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Risk Factors for Young Drivers in Fatal and Non-Fatal Crashes

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16. Abstract This report documents the results of analyses using data from young drivers (16 to 20 years old) from the Fatality Analysis Reporting System (FARS) from 2013 to 2017 and the second Strategic Highway Research Program's Naturalistic Driving Study (SHRP2 NDS). The research team conducted quasi-induced exposure analyses by calculating crash involvement ratios (CIRs) at each young driver age using multi-vehicle crashes each with only one driver with a contributing factor. CIRs were examined with respect to risk factors relevant to graduated driver licensing (GDL) and driver education (DE). For FARS data, CIR values for young drivers were compared to a 35-year-old reference group using logistic regression. The SHRP2 NDS data also permitted a comparison of trends between age and amount of driving experience in 6-month increments for a similar range of variables. Although young driver risk appeared to decline with increasing age, young drivers of all ages (i.e., 16 to 20) were at higher risk than 35-year-olds for most factors. Some situations were particularly risky for young drivers relative to 35-year-old drivers and relative to other kinds of situations. The results from this study may be useful for developing DE content or supervised driving practices targeted at the riskiest situations for young drivers, given that many young drivers are novices. Additional descriptive analyses are available in the Supplementary Report.		
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Executive Summary

A persistent traffic safety priority is developing countermeasures to reduce crashes, injuries, and fatalities among young drivers, many of whom are novices. While graduated driver licensing (GDL) is the most effective behavioral countermeasure for novice drivers younger than 18 (Venkatraman et al., 2021), an increasing proportion of young people are delaying licensure (Shults & Williams, 2017). Although most States' GDL provisions do not apply to novice 18 to 20 years old, some research suggests safety benefits in extending GDL to older novices (Curry, Metzger, et al., 2017). However, it is unknown whether driving situations that are risky for younger novices—to which GDL reduces exposure—are similarly risky for novices ages 18 to 20. Another approach for reducing crashes, injuries, and fatalities among young drivers is the development of countermeasures other than GDL. Although pre-licensure driver education (DE) has been used to teach driving skills and safe driving practices, most research in this area has not found that DE reduces crash rates (Venkatraman et al., 2021). Thus, there is a growing interest in refining or adding to existing DE (e.g., Association of National Stakeholders in Traffic Safety Education, 2017), potentially with material targeted at the riskiest driving situations for young novice drivers.

To answer these research questions, in the current study the research team conducted quasi-induced exposure analyses to determine the highest risk driving situations for young drivers 16 to 20 years old; drivers younger than 16 were excluded due to small sample sizes. The research team used two sources of data: information about young drivers involved in fatal crashes from 2013 to 2017 from the Fatality Analysis Reporting System (FARS), and information about young drivers involved in crashes or near-crashes in the second Strategic Highway Research Program's (SHRP2) Naturalistic Driving Study (NDS). Although time since licensure for young drivers involved in fatal crashes (FARS) was unknown, many young drivers—particularly those younger than 18—are novices. Additionally, young drivers in the SHRP2 NDS study reported amount of driving experience. With these sources of data, the research team conducted quasi-induced exposure analyses using multi-vehicle crashes involving only passenger vehicles that had (1) at least one driver at an age of interest, (2) less than six vehicles involved in the crash, and (3) only one driver in the crash listed as having one or more "contributing factors" (regardless of that driver's age). Then, by dividing the number of drivers with a contributing factor at each young-driver age (16 to 20) by the number of drivers of the same age without a contributing factor, the research team produced crash involvement ratios (CIRs) that signified the degree of over- or under-involvement of young drivers with respect to risk factors like driver, vehicle, roadway/environmental, and crash characteristics. For the SHRP2 NDS data only, CIRs were also calculated for amount of driving experience in 6-month intervals. Finally, CIRs for young drivers based on FARS data were compared to CIRs calculated from drivers 35 years old.

The results of the quasi-induced exposure analyses highlight several broad trends in young driver crash involvement. First, young drivers' crash involvement across many of the factors examined appeared to decline with age. Although the research team did not calculate formal statistical tests for trends in crash involvement with increasing young driver age, the visual pattern of greater CIR values at the youngest ages and lower CIR values at the oldest ages was present for most driver, roadway, and environmental characteristics examined, as well as for young drivers' crash involvement overall. Second, the current report highlights specific characteristics and situations that may increase young drivers' risk of crash involvement, relative to 35-year-old drivers and relative to other kinds of situations. For example, crashes occurring on roadways with two lanes, crashes occurring at stop signs, and crashes where initial impacts to the right sides of vehicles are common (e.g., left turns) appeared to highlight risky situations for young drivers. Finally, although young drivers' crash involvement appeared to decline with age, it was often the case that even at the older ages (19 and 20), young drivers remained at statistically significantly greater risk than 35-year-old drivers. However, older young drivers' increased risk was primarily observed for factors not currently the target of GDL restrictions (e.g., number of travel lanes in a roadway, roadway type); therefore, it is unclear whether extending GDL restrictions to novices 18 and older would reduce crashes in these situations. The results from this study may be useful for targeting driver education course content and supervised driving experiences to those situations where young drivers' increase in crash involvement is most pronounced.

Introduction

A persistent traffic safety priority is developing countermeasures to reduce crashes, injuries, and fatalities among young drivers, many of whom are novices. In 2019, there were 1,603 drivers 15 to 20 years old who were killed and an estimated 205,000 injured in motor vehicle crashes (NCSA, 2021). Young drivers are overrepresented in fatal crashes: In 2019 drivers 15 to 20 made up 7.8% of drivers involved in fatal crashes but only 5.3% of licensed drivers.

GDL laws have proven most successful among strategies addressing young driver risk, leading to marked reductions in young driver crashes as the result of restrictions on exposure (Venkatraman et al., 2021). In brief, GDL reduces risks to young novice drivers through its protective elements, like mandatory learner periods and night and passenger limits during intermediate license periods. These restrictions protect novices from the highest-risk conditions as they transition from driving only under adult supervision to independent driving. While GDL is the most effective behavioral countermeasure for novice drivers younger than 18 (Venkatraman et al., 2021), an increasing proportion of young people are delaying licensure (Shults & Williams, 2017). Although most States' GDL provisions do not apply to novices 18 to 20, some research suggests safety benefits in extending GDL to older novices (Curry, Metzger, et al., 2017). However, it is unknown whether driving situations that are risky for younger novices—to which GDL reduces exposure—are similarly risky for novices 18 to 20.

An approach for further reducing crashes, injuries, and fatalities among young drivers is the development of additional effective behavioral countermeasures like education and training. To that end, pre-licensure driver education (DE) has been used to teach driving skills and safe driving practices to young drivers who are novices. However, because most research in this area has not found that DE reduces crash rates (Venkatraman et al., 2021), there have been recent efforts to modernize and upgrade DE standards, and to integrate DE with GDL (e.g., ANSTSE, 2017; Thomas et al., 2012). Identifying the riskiest driving situations for young drivers, many of whom are novices, may be useful for the further improvement of DE and training material.

In the current study the research team conducted quasi-induced exposure analyses to determine the highest-risk driving situations for young drivers using data from FARS and SHRP2 NDS; the results of these analyses were intended to provide information that could be used to refine existing GDL programs or develop driver education and training. A supplementary report, *Risk Factors for Young Drivers in Fatal and Non-Fatal Crashes: Supplementary Report*, presents additional descriptive analyses and methodological details.

Methods

Following the extraction of FARS and SHRP2 data, the research team performed analyses for cohorts of young drivers. For FARS data these cohorts ranged in age from 16 to 20, in 1-year intervals, and included a 35-year-old comparison group. (Drivers younger than 16 were excluded from this study due to small sample sizes.) Drivers 35 years old were selected as a comparison group because while their fatal crash rates were similarly low to adults 36 to 54 years old (e.g., NCSA, 2019a), they were assumed to have driving patterns more comparable to young drivers than older adult drivers (i.e., those older than 35). For SHRP2 data, age cohorts ranged in age from 16.5 to 20.5 in half-year intervals. Additionally, SHRP2 data allowed examination of young drivers by experience cohorts, defined as self-reported time since licensure and ranging from 0.5 to 4.5 years driving experience.[1] Researchers carried out separate descriptive analyses of single- and multi-vehicle crashes, looking for situations where young drivers of a specific age were overrepresented compared to young drivers of other ages, and/or as compared to a reference group of 35-year-old drivers. These analyses relied on cross-tabulations of 12,998 FARS cases for the 5-year period from 2013 to 2017.

The focus of this report is a series of quasi-induced exposure analyses (Lyles et al., 1991; Stamatiadis & Deacon, 1997) that were undertaken for the multi-vehicle crashes (n = 2,801, FARS) to produce a crash involvement ratios (CIR) signifying the degree of over- or under-involvement of each group with respect to particular risk factors. Additionally, the SHRP2 dataset included 1,113 multi-vehicle events, including both near-crashes and crashes where the air bags were not deployed; researchers concluded that these event categories were qualitatively similar enough to be combined. Eight more severe crashes where the air bags were deployed were excluded from these analyses according to the same criterion (i.e., these crashes were not qualitatively similar enough to be combined with near crashes and crashes where the air bags were not deployed). For the FARS data the research team compared the calculated CIR values for each young driver age cohort to the 35-year-old reference group using logistic regression to identify significant differences in risk; lacking a comparison group, no such analyses were performed for the SHRP2 data.

A multi-vehicle crash had to meet the following criteria to be included in the analyses: (1) at least one driver of the ages of interest; (2) less than six vehicles in the crash; and (3) only one driver with one or more contributing factors (as defined in each data source), regardless of the age of the driver. Crashes where more than one driver or no driver was identified as having a contributing factor in the crash were excluded from these analyses, as were crashes where any involved entity was not a passenger vehicle (motorcycle, bicyclist, pedestrian, animal, etc.). Passenger vehicles were defined as passenger cars, SUVs, light vans, pickups, and other light trucks. Rules for defining contributing factors for analyses with FARS data are described in Appendix A of the supplementary report. For SHRP2 data, whether a driver had a contributing factor or not was determined using the variable "Fault" in the SHRP2 NDS Event Table.

[1] Although the SHRP2 NDS dataset contained some multi-vehicle crashes involving young drivers age 16 (n = 6), or young drivers with less than 6 months driving experience (n = 13), neither group met the minimum sample size to calculate CIR values of $n >= 20$.

To calculate CIR values, researchers compared the numbers of drivers with contributing factors to drivers without contributing factors across ages and, for the SHRP2 data, across experience levels (in half-year intervals), as follows.

$$\text{Crash Involvement Ratio (CIR)} = \frac{\text{Count of drivers with a contributing factor}}{\text{Count of drivers without a contributing factor}}$$

As a worked example, consider that for the period 2013 to 2017, there were 239 drivers 16 years old involved in multi-vehicle (defined as two to five vehicles) fatal crashes that only involved passenger vehicles (FARS). Additionally, these 239 drivers 16 years old were involved in crashes in which *only one* driver involved in the crash was listed as having one or more "contributing factors"—the driver with a contributing factor could be the 16-year-old driver or any other driver involved in the fatal crash, irrespective of their age. Among these 239 sixteen-year-old drivers, 151 drivers were listed as having one or more contributing factors for the fatal crashes, while 88 drivers did not have any contributing factors listed (i.e., it was another driver involved in the fatal crash for which a contributing factor was listed). The CIR in this instance, then, was 151/88 = 1.72. The CIR greater than one indicates that there were more 16-year-old drivers with contributing factors than 16-year-old drivers without contributing factors.

When a denominator of 0 was present as a consequence of no drivers without contributing factors in the analysis age range, no CIR value was calculated; this is indicated as a missing value in the graphs in the Results section. A CIR of zero indicates an absence of drivers with contributing factors for a given analysis. Additionally, the Results section only includes CIR values calculated from a minimum of 20 drivers (drivers with contributing factors plus drivers without contributing factors) within an age or experience cohort.

Results of the CIR calculations are displayed graphically, on a variable-by-variable basis. Definitions for all variables examined in the FARS and SHRP2 analyses may be found in Appendices B and C of the supplementary report. The supplementary report also contains tables of calculated CIR values and the frequency counts of drivers with and without contributing factors upon which they are based.

Note that in the Results section below, statistical tests were only performed to compare each young driver age group in the FARS dataset to the 35-year-old comparison group, using logistic regression. On each graph depicting FARS data, individual CIR values that are statistically significantly different from the 35-year-old comparison group ($p < .05$) are noted with black outlines around the data points. Exact *p*-values for the logistic regression analyses are included in the supplementary report. No other inferential statistical tests were calculated, and any additional comparisons noted in the Results section are only intended to be descriptive in nature.

Results

Driver and Occupant Characteristics

Vehicle Occupants

This section explores three variables related to vehicle occupants: the total number of vehicle occupants, the number of young passengers, and whether there was driver interaction with a passenger. The number of vehicle occupants also captures the number of passengers since vehicles with one occupant only had a driver and no passengers. Figure 1 shows that, according to the 2013-2017 FARS data, young drivers were often significantly more likely to have contributing factors in fatal crashes compared to 35-year-old drivers, when alone in the vehicle or when carrying one or more passengers. Numerically, CIRs tended to be highest at younger ages and lowest at older ages, with the exception of young drivers in fatal crashes carrying two or more passengers. Differences in risk by number of occupants are not visually apparent among CIR values based on FARS data. However, it is important to note that the research team did not test for statistically significant differences between CIR values for different numbers of occupants.

CIR values based on SHRP2 data by age (Figure 2) or experience (Figure 3) show higher risk when driving alone or carrying two passengers relative to the CIR = 1.0 threshold (i.e., equal numbers of drivers with and without contributing factors), without large numeric differences between CIR values for each situation. Although some values are omitted due to small sample sizes, visually, young driver risk appears to be higher at younger ages/less experience and lower at older ages/more experience when carrying one passenger. The same decline with increasing age or experience is not as apparent when driving alone.

Both data sources (FARS, SHRP2) suggest that young drivers are at heightened risk, both when they are alone in the vehicles or when they are carrying passengers. Additionally, FARS and SHRP2 data visually indicate that this risk is highest at younger ages (and, in SHRP2, with less experience).

The research team also looked specifically at crashes in which drivers were carrying young passengers (i.e., passengers 16 to 20 years old). Figure 4 shows that, overall, young drivers were at significantly greater risk than 35-year-old drivers when driving alone or carrying one (FARS) young passenger. Comparisons to 35-year-old drivers are not reported for young drivers carrying two or more (FARS) young passengers due to small sample sizes for 35-year-old drivers. CIR values tended to be numerically highest at younger ages and lowest at older ages. Finally, Figure 5 and Figure 6 show that, based on the SHRP2 data where video coders were able to determine secondary task involvement via in-vehicle cameras, the rate of young driver involvement in crashes when they were interacting with a passenger tended to be higher than the CIR = 1.0 threshold; however, many data points were omitted due to small sample sizes.

