Teens have the highest crash rate of any group in the United States.

Measuring Changes in Teenage Driver Crash Characteristics During the Early Months of Driving

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Brief Summary

Introduction. Several studies throughout the world have documented that novice driver crashes decline sharply during the first 6 to18 months of driving, regardless of the age at which driving begins. It is clear that a substantial amount is learned during this period, but what that is has rarely been studied and remains largely unknown. The present study sought to shed light on how, and perhaps why, young novice driver behaviors change during the first few years by examining month-to-month changes in various crash characteristics, as compared to the overall pattern of declining crash rates.

Method. North Carolina crash data from January 1, 2001 through December 31, 2008 were searched to identify crashes involving any person who had obtained an intermediate license (allowing unsupervised driving) at age 16 or 17 (N = 629,144). All crashes that occurred within the first 36 months after a teen obtained a license (N = 256,975) were included in the analyses. Plots of crash rates per licensed driver for each of the first 36 months of licensing were created, to examine whether certain crash types or characteristics declined more or less quickly. Data were also summarized in several other ways to provide detailed information about how young novice driver crash patterns change during the initial years of driving.

Results. The large majority of crashes involved two vehicles and occurred while the young person was driving a car, on a roadway with a moderate posted speed limit (35 – 54 mph). Crashes occurring when the young driver was making a left turn or entering a roadway from a parking lot or driveway, as well as those in which the young driver's vehicle overturned, ran off the road to the right, or hit a tree, utility pole, or legally parked vehicle declined at a particularly rapid rate. Additionally, crashes in which the young driver failed to yield, overcorrected or made an improper turn declined quickly. Crashes in which the young driver hit, or was hit by, another vehicle from the rear and those in which the novice was following too close declined more slowly than crashes overall.

Discussion. The pattern of rapid decline in several crash types/characteristics strongly suggests these improvements were largely a matter of learning rather than some other process or a combination of processes. The few crash characteristics that declined more slowly over the first few years of driving appear to be partly the result of increased exposure, but they also reflect a tendency of young novices either not to allow sufficient headway or to be unable to react quickly enough when a leading vehicle slows or stops. If learning is involved in the decline of these kinds of incidents, it is offset to some extent by other factors. The appearance of rapid learning about some seemingly straightforward driving maneuvers or situations, among drivers who had been required to drive while supervised for 12 months before beginning to drive on their own, was surprising.

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Conclusions. This study provides an extensive and detailed look at crashes during the first few years of driving during which dramatic improvement occurs. Such analyses are not possible in most jurisdictions, either because the necessary data do not exist or the samples are too small to identify clear month-to-month patterns. The exploratory nature of this study, along with some inherent limitations of crash report data, preclude firm conclusions. Nonetheless, there are some hints for how parents might better assist their teens in learning to drive. The findings also raise some questions that other research approaches – especially naturalistic driving studies – may be able to address more directly than analysis of crash report data.

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Introduction

Teenage driver crash rates are substantially higher than those of more experienced adult drivers, and they are particularly high during the initial year of driving (Williams, 2003). In general, the high crash rate among high school age teens reflects the combined effects of two factors: lack of driving experience and the inclination to impulsive actions that characterize adolescence (Keating, 2007). Although little can be done about the inherent nature of adolescent behavior (Steinberg, 2007), there is hope that beginning drivers can be provided with more and better experience as they begin driving. Doing this effectively should, in principle, lower the crash rate during the first months of driving and increase the rate at which crash risk declines.

There have been two main approaches to improving young driver safety in the U.S. One is to provide, and in many cases require, formal driver education for teenagers prior to licensing. The other is revision of the young driver licensing system to maximize the amount of driving practice obtained under reasonably safe, but real driving conditions during the initial 12 – 24 months of driving (Foss, 2007; Waller, 2003). Both the goals and the value of driver education have been discussed at length and these continue to be argued. Although some poorly designed early studies suggested driver education resulted in reduced crash rates, higher quality studies in the U.S. and throughout the world have shown little or no safety benefit from formal driver education (Nichols, 2003). Even assuming there may be some effects from formal driver education that have simply proved difficult to measure, crash rates among novice teenage drivers remain troublingly high in states where all new drivers are required to pass a driver education class before obtaining a license.

At best, driver education has not been sufficient to bring the crash rates of novice drivers in line with those of more experienced adult drivers. In view of this, beginning in the mid-1990s, a move to alter the young driver licensing process – with the goal of reducing high crash rates among teenage drivers – began in Florida, Michigan and North Carolina. This quickly spread to other states. In 1995, no state had embraced this new approach to licensing; by 1999, 17 had done so. Presently every U.S. state has adopted this approach to licensing young drivers (IIHS, 2011). This effort to ensure that beginning drivers have plenty of time to learn, without simultaneously being exposed to the high risks resulting from their lack of experience-based understanding, is known as graduated driver licensing (GDL). Early studies in Michigan and North Carolina documented substantial crash reductions following implementation of two of the first full GDL systems (Foss et al., 2001; Shope et al., 2001). Since then, at least two dozen studies have documented substantial crash reductions in numerous states after GDL was introduced (Shope, 2007; Shope & Molnar, 2003; Williams & Shults, 2010).

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Two North American studies conducted prior to adoption of GDL showed a pattern of initially high crash rates followed by sharp declines during the first several months of driving (Mayhew et al., 2003; McCartt et al., 2003). Although GDL systems have been highly successful in reducing crashes, novice drivers continue to crash at substantially higher rates than those with a few years of driving experience. Masten & Foss (2010) recently reported that the North Carolina GDL system appears to have reduced the occurrence of a first crash during the initial five years of driving by 10%, with a particularly notable effect during the first few months of driving. Nonetheless, the pattern of high initial crash rates followed by sharp declines during the next several months remained. This pattern is shown in Figure 1, which displays jurisdiction-wide crash rates or counts per month licensed for young drivers in three locations – North Carolina (U.S.), Nova Scotia (Canada) and Victoria (Australia).[1] To facilitate visual comparison, these series were standardized to a range of zero to 1, where 1 is the highest monthly crash rate/count. In all three, crash rates declined by 40% within 18 months. After 36 months crashes were about 60% lower than during the first month. This same general pattern has been reported for somewhat older beginning drivers in European countries as well (OECD, 2006; Vlakveld, 2004).

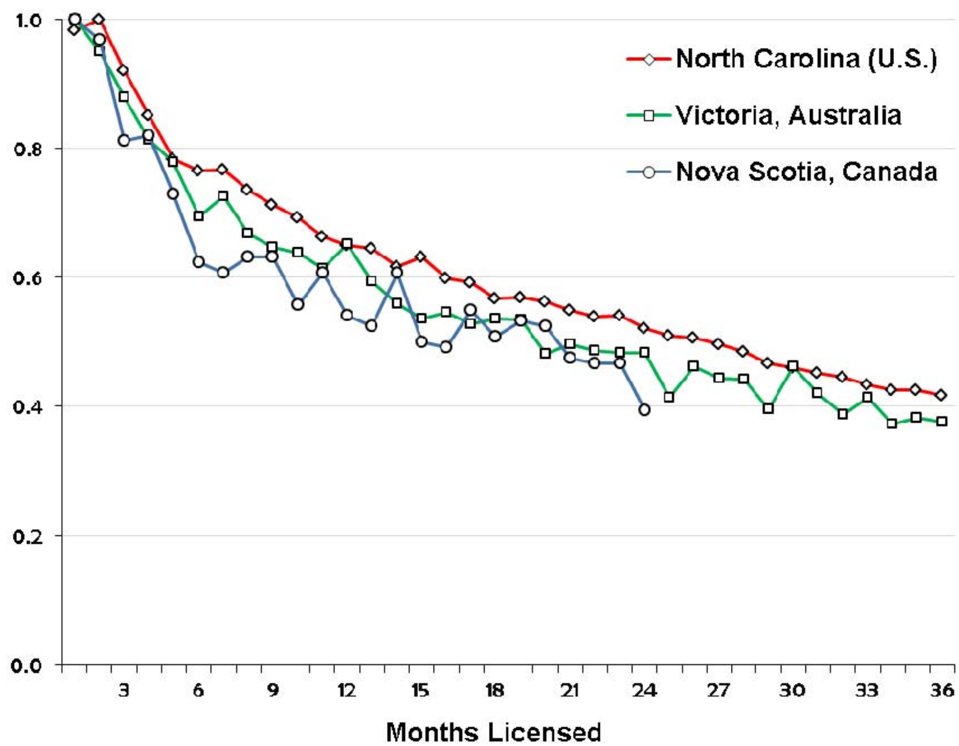

Figure 1. Young driver crashes by months licensed in North Carolina, Nova Scotia and Victoria.

[1] These three series represent somewhat different information. Nova Scotia and North Carolina are rates per licensed driver, whereas Victoria data (from VicRoads, 2005, reported in Lewis-Evans, 2010) are crash counts and reflect only casualty (injury) crashes. North Carolina data reflect drivers licensed under a comprehensive GDL system, whereas the other two do not.

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GDL systems have made good use of the fact that new drivers improve their ability to avoid collisions quickly with experience. Merely by increasing experience, under safe conditions, GDL systems have produced substantial benefits without understanding the mechanisms by which crash rates decline rapidly over time for newly licensed drivers. The fact that this occurs, and that there is little research addressing how or why it does, prompted the Transportation Research Board's Subcommittee on Young Drivers to identify this issue as one of the most critical research questions concerning young drivers (TRB, 2009). Until a better understanding of what changes during the first 18-24 months of driving is developed, traffic safety practitioners will be greatly handicapped in their efforts to develop programs, policies or other interventions to bring young driver crash rates more closely in line with those of experienced adult drivers.

The present study is an attempt to begin developing a sense of the type of learning that occurs among novice drivers by examining whether particular crash characteristics change at differing rates during the first 36 months of unsupervised driving. It is clear that something is learned, and learned fairly quickly, in the initial months of driving. This may simply involve generalized improvement in performance that characterizes the initial period when humans repeatedly engage in any cognitively complex task (Anderson, 1993, 1996). On the other hand, it may be that certain domains of behavior or understanding improve faster than others. For example, basic vehicle handling probably improves more quickly than recognition of potential hazards. The ability to control the impulsive actions common among adolescents that can lead to crashes probably improves even more slowly (Steinberg, 2007). In addition, it is likely that certain kinds of risky driving behaviors increase in frequency during the initial years of licensing. Driving after drinking is the most obvious of these. Alcohol use by teenage drivers involved in fatal crashes is quite low among 16-year-olds, but increases sharply with each additional year of age, reaching a peak at about 22-23 (Subramanian, 2005). Other risky behaviors may also become more common, or caution may decrease, as novices' confidence in their driving abilities develops.

Learning

It is well-established that learning takes the form of a power function (Anderson, 1993). When either the number of errors made or the time to perform a task are plotted over time, the shape of the "learning curve" shows many errors or lengthy task performance times at the beginning. These decline fairly sharply with practice, with the greatest performance gains at the beginning. The difficulty of the task influences the absolute number of errors (or task performance times), as well as the rate of improvement, but the shape of the curve is remarkably similar across a wide range of tasks. The plots of young novice driver crashes per month licensed in North Carolina, Nova Scotia and Victoria, shown above in Figure 1, bear a striking resemblance to the standard learning curve. It turns out that all three of these are fit quite nicely by a power function, of the form: $y = ax^b$

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For:

North Carolina, $y = 1.224\ x^{-0.273}$
Victoria, $y = 1.212\ x^{-0.302}$
Nova Scotia, $y = 1.089\ x^{-0.268}$

Where y = monthly crash rate (or count) and x = months licensed; x = 1, 2, 3, …, 36 for North Carolina and Victoria; for Nova Scotia x = 1, 2, 3, …, 24. The exponent, *b,* represents the rate at which the curve declines and *a* is a constant that describes the overall level or height of the curve. Using a simple formula we can obtain a relatively straightforward interpretation of *b*. In a process described by a power function, as experience (measured here as months licensed) doubles the level (crash rate in this case) declines by $(1 - 2^{b})$. Applying this to the North Carolina data, we see an improvement or "learning" rate (LR) of:

$$LR = (1 - 2^{b}) = 1 - 2^{-0.273} = 1 - .8276 \approx .17$$

Thus the crash rate is approximately 17% lower in the 4th month compared to the 2nd month, 17% lower in the 12th month than in the 6th, and so forth. In Victoria, the improvement is just slightly greater:

$$LR = (1 - 2^{b}) = 1 - 2^{-0.302} = 1 - .8111 \approx .19$$

The close fit of these curves to the data is indicated by R^2 values of 0.94, 0.94 and 0.91 for North Carolina, Victoria and Nova Scotia respectively. The power function described by the equation for Victoria is shown, along with the monthly crash counts, as the dotted line in Figure 2. This provides a visual illustration of how well the estimated crash curve fits Victoria data.

