	1.55- (1.48-)	0.73- (0.68-)	0.93- (0.95)	0.62- (0.64-)	0.71- (0.40-)	1.62- (1.58-)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Road Departure/ Passenger	0.90 (0.85)	1.26- (1.17)	0.54* (0.56*)	0.48* (0.48*)	1.21- (1.14)	0.88+ (0.84*)	2.02** (1.94*)	0.71- (0.77-)	2.19* (2.22*)	1.99* (1.92*)	0.35+ (0.33*)	0.77- (0.77-)	1.01 (1.03)	3.32- (2.12-)	2.34* (2.28*)
Casualty/ Passenger	0.81 (0.75+)	1.38+ (1.26-)	0.67** (0.69**)	0.63* (0.63*)	1.32* (1.23-)	0.90 (0.85)	1.43** (1.38*)	1.06 (1.16)	1.68* (1.72*)	1.85*** (1.77***)	0.64- (0.60-)	0.85 (0.86)	1.03 (1.05)	0.91 (0.54-)	2.07*** (2.02***)

Table 21. Regression results for women: Odds ratios for all crash types (Odds ratios adjusted for age at licensure)															
	Parental Influences			Attachment to Conventional Society			Contextual Alcohol Influences			Psycho-Emotional Factors					Alcohol
	Parental Monitoring	Global Parental Permissiveness	Parental Nurturance	Parent vs. Peer Orientation	Tolerance of Deviance	Marks in School	Peer Alcohol Use	Sibling Alcohol Use	Parental Permissiveness toward Teen Alcohol Use	Susceptibility to Peer Pressure	Self-Esteem	Reasons to Drink	Reasons to Abstain	Health Locus of Control	Past Year Alcohol Misuse
Single Vehicle/Road Departure/Speeding	0.82 (0.77-)	1.23- (1.13)	1.00 (1.01)	0.87 (0.85)	1.83- (1.72-)	0.98 (0.95)	1.90* (1.83+)	0.53- (0.58-)	1.82- (1.85-)	2.02- (1.95+)	0.84 (0.79-)	1.08 (1.08)	1.05 (1.07)	22.16 (13.37-)	1.81- (1.77-)

+<1.0. *<.05; **≤.01; ***≤.001, - not significant, however, 20% increase or decrease in odds and the confidence interval is not especially large

4 Discussion

The results of this study demonstrate the added value of examining crash rates and rate ratios using multiple characteristics of crashes to create types of crashes. While it is intuitive that risk levels would change for different combinations of crash characteristics, and that combinations of characteristics considered together provide a more realistic estimate of crash risk, such an approach has not been used extensively in research examining crashes. Using crash types rather than single characteristics of crashes in research results in a better approximation of the real-world, in which crashes seldom involve only one characteristic, or result from one condition. Because of its closer approximation to real-world situations, the examination of crash types provides richer information from which to design interventions, programs, policies, and driver training programs so they are better targeted to reduce the likelihood of crashes. Also, by examining crash types, we are better able to identify variables and crash characteristics that, because of their relatively low risk based on rates and rate ratios, are not of particular concern for inclusion in teen crash risk reduction programs.

4.1 Influences of Rate Calculation Methods

Several sex differences emerged from the analyses, most relating to differences in the size of the rates and rate ratios, with considerably fewer arising from differences between the crash types that represent the highest risk. Women had smaller rate ratios than men, indicating that there was a smaller difference in the crash rates of teen and adult women than between teen and adult men. It may also suggest that women's rates decline less as they gain driving experience and maturity, but additional research is needed to examine this issue.

Higher crash rates were consistently observed for women than men, both for teens and adults, as well as when crash elements and crash types were examined; the only exceptions were the alcohol crash element and alcohol crash types. This is an interesting deviation from other research on crashes that have used different methods than those used in this study to calculate crash rates. Many studies of crashes base their rate calculations on either vehicle miles traveled (VMT), or using per population methods (PPM). This study used a unique approach that estimated crash rates in terms of person miles driven. The differences in outcomes of this research versus those of other studies of crashes may arise from what information is provided when crash rates are calculated using different methods.