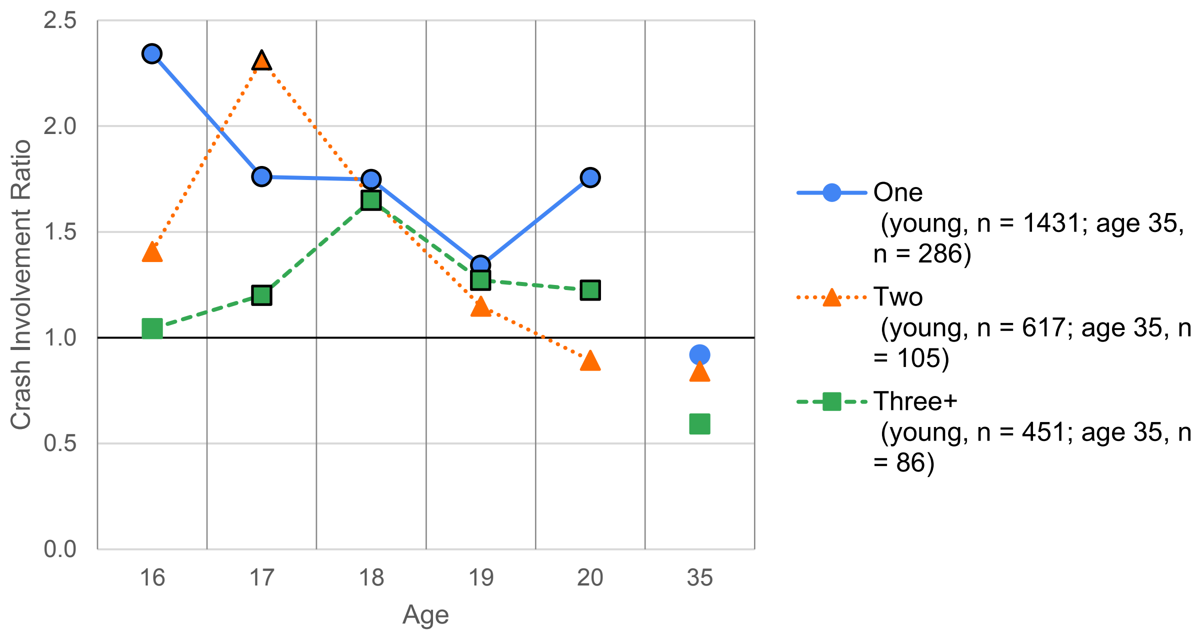

Figure 1. FARS - Crash Involvement Ratio by Number of Occupants and Driver Age

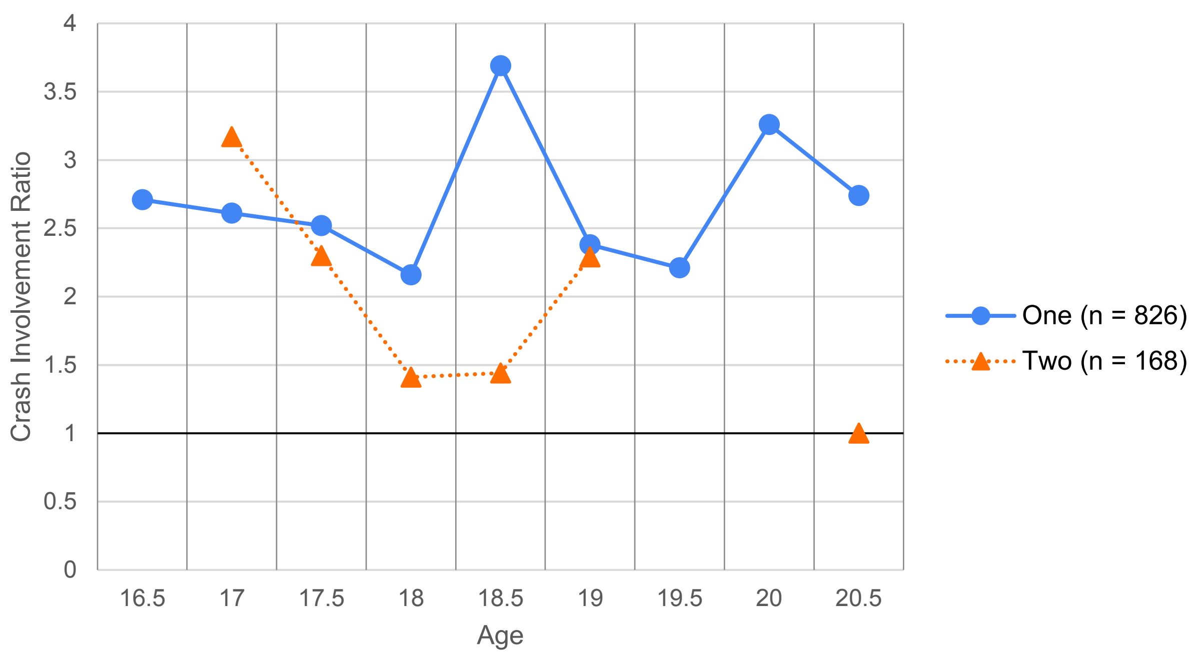

Figure 2. SHRP2 - Crash Involvement Ratio by Number of Occupants and Driver Age

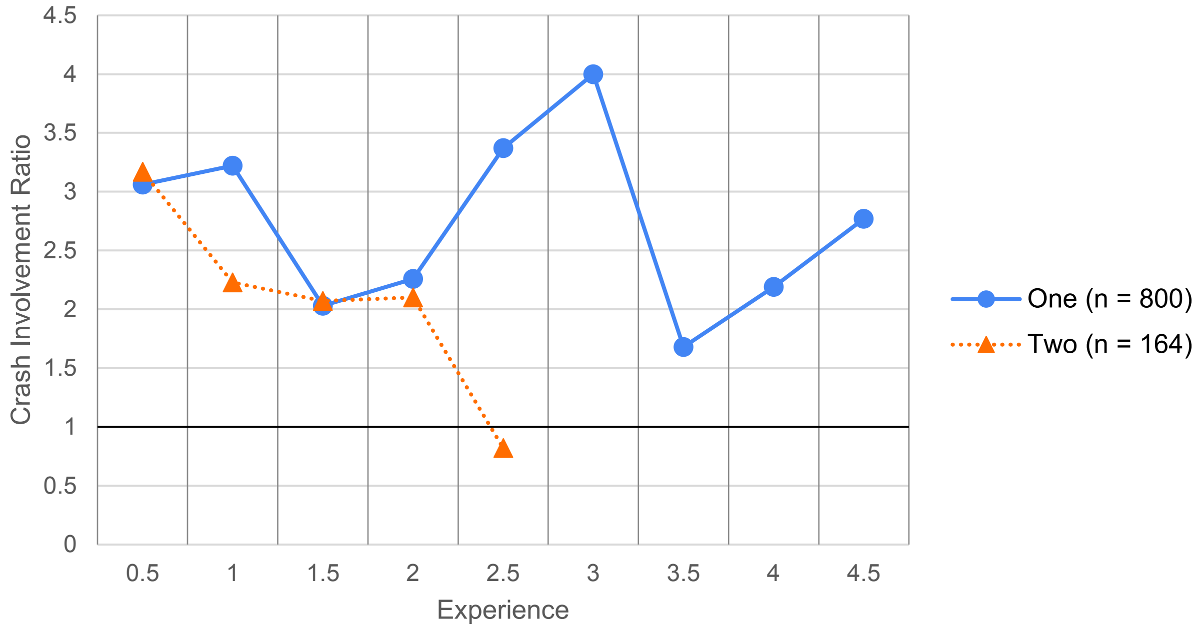

Figure 3. SHRP2 - Crash Involvement Ratio by Number of Occupants and Years Driving Experience

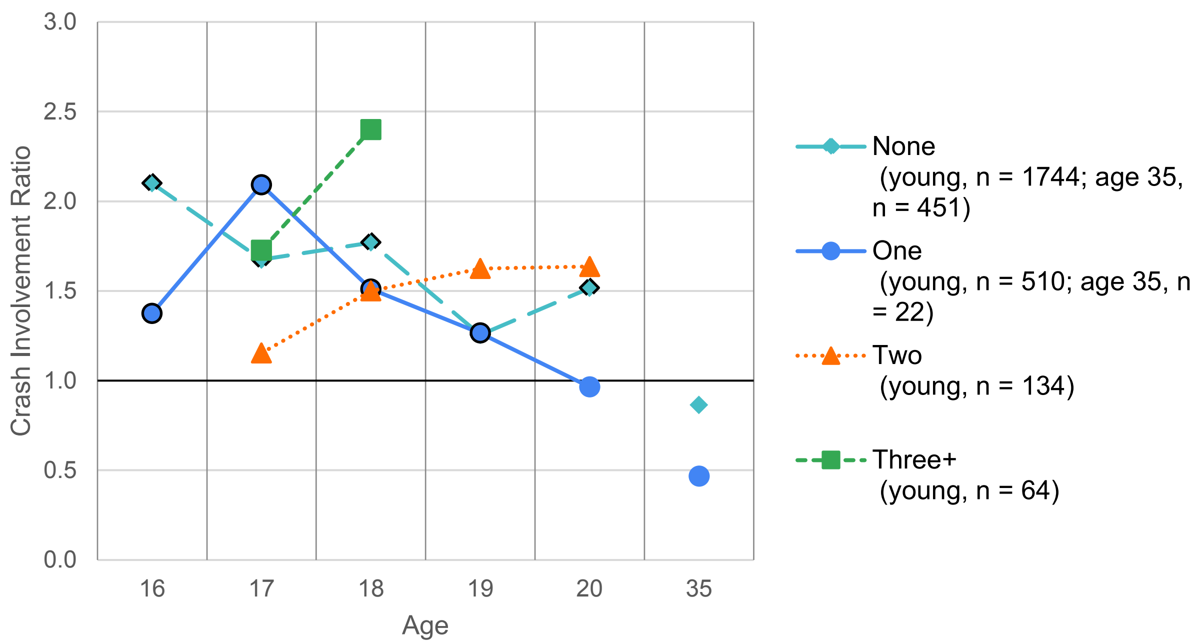

Figure 4. FARS - Crash Involvement Ratio by Number of Young Passengers and Driver Age

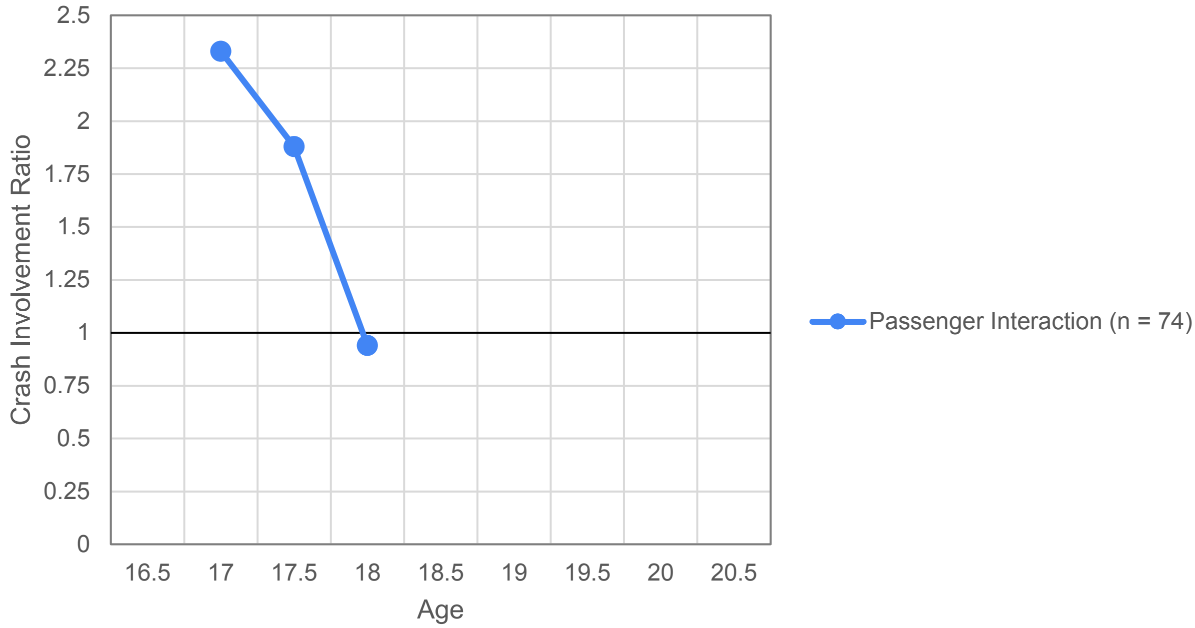

Figure 5. SHRP2 - Crash Involvement Ratio by Driver Interaction With Passenger and Driver Age

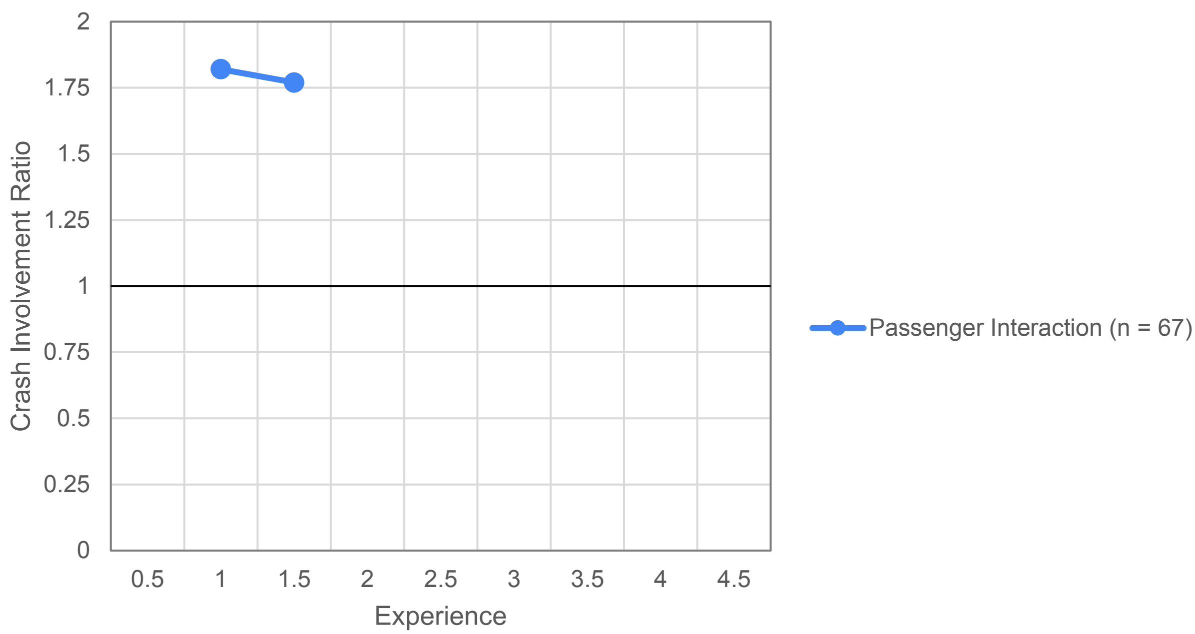

Figure 6. SHRP2 - Crash Involvement Ratio by Driver Interaction With Passenger and Years Driving Experience

Police-Reported Alcohol Involvement for Driver

Figure 7 shows CIR values for drivers in fatal (FARS) crashes for whom police reported alcohol involvement (in FARS, the "police reported alcohol involvement"/DRINKING variable). This figure shows that the likelihood of a driver having a contributing factor in a fatal crash was numerically higher for drivers of all ages (including 35-year-old drivers) when police reported alcohol involvement for a driver versus when they did not. However, CIR values among young drivers with police-reported alcohol involvement were not significantly different than that of alcohol-involved 35-year-old drivers. When police did not report that alcohol was involved for a driver, CIR values for young drivers remained significantly higher than those of 35-year-old drivers and tended to be highest at younger ages and lowest at older ages. When police did report that alcohol was involved for a driver, although one data point was omitted due to a small samples size, the highest CIR value occurred at the lowest young-driver age.

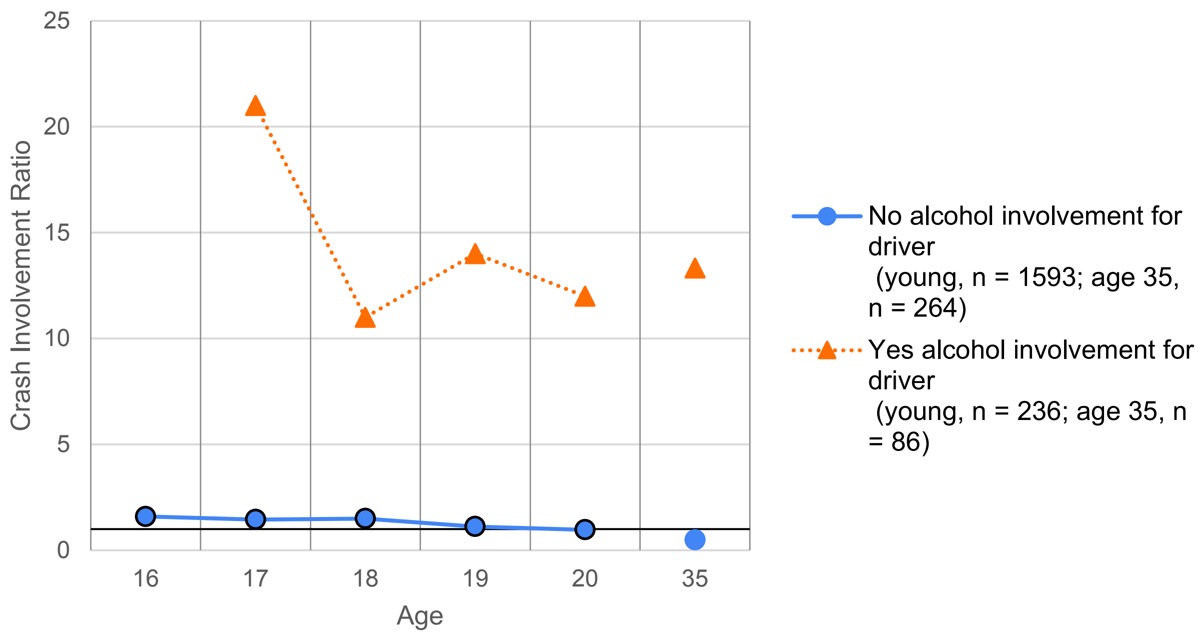

Figure 7. FARS - Crash Involvement Ratio by Police-Reported Alcohol Involvement for the Driver and Driver Age

Prior Speed Violation

Figure 8 shows CIR values for young drivers and 35-year-old drivers who were involved in fatal crashes by whether the drivers had prior speed violations. Some data points were omitted due to small sample sizes. Drivers 19 years old with one prior speed violation were at significantly greater risk than 35-year-old drivers with one prior speed violation; CIR values for young drivers with one prior speed violation at other ages, or with more than one prior speed violation, were not significantly different than 35-year-old drivers. The trend for drivers with no prior speeding violations follows the pattern for overall fatal crashes, with young drivers at every age being at significantly greater risk than 35-year-old drivers and with the highest CIR values occurring at the youngest ages.

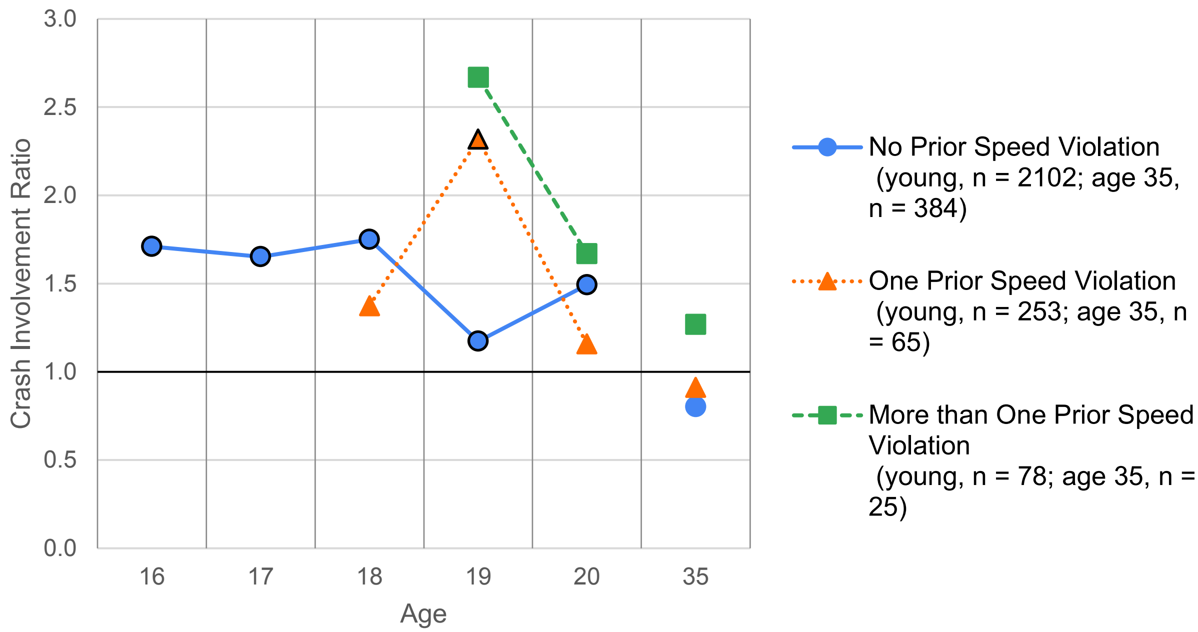

Figure 8. FARS - Crash Involvement Ratio by Prior Speed Violation and Driver Age

Restraint Use

Figure 9 shows restraint use among young drivers involved in fatal (FARS) crashes. Like 35-year-old drivers, unrestrained young drivers had numerically higher crash involvement ratios than their seat-belt-wearing counterparts. However, when unbelted, young drivers were not at significantly greater risk than 35-year-old drivers of having contributing factors in fatal crashes, with the exception of 20-year-old drivers. As with young drivers *without* police-reported alcohol involvement, the CIR values for young drivers who wore seat belts were significantly higher than that of 35-year-old drivers at every age. Additionally, CIR values for restrained young drivers visually appear to decline as age increases. While Figure 9 shows generally higher CIR values for younger unrestrained young drivers and lower CIR values for older unrestrained young drivers, risk remained elevated relative to restrained drivers at all ages. Note that higher CIR values for unrestrained drivers of all ages likely indicate that belt use co-occurs with other behaviors or situations that increase the likelihood of having a contributing factor in a fatal crash, rather than that belt use itself directly increases this likelihood.