Although the decline in crashes among newly licensed drivers is highly consistent with a learning process, the question remains as to what is learned that brings about this rapid decline in crash rates. It is overly simplistic to assume that only learning is involved in the trajectory of teenage driver crash rates. During this 2- to 3-year period, rapid social, emotional and neurocognitive development occurs among adolescents. Several contextual changes also take place in the lives of many teens during this time period as well. They may begin working full-time or enter post-secondary education. Many begin living separately from parents. All these developments and transitions are accompanied by substantial increases in the overall amount of driving (cf., Ferguson et al., 2007), as well as likely increases in some kinds of risky driving (e.g., more driving late at night, increased prevalence of driving after drinking) and decreases in others (e.g., transporting age-peers as passengers).

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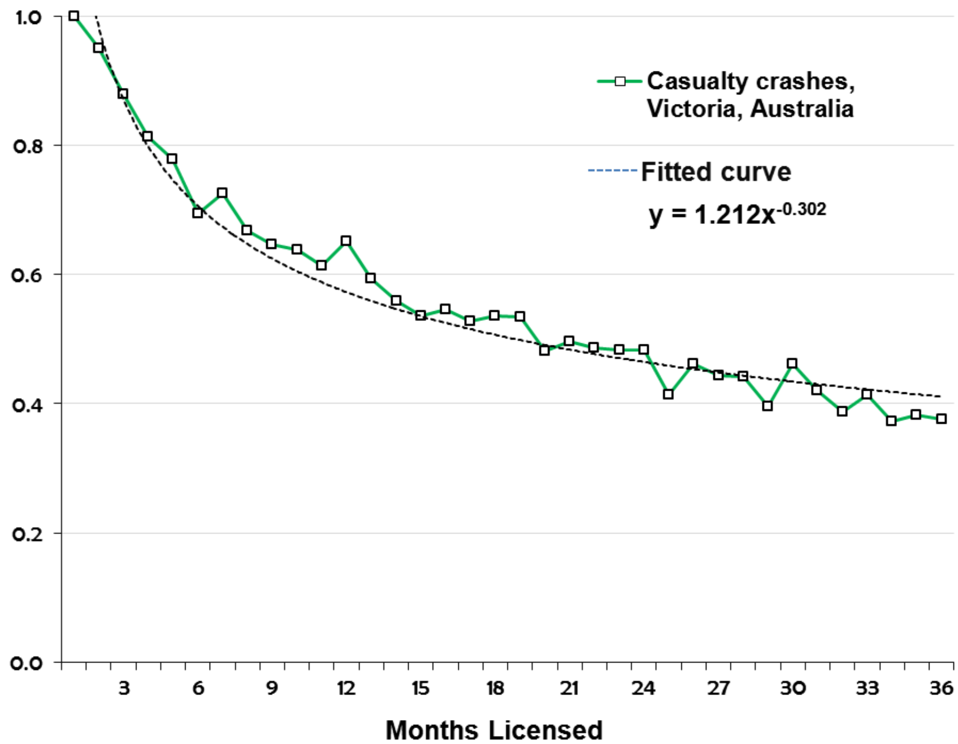

Figure 2. Victoria, Australia casualty crashes by months licensed and fitted power function

The present exploratory study was undertaken to determine whether the trajectories for specific kinds of crashes or crash characteristics differ and, if so, how. Rather than simply comparing crash types by driver age, we have taken a substantially more detailed look at differences in crash characteristics by months licensed. By examining crashes as a function of time licensed (a proxy for driving experience), the effects of age-specific issues are controlled somewhat, though age and experience are closely related. Looking at differences over successive 30-day time periods it should be possible to distinguish changes that occur rapidly from those that occur more slowly. Mayhew et al. (2003) attempted such an analysis with Nova Scotia crash data, but they were unable to examine subcategories because their sample was relatively small. The population of North Carolina is about ten times that of Nova Scotia, providing a great deal more crash data to examine.

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Crash and License Data

The beginning dates for the study period were selected to provide the largest possible inclusion window during which no changes occurred in the licensing or crash data systems that would introduce confounding or inconsistency. The North Carolina crash report form was changed substantially beginning January 1, 2000. This resulted in inconsistencies in the crash data, with numerous variables being defined, coded or interpreted differently than previously. By the end of 2000, most of these inconsistencies had been resolved. Accordingly, we examined crashes beginning January 1, 2001.

To select crashes for study we first identified all individuals who had obtained a North Carolina Limited Provisional (intermediate) License[2] between the ages of 16 and 17 years 364 days, during the period from January 1, 1998 through December 31, 2008 (N = 629,144). The North Carolina crash data file was then searched to identify crashes involving the identified individuals from January 1, 2001 through December 31, 2008. Crashes were selected for analysis if the crash occurred within 36 months of the young driver's intermediate license date.[3] Using this approach, drivers licensed in another state or who had no license were excluded from the analysis.

The identified drivers were involved in 256,975 crashes during the 8-year study period. The intermediate license date, obtained from the driver licensing file, was used to determine how long drivers had been licensed at the time of the crash. In addition we used the driver licensing file to estimate the number of young drivers who had been licensed for each duration of interest (1 month, 2 months, … , 36 months) to compute crash rates per licensed driver. Although the existing number of licenses in any age cohort is generally quite stable across short to moderate time periods, it was necessary to account for the shrinking number of eligible drivers near the end of the window for which crashes were identified (this is commonly referred to as "right censoring"). That is, the aggregate opportunity for members of the group under study to crash declined in the final years, because those licensed after January 1, 2006 were not tracked for a full 36 months and it was necessary to adjust for this.[4]

[2] Although drivers with a first-stage (learner) license do crash on occasion, this is infrequent (Mayhew et al., 2003; Kloeden, 2008, Lewis-Evans, 2010). For practical purposes, meaningful crash exposure while driving begins when the young driver is no longer required to have an adult supervisor in the vehicle.

[3] Crashes involving the identified individuals as motorcycle operators were excluded, as motorcycle operation involves notably different skills as well as additional licensing requirements.

[4] To illustrate, a driver licensed on January 1, 2007 had only spent 24 months driving by the time data collection ended. A person licensed on Dec. 1, 2008 only spent one month driving during the data collection period.

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Analysis

The analyses reported here are largely visual and are exclusively descriptive. This is somewhat of a departure from common practice, but it has long been encouraged as a vital first step toward extracting meaning from data prior to formal hypothesis testing (Tukey, 1977). Hypothesis testing – especially in non-experimental research – has continued to lose favor, with careful inspection of patterns in data and appropriate interpretation of those patterns increasingly recommended (cf., Rothman, 1998; Savitz, 2003).

In brief, exploratory data analysis involves (1) using visual displays and/or numerical summaries of data to (2) describe general patterns and identify noteworthy deviations from general patterns, followed by (3) interpreting the results in context. This was the goal of the present study: to explore a large and relatively unique set of data, with the intent to lay the ground work for future conceptual analysis and, perhaps, formal hypothesis testing. Formal statistical methods to quantify and conduct hypothesis tests on the kinds of issues considered here are available (e.g., survival analysis), but doing so is premature given how little is presently known about the etiology of teenage driver crashes.

The general research question addressed here was specified by the *TRB Subcommittee on Young Drivers*: "Determine what teenage drivers learn that sharply reduces crashes during the initial months of unsupervised driving" (TRB, 2009). By examining whether particular kinds of crashes – or characteristics of crashes – decline more or less rapidly than the overall crash rate during the first 36 months of driving, we sought to obtain some insights into the changing nature of teenage driving over these initial years.

Substantial attention was devoted to creating clearly interpretable charts showing the trend in individual crash characteristics during the initial 36 months of licensed driving. Originally, crashes for those who began driving at 16 were plotted and examined separately from those who began driving at 17, but this proved overly complicated. Reasoning that this was an artificial distinction, and considering that only about 20% of the drivers in the analysis file began driving after they had turned 17, we combined these into a single group for analysis.

Crash report data in North Carolina include 86 separate variables. Some of these describe the environment (e.g., weather, ambient light, roadway characteristics), others identify driver behaviors (e.g., running off road, exceeding the speed limit), and many other circumstances characterizing the crash. The present analyses focused on the crash characteristics considered most likely to shed light on the actions of teenage drivers that result in a crash. These include the descriptions of vehicle movement, the first and most harmful events in the crash sequence and driver actions that appear to have contributed to the crash.

Several interesting crash characteristics could not be meaningfully examined because they were too rare to provide a stable indication of the phenomenon. For example, the ability of novices to handle snowy/icy road conditions is of great interest. However, snow is relatively

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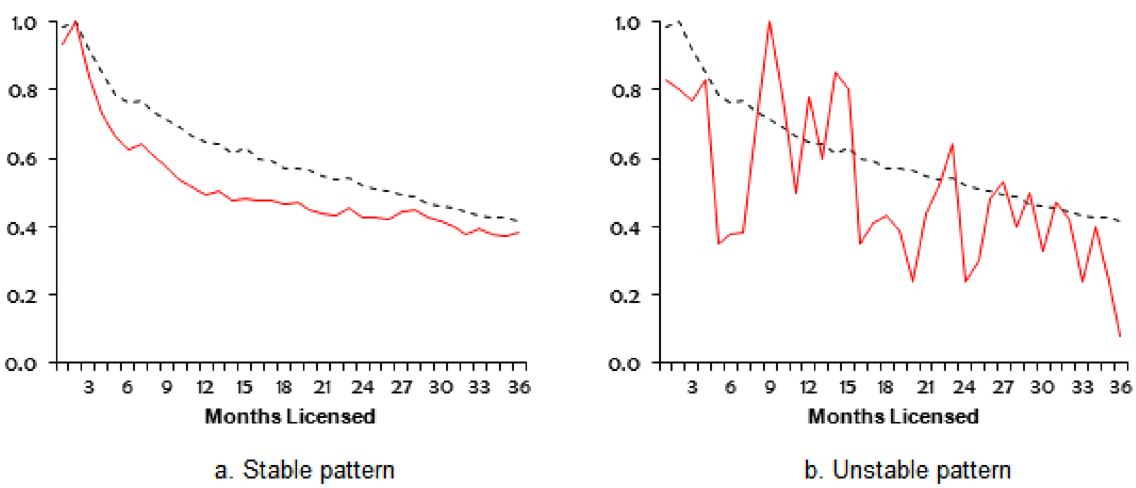
uncommon in North Carolina and many drivers avoid travel when there is snow on the roads. As a result there were not enough crashes in these conditions for the population studied to exhibit a stable pattern over time of crashes on snowy/icy roads.

Figure 3 shows examples of: (1) a crash descriptor with adequate data (panel a) and (2) one with an insufficient number of cases (panel b) to establish a clear month-to-month pattern across the initial 36 months of driving. The dashed line shows the overall crash rate for young novice drivers and the red line shows the rate for a particular crash characteristic. Figure 3.a., on the left, shows a crash type that declines in a relatively stable pattern and more quickly than all crashes. The crash type shown in 3.b. is so erratic that it is difficult to identify a pattern. Although there appears to be a downward trend, the month-to-month variability is so great that no conclusion about the trajectory can safely be drawn. The reason for the wide variation is that this crash characteristic was rare (generally ranging from 5 to 20 crashes per month of the "type" depicted), whereas the crash characteristic shown in 3.a. occurred commonly (with more than 300 cases per month).

Figure 3. Examples of stable and unstable crash patterns across the initial 36 months of licensed driving.



Some further explanation of the figures used to illustrate the crash trajectories is needed. As noted above, each figure shows the overall crash rate per month licensed as a dashed line. The monthly rate for all crashes ranges from a high of 23.2 per 1000 licensed drivers (in the 2^{nd} month post-licensure) to a low of 9.7 per 1000 (in the 36^{th} month) – an overall decrease of 58%. The principal research question of interest here is "Which crash types or characteristics, if any, decrease differently from the overall rate?" This includes the amount as well as the pattern of decline (described here as the trajectory). The amount is useful to know, but the trajectory provides a better indication of how the change comes about and may offer some hint of what underlies the decline (or lack thereof). A sharp initial decline followed by progressively slower improvement suggests learning is at least partly involved.