VMT and PPM approaches provide important information, but information that is quite distinct from that derived from rates calculated using PMD. VMT is the total miles of vehicular travel on a road network over a specific time interval (e.g., annually). There are various methods of estimating VMT. In small samples of vehicles, intensive study designs can allow VMT to be based on odometer readings, and this approach has become easier and more accessible with the advent of onboard computers and the OBD II Buss Port to access data, and more recently, with the public availability of electronic devices for capturing OBD II data. However, this approach is costly, and impossible to achieve on a population basis. A more common approach is the Highway Performance Monitoring System, developed by the Federal Highway Administration. This approach calculates VMT using a complex sampling design to select roadway segments, and using counts of vehicles traversing the segments and the centerline length of the segment to estimate VMT (Hoang, Poteat, 1980; Kumapley, Fricker, 1996). This method is commonly used in crash rate estimation. Because the number of vehicles is measured mechanically, there is no method of comparing crash rates of men and women or of people from different age groups that takes into account the VMTs of the separate sexes.

Because of this limitation, as well as its reliance on population- and not person-level data, crash rates per VMT that compare men and women must assume that on average men and women drive the same number of miles, which, although women are rapidly catching up with men in annual miles driven, is not true (Rosenblum, 1995, 2000). Hence, sex differences in crash rates using VMT can be misleading. For example, if men in a particular population were observed to have more crashes per person than women while driving the same average number of miles, this would suggest that men have a higher crash rate per VMT than women. However, if in truth women drive fewer vehicle miles than men, then the crash rate for women is underestimated. The underestimation could be great enough to result in women appearing to crash less than men, when they are actually crashing at a higher rate when the amount of driving is taken into account.

PPM bases crash rate estimation on a highly generalized denominator. This approach examines the number of crashes per unit of population, such as number of licensed drivers. This approach does allow for rates to be calculated readily for men and women separately, because the number of drivers of each sex can be known. However, rates per unit population do not take into account differences in miles traveled on average per person. As a result, if men have more crashes per person on average than women, their rates per unit of population will be higher than that of women. However, if the reason men average more crashes per person than women is that they drive more miles, it is possible that the rates of men and women may reverse in order when differences in miles driven are taken into account.

Men drive more miles than women on an annual basis (Rosenblum, 2000). It is not terribly difficult to imagine why this difference is observed. First, women are more likely than men to be stay-at-home parents for at least some portion of their adult lives, if not their entire adult lives. Hence, while men are driving many miles commuting to work, women, in this case, are generally traveling to locations nearer their homes, running errands and shuttling children, and driving fewer miles overall. Second, there is a common sex role difference in who drives when families or couples travel, with the father, or male partner doing a larger proportion of the driving than the mother or female partner.

One contributor to the higher observed crash rate among women is the difference in the type of driving men and women do. Women who work outside the home have more complicated commutes to and from work, because in addition to having the responsibilities and driving demands that come with employment, women often retain most or all of their household responsibilities. As a result, a larger proportion of the miles driven by men while commuting are likely spent on freeways, while women are leaving the freeway to run errands on the way to and from work. Similarly, stay-at-home moms do most of their driving on roadways other than the freeway. A much higher crash risk is associated with driving on surface roads, and women may drive more miles on these high-crash-risk roadways than men. Given what is known about differences between men and women in miles traveled, not to mention in their travel habits and trip purposes, it can be assumed that crash rates per VMT or unit population do not accurately assess sex differences in actual crash rates per mile driven by individuals.

The degree of generalization in estimates based on VMT or unit of population, while making it possible to identify trends and compare crash risk across time, does not provide the same degree of precision that can be obtained when rates are calculated on a per person mile basis. In this study, rates were calculated per 100,000 PMD. This approach is much more specific, taking into account in the denominator both the numbers of people and miles traveled per person for each sex and age-group. This degree of specificity allows much greater precision in

accounting for differences in individual travel behavior, and a more discrete parsing of exposure to crash risk for people of separate sub-groups, such as men and women, or teens and adults.

Hence, the conclusion of this study, that women have higher crash rates than men, is potentially accurate, not only given the methodology used in this study, but also based on what is known about the estimation of rates per VMT and PPM. An obvious question is, why are women's crash rates higher than men's? While empirical evidence that women and men differ in their driving skill is lacking, and in spite of the clichéd references to "women drivers," there is consistent empirical evidence that the driving patterns of men and women are distinct, and result in driving patterns that expose women drivers to greater crash risk. While this presents a compelling hypothesis explaining differences in the crash rates of adult men and women, it does not seem to be as likely an explanation for observed differences in teens. Clearly, additional mechanisms are at work for teen drivers, and most likely adults as well, and more research on the sources of higher per person mile crash rates for women is needed.