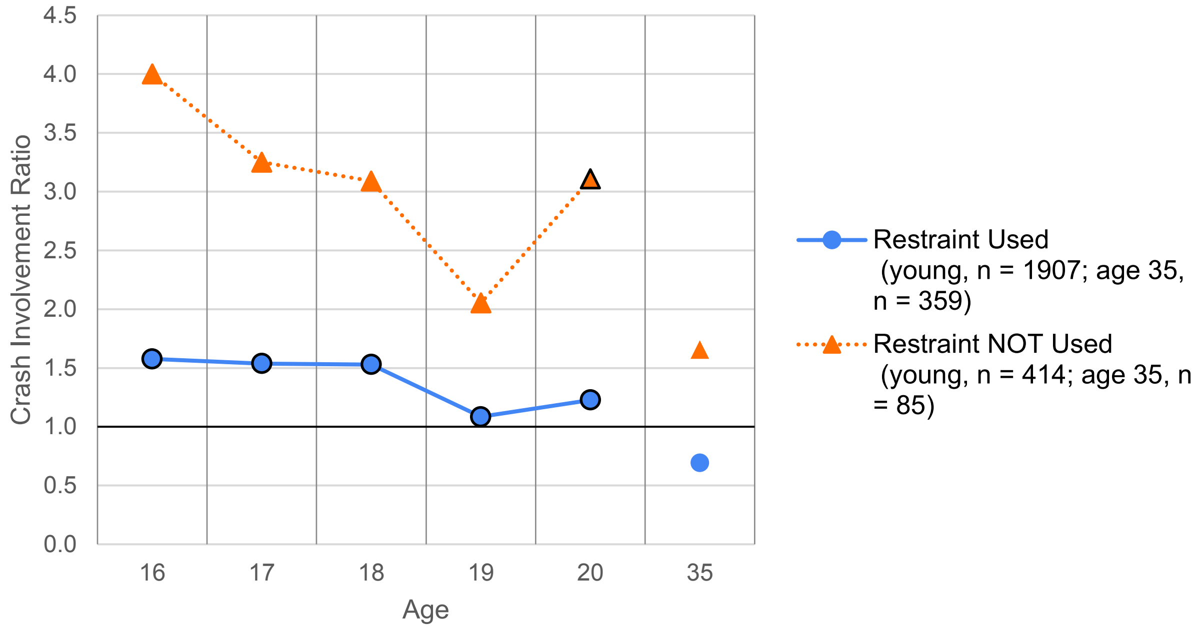

Figure 9. FARS - Crash Involvement Ratio by Restraint Use and Driver Age

Roadway and Environmental Characteristics

Road Type

Young drivers at almost every age had a significantly higher risk than 35-year-old drivers of having contributing factors in fatal crashes on local/collector and non-interstate/freeway arterial roads (Figure 10). Risk on these road types was numerically higher at every young driver age than on limited access highways, and highest for local/collector roads. For both local/collector and arterial road types, CIR values visually tended to decrease with increasing age. However, the CIRs for young drivers involved in fatal crashes on limited access highways were not significantly different than that of 35-year-old drivers, and there is no clear visual trend with increasing young driver age.

The SHRP2 data (Figure 11 and Figure 12) show that CIR values for both divided and not divided/simple two-way road types were higher than the CIR = 1.0 threshold, but there is no obvious visual trend in CIR values for any road type for either increasing age or experience. No CIR values for a third road type in SHRP2, not divided/center two-way left turn lane, met the minimum sample size criterion.

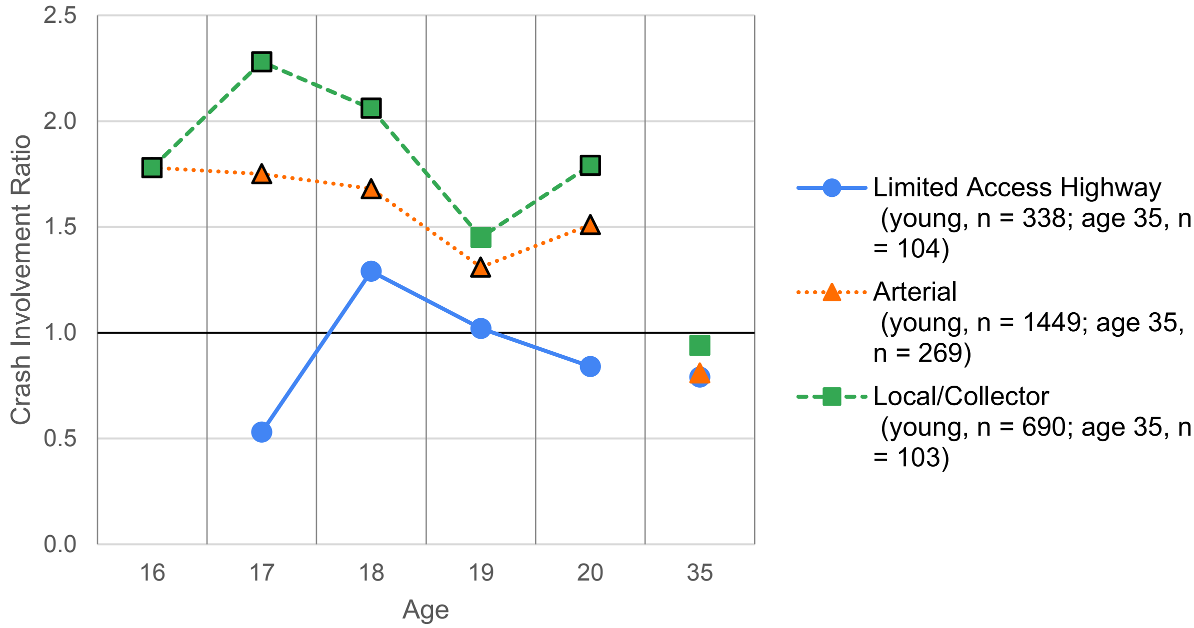

Figure 10. FARS - Crash Involvement Ratio by Road Type and Driver Age

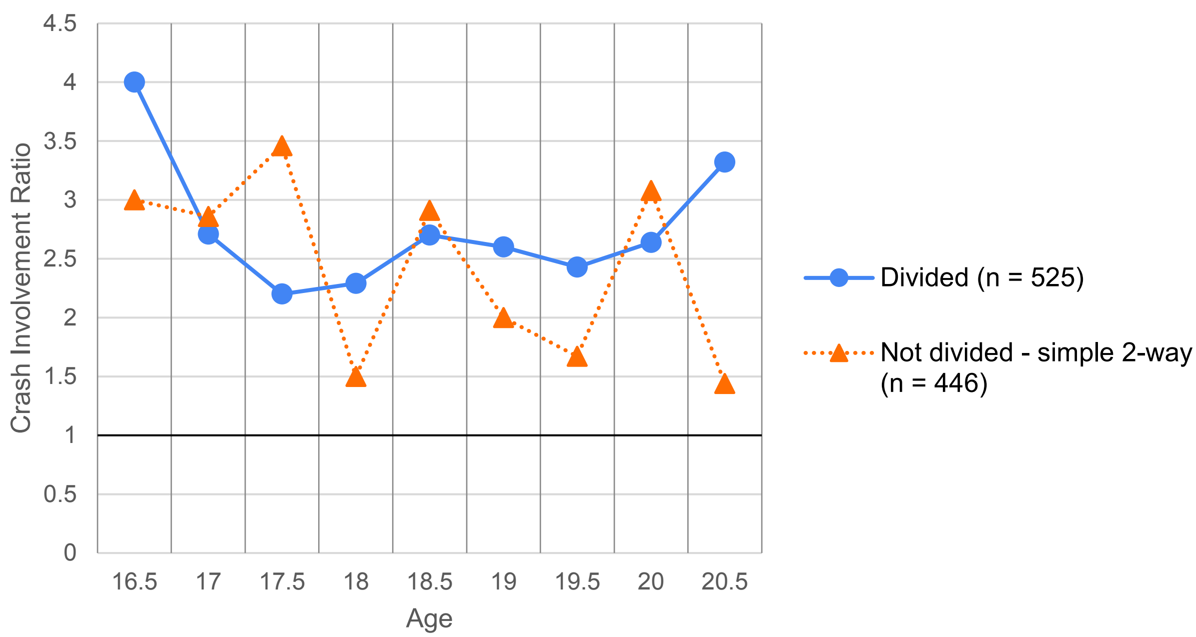

Figure 11. SHRP2 - Crash Involvement Ratio by Traffic Flow by and Driver Age

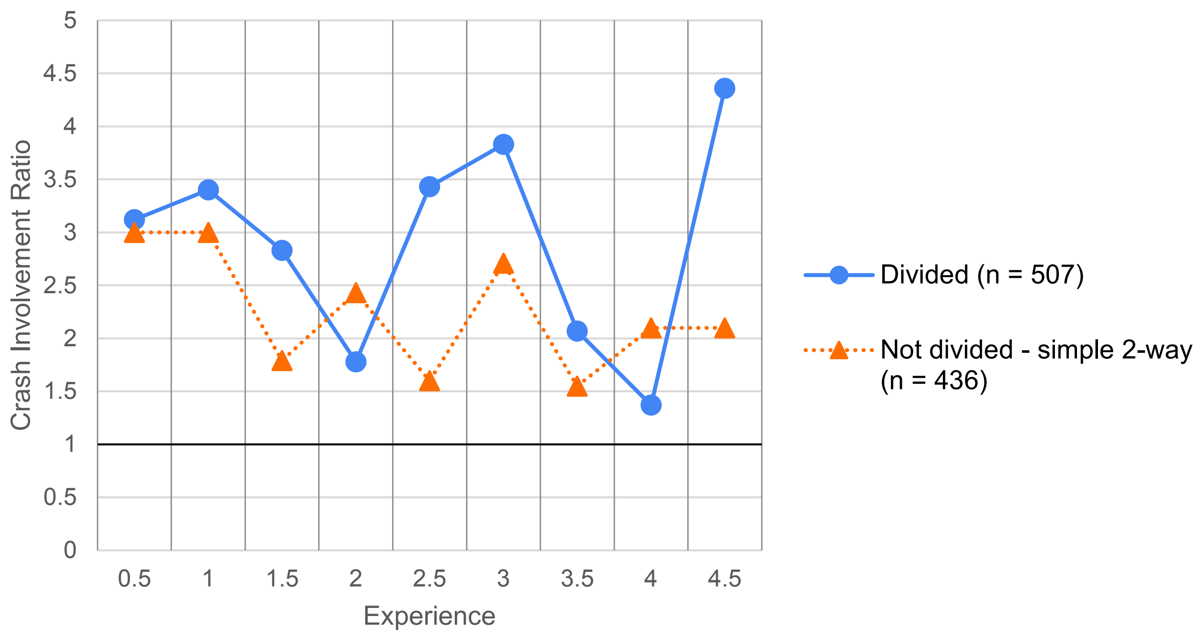

Figure 12. SHRP2 - Crash Involvement Ratio by Traffic Flow and Years Driving Experience

Number of Travel Lanes

Figure 13 shows the CIRs for young drivers and 35-year-old drivers involved in fatal (FARS) crashes by number of continuous travel lanes.[2] Young drivers were at numerically highest risk on two-lane roads, and this risk was significantly higher than that of 35-year-old drivers at each young-driver age. Young drivers were not at a significantly higher risk than 35-year-old drivers for fatal crashes on roads with three or more lanes, with the exception of 20-year-old drivers. CIR values for young drivers on roads with two lanes, or three or more lanes, were generally numerically higher at younger ages and lower at older ages. Fatal crashes on one-lane roads were much rarer occurrences, and none of the young-driver ages met the minimum sample size requirement (i.e., at least 20 drivers). The crash involvement ratios for 35-year-old drivers did not appear to differ by number of travel lanes.

Figure 14 and Figure 15 show crash involvement ratios from SHRP2 data for roads with two, or three or more, contiguous travel lanes, by age and experience, respectively.[3] In both graphs all CIR values were above the CIR = 1.0 threshold, but there are not any strong visual trends with either increasing age or experience.

[2] In FARS (NCSA, 2019b), "number of travel lanes" refers to the number of lanes of a continuous cross-section of roadway. Therefore, a local roadway with one lane going north and one lane going south would be considered “two lanes.” A divided highway with two lanes going north, a median, and two lanes going south would also be considered “two lanes.”

[3] In SHRP2, number of travel lanes was based on the "contiguous travel lane" variable, which describes the total number of contiguous travel lanes into which vehicles could easily maneuver, including any turn lanes, at the time of the event.

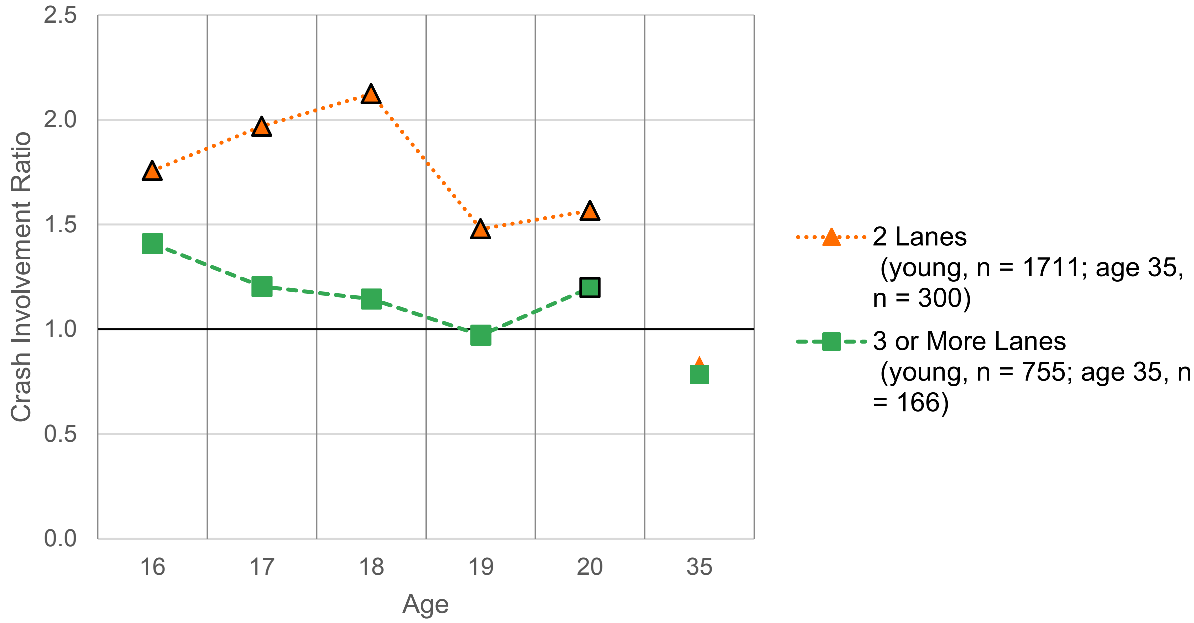

Figure 13. FARS - Crash Involvement Ratio by Number of Travel Lanes and Driver Age

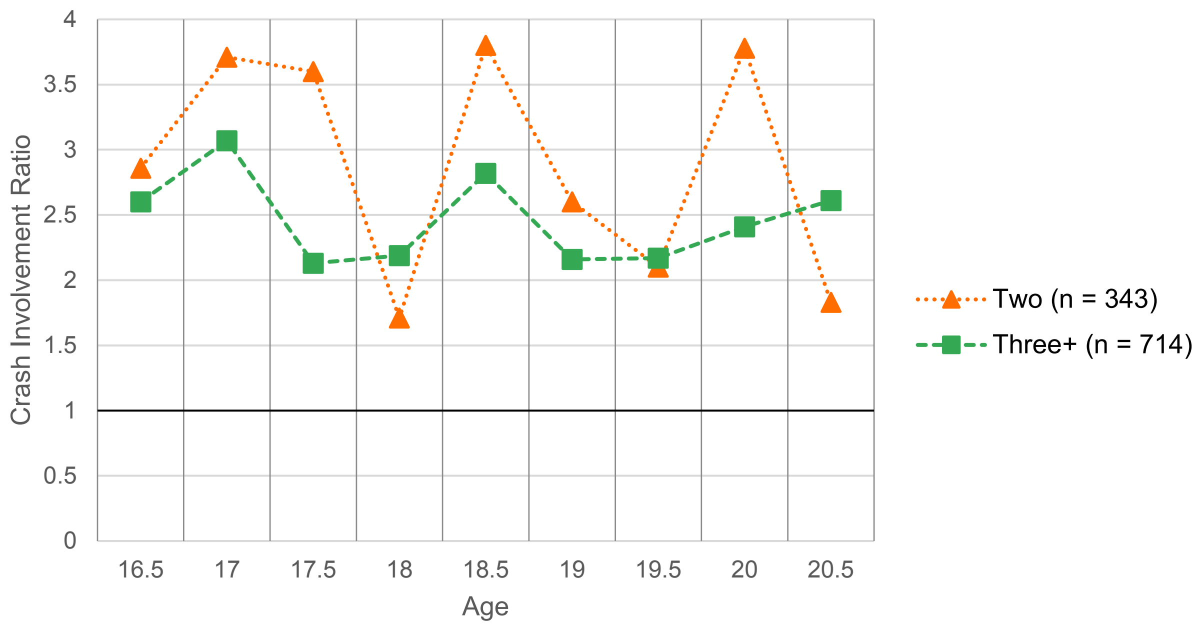

Figure 14. SHRP2 - Crash Involvement Ratio by Number of Travel Lanes and Driver Age

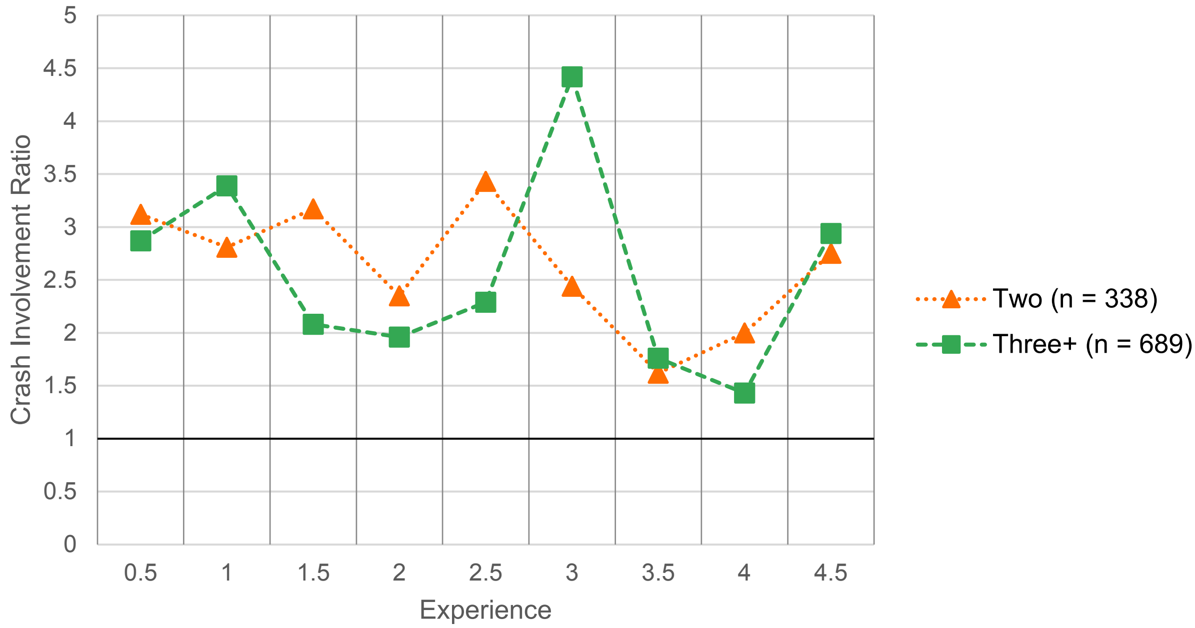

Figure 15. SHRP2 - Crash Involvement Ratio by Number of Travel Lanes and Years Driving Experience

Rural/Urban Roadways

The FARS data show that young drivers had significantly higher crash risks than 35-year-old drivers on both urban and rural roadways[4] (Figure 16). Visually, risk declines for young drivers on both rural and urban roadways with increasing age. CIRs for crashes on urban roadways were often numerically higher than CIRs for crashes on rural roadways, but the differences were not large.