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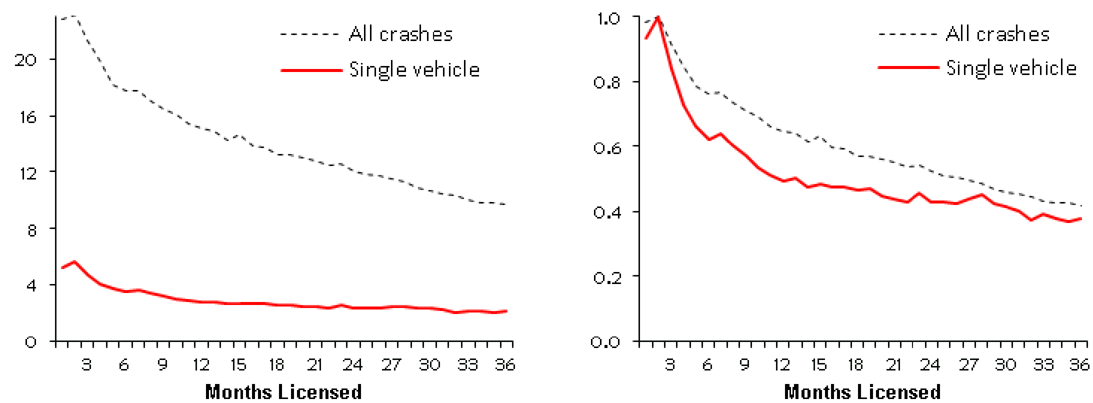
To facilitate visual comparison of the trajectories for specific crash types with one another, and with the overall crash rate, they need to be plotted on a comparable scale. Therefore, the distribution of each crash type/characteristic was standardized, setting its maximum value at 1. Although this standardization allows easy comparison of the trajectories over the first 36 months of driving, conclusions can only be drawn about the *shapes* of these trajectories and the relative amounts by which they change. Because they have been standardized, inferences about the relative *frequencies* represented by the two lines are inappropriate. For all crash types and characteristics, the absolute rates are lower than for crashes as a whole, since each type or characteristic represents a subset of that total. The *value* shown for each plotted crash characteristic in month 36 indicates the extent to which it declined during the initial 3 years of driving. The *shape of the curve* provides a visual indication of the rate at which the crash type declines.



a. Single vehicle vs overall crash rate, unstandardized b. Single vehicle vs overall crash rate, standardized

Figure 4. Illustration of unstandardized and standardized comparison of single vehicle vs. overall crash rates

To illustrate, Figure 4 shows the unstandardized and standardized distribution of single vehicle crashes compared to all crashes among drivers licensed between the ages of 16 and 17 years, 364 days. These figures show 3 years of crash experience for individual drivers. Hence it's incorrect to speak of crashes among an age group, since the first month includes drivers licensed anywhere from 16 through 17 and 364 days; the rightmost point represents drivers ranging in age from 18 years and 364 days to 21 years and 364 days. Henceforth these will be referred to as young novice drivers.

Although the unstandardized rates (Fig. 4.a.) show the relative frequency of all crashes and single vehicle crashes, it is difficult to compare their trajectories or to see the degree to which the less common type (single vehicle) has declined. The standardized rates (Fig. 4.b.) show both of these clearly. Single vehicle crashes decline more quickly in the early months of driving, but the decline levels out after about 12 months, after which these decline at a slower rate. As a result, despite the initial rapid decline, over 36 months single vehicle crashes decline just slightly more than all crashes (62% vs. 58%).

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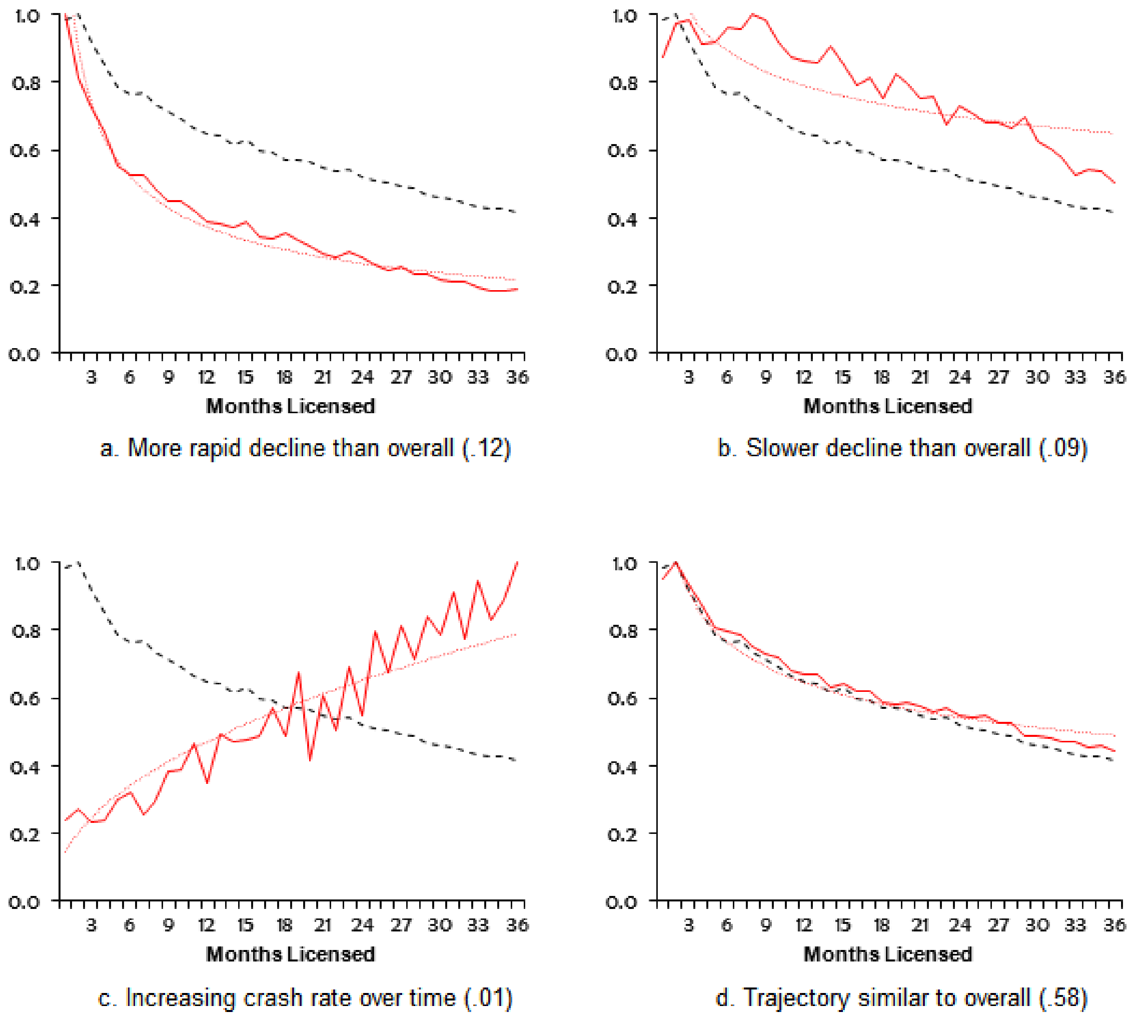

Figure 5. Four crash type trajectories: (a) shows quicker improvement and (b) shows slower improvement than the overall crash decline, (c) shows a crash type that increases with experience and (d) shows a crash type that declines almost identically with the overall crash rate.

Figure 5 shows examples of the different kinds of patterns exhibited by various crash characteristics. Fig. 5.a. shows an example of a characteristic that declines more quickly than crashes in general among young novice drivers. This pattern is consistent with learning, and the steeper the original decline the more quickly the ability to make pertinent judgments and engage in appropriate behaviors seem to have been learned. Fig. 5.b. shows a case where a particular crash characteristic declines less quickly than crashes overall. This pattern does not reflect a simple case of learning. Here the beneficial effects of learning may be attenuated by increased exposure or changes in driving demeanor, such as a decrease in caution, as new drivers gain experience and become more comfortable. Fig. 5.c. shows a pattern where a certain type of crash actually becomes more common with greater experience. These are rare and appear to represent crash types where increased exposure

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completely overwhelms any benefits of learning. The fourth general pattern, shown in Fig. 5.d., is where a particular type of crash declines on essentially the same trajectory as crashes overall, with the trajectory for the particular crash type closely tracking that of the overall crash rate curve.

The smoothness of the plotted lines generally provides a visual marker for the incidence of each crash characteristic. A more jagged line indicates a relatively uncommon characteristic, whereas a smooth line indicates a more common occurrence. In a convention to be followed throughout this report, the relative frequency (proportion) of the particular crash type/characteristic is shown in parentheses following the description at the bottom of each chart panel. For example, the crash characteristic shown in Fig. 5.a. occurred in 12% of all crashes, whereas the characteristic shown in Fig 5.c. was much less common, occurring representing just 1% of all crashes during the first 36 months of driving in this age group.

To provide some quantitative description of the charted crash characteristics, an equation of the form $y = ax^{b}$ was fit to each series.[5] The resulting fitted curve is included in each figure. Examples of fitted curves – the smooth red light (dotted) lines – are provided for the four general trajectories shown in Figure 5. Throughout the results section below, figures are followed by a table showing several quantitative descriptions of the crash characteristics being considered.

[5] Fit was assessed using a least-squares criterion, minimizing the sum of the squared deviations of the line from the individual data points.

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Description of the sample studied

Table 1 provides basic descriptive features of the drivers, vehicles and crash settings included in the data examined. This highlights the fact that although the studied drivers were 16 or 17 years old when they were licensed to begin driving without supervision, they were tracked for up to 36 full months. Consequently, 40% of these crashes involved a driver who was age 18 or older at the time of the crash. Seventy percent were driving a passenger car

Table 1. Young driver age, vehicle type, number of vehicles involved and speed limit at location of crash for study sample (N = 256,975).

Category	Count	%
Age at time of crash		
16	67,704	26.3
17	87,877	34.2
18	72,510	28.2
19	24,789	9.6
20	4,083	1.6
Total	256,963	
Vehicle type		
Passenger car	179,524	69.9
SUV	37,257	14.5
Pickup	32,867	12.8
Light Truck/Van/Minivan	5,635	2.2
Motorcycle	594	0.2
Other	1,081	0.4
Total	256,958	
Vehicles involved		
One	52,369	20.4
Two	176,431	68.7
Three	22,743	8.9
Four or more	5,406	2.1
Total	256,949	
Posted Speed limit (mph)		
<20	8,195	3.5
20-34	14,322	6.1
35-44	73,146	30.9
45-54	81,198	34.4
55-64	53,375	22.6
65+	6,141	2.6
Total	236,377	

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and nearly all the rest were driving a pickup or SUV. Only a small proportion of crashes occurred on either low or high speed roads, with the vast majority occurring at locations where the posted speed limit was between 35 and 64 mph. Finally, one fifth of these crashes involved only the young driver's vehicle (compared to 33% of crashes for all North Carolina drivers), whereas 11% involved 3 or more vehicles. The latter is an unusually high proportion of multiple vehicle collisions. Typically about 6% of crashes in North Carolina involve more than two vehicles.

Some crash types have been documented as characterizing either "teens" or "novice drivers." Speeding/driving too fast for conditions, failure to yield, poor gap selection on left turns across traffic, following too closely/late braking, and failure to scan (or at least to recognize potential problems) are widely cited as typical young driver errors (Braitman et al., 2008; McKnight & McKnight, 2003; Williams, Preusser & Ferguson, 1998). An important question is whether these are more a matter of youthfulness or of inexperience. If these decline quickly, it seems reasonable to conclude they are more experience-related than the result of conditions endemic to adolescence. On the other hand, if they decline slowly, or not at all, then they can probably more accurately be described as age- or development-related. The next section examines how the rates of various crash characteristics/types change during the initial 3 years of driving.

Crash rate trajectories

Movement of young driver's vehicle

Figure 6 shows the monthly rates, per licensed driver, of the eight most common types of crashes as described by the young driver's vehicle movement. These account for more than 95% of all crashes examined. There are 16 possible codes for vehicle movement; Appendix A provides a full list of all possible categories for each of the crash characteristics examined. Crashes that involved the vehicle going straight ahead (Fig. 6.a.) account for nearly 60% of all crashes studied (see Table 2 below). Because these constitute a majority of all crashes, they declined almost identically with crashes overall. Crashes in which the young driver was turning left (Fig. 6.b.) declined more quickly over time, as did those that occurred when making a right turn or entering a roadway (typically from a driveway or parking lot). This suggests a relatively rapid improvement in the ability to handle the mechanics and judgment involved in making turns in traffic as well as the judgmental complexities involved in entering a busy roadway.