4.2 Prediction of Involvement in Crash Types

Essentially no simple differential prediction of the crash types was found. Instead, several of the predictors used were significant for various crash types, with greater prediction being found for women's crashes than men's. The measures that were most commonly predictive for women were greater peer alcohol use, parental permissiveness toward teen alcohol use, susceptibility to peer pressure, and greater alcohol misuse in the prior year. The best predictor for men was past year alcohol misuse. Some of the measures used may be indicators of the individuals' risk level and their susceptibility to crash involvement. Other variables, such as alcohol misuse, may contribute directly to increased risk of being involved in a motor vehicle crash, as well. These characteristics might be used to identify teens who are at excess risk of being in a motor vehicle crash, or to tailor interventions to reduce their crash risk. Parental characteristics, however, might be targeted through parent-directed interventions that would enhance teen supervision by parents, increase restrictions and provide better enforcement of rules to keep teen drivers safe. Several parent directed interventions have proven effective (Carlson et al., 2000; Jaccard, Turrisi, 1999; Loveland-Cherry et al., 1999), with some effective interventions designed to address teen driver safety, specifically. Checkpoints is one evidence-based intervention that has been used successfully to reduce risky driving and negative driving outcomes among teens (Simons-Morton et al., 2002; Simons-Morton et al., 2005; Simons-Morton et al., 2006; Hartos et al., 2001). These results suggest that continued efforts should be made to assist parents in being effectively involved in lowering their teen drivers' crash risk.

Perhaps of greatest interest is that psychosocial characteristics of teens are predictive at all of crash risk. Many stochastic elements are involved in the occurrence of a crash, making it difficult to identify predictors that are not immediate characteristics of the driver or context at the time the crash occurs. The associations between psychological, cognitive, emotional, and social variables that contribute to elevated crash risk among teens should continue to be investigated so that interventions and programs to reduce teen crash risk can be improved.

4.3 Implications and Recommendations

The results of this study not only identify high risk crash types, but also indicate which crash types occur most often. Importantly, this research, and other studies like it, can be used to identify crash types that are associated with both an elevated rate and elevated risk of a crash.

These crash types need to be addressed most urgently in future research, and in programs, policies, and driver training.

Table 22 lists the elements found in the top eight crash types for the overall sample, and for men and women separately. Each crash element is indexed by the approach that could be used to target the element to reduce its occurrence. The approaches are Driver Education/ Training, Programs, Policy, Legislation, and Law Enforcement.

Table 22. Crash elements included in the eight crash types with the highest rate ratios for the entire sample of teens, and for male and female teens separately.

Crash Elements	Driver Education/ Training	Programs	Policy	Legislation	Law Enforcement
Men and Women Combined					
Speeding		X	X	X	X
Passengers		X	X	X	X
Nighttime	X		X	X	X
Road departure	X		+[1]		+
Weather	X				X
Weekend		X	X	X	X
Driver action	X				
Men					
Nighttime	X		X	X	X
Speeding		X	X	X	X
Passenger		X	X	X	X
Road departure	X		+		+
Single vehicle	X				X
Weather	X				
Weekend		X	X	X	X
Women					
Nighttime	X		X	X	X
Passenger		X	X	X	X
Speeding		X	X	X	X
Weather	X				
Weekend		X	X	X	X
Driver action	X				
Road departure	X		+		+

1- + indicates approaches that may target some but not all causes of a given crash element. For example, to the extent that road departure crashes are caused by driving after drinking, policies, such as zero tolerance, will reduce their occurrence.

Some of the crash elements could conceivably be targeted by all of the approaches listed across the top of Table 22. Approaches that are not currently being broadly applied to target a specific element, as well as approaches that seemed more feasible or likely to achieve the desired outcome were marked.

Falling into the category of driver education/ training are formal driver education classes that are a required part of obtaining a driver license in some states, as well as the training novice teen drivers receive from their parents/guardians during supervised driving. However, education/training could go beyond these two more structured instructional processes to include the socialization that teens receive from watching their parents and older siblings drive. Hence, driver education and training may be targeted by programs designed to improve parental instruction during supervised driving, encouraging parents to monitor their licensed teens more closely, and programs that remind parents that their teens are likely to adopt many of the driving habits they observe in their parents and other family members. It is recommended that driver education and training place more emphasis on preparing teens to drive at night, in poor weather conditions, and on helping teens become more proficient at basic vehicle maneuvers, such as backing, turning, and braking. To the extent that road departure is a result of misjudging cornering speeds, or the poor execution of driving maneuvers, this also should be addressed through education and training. These advancements in novice teen driver preparation require more than instruction in the driver education classes, and it would undoubtedly be helpful if these behaviors were addressed using a structured approach that assists parents to better train their teens.