Among the SHRP2 data, only crashes on suburban/commercial roadways (versus urban or rural roadways) met the minimum sample size criterion.[5] As seen in both Figure 17 and Figure 18, CIR values were always above the CIR = 1.0 threshold, but no clear visual trends with increasing young driver age or experience are apparent.

[4] For FARS data from 2013 to 2015, urbanicity was determined using the FARS variable "Roadway Function Class." This variable identifies the functional classification of the trafficway on which the crash occurred, and its values are categorized as "rural" or "urban." For FARS data from 2015 to 2017, urbanicity was determined using the FARS variable "Land Use," which is a classification of the segment of the trafficway on which the crash occurred based on FHWA-approved adjusted Census boundaries of small urban and urbanized areas (NCSA, 2019b).

[5] For SHRP2 data, urbanicity was determined based on the "locality" variable, which was coded based on the "surroundings that influence or may influence the flow of traffic at the time of the start of the precipitating event." "Open residential" and "open country" localities were considered "rural," while "moderate residential" and "business industrial" localities were considered "suburban/commercial." Finally, localities coded as "urban" were considered "urban" in this analysis.

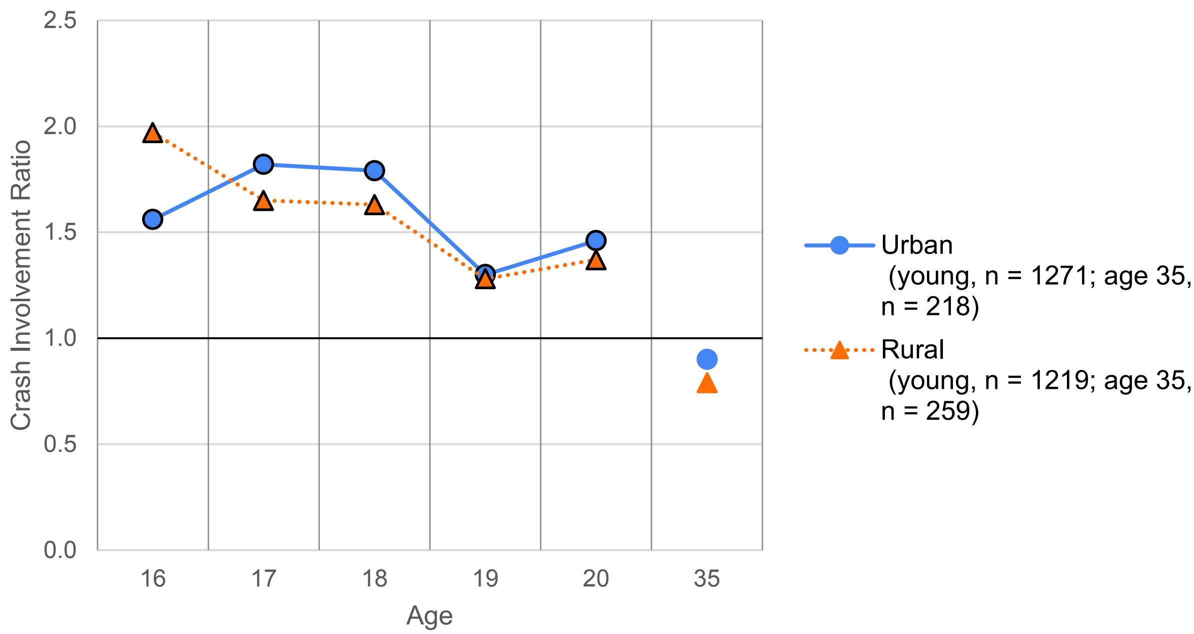

Figure 16. FARS - Crash Involvement Ratio by Urban/Rural Roadway and Driver Age

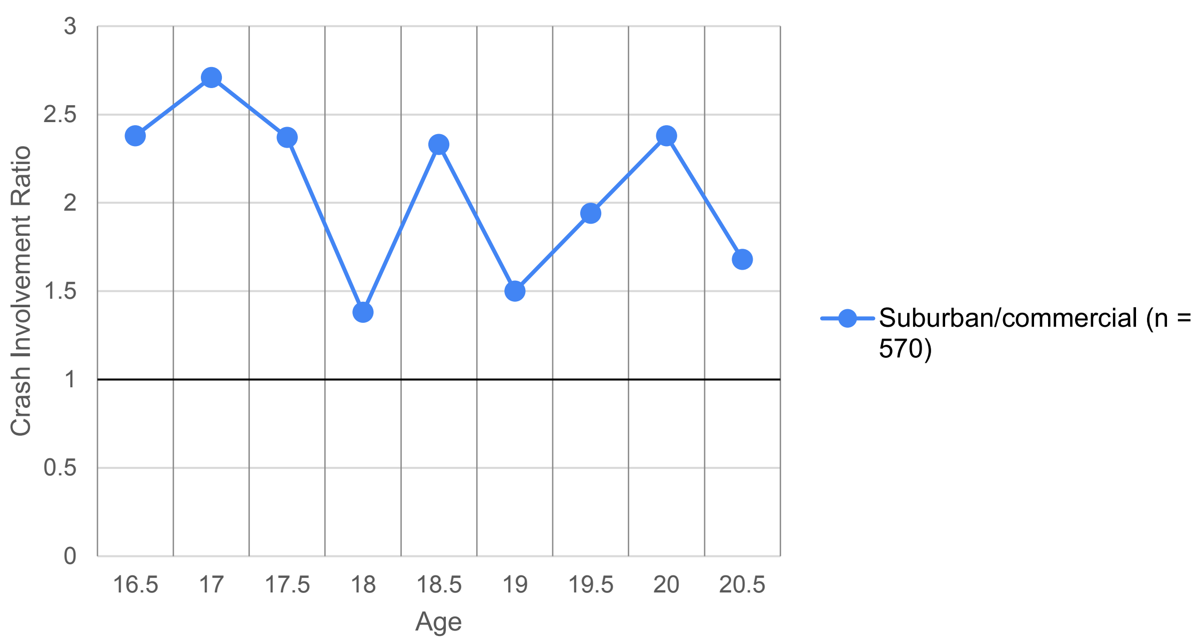

Figure 17. SHRP2 - Crash Involvement Ratio by Urban/Rural Roadways and Driver Age

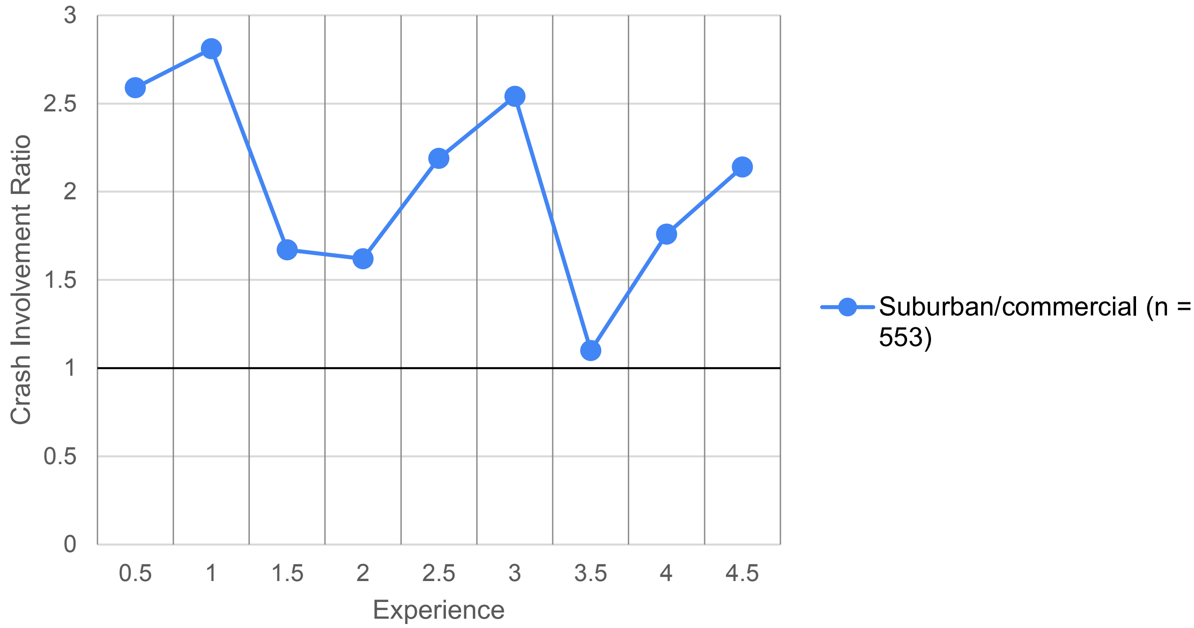

Figure 18. SHRP2 - Crash Involvement Ratio by Urban/Rural Roadways and Years Driving Experience

Posted Speed Limit

Figure 19 shows the CIR values for fatal (FARS) crashes by the roadway posted speed limit. Young drivers at each age interval had significantly higher fatal CIRs than 35-year-old drivers on roads with speed limits of 40-to-45 and 50-to-60 mph. On low-speed roadways (5-35to mph), 17-year-old drivers and 20-year-old drivers had a significantly higher fatal crash risk than 35-year-old drivers, and 18-year-old drivers were the only group to have a significantly higher crash risk than 35-year-old drivers on the highest speed roads (posted speed limits of 65-to 95 mph). Numerically, for roads with speed limits of 40- to 45 mph or 65- to 95 mph,[6] the highest CIR values tended to occur at the youngest young driver ages, and the lowest CIR values tended to occur at older young driver ages. No such trends were visible for roads with speed limits of 5- to 35 or 50- to 60 mph. Additionally, CIR values for young drivers on roadways with different speed limits did not obviously differ from one another.

[6] According to the Insurance Institute for Highway Safety, only State Highway 130 in West Texas has a posted speed limit of 85 mph; no other State or Federal roadway has a posted speed above 80 mph. www.iihs.org/topics/speed/speed-limit-laws

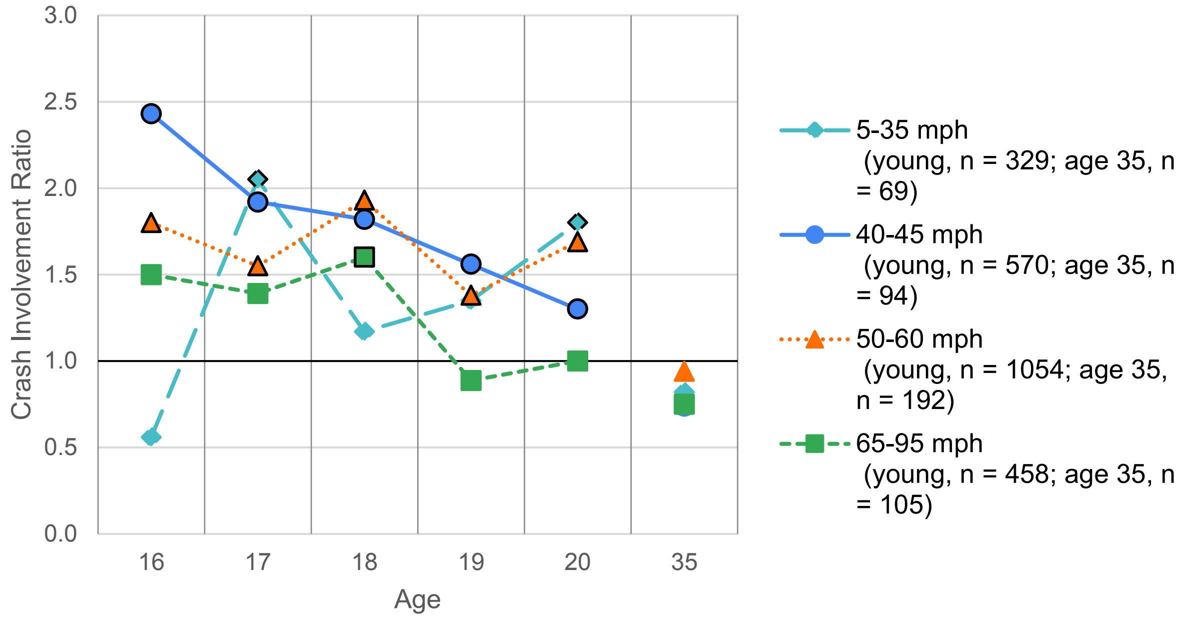

Figure 19. FARS - Crash Involvement Ratio by Posted Speed Limit and Driver Age

Roadway Alignment

Figure 20 shows young drivers' involvement in fatal (FARS) crashes compared to 35-year-old drivers on curved and straight roads. Young drivers' likelihood of having a contributing factor in a fatal crash on either straight or curved roadways was significantly higher than that for 35-year-old drivers at most young driver ages. Numerically, the highest CIR values occurred for curved roadways at younger ages; these values decreased by age 19 to the point where they were no longer significantly different than that of 35-year-old drivers. For straight roadways, there was not a visually apparent change in CIR values with increasing age.

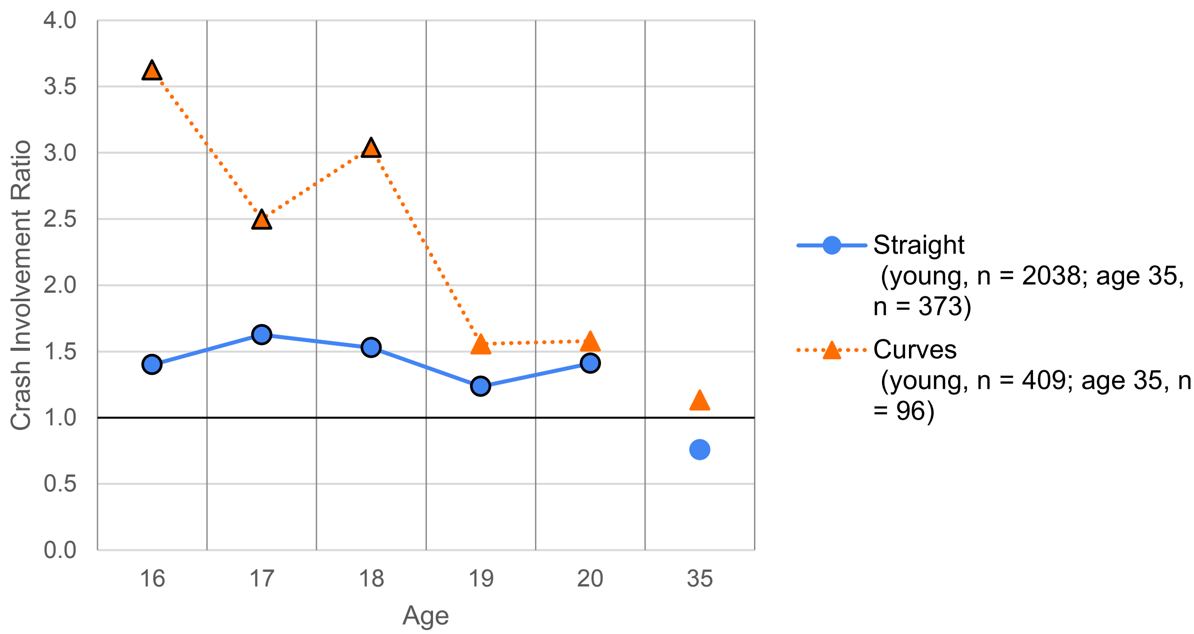

Figure 20. FARS - Crash Involvement Ratio by Roadway Alignment and Driver Age

Intersection Type

Figure 21 to Figure 26 present CIRs for young drivers (and 35-year-old drivers, where available) by type of and proximity to intersections, as well as by types of traffic control, for the FARS and SHRP2 datasets. Figure 21 shows that young drivers of each age had significantly higher fatal CIR values than 35-year-old drivers for both the "not an intersection" and "four-way intersection" categories; CIR values for the "T-intersection" category were significantly higher than 35-year-old drivers at ages 17, 18, and 20. Numerically, CIR values for young drivers for "not an intersection" and "four-way intersection" categories were generally highest at younger ages and lowest at older ages. Additionally, "no intersection" and "four-way intersections" tended to have numerically higher CIR values than T-intersections.