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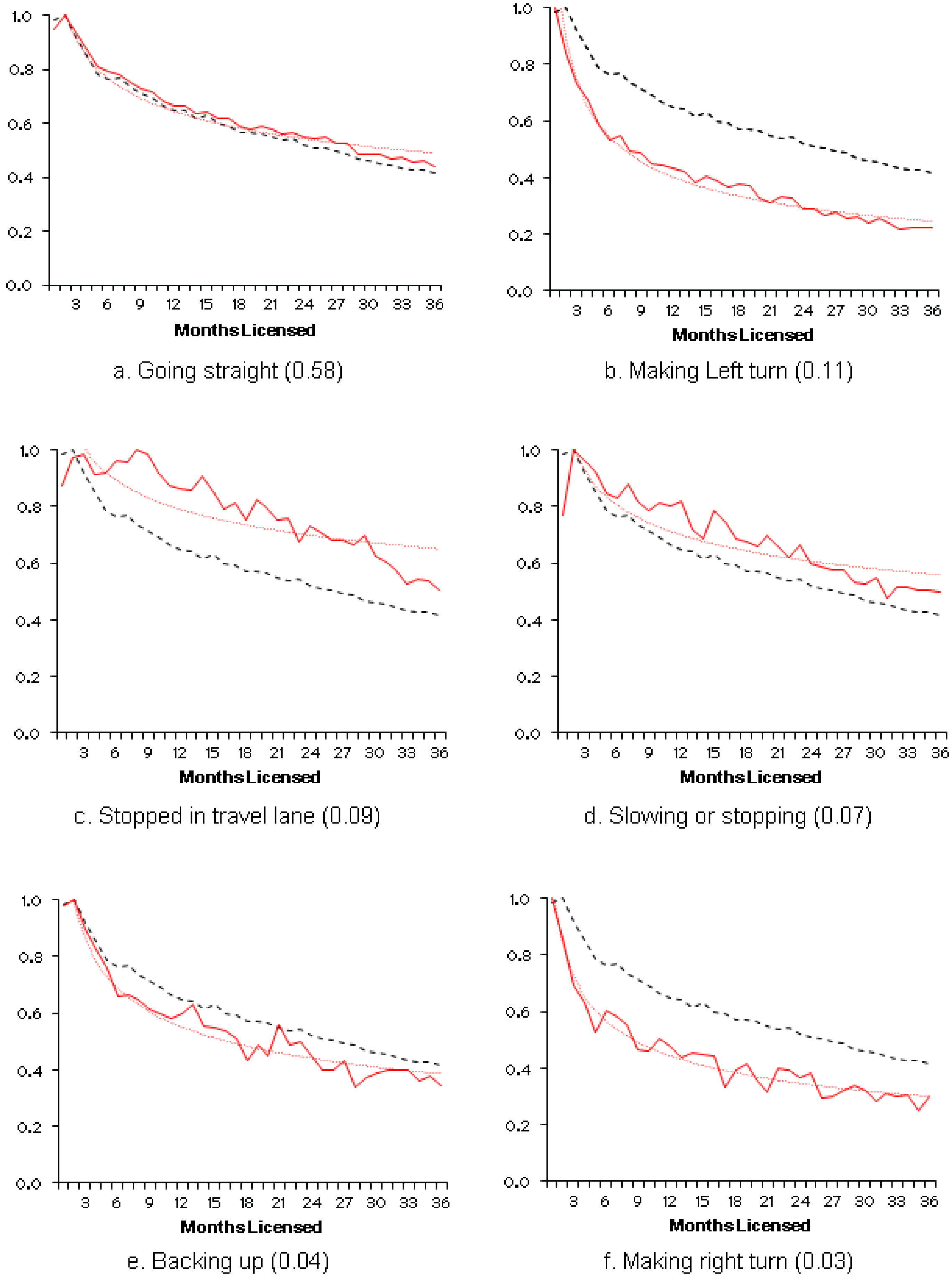

Figure 6. Young driver's vehicle movement at time of crash

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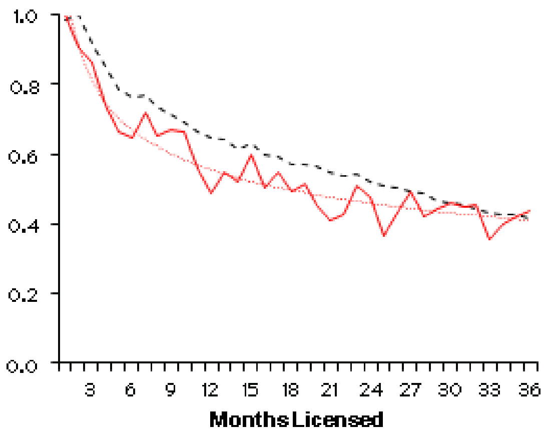
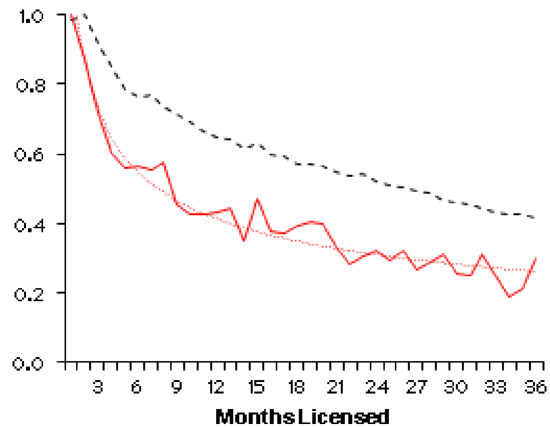


g. Changing lanes (0.03)



h. Starting in road (0.02)

Figure 6 (continued)**.** Young driver's vehicle movement at time of crash

Crashes that occurred when the young driver's vehicle was slowing or stopping (Fig. 6.d.), and especially those that occurred when the vehicle was stopped (e.g., at a stoplight or stop sign, Fig. 6.c.), declined at a substantially slower rate than crashes overall. These do not exhibit a learning pattern, as exhibited by the poor fit of a power curve to their trajectories. The rate of collisions while stopped actually increases slightly during the first 9-10 months, then declines linearly for the next two years. Involvement in a crash when one is stopped generally indicates an error on the part of another driver, though on occasion the stopped vehicle's driver may have stopped too abruptly, at an inappropriate time or unexpected location, creating a hazard for other drivers. One likely reason this kind of crash declines more slowly is because of the increased exposure (greater amount of driving) of young drivers as they age. Data from the *2001-02 National Household Transportation Survey* indicated that 17-, 18- and 19-year-olds respectively drove 37%, 77% and 117% more than 16-year-olds (Ferguson, Teoh & McCartt, 2007).

Table 2 contains several quantitative measures of the crash characteristics shown visually in Figure 6. These provide additional information about the characteristics and help place them in a broader context. The first three columns show the proportion of young driver crashes involving each characteristic during the first 36 months of licensure, along with the proportions during the 1st and 36th month individually. These provide a sense of the prevalence of a particular crash characteristic among young drivers generally and specifically in the first month of driving and three years later. For example, during their first three years of driving, 58% of crashes occur when the young driver's vehicle is going straight ahead, whereas 11% occur while making a left turn. Compared to the entire 36-month period, a somewhat smaller proportion of crashes that occur in the first month of driving involve going straight (54%) and more involve a left turn (17%). By the 36th month, left turns account for only 9% of crashes. Percentage distributions can be misleading, however, as the value for one characteristic depends in part on the others (e.g., if left turn crashes decrease to zero,

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the proportion involving other vehicle movements have to increase because percentages always sum to 100%). In the present case, rates are easier to interpret than percentages and provide a more direct indication of novice driver improvement over time.

Table 2. Movement of young driver's vehicle in crashes – percentage distributions during the entire 36-month period, 1st month, 36th month; rates in 1st and 36th month; and characteristics of the best-fitting power function to the standardized 36-month crash rate trajectory.

	Percent of all crashes			Rate per 1000 licensed drivers		Model parameters		
	36 mo.	1st mo.	36th mo.	1st mo.	36th mo.	*b*	R^2	LR
Going straight	58.0%	54.1%	59.2%	12.33	5.72	– 0.249	0.93	0.16
Making left turn	**11.0%**	**17.0%**	**9.0%**	**3.88**	**0.87**	**– 0.448**	**0.96**	**0.27**
Stopped in travel lane	8.6%	6.0%	8.2%	1.37	0.79	– 0.178	0.60	0.12
Slowing or stopping	7.1%	4.9%	7.6%	1.12	0.73	– 0.205	0.71	0.13
Backing	3.7%	4.1%	3.4%	0.94	0.33	– 0.324	0.91	0.20
Making right turn	**2.9%**	**4.1%**	**2.8%**	**0.93**	**0.28**	**– 0.356**	**0.93**	**0.22**
Changing lanes	2.5%	2.8%	2.9%	0.65	0.28	– 0.275	0.88	0.17
Entering roadway	**1.8%**	**2.7%**	**1.9%**	**0.61**	**0.18**	**– 0.413**	**0.90**	**0.25**
All crashes	---	---	---	22.79	9.66	– 0.273	0.94	0.17

Note. *b* is the exponent of the power function that best fits the data. R^2 is a measure of how well a power function fits the plot of the crash characteristic during the first 36 months of driving. LR is derived from the best-fitting power function and indicates the amount by which the crash rate declines as experience doubles. Crash types that exhibit notably different trajectories from overall crashes (based on $|\text{LR}| \geq .21$, if $R^2 \geq 0.90$) are shown in bold type (see footnote 6).

The table shows the rate for each crash characteristic per 1000 licensed drivers during the 1st and 36th month. Crashes involving most all types of vehicle movement decreased during the initial 36 month driving period studied and this can be seen in the table by comparing the 1st and 36th month rates. The clearest indication of the overall changing role of a particular characteristic of young driver crashes is obtained by considering the rates in the table along with the visual depiction in the figure. As noted above, the figures obscure the actual incidence of crash characteristics because they are standardized, but the actual 1st and 36th month rates provide information about how commonly the various characteristics are found in young driver crashes. For example, the pattern of change for left turns (Fig. 6.b.) and entering a roadway (Fig. 6.h.) are highly similar, but collisions involving a left turn are much more common (3.88 vs. 0.61 per 1000 licensed drivers in the first month).

The table also shows parameters of the fitted equation, providing quantitative information to further describe the patterns depicted visually in the figures. These parameters are the exponent of the fitted power curve (*b*) which indicates the rate of change in the crash rate, the R^2 indicating how well a power function fits the data and a clearly interpretable measure of the learning rate (LR), calculated using the formula LR = $1 - 2^b$. To illustrate, it is clear in Fig. 6.c. that the plotted power curve does not fit the trajectory for crashes where the young driver's vehicle was stopped in the travel lane. This poor fit is indicated by the relatively low

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$R^2 = 0.60$, shown in the table. By comparison, the plotted curve in Fig. 6.b., which shows crashes that occurred when the young driver was turning left, fits the crash pattern quite well. This is indicated by the R^2 of 0.96. An $R^2 \geq 0.90$ was considered to indicate a good fit of a power (learning) curve to the crash trajectory. When the trajectory is described accurately by the fitted curve, the learning rate (LR) calculated from the exponent of the equation can be clearly interpreted. For characteristics with R^2 values below 0.90, the LR is not a particularly good indicator of the rate at which a crash characteristic declines. In this case, the meaning of *b* and LR are unclear.

The rapid initial decline in the crashes involving a left turn is described by the *b* of -0.448, which indicates a learning rate (LR) of $(1 - 2^{-.448}) = 0.27$. As mentioned previously, the LR is the amount by which the rate for this crash characteristic declines with a doubling of experience. Thus, the rate of left turn crashes is approximately 27% lower in the 4th month than in the 2nd month, 27% lower in the 24th month than the 12th month, and so forth. In contrast, crashes in which the young driver's vehicle was going straight also decline as a power function of months licensed ($R^2 = 0.93$), but the learning rate (0.16) is much slower.

The figures show clearly whether a crash characteristic declines notably faster than overall crashes. In the table this is signified by the difference between the LR for each characteristic and for crashes overall. Information for notably different trajectories, those where $| LR | \geq 0.21$, is highlighted in bold.[6] Overall, three crash types (defined by vehicle movement) declined particularly rapidly among young drivers: making a left turn, making a right turn, and entering the roadway. All three have LR values of 0.22 or higher (compared to a LR of 0.17 for all crashes). These three crash types account for about 16% of crashes during the first 36 months of driving by young novices.

First harmful event in the crash

Figure 7 shows the crash rate trajectories for the 15 most commonly occurring first harmful events in a crash.[7] Although there are 32 possible codes (see Appendix A), these 15 account for more than 95% of crashes studied. Five crash characteristics exhibit a notably more rapid decline than crashes overall: Rollovers (Fig. 7.k.), running off the road to the right (Fig. 7.h.), colliding with another vehicle on an intersecting road while making a left (Fig. 7.d.) or right turn (Fig. 7.n.) and hitting a fixed object or parked vehicle (Fig. 7.c.). The trajectory of right turn collisions does not fit the power learning curve nearly so well as the other crash types ($R^2 = 0.86$, whereas the others have R^2s ≥ 0.91; see Table 3). This poorer fit is due largely to the relative instability of the right turn crash pattern, resulting from the smaller number of such crashes.

---

[6] LR of 0.21 was selected, somewhat arbitrarily, because it reflects approximately a 25% more rapid change than the rate for LR of 0.17 for crashes overall: $(0.21 - 0.17)/0.17 = 0.235$. Because the meaning of LR is unclear if the data don't fit a power curve, for characteristics with $R^2 < .90$, a 36th month rate ≤ 25% of the 1st month rate was considered a noteworthy decline.

[7] This measure characterizes the crash and not necessarily the young driver specifically.

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The most common first harmful event, a rear-end collision (Fig. 7.a.), declines at a slower rate than crashes overall. In a somewhat unique pattern this increases during the first two months, before beginning to decline in a generally linear pattern thereafter. This type of collision may have been the fault of either driver in the crash, so the failure of this to exhibit a learning pattern is not surprising. This example highlights the difficulty of interpreting the meaning of certain crash characteristics, many of which may reflect behaviors of any involved driver, not merely the young driver.

There is a small but notable deviation from the downward trajectory of all crashes in the 7^{th} month. This coincides with the end of the intermediate license stage. After the first 6 months of licensure to drive unsupervised, driving after 9 pm is allowed and there is no longer a limit on the number of young passengers a driver is allowed to transport. Several specific crash characteristics exhibit a similar deviation to the overall crash pattern in the 7^{th} month. The trajectories for angle collisions, hitting a fixed object, collisions with vehicles on an intersecting road while making a left turn and running off the road to the right (Figs. 7.b., 7.c., 7.d., 7.h.) all deviate in a manner similar to that of all crashes at the end of the 6-month intermediate license period. Rollover crashes (Fig. 7.k.) may also fit this pattern, although their trajectory is not particularly stable after 7 months and the “bump” at about 6-7 months may simply be the beginning of this fluctuation.