Programs and policies are often closely intertwined. Programs include interventions, community education, media campaigns, student-directed safety campaigns, and enforcement mobilizations, and can target the individual novice teen driver, parents of teen drivers, driver training schools, or other entities. Programs intended to influence the teen driver directly are likely to be most productive if they target driving behaviors, like speeding or drinking and driving. As already mentioned, some programs could better reach the teen through the parent, and might target high-risk driving situations, such as driving on the weekend, at night, or with passengers. Because of the breadth of this approach, it could be used to change public or teen opinions about these risk factors, to better equip parents to train and monitor their teen drivers, or to change driver behavior.

Policy includes elements of law, licensure policies, or driver safety programs that are adopted by states. Where teen drivers are concerned, policies that toughen the consequences of driving infractions during supervised and restricted independent driving would be useful by enhancing existing graduated driver licensing programs, and providing teens with greater motivation to maintain a clean driving record while they are licensed under a GDL program.

The crash types with the highest rate ratios were often clearly associated with the social behavior and activities of teens, such as weekend/nighttime/passenger, speeding/nighttime, passenger/nighttime, road departure/passenger, speeding/weather/nighttime, weekend/nighttime, single vehicle/road departure/speeding, alcohol/passenger/speeding, alcohol/passenger/nighttime, alcohol/nighttime/speeding, alcohol/weekend/speeding, casualty/passenger/nighttime, and casualty/passenger/alcohol. One advantage of using crash types rather than focusing on crash elements to understand teen crash risk, is that programs and policies can then address the combined risk presented by a several simultaneously occurring crash elements.

The common crash types for teens that were identified in this study suggest policy enhancements that involve both a slower reduction in driving restrictions implemented by GDL programs, and using multi-faceted restrictions that target more than one crash element at a time. Currently, some state's GDL programs include various combinations of restrictions on nighttime driving, passengers, and weekend driving (IIHS, 2007). The results of this study provide strong evidence that, first, all of these restrictions should be included in all GDL programs. This would target several of the crash types that are the greatest threat to teens' well-being. Second, because the restrictions do target elements of high-risk crash types, reductions in the restrictions should not just target one driving situation at a time, but the restrictions should be decreased in concert with each other so that crash types and not just the individual elements are addressed. This would also result in restrictions being lifted more slowly, and a more gradual increase in the exposure of teens to high-risk driving conditions. For example, immediately after licensure, GDL programs might impose restrictions on nighttime driving that are uniform across days of the week, such as no driving between 10pm and 6am on any evening, and that does not allow passengers. In the next phase these restrictions could be eased by allowing driving to a later hour on weekends, such as no driving 10pm-6am Sunday though Thursday, and no driving midnight to 6am on Friday and Saturday nights, but still not allow passengers. Next, the night time restrictions might remain unchanged, but passengers would be allowed during daytime driving. The following phase might ease restrictions more on passengers, allowing passengers at night on weekdays, and so forth. In this manner, what is now basically a two step reduction in restrictions from some restrictions to none, could be broken down into multi-step reductions in several restrictions. Rates and rate ratios for crash types could be used to provide an empirical basis guiding the formulation of restrictions, and identifying an order in which the restrictions might be reduced.

A variety of policies and programs have effectively targeted drinking and driving by teens either directly with strong drinking and driving laws that target teens, such as zero tolerance, or indirectly by reducing teens' access to alcohol (Voas, Tippets, Fell, 2003). Continued effort should be focused on these programs, and research to find ways of enhancing their success should be conducted; however, other approaches are also possible. One enhancement would be to require that tough action be taken against underage drinking drivers. This could be implemented through GDL, by increasing teens' driving restrictions or requiring that the time with certain restrictions be extended.

Changes in crash rates and rate ratios by age, as well as the association of age at licensure with crash types using the AMPS data support past research indicating that crash risk for novice teen drivers is strongly age-graded. This age-grading has two components. One is age at licensure, with a delay in licensure by even one year attenuating the prediction of crash risk. Second is experience driving, with each additional year of age being associated with a significant reduction in teens' crash risk, as measured by crash rates and rate ratios. These effects of age on crash risk suggest that policies and programs, such as GDL, that effectively delay the onset of independent driving, and that gradually expose teens to higher risk driving conditions over time would have notable influences on teen crash rates and crash-related injuries. Some regions have chosen to delay driver licensure until age 18 (e.g., New York City), and, while such measures have different implications in areas where availability of public transportation is limited or non-existent, the adoption of delayed licensure in areas where alternative modes of transportation are readily available should be considered. This would not, however, prevent crashes in rural areas, where driving conditions typically present higher risk, and where, as a result of conditions, crashes are more likely to occur than in urban and suburban settings.