The SHRP2 data are presented differently, showing young drivers' crash risk by intersection (within a standard car length of the roads crossing), non-junction (normal roadway), and intersection-related (approaching or exiting the intersection, within 4 standard car lengths) by age (Figure 22) or years of driving experience (Figure 23). For intersection and intersection-related junctions, most data points are missing due to small sample sizes. Figure 22 shows that when examining CIR values by age, the numerically highest risk occurred for non-junctions at age 18.5, with no visually consistent trend in the non-junction category with increasing age. By experience (Figure 23), the numerically highest CIR value was observed non-junction locations at the 3-year experience mark, with no clear change in CIR values for non-junctions with increasing age.

Figure 24 (A and B) shows that the numerically highest risk by intersection traffic control type occurred for stop signs. Young drivers had increased crash involvement at all ages relative to 35-year-old drivers for crashes occurring in places without traffic control; for crashes at stop signs, young drivers' risk was significantly higher than 35-year-old drivers at ages 17 and 18 only

(Figure 24A). For crashes at signals, young driver CIR values were not significantly different from driver age 35 at any age (Figure 24B). For all traffic control types, the highest CIR values tended to occur at the youngest ages.

For the SHRP2 data, most data points are missing due to small sample sizes. The CIR values plotted indicate that CIR values for events at traffic signals were higher than the 1.0 threshold when examined by age (Figure 25) or experience (Figure 26).

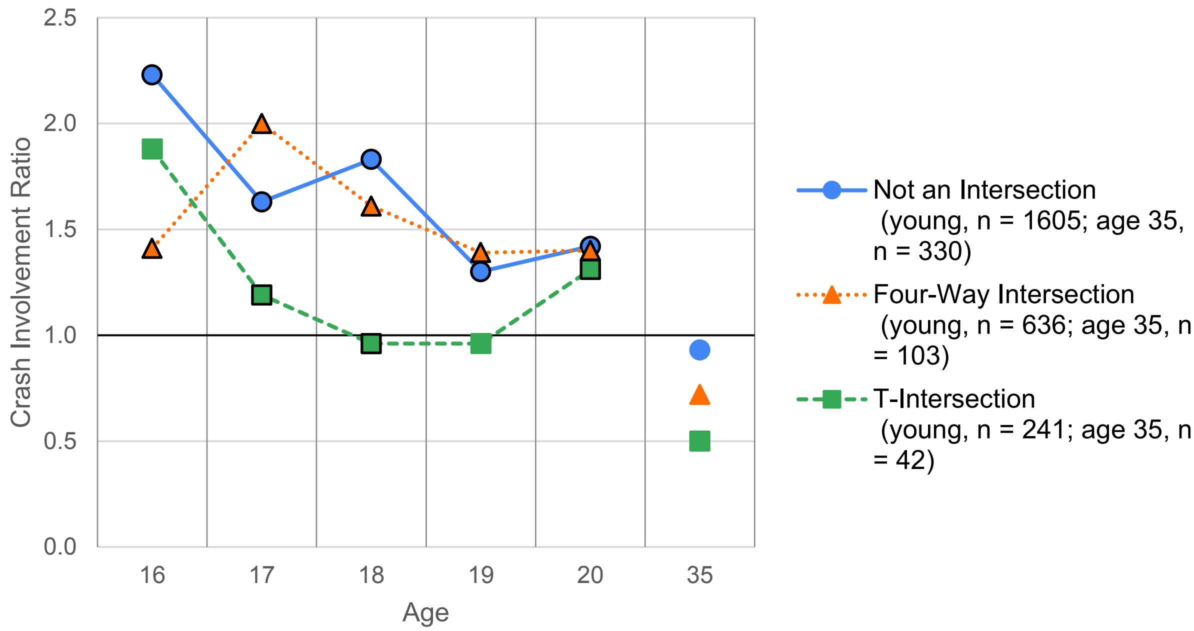

Figure 21. FARS - Crash Involvement Ratio by Intersection Type and Driver Age

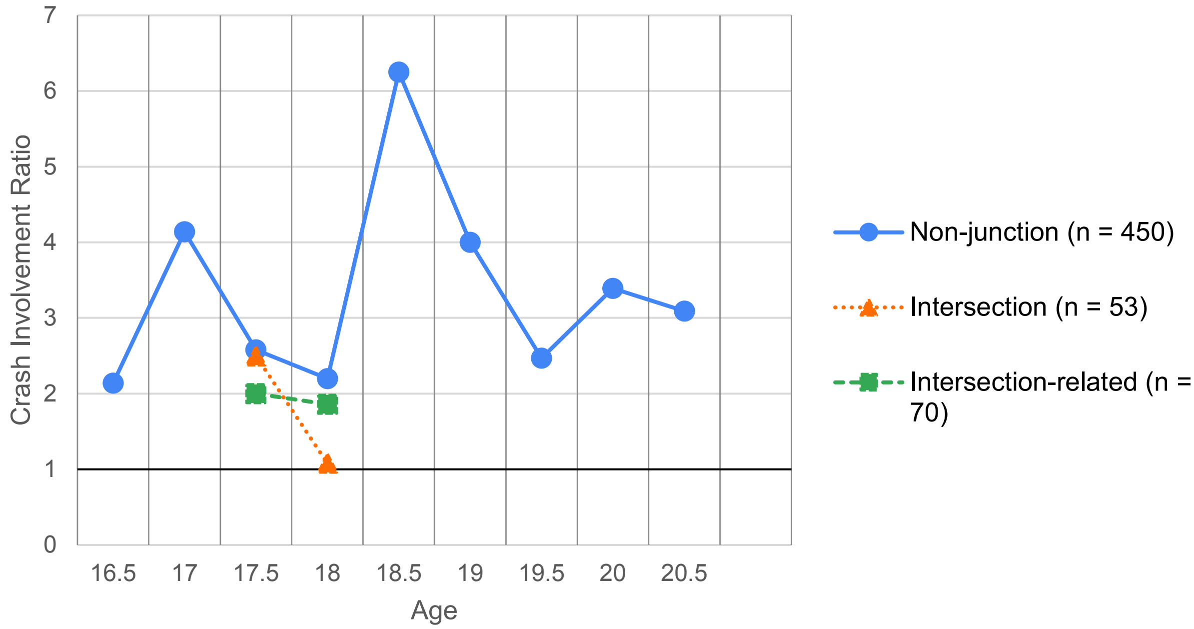

Figure 22. SHRP2 - Crash Involvement Ratio by Relation to Junction and Driver Age

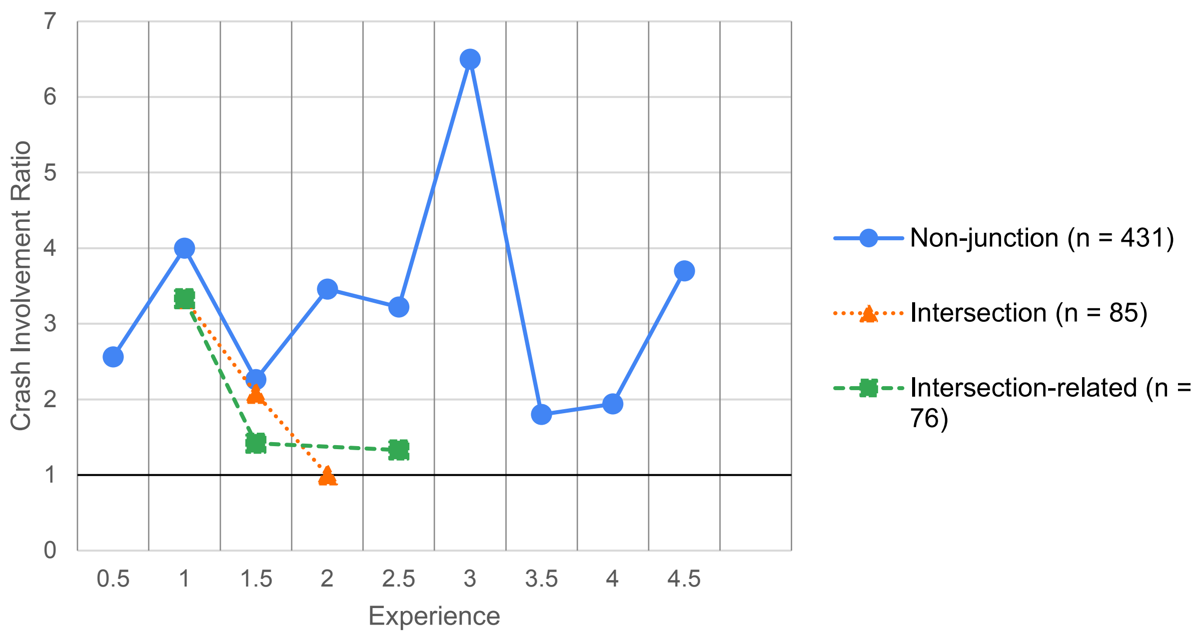

Figure 23. SHRP2 - Crash Involvement Ratio by Relation to Junction and Years Driving Experience

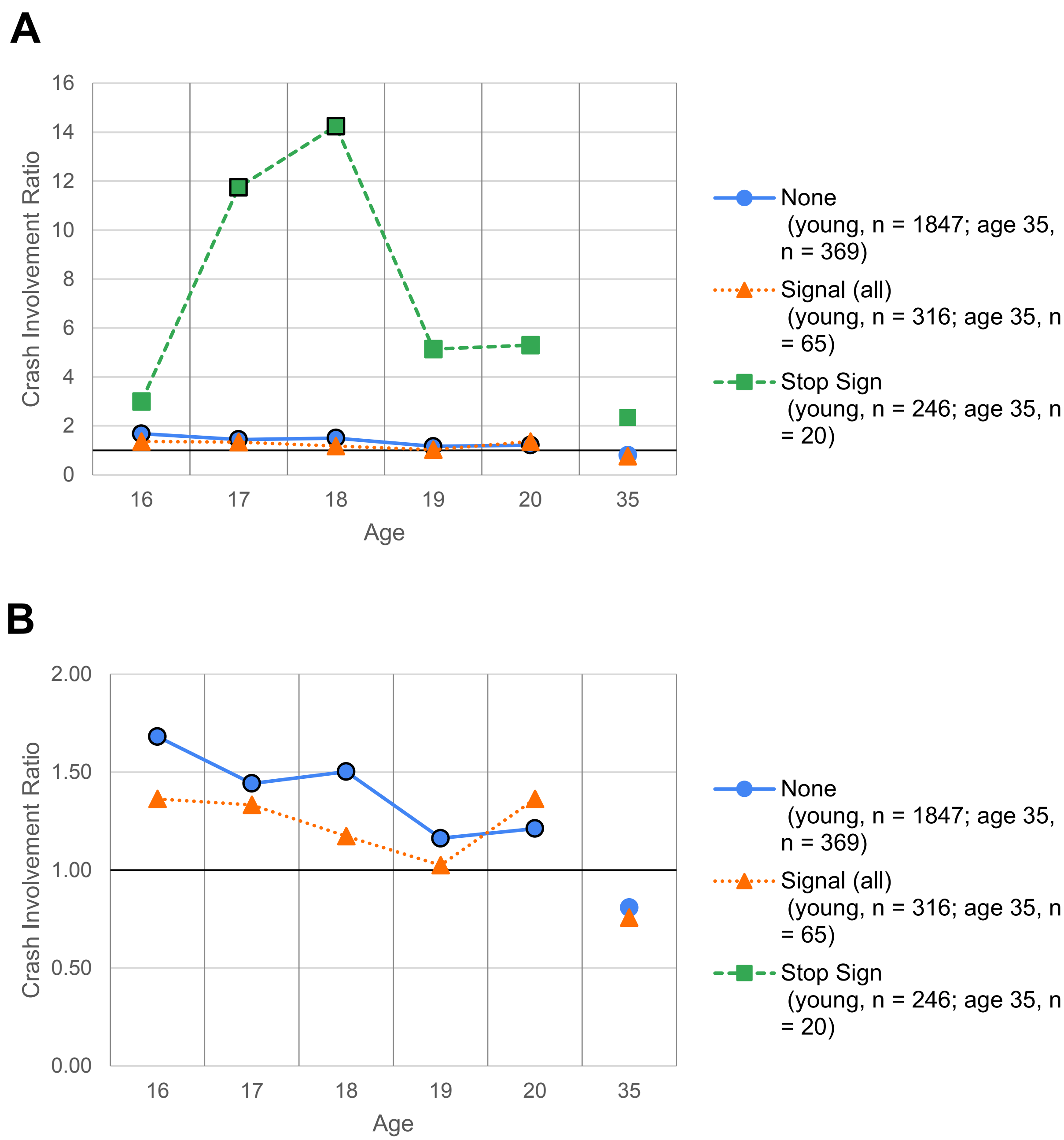

Figure 24. FARS - Crash Involvement Ratio by Traffic Control and Driver Age. (A) Graph scaled to display all three categories of traffic control. (B) Graph scaled to only display "none" and "signal" traffic control categories.

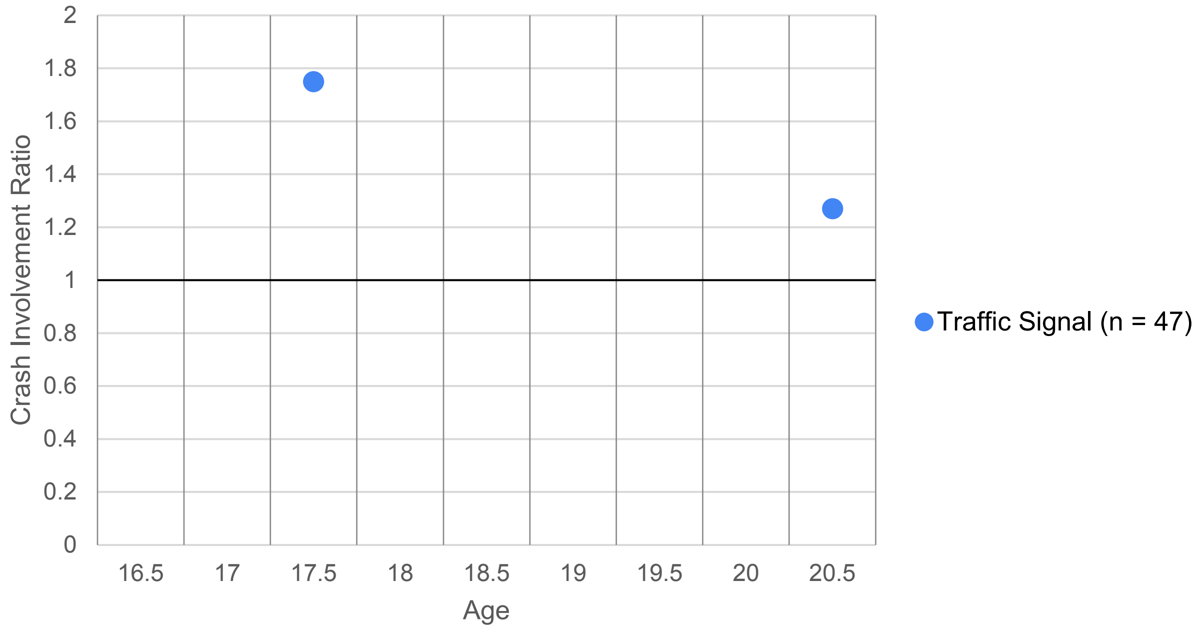

Figure 25. SHRP2 - Crash Involvement Ratio by Traffic Control and Driver Age

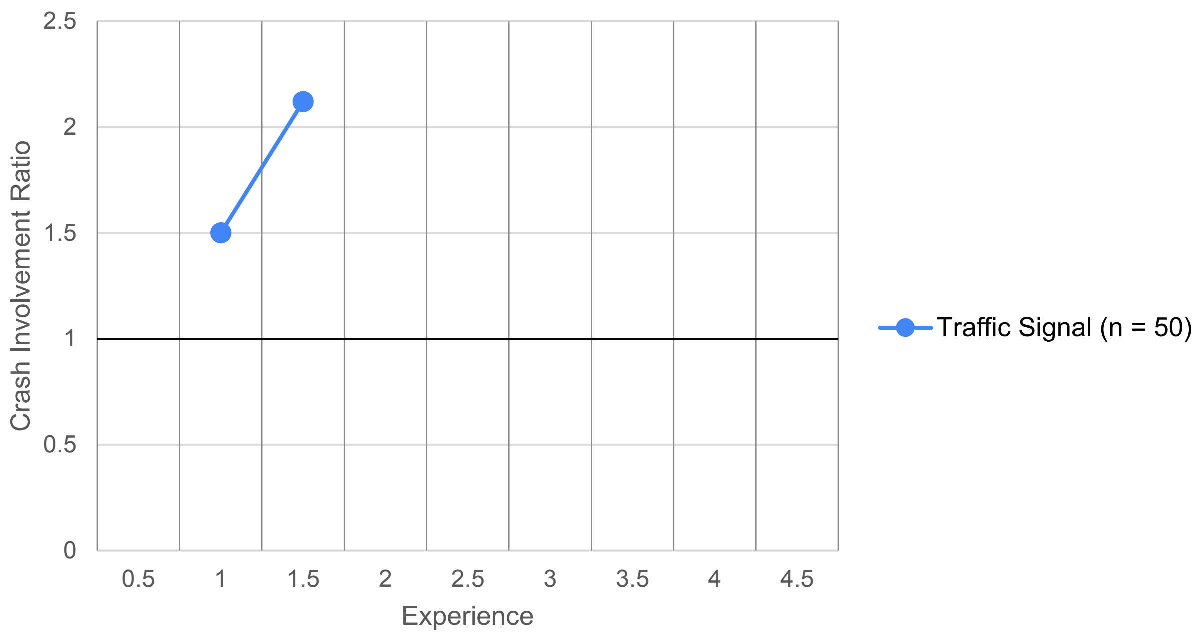

Figure 26. SHRP2 - Crash Involvement Ratio by Traffic Control and Years Driving Experience

Time of Day and Lighting Conditions

Figure 27 shows the crash involvement ratios for young drivers and 35-year-old drivers for fatal (FARS) crashes by time of day. Young drivers' CIR values at each age were significantly higher than that of 35-year-old drivers from 6 a.m. to 3 p.m. and 3 p.m. to 6 p.m.[7] A young driver's likelihood of having a contributing factor in a fatal crash was numerically highest during daylight hours (6 a.m. to 6 p.m.). Additionally, young driver CIRs occurring during these hours were highest at younger ages and lowest at older ages.