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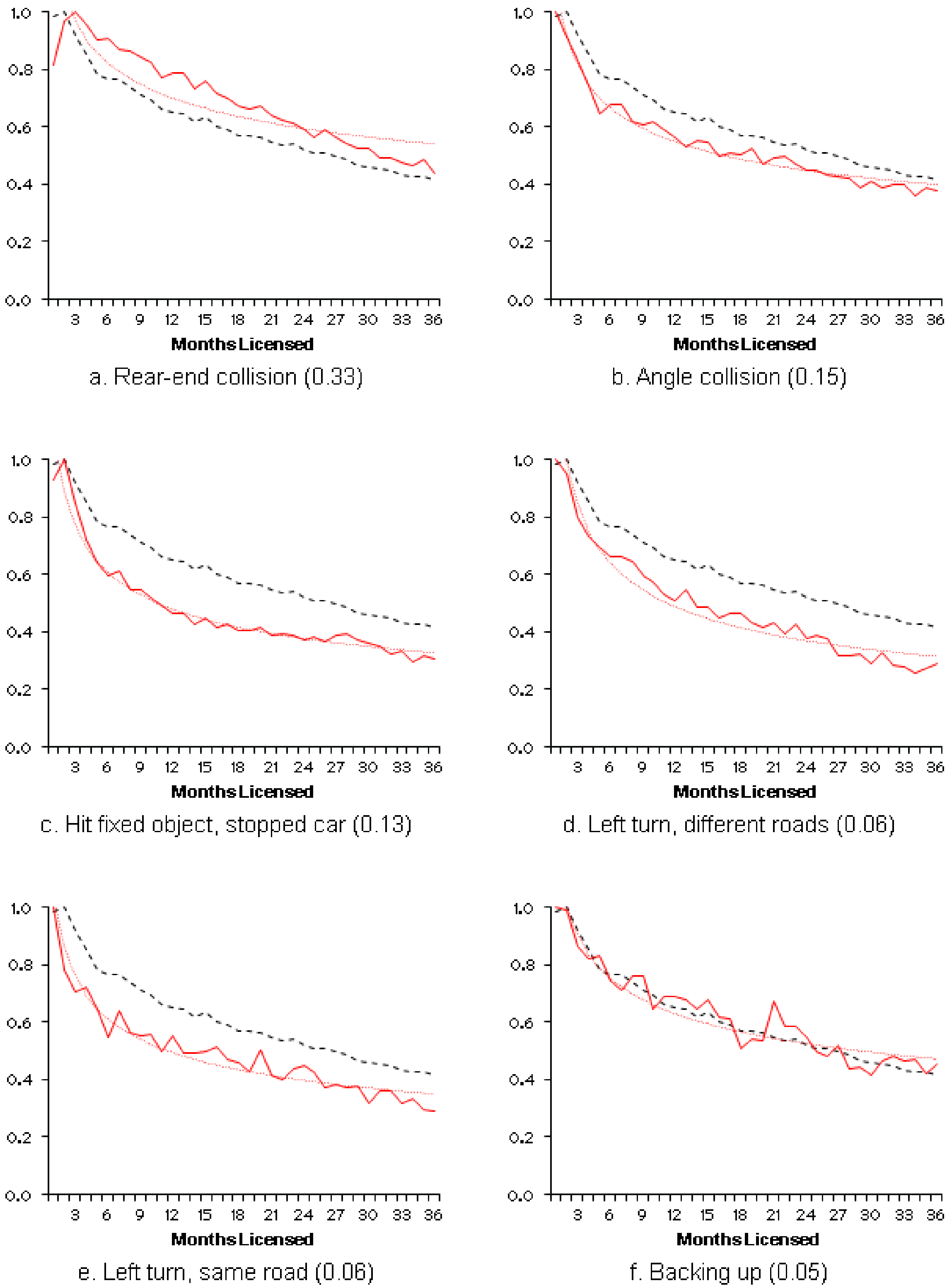

Figure 7. First harmful event for young driver’s vehicle

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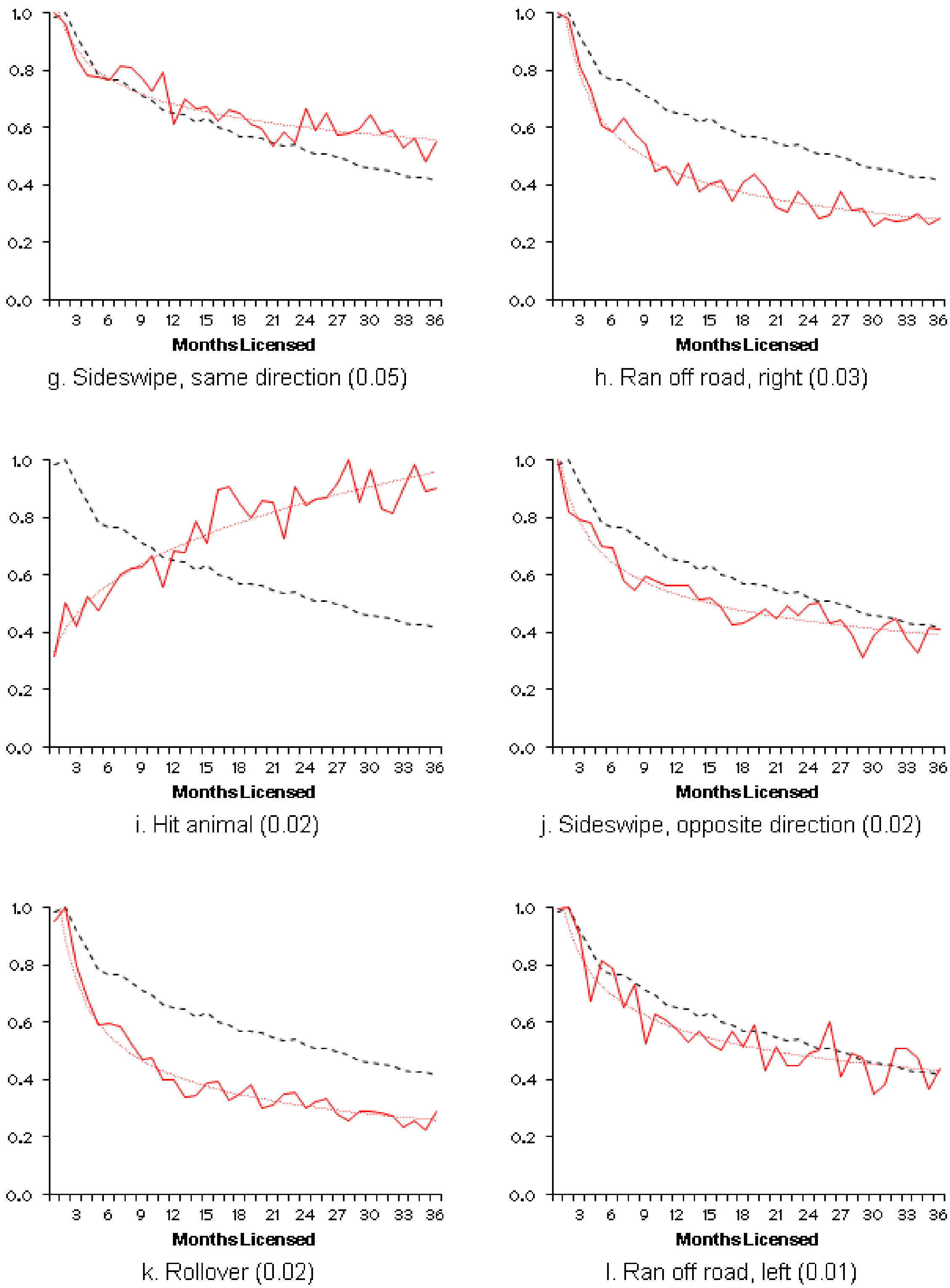

Figure 7 (continued)**.** First harmful event for young driver's vehicle

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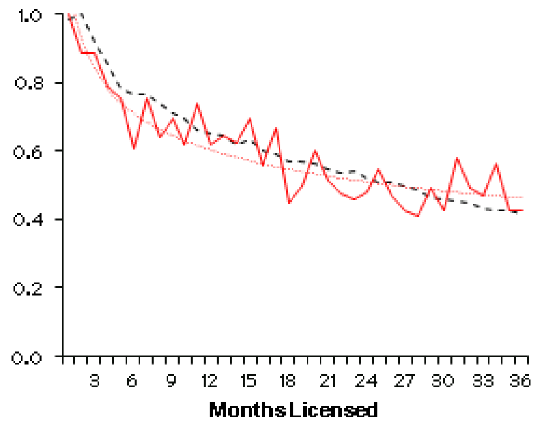
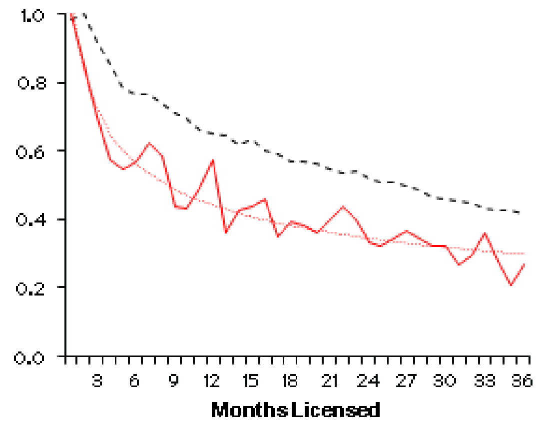
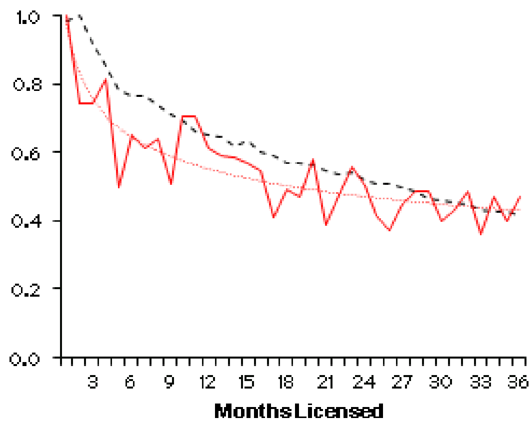


m. Head-on collision (0.01)



n. Right turn, different roads (0.01)



o. Right turn, same road (0.01)

Figure 7 (continued)**.** First harmful event for young driver's vehicle

Most other crash types, when categorized by the first harmful event, decline at rates similar to overall crash rates. There is one notable exception: collisions with an animal increase fairly sharply during the first 36 months, from 0.14 per 1000 licensed drivers during the first month of unsupervised driving to a (still quite low) rate of 0.40. The most likely explanation for this pattern is increased exposure. Young drivers appear to drive increasing at times and locations where deer collisions are more likely.

The pattern in crashes where a rear-end collision was the first harmful event provides an example of how examining percentages can be misleading. The percent of young driver crashes of this type is greater in 36th month than in the 1st month (32% vs. 25%). However, despite the apparent indication that this crash type becomes more common, it does not. It merely becomes *relatively* more common at 36 months, among a dramatically lower number of crashes. The *rate* of this kind of crash declines substantially from the 1st to 36th month

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(from 5.72 to 3.11 per 1000 licensed drivers). Percentage distributions can provide useful information about young driver crashes, identifying the main contributors to the overall crash problem at a given point in time for a particular age group, but they must be interpreted with caution.

Table 3. First harmful event in young driver crashes – percentage distributions during the entire 36-month period, 1st month, 36th month; rates in 1st and 36th month; and characteristics of the best-fitting power function to the standardized 36-month crash rate trajectory.

	Percent of all crashes			Rate per 1000 licensed drivers		Model parameters		
	36 mo.	1st mo.	36th mo.	1st mo.	36th mo.	*b*	R^2	LR
Rear-end, slowing/stopped	33.2%	24.3%	30.9%	5.54	3.09	– 0.235	0.74	0.15
Angle collision	15.1%	17.4%	15.6%	3.98	1.51	– 0.288	0.96	0.18
Hit fixed object/parked car	**13.1%**	**16.1%**	**12.4%**	**3.66**	**1.20**	**– 0.346**	**0.96**	**0.21**
Left turn, different roads	**5.9%**	**7.6%**	**5.2%**	**1.73**	**0.50**	**– 0.399**	**0.91**	**0.24**
Left turn, same road	5.7%	7.2%	5.0%	1.65	0.48	– 0.313	0.91	0.20
Backing	4.8%	4.8%	5.2%	1.10	0.50	– 0.261	0.86	0.17
Sideswipe, same direction	4.5%	4.2%	5.4%	0.95	0.52	– 0.181	0.84	0.12
Ran off road, right	**3.0%**	**4.2%**	**2.8%**	**0.95**	**0.27**	**– 0.412**	**0.93**	**0.25**
Hit animal	***2.4%***	***0.6%***	***4.2%***	***0.14***	***0.40***	***+ 0.293***	***0.89***	***– 0.23***
Sideswipe, opposite dir.	1.7%	2.0%	1.9%	0.46	0.19	– 0.278	0.88	0.18
Rollover	**1.7%**	**2.4%**	**1.7%**	**0.55**	**0.17**	**– 0.427**	**0.94**	**0.26**
Ran off road, left	1.4%	1.5%	1.6%	0.35	0.15	– 0.267	0.81	0.17
Head-on collision	1.3%	1.3%	1.3%	0.30	0.13	– 0.241	0.78	0.15
Right turn, different roads	1.1%	1.6%	1.0%	0.37	0.10	– 0.356	0.86	0.22
Right turn, same road	0.9%	1.1%	1.2%	0.25	0.12	– 0.228	0.70	0.15
All crashes	---	---	---	22.79	9.66	– 0.273	0.94	0.17

Note. *b* is the exponent of the power function that best fits the data. R^2 is a measure of how well a power function fits the plot of the crash characteristic during the first 36 months of driving. LR is derived from the best-fitting power function and indicates the amount by which the crash rate declines as experience doubles. Crash types that exhibit notably different trajectories from overall crashes (based on $|\text{LR}| \geq 0.21$, if $R^2 \geq 0.90$) are shown in bold type. Italics indicate an increasing rather than decreasing rate over time.