Legislation is often used to back up policies and programs. Legislation could be used to revise licensure laws in a manner that enhances teen driver safety. Examples might include introducing penalties for receiving citations, such as a demotion to a previous level of GDL or a delay of progress to the next level. Legislation is also necessary to enhance GDL components, such as passenger restrictions or greater limits on nighttime driving.

Finally, teen crash risk would be reduced and GDL effectiveness increased by greater emphasis on the enforcement of GDL restrictions as well as general driving laws with teens. This can be accomplished with highly publicized and visible mobilizations targeting teen drivers, as well as through community outreach to teen drivers and their parents, such as police-sponsored teen driving programs. One of the reasons that law enforcement has not directed more effort toward enforcing GDL restrictions is the inherent difficulty in judging drivers' ages. This issue needs to be addressed, either by loosening probable cause restrictions in the case of GDL, by passing legislation that requires teens to drive a vehicle with an indicator that they are driving under a GDL program, or by allowing parents to receive citations for knowingly allowing their teens to drive in conditions that are restricted by GDL.

4.4 Data Considerations

There are several characteristics of the data from the NPTS and NHTS and the estimation of miles driven that should be considered for their potential implications for the results. The stability of the rates and rate ratios are dependent on the accuracy of the person-mile estimates. Several steps were taken to enhance these estimates, but these steps have their own limitations, and if the assumptions underlying the steps taken are not accurate they may have reduced, rather than enhanced the stability and accuracy of the person-mile estimates.

In order to enhance stability, NPTS and NHTS data for the northern Midwest region of the US, which includes Michigan, was used to estimate miles driven by age and sex group. Then the data for the other states were dropped and only estimates for Michigan were used to estimate the rates and rate ratios. While the inclusion of more states than Michigan in the initial estimate of miles driven improves the stability of those estimates, the validity of the resulting data is dependent on the assumption that individual driving patterns are homogeneous across the states in that region. If this is not the case, then the estimates of miles driven for the teens and adults in Michigan would be biased. To examine the potential that the assumption of homogeneity in driving patterns was incorrect, miles driven was estimated using only Michigan data, rates and rate ratios calculated from these estimates, and comparisons were made to the rates and rate ratios using the larger region. Only slight differences were found, suggesting that the homogeneity assumption is most likely valid.

Also in an attempt to improve the estimates of miles driven, NPTS data from 1990 and 1995 were combined with data from the 2001 NHTS. These three data points provided a window that corresponded closely to the years studied (1989 – 1996). This increased the likelihood that the estimates of person miles would be representative for the years of crash records that were examined.

Finally, the three years of NPTS and NHTS data were used to estimate miles traveled in intervening years on the assumption that the pattern of change in miles driven in the years between NPTS and NHTS surveys was at least monotonic, if not nearly linear. If this assumption does not hold, and intervening years have either peaks or troughs in the trend, the estimates will be biased, but, because the rates and rate ratios were estimated over the entire

period and not year-by-year, the bias would likely not be very great for rates and rate ratios calculated over the entire period.

4.5 Strengths, Limitations, and Future Directions

One of the key strengths of this study is the data that were available to allow risk estimates to be generated on a large sample of teens and adults, and the availability of data on a longitudinal sample to examine the association between crash types and individual psychosocial characteristics. Such a rich combination of datasets is rare, and is an asset of this study. In spite of the rich dataset used, the study results are based on crash data from only one state, and the longitudinal sample was not selected in a manner to make it necessarily representative of the general population. Future research should examine data from other states and samples to further our understanding of the risk associated with difference crash types, and to further elucidate the association between individual characteristics and driving outcomes.

Another strength of this study is that it is the first study examining teen crashes that has used NPTS and NHTS data to estimate person miles driven for use in calculating rates and rate ratios. This approach should be used more frequently in studies of this type, because it allows a clearer picture of individual crash patterns, and how these patterns differ between groups of people. Limitations associated with this approach also include its novelty. Because it is a new method there are no other results similar to it that can be used to confirm or disconfirm the results. In addition, this approach has not been validated for use with crash data, but this method has been used for research on other topics and using other datasets, future research should further focus on its application.

Finally, crash types appear to provide a useful means of examining crash risk; however, which types are most relevant, and how crash types can be constructed so that they are relatively independent of each other needs further investigation. One difficulty encountered in this study was avoiding excessive overlap in the individual crashes that were identified by more than one crash type. Crashes are complex events, and often the circumstances surrounding them reflect that complexity. As a result, crashes can have many elements associated with them, raising the question about which combinations of elements best characterize crashes so that has real-world relevance while remaining useful measuring crash risk. Future research should examine this issue, and methodologies should be developed that would allow crash types to be identified in a manner that minimizes the level of dependence across crash types.

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