The FARS data show similar findings when examined by light conditions (Figure 28), in that a young driver was at increased likelihood of having a contributing factor in a fatal crash during daylight, and this increased likelihood was significantly higher than that of a 35-year-old driver at each young driver age. Young driver likelihood of having contributing factors in fatal daylight crashes was highest at younger ages and lowest at older ages.

However, it is important to note that the quasi-induced exposure analyses conducted here included only drivers in multi-vehicle crashes; drivers in single-vehicle crashes were excluded. Prior research using a different kind of induced exposure metric that included both multi- and single-vehicle injury crashes found that a young driver had the highest odds of a crash between midnight and 5:59 a.m. (Rice et al., 2003). Additionally, although the rates of non-fatal, single-vehicle crashes per mile driven were highest for *all* drivers from 9 p.m. to 11:59 p.m. relative to daytime, nighttime crash rates were even higher for teens than adults (Shults et al., 2019). The current results, on the other hand, only speak to a young driver's likelihood of having a contributing factor in a fatal multi-vehicle crash, and this likelihood appears to be higher during the day.

The SHRP2 data allow for an examination of young drivers' crash risk during various light conditions by driver age (Figure 29), as well as by years of driving experience (Figure 30). Most CIR values for dark lighted conditions were omitted from the graphs due to small sample sizes; additionally, other lighting conditions (dark but not lighted, dawn, and dusk) were omitted from the graphs entirely because no ages had sufficient sample sizes to calculate CIR values. Both graphs show that CIR values were generally highest during daylight conditions, but there is not a visually apparent change with CIR values by either age or experience.

[7] Note that the time windows used in this analysis are of different durations, 9 hours versus 3 hours. These time windows were selected based both on existing GDL restrictions on nighttime driving, as well as presumed differences in young drivers' travel patterns across these time windows.

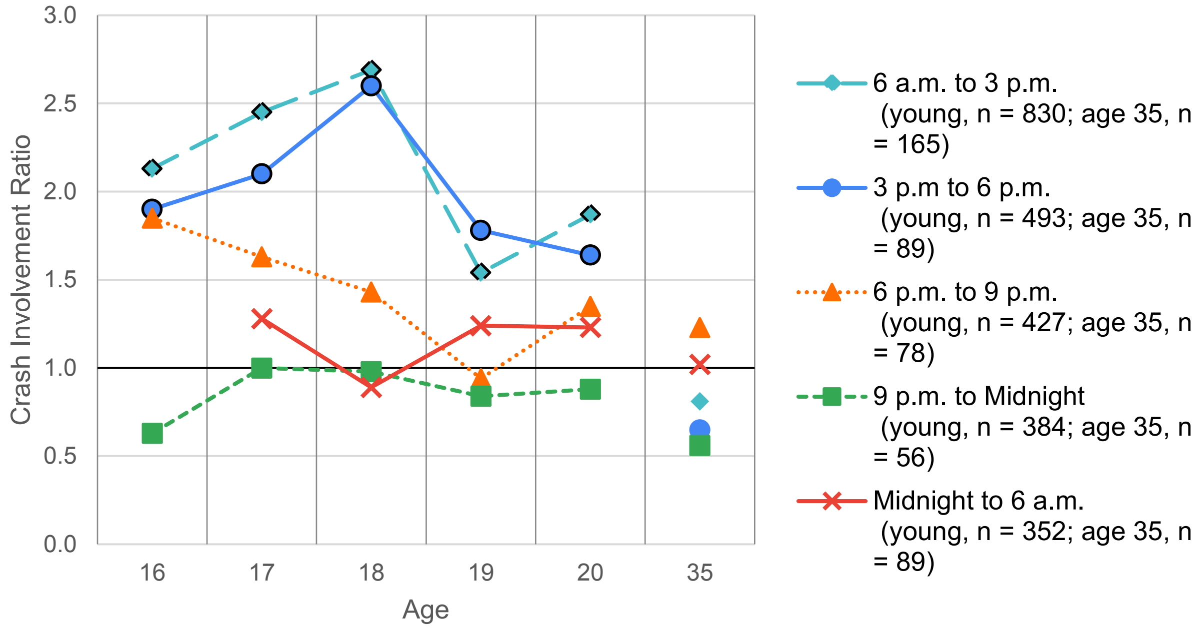

Figure 27. FARS - Crash Involvement Ratio by Time of Day and Driver Age

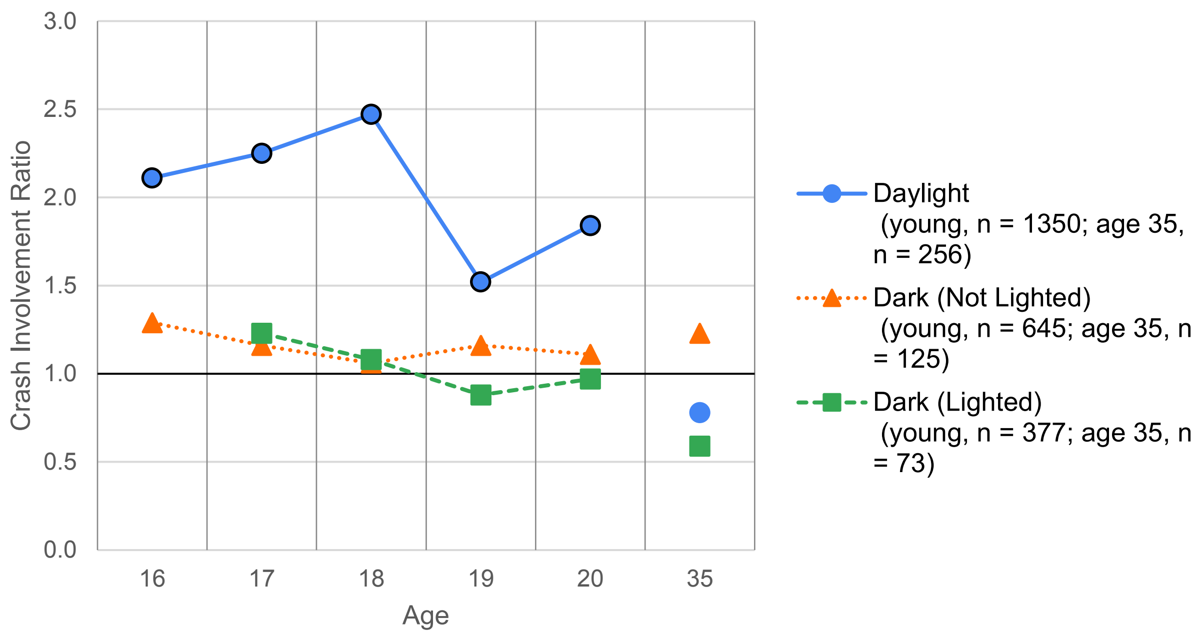

Figure 28. FARS - Crash Involvement Ratio by Light Conditions and Driver Age

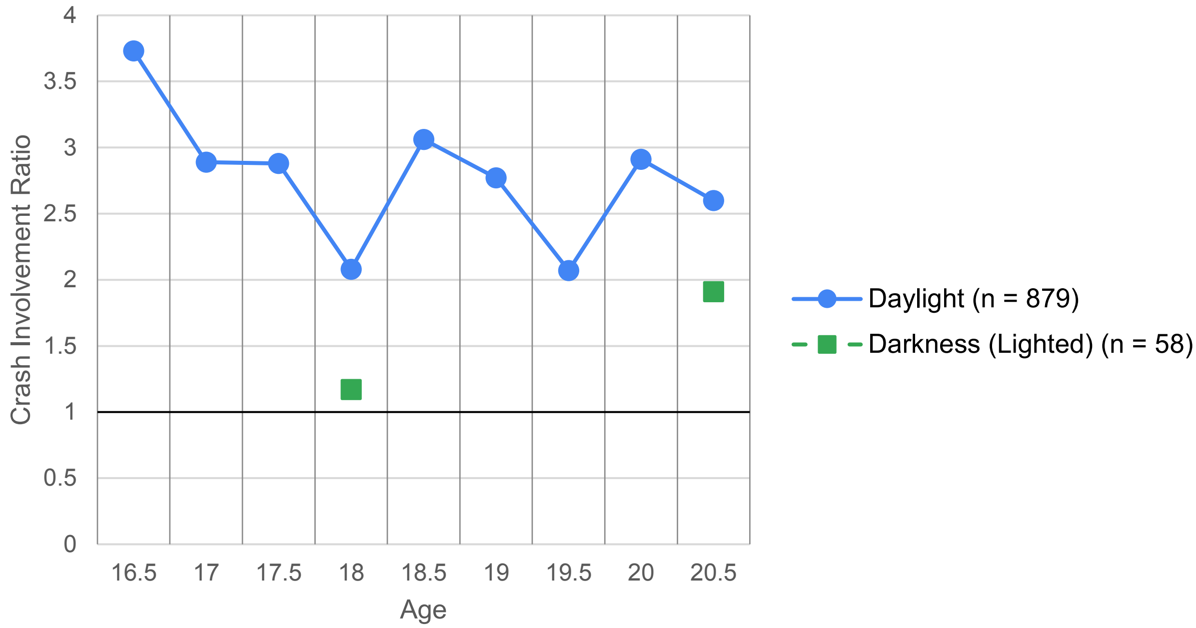

Figure 29. SHRP2 - Crash Involvement Ratio by Light Conditions and Driver Age

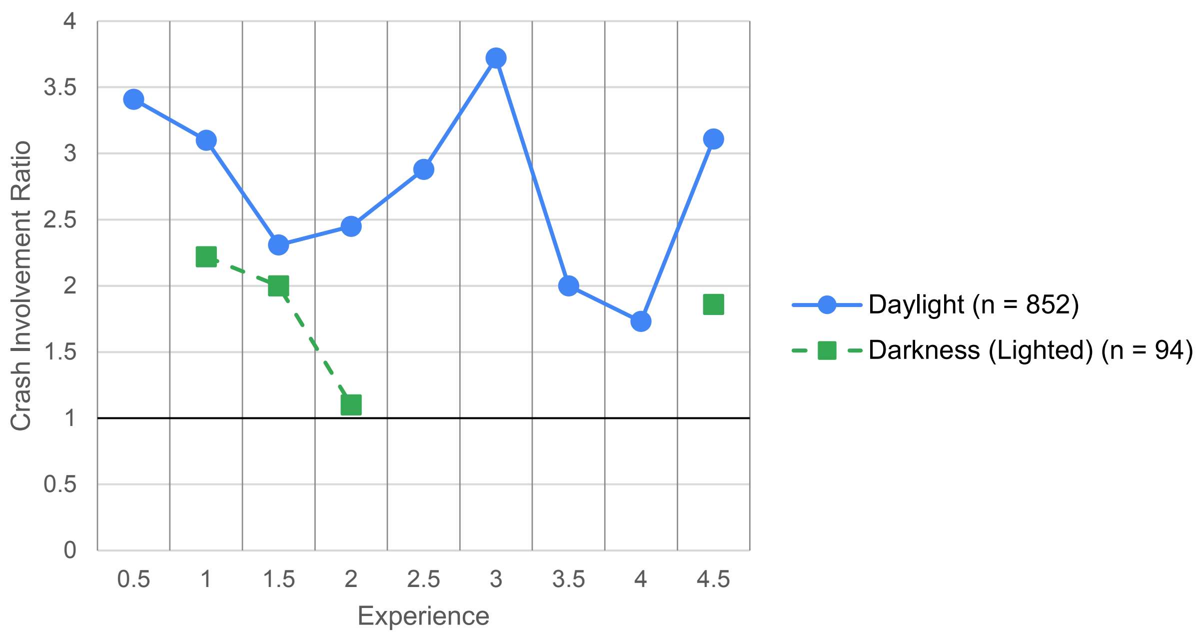

Figure 30. SHRP2 - Crash Involvement Ratio by Light Conditions and Years Driving Experience

Day of Week

The FARS (Figure 31) data show that young drivers generally had higher crash risk than their 35-year-old counterparts on both weekdays and weekends, with this risk being numerically higher on weekdays (from 6 a.m. Monday to 6 p.m. Friday). Figure 31 shows that the risk on weekdays and weekends was higher for young drivers at younger ages and lower at older ages. By contrast, crash involvement ratios for 35-year-old drivers did not appear to be different for fatal crashes occurring on weekdays versus weekends.

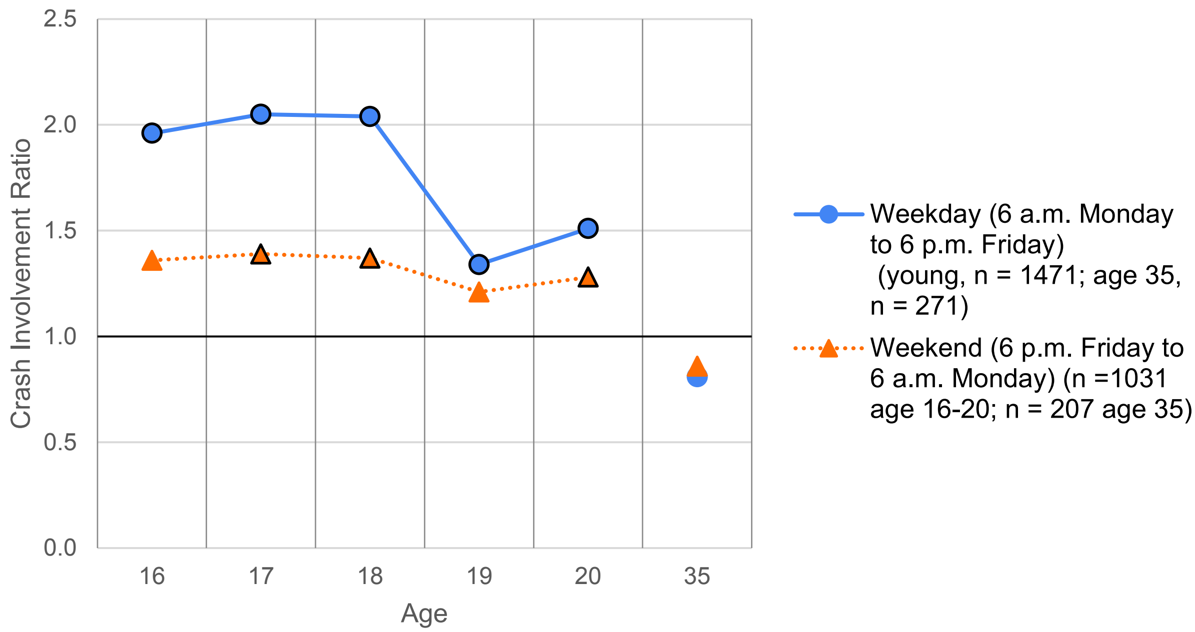

Figure 31. FARS - Crash Involvement Ratio by Day of Week and Driver Age

Crash Characteristics

Collision Type

Figure 32 shows crash involvement ratios for young drivers and 35-year-old drivers by the type of collision for fatal (FARS) crashes. These analyses are based on the first injury or damage-producing event of the crash, called the "First Harmful Event" variable (NCSA, 2019b). A collision with a motor vehicle in transport was the most frequent crash type in each dataset, representing at least 95% of the relevant crashes in FARS; the next highest crash type was collision with fixed object (approximately 3%). The research team calculated CIR values for these two most frequent crash types only.

Young drivers had a significantly higher crash risk in a collision with a motor vehicle in transport than their 35-year-old counterparts at each young driver age. Young driver risk for fatal collision with a motor vehicle was numerically highest at younger ages and lower at older ages. Some young driver fatal CIRs for collisions with fixed objects were omitted due to small sample sizes; of those included, none were significantly higher than that for 35-year-old drivers.

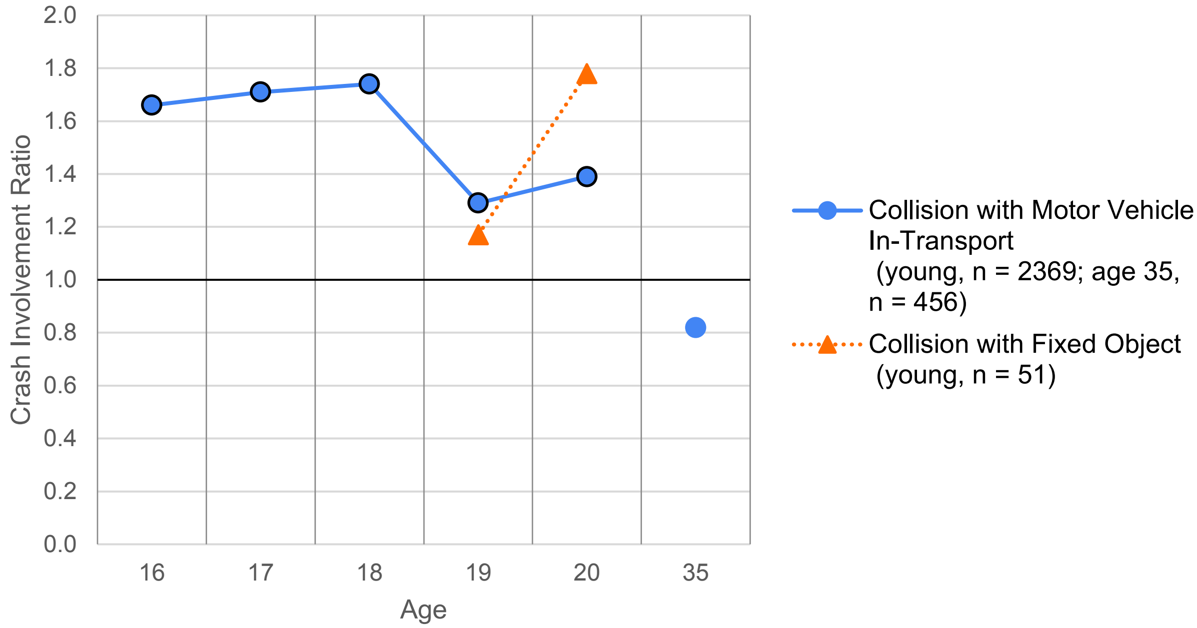

Figure 32. FARS - Crash Involvement Ratio by Collision Type and Driver Age

Manner of Collision and Impact Location

The following figures present crash involvement ratios for young drivers and 35-year-old drivers, where applicable, by the manner of collision and impact location, including only the variable levels with a substantial number of crashes within each dataset. Figure 33 shows young drivers' risk compared to 35-year-old drivers by manner of collision for fatal (FARS) crashes. The manner of collision variable describes the orientation of two motor vehicles in-transport when they are involved in the "first harmful event," i.e., first injury or damage producing event of the crash (NCSA, 2019b).