Most harmful event for young driver's vehicle

The first harmful event and the most harmful event in a crash are often the same, but in some cases more harm results after the initial event in the crash. For example, running off the road often precedes a rollover crash and in such a case, the latter is typically more harmful. Moreover, information describing the first harmful event in the crash sequence does not necessarily clearly describe the young driver's involvement. It characterizes the crash (in the crashes examined here, 80% involved at least one other driver). The information shown in Figure 8 below, describing the *most harmful* crash event, is specific to the young driver's vehicle. Accordingly, it provides a somewhat more direct indication of the young driver's involvement in the crash, though it does not necessarily indicate fault of the young driver.

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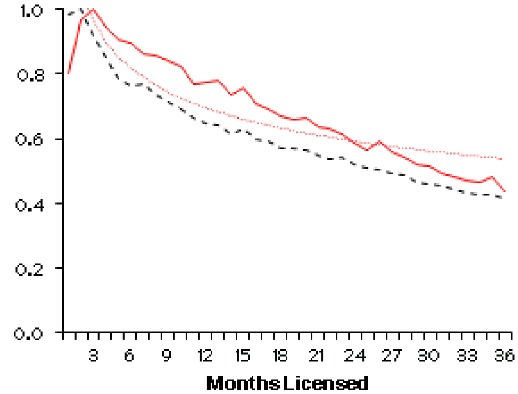
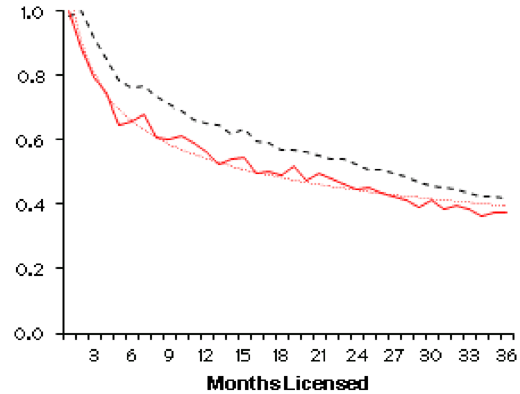
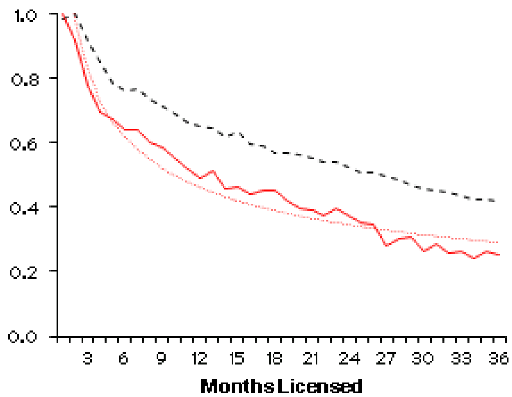


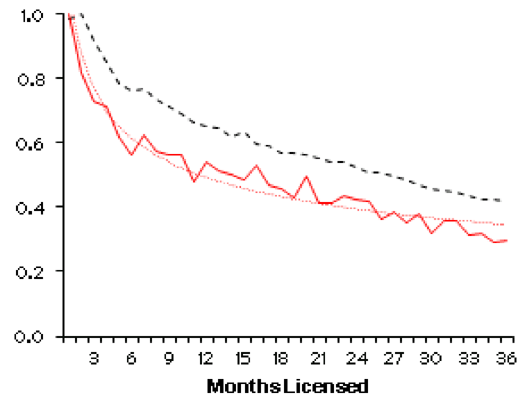
a. Rear-end collision (0.34)



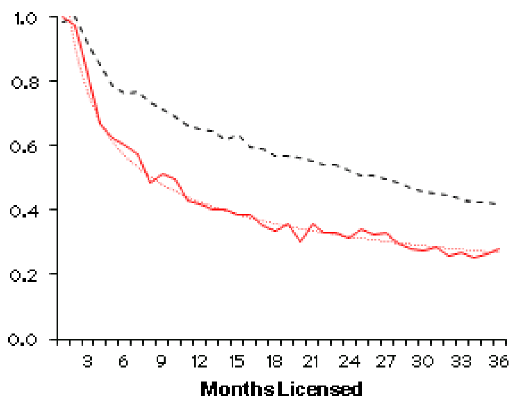
b. Angle collision (0.17)



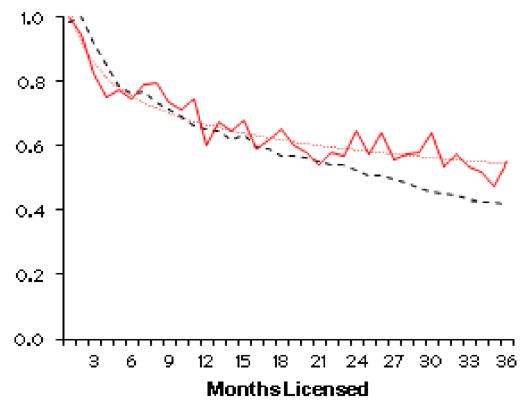
c. Left turn, different roads (0.05)



d. Left turn, same road (0.05)



e. Rollover (0.05)



f. Sideswipe, same direction (0.05)

Figure 8. Most harmful event for young driver's vehicle

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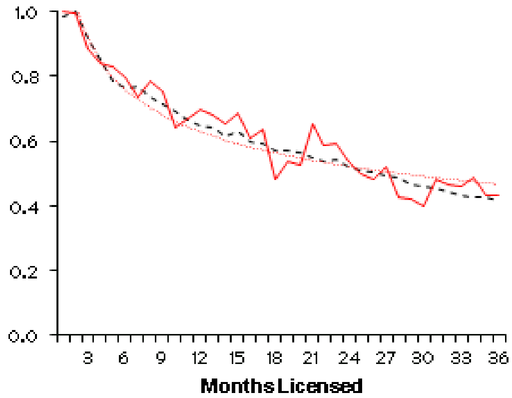
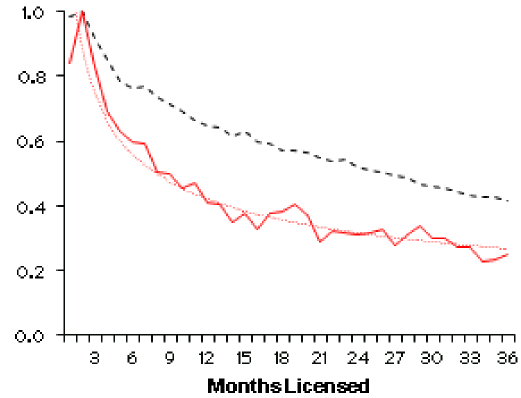
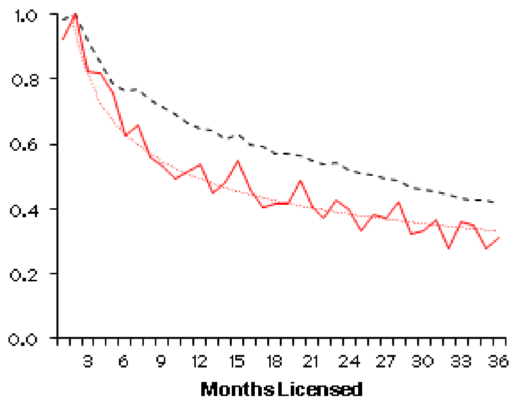


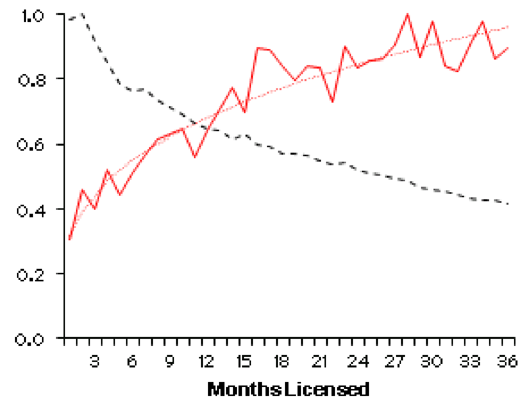
g. Backing up (0.04)



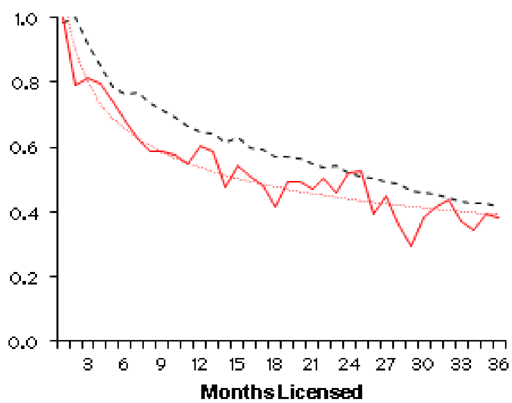
h. Hit tree (0.03)



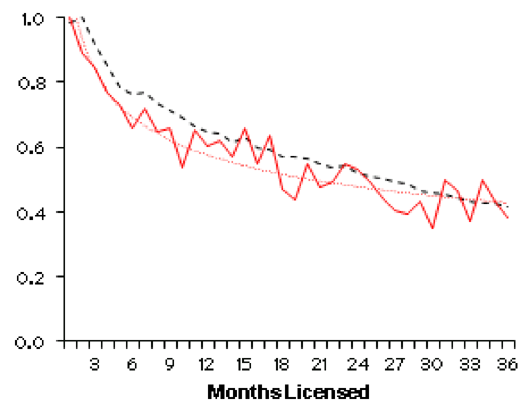
i. Hit ditch (0.02)



j. Hit animal (0.02)



k. Sideswipe, opposite direction (0.02)



l. Head-on collision (0.02)

Figure 8 (continued). Most harmful event for young driver's vehicle

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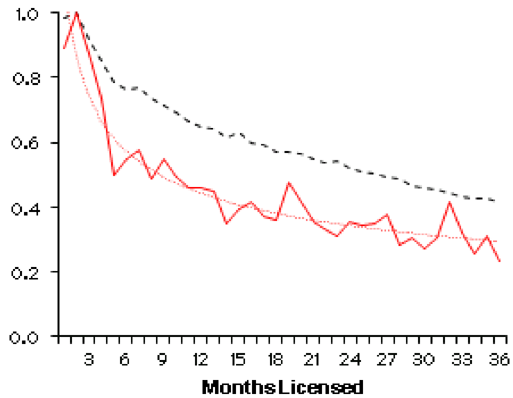
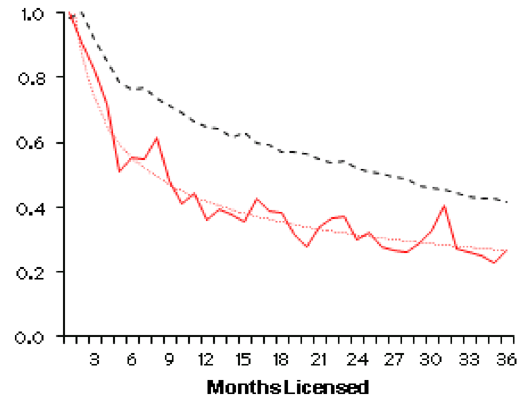


m. Hit parked vehicle (0.02)



n. Hit utility pole (0.01)

Figure 8 (continued). Most harmful event for young driver's vehicle

The most harmful crash characteristics represented here overlap substantially with those shown above in Figure 7 (first harmful). Highly similar trajectories are evident for first and most harmful crash events, with a few exceptions. Running off the road, either left or right, as well are right turn collisions are much less commonly the most harmful event. Because hitting certain fixed objects (e.g., a tree) can be substantially more harmful than others (e.g., a mailbox), collisions with different types of fixed objects are shown separately in Figure 8 (and Table 4).