Young drivers were at a significantly higher risk than 35-year-old drivers for fatal (FARS) angle crashes at each young driver age, fatal front-to-front crashes at ages 16, 17, and 18, and fatal front-to-rear crashes at ages 18 and 20. Young driver CIR values for manners of collision significantly higher than age 35 tended to have higher values at younger ages and lower values at older ages. There was not clear visual differentiation between CIR values for different manners of collision.

Figure 34 and Figure 35 show young drivers' risk by manner of collision (i.e., incident type) for the SHRP2 events by age and years of driving experience. Here, young drivers were most at risk for rear end-striking events; these are events where the young drivers contacted or nearly contacted any portions of the back planes of the lead vehicles. Rear-end collisions were the only incident type to consistently show a CIR above the protective threshold of 1.0; most CIR values for sideswipe-same direction crashes were omitted due to small sample sizes. Although the CIR values vary substantially across age and experience, the numerically lowest CIR values are observed at older ages and more years of driving experience.

Figure 36 presents CIRs for young drivers and 35-year-old drivers by the initial impact location for the FARS dataset. The initial impact location is the area on the driver's vehicle that resulted in the first instance of injury or damage as indicated on the police report. Figure 36 shows that young drivers were often, but not always, at higher risk for fatal (FARS) crashes relative to 35-year-old drivers where the initial impact location was the front, right side, rear, or left of the vehicle. For front and left side initial impact locations, numerically higher CIR values tended to occur at younger ages and lower CIR values at higher ages; for crashes where the initial impact locations were the right side, however, the numerically highest CIR values occurred at ages 17 to 19. Additionally, CIR values for crashes with right side initial impact locations were almost always numerically higher than crashes with other impact locations.

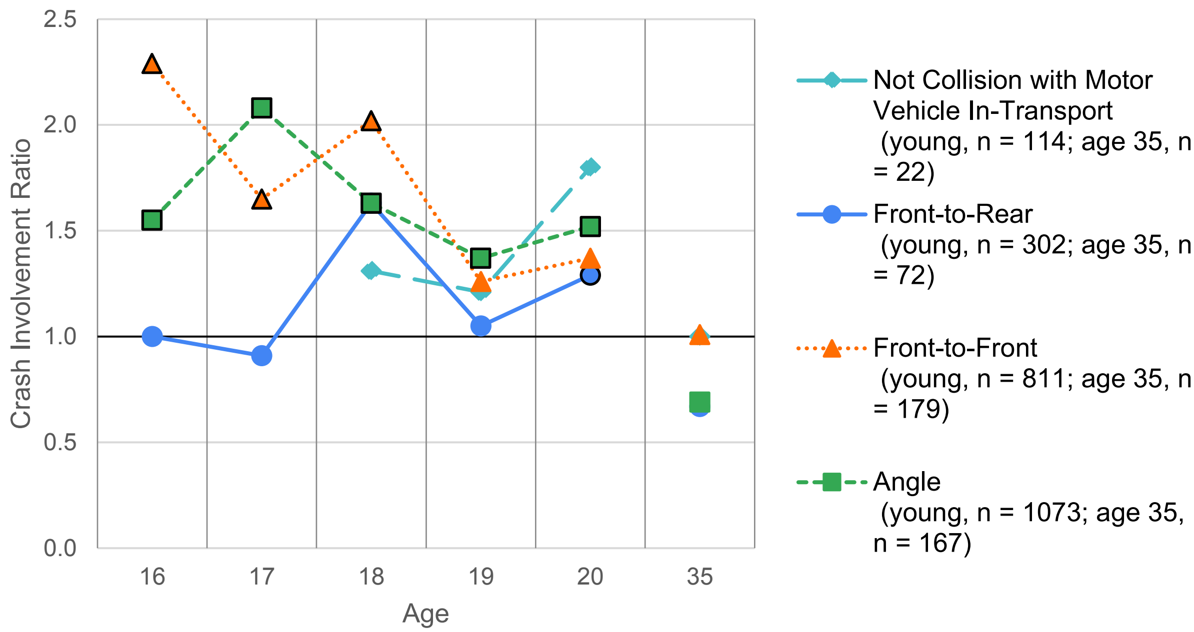

Figure 33. FARS - Crash Involvement Ratio by Manner of Collision and Driver Age

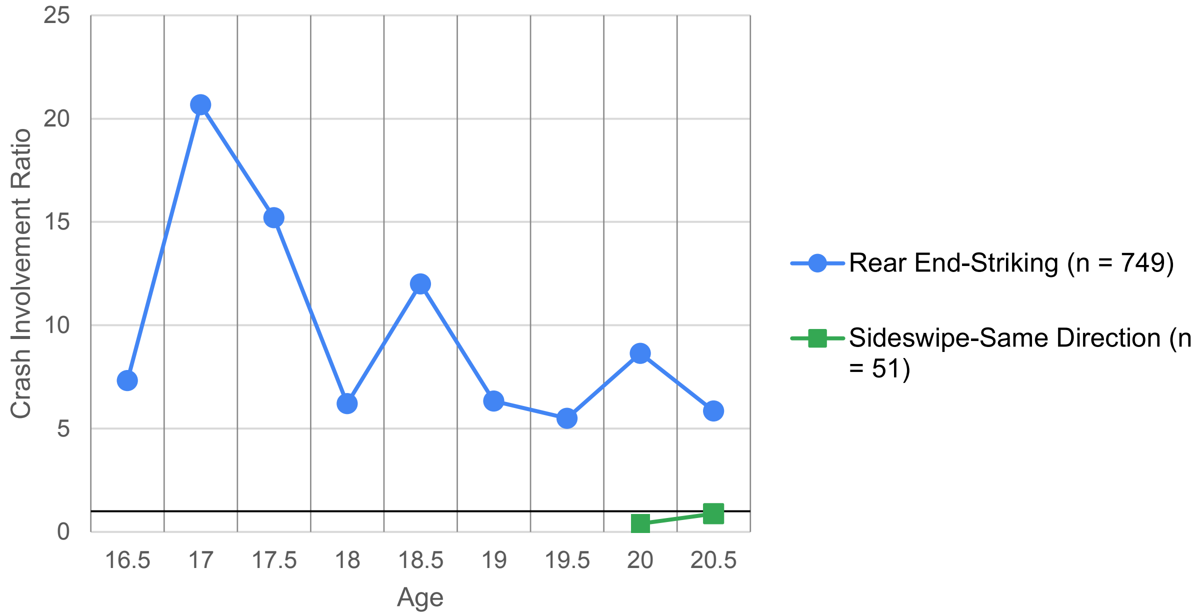

Figure 34. SHRP2 - Crash Involvement Ratio by Manner of Collision and Age

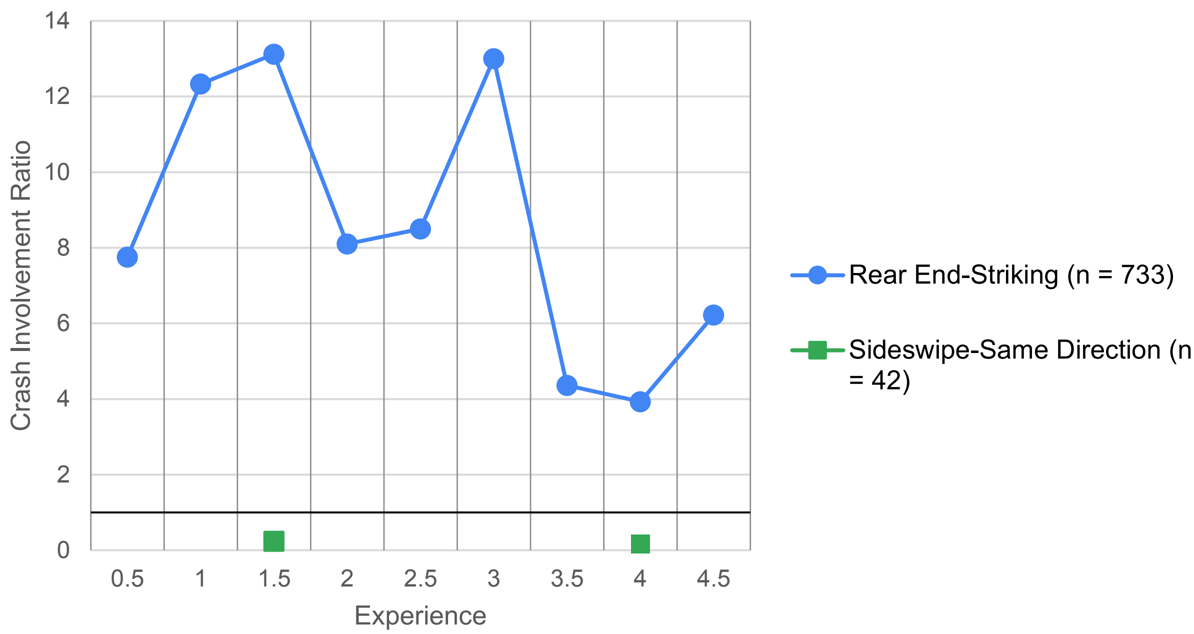

Figure 35. SHRP2 - Crash Involvement Ratio by Manner of Collision and Years Driving Experience

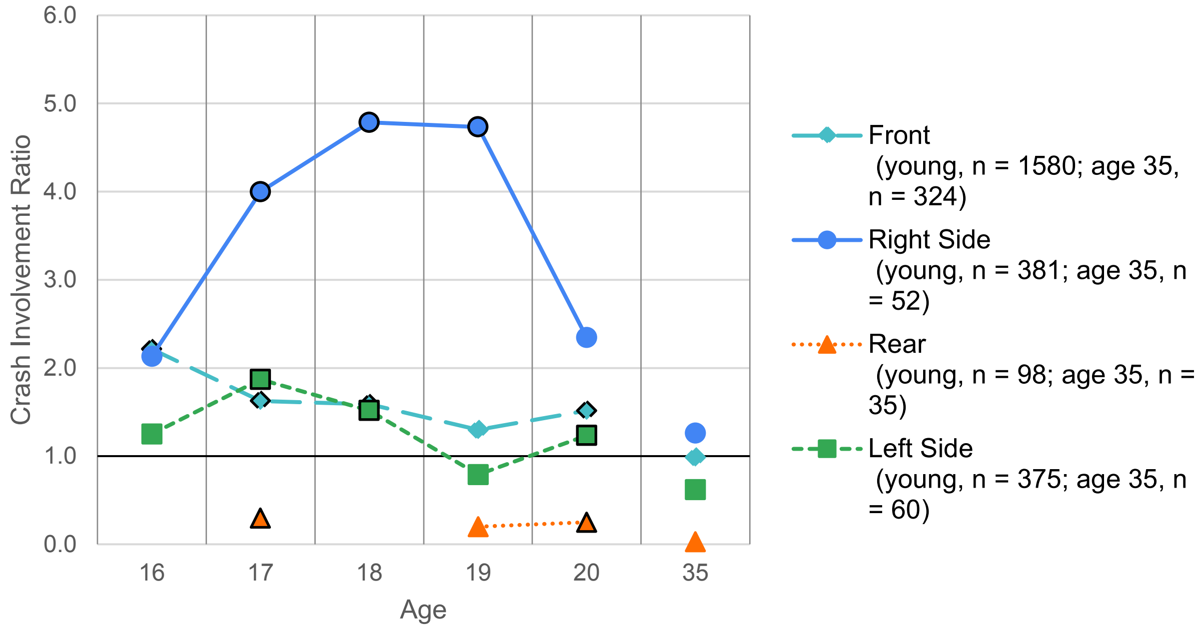

Figure 36. FARS - Crash Involvement Ratio by Initial Impact Location and Driver Age

Pre-Crash Vehicle Maneuvers

Figure 37 through Figure 40 present crash involvement ratios by driver maneuvers prior to the crash/event for FARS and SHRP2 NDS data, including only the variable levels with a substantial number of crashes. Figure 37 shows the CIRs for young drivers and 35-year-old drivers by pre-crash vehicle maneuver for fatal (FARS) crashes. A young driver's likelihood of having a contributing factor in a fatal crash while going straight was significantly higher than that of a 35-year-old driver at all young driver ages, and for a fatal crash while negotiating a curve ages 16, 17, and 18. Due to a small sample size for 35-year-old drivers, young driver CIR values for turning left could not be compared to their 35-year-old counterparts. For all three pre-crash vehicle maneuvers, young driver CIR values were generally highest at younger ages and lowest at older ages. CIR values for crashes involving a pre-crash maneuver of turning left were numerically higher than negotiating curves or going straight.

In the SHRP2 data, crashes were differentiated by whether the pre-crash vehicle maneuver occurred at a non-junction or signal-controlled location. For crashes at non-junctions, only crashes involving a pre-crash vehicle maneuver of going straight had a sufficient sample size to calculate CIR values. All CIR values were higher than the 1.0 threshold, when examined either by age (Figure 38) or by years of driving experience (Figure 39), and neither graph shows a clear visual change in CIR values with either increasing age or experience. For crashes at signal-controlled locations, no pre-crash vehicle maneuver types met the minimum sample size criterion.

Finally, crash involvement ratios were analyzed for FARS data (Figure 40) according to which avoidance maneuvers were performed by the drivers prior to the crashes, if any. Young drivers were at significantly higher risk than 35-year-old drivers at each young driver age when steering to avoid crashes and when performing no avoidance maneuvers. Although young driver CIR values for most maneuvers were lower at older ages, this pattern was not present for all maneuvers.

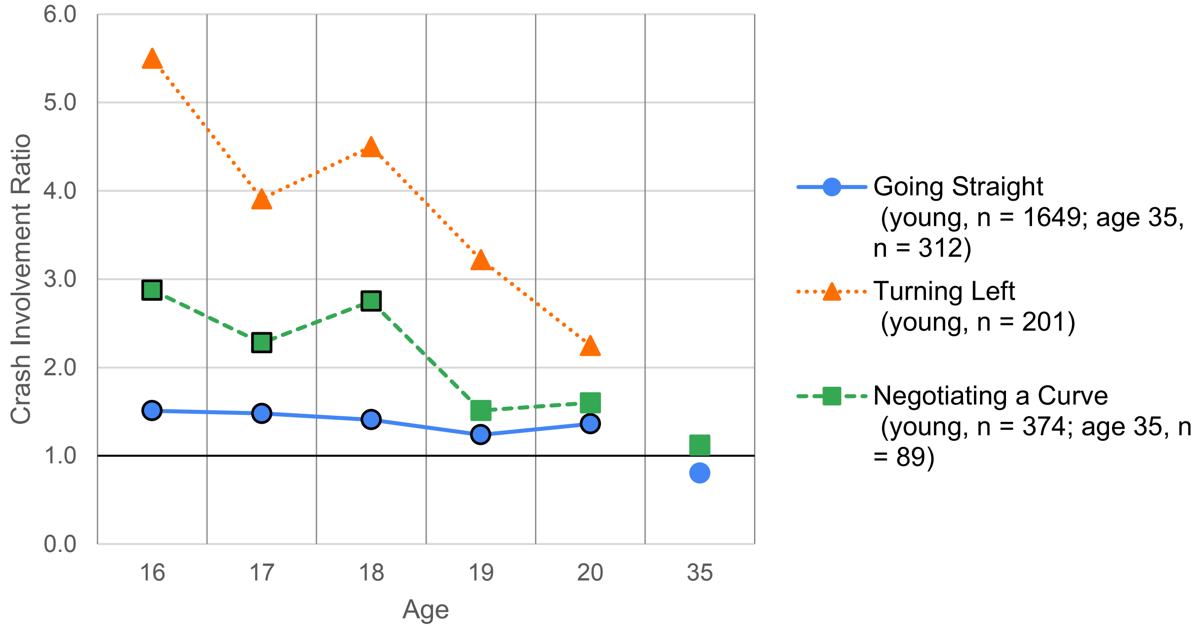

Figure 37. FARS - Crash Involvement Ratio by Pre-Crash Vehicle Maneuver and Driver Age

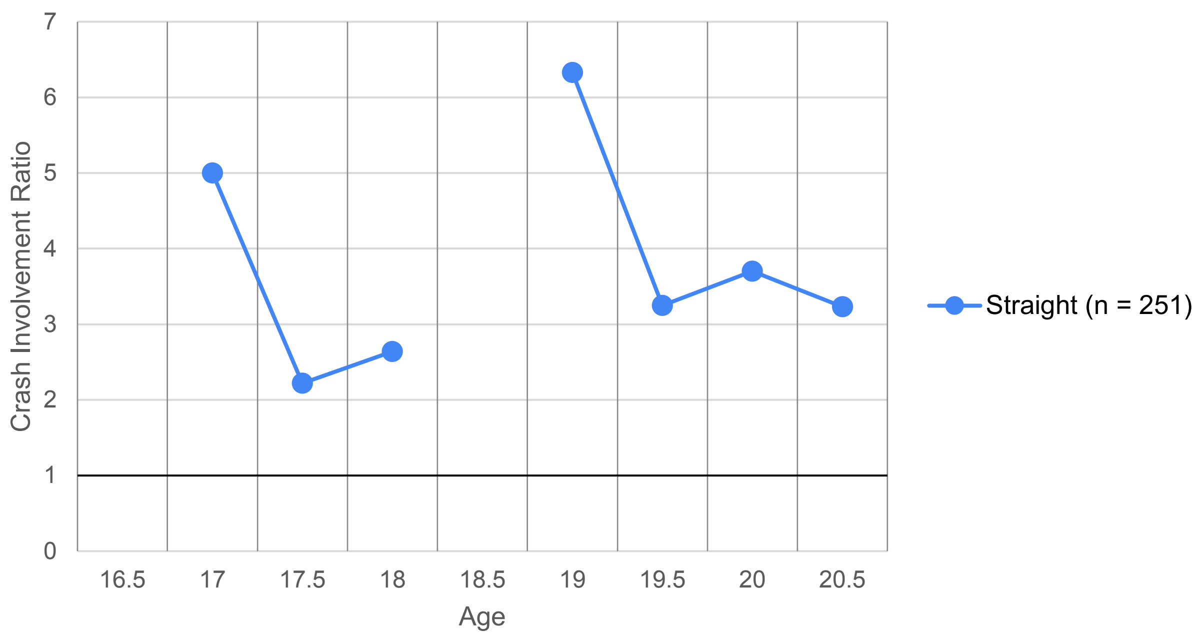

Figure 38. SHRP2 - Crash Involvement Ratio by Vehicle Maneuver at Non-Junction Locations and Driver Age

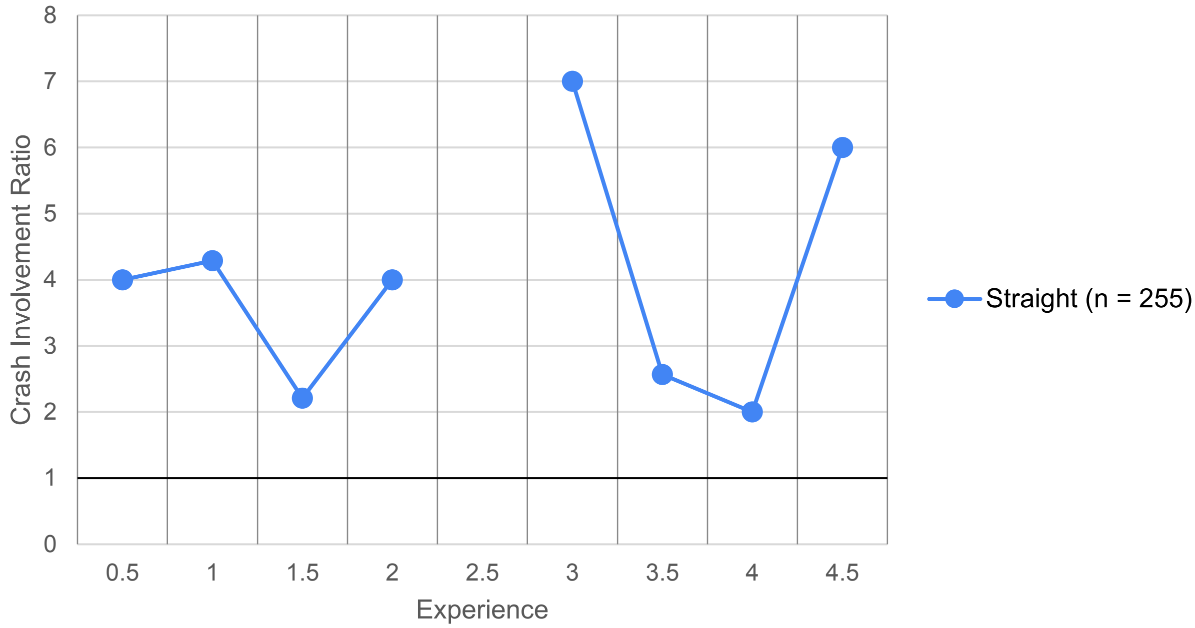

Figure 39. SHRP2 - Crash Involvement Ratio by Vehicle Maneuver at Non-Junction Locations and Years Driving Experience

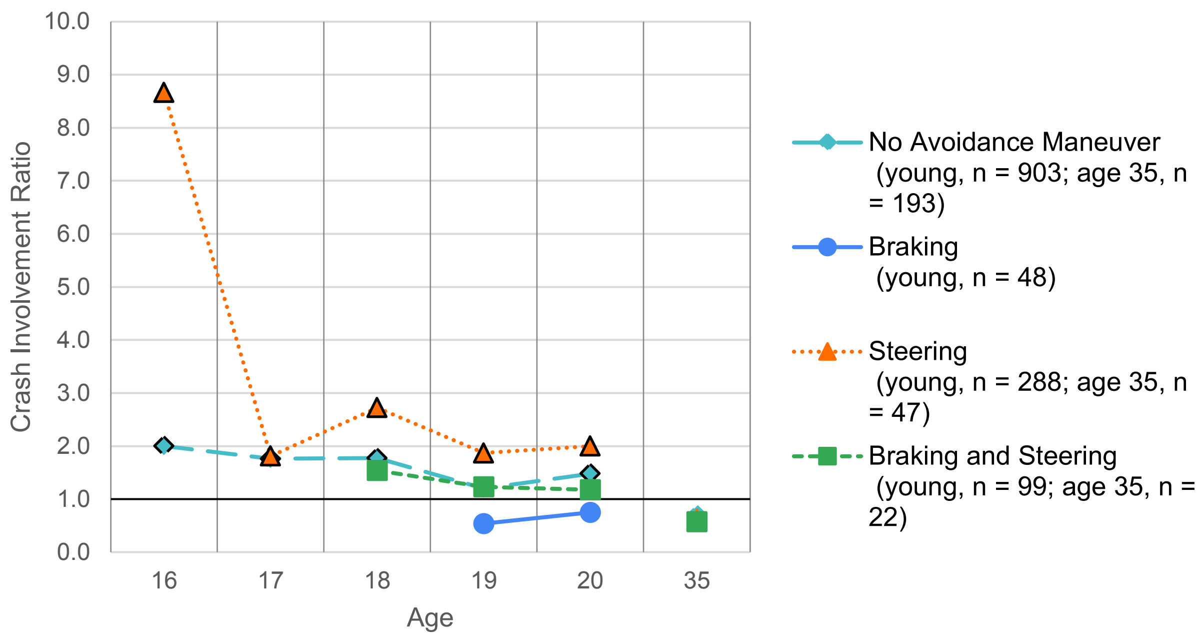

Figure 40. FARS - Crash Involvement Ratio by Pre-Crash Avoidance Maneuver and Driver Age

Driver Age and Experience: A Broad Comparison

Figure 41 shows the broad pattern of likelihood of having a contributing factor in a fatal crash across young driver ages. For fatal (FARS) crashes, young drivers' crash involvement was significantly higher than 35-year-old drivers at each young-driver age. Additionally, young-driver CIR values were numerically higher at younger ages and lower at older ages.

The SHRP2 data uniquely allow for a broad comparison of the relationship of increasing driving experience versus increasing driver age at the time of an event—measured in 6-month intervals—with young drivers' (quasi-induced) exposure-based crash risk. Figure 42 and Figure 43 show the overall differences in CIR trends by age and experience. Unlike the FARS dataset, CIR values derived from SHRP2 do not show a strong visual trend with either increasing age or experience. Additionally, CIR values never fall below the 1.0 threshold for either age or experience.

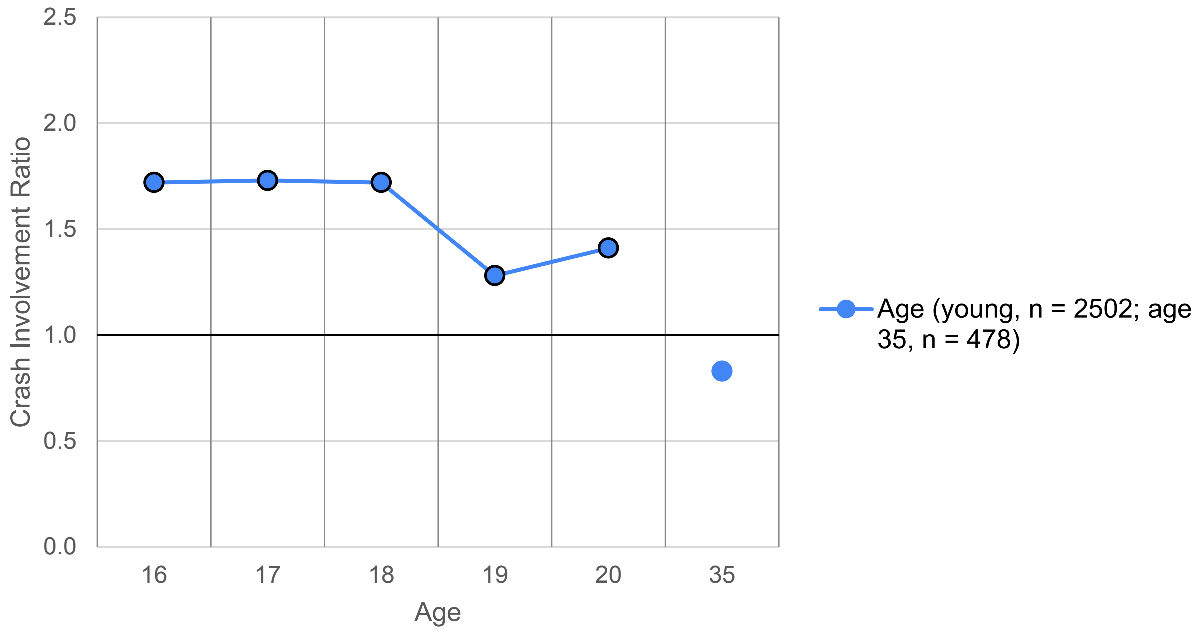

Figure 41. FARS - Crash Involvement Ratio by Driver Age

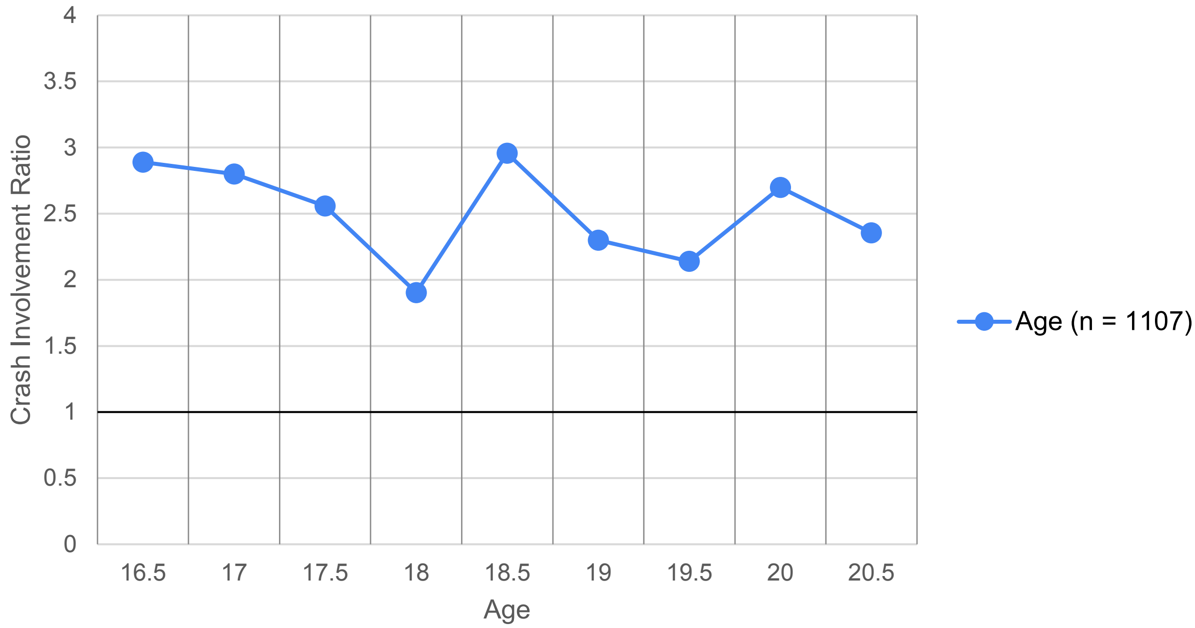

Figure 42. SHRP2 - Crash Involvement Ratio by Driver Age

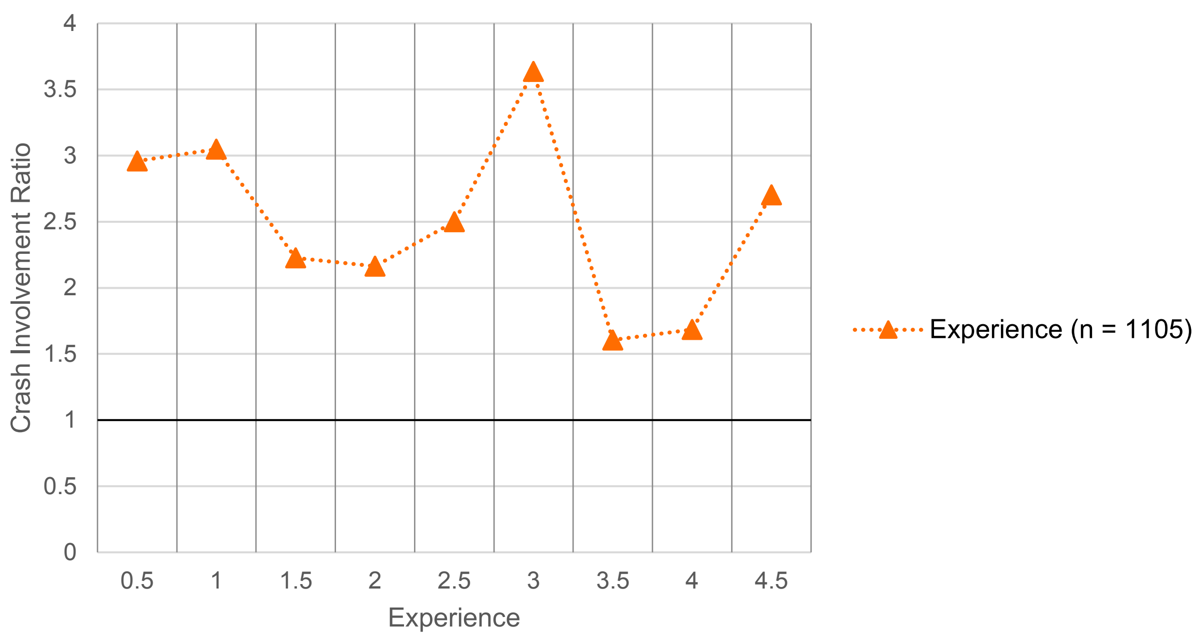

Figure 43. SHRP2 - Crash Involvement Ratio by Years Driving Experience

Discussion and Conclusions

In this study the research team analyzed young-driver crash involvement using FARS and SHRP2 NDS data, investigating risk factors that appeared to hold the greatest potential to inform and guide the future direction of GDL and DE programs in the United States. An exhaustive presentation of all descriptive statistics and test results for significant differences between young driver cohorts and a comparison group of 35-year-old drivers may be accessed in the supplementary report noted in the Introduction.

In brief, CIR analyses for multi-vehicle crashes where only one of the drivers had a contributing factor were calculated using a quasi-induced exposure technique. CIR values for each young driver cohort in one-year increments at ages 16 to 20 years old were compared to a 35-year-old reference group, using logistic regression for the FARS data. The SHRP2 NDS data permitted an additional comparison of trends across age versus amount of early driving experience and applied more focused (6-month) increments of driver age for a similar range of variables. Also, attributions of a driver's "crash contribution" status in the SHRP2 data were made by coders watching video recordings of actual events, while after-the-fact inferences from police reports led to such attributions in the FARS data.

The analyses highlight several broad trends in young driver crash involvement. First, CIRs across many of the factors examined here, particularly those CIRs derived from the FARS dataset, appeared to decline with age. Although the research team did not calculate formal statistical tests for trends in crash involvement with increasing young driver age, the visual pattern of higher CIR values at the youngest ages, and lower CIR values at the oldest ages, was present for most driver, roadway, and environmental characteristics examined, and this pattern was also apparent when examining CIR values overall for the FARS datasets. This result is consistent with a large body of prior research showing that young driver crash risk decreases with age and driving experience (e.g., Curry et al., 2015; see McCartt et al., 2009, for a review). Although the SHRP2 data afforded the possibility of finding different patterns with increasing age versus experience, CIR values derived from the SHRP2 dataset did not exhibit a strong visual change with either age or experience; this result may reflect unique characteristics of the smaller, convenience sample of young drivers who participated in the SHRP2 study.

Second, the current report highlights specific characteristics and situations that may be especially risky for young drivers. Although crash involvement was numerically higher for young drivers engaging in risky or unsafe behaviors (police-reported alcohol involvement and restraint non-use) relative to young drivers *not* engaging in those behaviors, this pattern held true for 35-year-old drivers, and young drivers' overinvolvement was not statistically significantly different from 35-year-old drivers. By contrast, some situations appeared particularly risky for young drivers, relative to 35-year-old drivers and relative to other categories of situations. These situations included multi-vehicle fatal crashes occurring:

- on local/collector and non-interstate/freeway arterial roads;
- on roadways with two lanes;
- at stop signs;
- during the hours of 6 a.m. to 6 p.m. and during daylight; and

- in situations where initial impacts to the right sides of vehicles are common (e.g., misjudging the timing of left turns, running stop signs or stop lights).

Understanding the situations in which young drivers are more likely than adults to have contributing factors in multi-vehicle fatal crashes may be useful for developing driver education course content to familiarize young novice drivers with the unique demands of these situations. For example, driver education courses could include visual search strategies for making left turns safely, or training on skills like hazard perception (e.g., Thomas et al., 2016; see Horswill, 2016, for a review) that may improve novices' awareness of visually occluded stop signs or stop lights. Additionally, parents/guardians and driver education instructors can ensure that novice drivers receive supervised behind-the-wheel training in diverse environments that allow for exposure to risky situations, like local/collector and arterial roads, two-lane roads, and at stop signs. Prior research indicates that teen novices who receive supervised practice in broader ranges of driving environments perform better on on-road driving assessments (Mirman et al., 2014). The scenarios identified in this study as being particularly risky for young drivers may be useful for identifying a diverse set of supervised driving environments for novices.

Finally, although CIR values for many of the analyses presented here visually appeared to decline with increasing age—including CIR values for young drivers, overall (Figure 41)—it was often the case that young drivers even at the older age cohorts (i.e., 19 and 20) remained at statistically significantly greater risk than 35-year-old drivers. Currently, just New Jersey, Indiana, and the District of Columbia apply their jurisdiction's GDL programs, including nighttime and passenger restrictions, to all novice drivers younger than 21 (Curry, Foss, et al., 2017), and many States allow the lifting of restrictions at age 18 (Curry, Foss, et al., 2017; Foss et al., 2014). However, the pattern of greater risk for older young drivers relative to 35-year-old drivers in this study was observed primarily for factors that are not currently the target of GDL restrictions (e.g., number of travel lanes in a roadway, roadway type). Therefore, it is unclear based on the current data whether extending typical GDL restrictions to novice drivers 18 to 20 (e.g., nighttime or passenger restrictions) would reduce older novices' likelihood of having contributing factors in multi-vehicle fatal crashes in these scenarios. Additionally, data from FARS used in this study do not contain information about drivers' amount of driving experience. Therefore, the proportion of drivers 18 to 20 who were novices at the times of their fatal crash involvements is unknown, and non-novices would not be subject to GDL restrictions even if they were extended to novices 18 to 20 years old. An alternative approach to addressing this issue would be to ensure that the youngest novice drivers gain supervised practice and/or receive targeted driver education content for the situations that remain risky for drivers 18 to 20 so that any benefits are sustained as these drivers age.

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