The 14 most commonly recorded most harmful events shown (of 32 possible) account for 89% of crashes studied. Five crash types that decline particularly rapidly (as indicated by LR ≥ .21 and good curve fit) – left turns involving vehicles on different roads, rollover, hitting a tree, ditch or utility pole – account for about 19% of crashes during the first 36 months of unsupervised driving (see Table 4). Notably, most of these involve hitting something other than another vehicle on the road. The rapid decline fitting a learning curve suggests these were often a matter of the young driver's poor understanding, resulting in an incident involving loss of vehicle control. It is not possible to know, however, whether this is was poor ability to handle the vehicle, poor emergency handling skill or poor judgment that led to a loss of control in the first place.

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Table 4. Most harmful event for young driver's vehicle – percentage distributions during the entire 36-month period, 1st month, 36th month; rates in 1st and 36th month; and characteristics of the best-fitting power function to the standardized 36-month crash rate trajectory.

	Percent of all crashes			Rate per 1000 licensed drivers		Model parameters		
	36 mo.	1st mo.	36th mo.	1st mo.	36th mo.	b	R^2	LR
Rear-end collision	34.5%	25.1%	32.2%	5.72	3.11	− 0.235	0.74	0.15
Angle collision	16.5%	19.3%	16.9%	4.39	1.63	− 0.286	0.96	0.18
Left turn, different roads	**5.3%**	**7.1%**	**4.3%**	**1.62**	**0.41**	**− 0.420**	**0.91**	**0.25**
Left turn, same road	5.0%	6.4%	4.5%	1.47	0.43	− 0.321	0.91	0.20
Rollover	**4.8%**	**7.1%**	**4.7%**	**1.61**	**0.45**	**− 0.420**	**0.97**	**0.25**
Sideswipe, same direction	4.5%	4.3%	5.6%	0.98	0.54	− 0.182	0.86	0.12
Backing up	4.4%	4.4%	4.5%	1.00	0.43	− 0.272	0.85	0.17
Hit tree	**3.2%**	**3.9%**	**2.8%**	**0.89**	**0.27**	**− 0.412**	**0.93**	**0.25**
Hit ditch	**2.4%**	**2.8%**	**2.2%**	**0.63**	**0.21**	**− 0.360**	**0.90**	**0.22**
Hit animal	***2.3%***	***0.6%***	***4.0%***	***0.13***	***0.39***	***+ 0.311***	***0.90***	***− 0.24***
Sideswipe, opposite dir.	1.7%	2.0%	1.8%	0.46	0.18	− 0.288	0.85	0.18
Head-on collision	1.6%	1.8%	1.6%	0.40	0.15	− 0.268	0.83	0.17
Hit parked vehicle	**1.5%**	**1.9%**	**1.2%**	**0.43**	**0.11**	**− 0.372**	**0.87**	**0.23**
Hit utility pole	**1.2%**	**1.7%**	**1.1%**	**0.39**	**0.10**	**− 0.409**	**0.90**	**0.25**
All crashes	---	---	---	22.79	9.66	− 0.273	0.95	0.17

Note. b is the exponent of the power function that best fits the data. R^2 is a measure of how well a power function fits the plot of the crash characteristic during the first 36 months of driving. LR is derived from the best-fitting power function and indicates the amount by which the crash rate declines as experience doubles. Crash types that exhibit notably different trajectories from overall crashes (based on $|LR| \geq 0.21$, if $R^2 \geq 0.90$) are shown in bold type. Italics indicate an increasing rather than decreasing rate over time.

Young driver behaviors judged to have contributed to the crash

The data element in the North Carolina crash report that most directly indicates what, if anything, the young driver did that contributed to the crash is probably the most sensitive indicator of how novice drivers' knowledge, understanding and demeanor change over time. The NC crash report form includes 31 specific behaviors that may be coded as having contributed to the crash.[8] In about one-third (31.5%) of the young driver crashes examined here, the investigating officer did not identify any action on the part of the young driver as having contributed to the crash. For those crashes where at least one driver behavior was indicated, the 36 month trajectories for the 12 most common actions are shown in Figure 9. Each of these accounted for at least one percent of the crashes in which a young driver action was indicated as contributing to the crash. In combination, these 12 actions represent 80% of all crashes in which the young driver was seen as having contributed, at least in part (and 54.7% of all crashes included in this analysis).

[8] Unfortunately, no definitions, explanations or examples are provided for any of these in the *North Carolina Crash Report Instruction Manual.*

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The trajectories of most of these contributing behaviors exhibit a pattern consistent with learning. Five of the six most commonly cited actions fit a power curve and declined substantially more rapidly than crashes overall; these include inattention, failing to yield, exceeding safe speed for conditions, crossing the center line/going the wrong way, and overcorrecting. Including the two others that declined rapidly – exceeding the speed limit and improper turn – about half (52%) of the driver behaviors indicated as contributing to the crash declined rapidly and in a manner consistent with learning.

The most commonly cited behavior – failing to reduce speed (Fig. 9.a.) – does not exhibit a learning pattern. Instead it increases during the first 3 months then decreases linearly thereafter, suggesting a different process is involved in this kind of crash. Following too close (Fig. 9.i.), though much less common, exhibits a similar pattern to failing to reduce speed.

The trajectories for the involvement of speed in young driver crashes exhibit an interesting and somewhat surprising pattern. The two clear measures of inappropriate speed – driving too fast for conditions (Fig. 9.d.) and exceeding the speed limit (Fig. 9.h.) – decline similarly and more quickly than crashes in general during the first few years of driving. The close fit of the trajectories for both to a power curve suggest that learning plays a substantial role in speeding-related crashes among young drivers. Were speeding largely a matter of decreased caution associated with experience (overconfidence), cavalier disregard for safety, perceived invincibility, male aggressiveness, or any of several other commonly offered explanations for young driver speeding, the trajectory for these actions would not exhibit such a clear learning pattern.

Inattention (Fig. 9.b.) and distraction (Fig. 9.k.) are similar phenomena – the latter being one possible explanation, or reason, for the former – and they exhibit similar trajectories. Distraction is indicated far less frequently and, consequently, exhibits a more erratic pattern. Both of these are exceedingly difficult to measure in a post-crash investigation.

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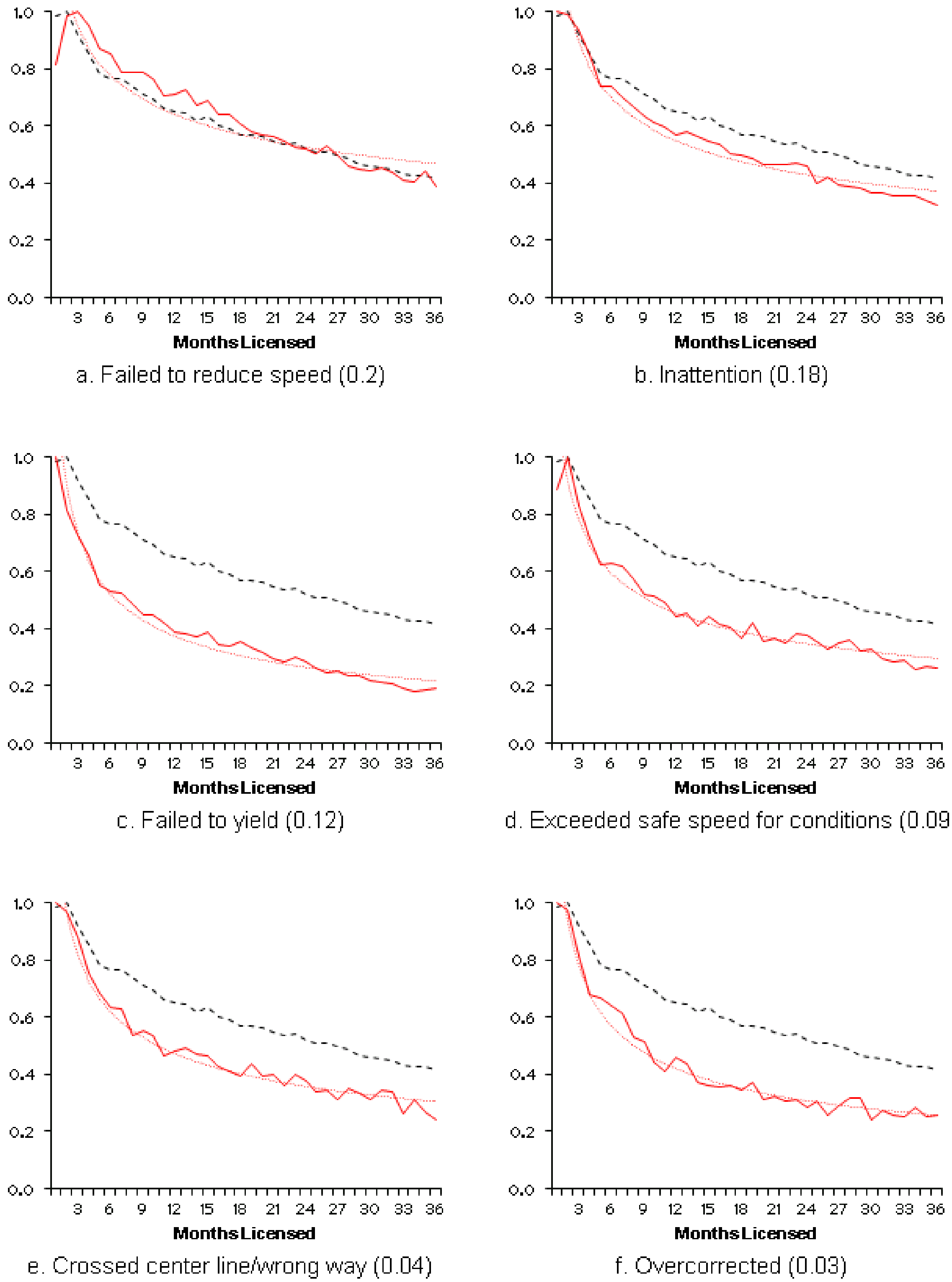

Figure 9. Young driver behaviors contributing to the crash by months licensed

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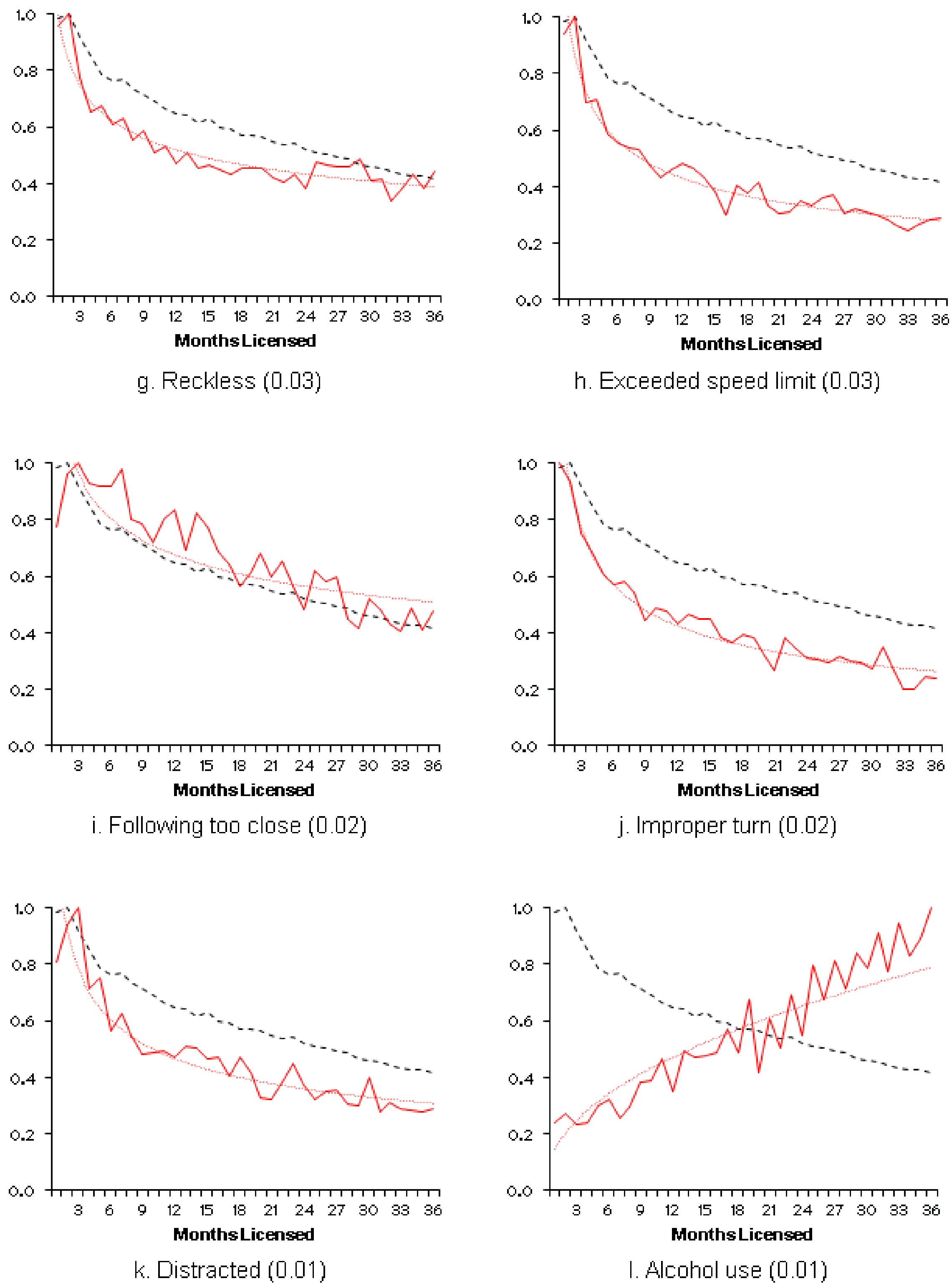

Figure 9 (continued). Young driver behaviors contributing to the crash by months licensed

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Unless a driver both realized he or she was not attending adequately to driving and reported this to the investigating officer, it is nearly impossible to know inattention was involved in the crash. Distraction is a more distinct notion and is something a driver might more easily be aware of and able to report.

Most driver behaviors noted as contributing to the crash declined rapidly, suggesting a broad range of learning. Only failing to reduce speed, following too close and reckless driving declined more slowly, while driver alcohol use increased (though to a still quite low peak rate of 0.25 crashes per 1000 licensed drivers in the 36th month). Several of the behaviors that declined rapidly, including those that decline most rapidly – failing to yield, overcorrecting and improper turns – seem to evince what McKnight & McKnight (2003) described as more a matter of cluelessness (lack of understanding) rather than carelessness (lack of concern). These are precisely the kinds of things novices would be expected to learn, fairly quickly, with practical driving experience. Actions that represent dispositions rather than understanding, such as adolescents' inability to fully control impulsiveness, a disregard for safety or lack of consideration for others, would not be expected to decline in the rapid manner that learning produces.

Table 5. Most common young driver actions identified as contributing to the crash – percentage distributions during the entire 36-month period, 1st month, 36th month; rates in 1st and 36th month; and characteristics of the best-fitting power function to the standardized 36-month crash rate trajectory.

	Percent of all crashes*			Rate per 1000 licensed drivers		Model parameters		
	36 mo.	1st mo.	36th mo.	1st mo.	36th mo.	*b*	R^2	LR
Failed to reduce speed	20.3%	16.3%	18.3%	3.72	1.77	− 0.284	0.80	0.18
Inattention	**18.0%**	**20.6%**	**15.7%**	**4.70**	**1.52**	**− 0.353**	**0.94**	**0.22**
Failed to yield	**12.3%**	**20.2%**	**9.1%**	**4.61**	**0.88**	**− 0.491**	**0.95**	**0.29**
Exceeded safe speed	**9.4%**	**11.4%**	**7.9%**	**2.60**	**0.77**	**− 0.390**	**0.94**	**0.24**
Crossed center line/wrong way	**3.7%**	**4.9%**	**2.8%**	**1.11**	**0.27**	**− 0.398**	**0.94**	**0.24**
Overcorrected	**3.4%**	**5.1%**	**3.1%**	**1.15**	**0.30**	**− 0.447**	**0.96**	**0.27**
Reckless	3.4%	4.0%	4.4%	0.91	0.42	− 0.263	0.88	0.17
Exceeded speed limit	**2.8%**	**3.9%**	**2.8%**	**0.88**	**0.27**	**− 0.388**	**0.93**	**0.24**
Following too close	2.4%	1.7%	2.5%	0.40	0.24	− 0.257	0.66	0.16
Improper turn	**2.1%**	**3.0%**	**1.7%**	**0.69**	**0.17**	**− 0.432**	**0.91**	**0.26**
Distracted	1.1%	1.2%	1.0%	0.27	0.10	− 0.377	0.87	0.23
Alcohol use	***1.0%***	***0.3%***	***2.6%***	***0.06***	***0.25***	***+ 0.468***	***0.83***	***− 0.38***
All crashes	---	---	---	22.79	9.66	− 0.273	0.95	0.17

Note. *b* is the exponent of the power function that best fits the data. R^2 is a measure of how well a power function fits the plot of the crash characteristic during the first 36 months of driving. LR is derived from the best-fitting power function and indicates the amount by which the crash rate declines as experience doubles. Crash types that exhibit notably different trajectories from overall crashes (based on $|\text{LR}| \geq 0.21$, if $R^2 \geq 0.90$) are shown in bold type. Italics indicate an increasing rather than decreasing rate over time.

* In nearly 32% of crashes, no contributing young driver action was indicated. Percentages are based on crashes where at least one contributing driver action was recorded (N = 175,992).

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Up to three driver actions judged to have contributed to the crash can be recorded on the North Carolina crash report form, but in the majority (76%) of cases where any driver behavior is identified, only one is mentioned. Because multiple contributing driver actions were relatively infrequent, all recorded contributing actions were combined for the present analyses. It is noteworthy that when a second or third contributing driver action is listed, inattention is by far the most common (35% of all 2nd and 3rd mentions). Rather than being a discrete secondary driving action, this gives context to the driver's behavior. Two of the most common driver "errors" involve failing to take appropriate action – failing to reduce speed and failing to yield. Inattention provides a plausible explanation, though perhaps not the actual reason, why these actions were not taken.

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Discussion

The information shown in the figures and tables above represent the most extensive and detailed description of young novice driver crashes ever conducted. The opportunity to do these analyses is somewhat unique to North Carolina. Many states' driver license files do not retain the detail on license type and issue date needed to conduct time to crash analyses. Moreover, a large young driver population is needed in order to identify consistent patterns among specific crash subtypes or characteristics, for a narrow age range by months licensed. The majority of states currently do not have a sufficient number of young drivers to allow such analysis.

As befits an exploratory study, the findings reported here are purely descriptive. Despite the unique and detailed view of the young novice driver crash picture they portray, they are merely suggestive of the mechanisms underlying various crash characteristics. The analyses undertaken here were different, in several ways, from those typically conducted in the study of young driver crashes. Accordingly, we have tried not to over-interpret the figures and numeric summaries shown above. These were designed primarily to illustrate and examine the *trajectory* of crash rates during the initial 36 months of licensure to drive without adult supervision. Only the shape of the crash rate curves (shown in red) can easily be interpreted, and then only in relation to the overall declining rate of crashes in this age cohort. Although the overall prevalence of the various crash characteristics is important, it is tangential to the purpose of this study. Thus, we included this information in the tables, but do not generally address prevalence when discussing the results.

The crash characteristic curves were standardized to range from their maximum rate to their minimum rate per licensed driver during the first 3 years of driving. This distorts the absolute levels of crash characteristics. Further, in several cases the change shown in the figures represent relatively small absolute changes (the difference between highest and lowest rates shown), even though they may exhibit substantial relative decreases. These substantial relative decreases are highly informative about the issue of interest here, but can be misleading about the actual incidence of the crash characteristics. The magnitude of decline, as well as the actual incidence, is shown by the difference between the 1st and 36th month rates shown in the tables.

To minimize complexity in describing the findings, and to avoid over-interpreting purely descriptive data, we have generally avoided discussing the multiple indications available in the figures (and tables), focusing primarily on the crash trajectories. We do believe that both the relative and direct summaries provide valuable, heretofore unavailable information about young novice driver crashes. One of the principal goals of the present study was to provide these detailed descriptions, with the hope that they might prompt future, conceptually-driven inquiry into young driver crashes.

Inspection of the many crash type trajectories shown above reveals some interesting patterns. The rates of certain crash characteristics increase in the first month or two, whereas

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others peak in the initial month. These differences may suggest different phenomena are involved or, more likely, that multiple phenomena are involved to differing degrees. The increase in crash rates in the 2nd and sometimes 3rd month appear to reflect increased driving, but they could also indicate developing overconfidence among teens who are just beginning to drive on their own. The increase in crashes where the young driver was not likely at fault – being hit while stopped – clearly suggests that exposure increases from the first to second month of licensure.

Classifying young driver improvement

A few crash types and characteristics declined particularly rapidly. Many others either parallel the overall decrease in crash rate per month licensed, or were so infrequent that a clear trajectory during the initial 36 months of driving could not be identified (the latter were not shown above). A small number declined quite a bit more slowly than the overall rate. Few crash types increased with experience. The two notable instances of this – animal collisions and driver-drinking crashes – appear to represent changes in behavior or exposure rather than deterioration of driving knowledge or ability.

Rapidly declining crash characteristics

The following crash types declined at a notably more rapid pace than young driver crashes generally (indicated by LR $\geq$ 0.21 or, when the trajectory did not follow a power function, a 36th month rate $\leq$ 25% of the 1st month rate):

- Collisions involving left turns or entering a roadway from a parking lot/driveway
- Crashes where the young driver's vehicle overturned, ran off the road to the right, or hit a tree, utility pole, or legally parked vehicle

In addition, crashes involving the following driver errors declined particularly sharply:

- Failing to yield
- Overcorrecting
- Making an improper turn
- Crossing the center line/going the wrong direction

It is difficult to detect a clear unifying thread or pattern among these that might provide insight into why or how their incidence rate declined more rapidly than the majority of crash types and characteristics. They all seem to indicate what McKnight & McKnight (2003) described as "cluelessness" – drivers simply not yet knowing very well how to handle the full range of driving situations. It is somewhat puzzling that drivers who had 12 months to practice driving with an adult would know so little. This is what GDL was designed to address – those things drivers learn best, or can only learn, by actually driving. It may be that those who crashed because of "clueless" behavior represent a subset of teenagers who obtained insufficient experience driving during their 12-month learner license period. The trajectories of these

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crash characteristics clearly indicate learning, beginning almost immediately after unsupervised driving begins. It may be that a central element in avoiding crashes like these requires young drivers to learn self-control, something that is not likely to occur while driving with a parent. There is a clear suggestion in these findings that parents should ensure their children get extensive practice making left turns, and turning onto roads from driveways and parking lots, in a wide variety of circumstances.

The implication for supervised driving of the high, but quickly declining, incidence of crashes that involve running off the roadway is less clear. Broadly these seem to indicate the teen had gotten into a situation he or she was unprepared to handle. But how, or whether, that can be addressed through supervised driving is unclear. It may simply be the sort of thing that is learned only through experience. Fortunately, most of these incidents were relatively uncommon even during the early months of driving.

Unusually slow declines

Crash types that declined notably more slowly mostly involved rear-end collisions, including cases where the young driver's vehicle was hit while slowing or stopped, cases where the young driver collided with a leading vehicle and instances where the young driver was following too closely. Another type that declined particularly slowly was sideswipe collisions where both vehicles were going in the same direction. Such incidents can result from the same conditions that produce rear-end collisions, but where a driver was able to partially avoid a direct hit.

Most of the crash characteristics that stood out with unusually fast or slow declines have been identified in previous research as common in teenage driver crashes. The findings here provide a more fine-grained look at these issues. Left turn crashes, overturning, hitting a fixed object and failing to yield seem relatively more common during the early months. By virtue of their relatively sharp decline, these appear to reflect lack of understanding rather than a consciously risky demeanor, or disregard for safety by teenage drivers. On the other hand, rear-end collisions and sideswipes, resulting from following too closely or failing to slow down when needed, endure at higher rates for many more months. This would seem to suggest that these are more a matter of a driving style that characterizes some young drivers rather than of lacking knowledge about driving. Research on adolescents indicates that such drivers may well "know better," but are simply not yet well-equipped to act on what they know (Steinberg, 2007). The first naturalistic driving study to examine parental supervision of teenager learners found that not slowing as quickly as the parent thought appropriate was among the most commonly observed incidents (Goodwin et al., 2010). Thus, it starts early and the results here suggest it endures longer among young novices than most any other untoward driving behavior.

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Moderate crash rate declines

Several identifiable trajectories closely paralleled the overall decline in crashes over the initial 3 years of driving. These are difficult to interpret. They probably represent a combination of the effects of learning, altered exposure and dispositional characteristics that change slowly, if at all, during the initial years of driving. Clearly the overall crash rate decline reflects the combination of all possible influences, so it seems reasonable that specific crash types with similar trajectories may also be influenced by multiple factors. In contract, those that stood out as particularly quick or slow to decline may represent crash types whose etiology is more homogeneous, for example, being mostly the result of learning, or mostly the result of altered exposure. But it might also be that the more slowly declining types simply manifest other contributing factors. On possibility is that what novices learn from experience broadly influences their ability to avoid a wide variety of behaviors, mistakes, and conditions that lead to crashes as they accumulate driving experience. This is consistent with learning self-control, the benefits of which should apply generally rather than to specific kinds of crash risks. Another plausible explanation, however, is simply that the information available in crash data is not sufficiently precise to allow identification of perhaps subtle, though important, changes in drivers' behavior.

The role of speeding in young driver crashes

Speeding is routinely mentioned as a particular problem among young drivers (Ferguson, 2003; Shope & Bingham, 2008). The findings here suggest the belief that speeding is a widespread problem, or a common cause of teenage driver crashes may be exaggerated. The two clear indicators of speeding combined (exceeding the speed limit or driving too fast for conditions) account for only 12.2% of young driver behaviors indicated as contributing to a crash during the first 3 years of driving. Speeding-related crashes occur at a rate of only 3.5 per 1000 drivers in the first month of driving, declining to 1 per 1000 in the 36th month. It is particularly interesting that speed-related crash involvement decreases rapidly in a pattern suggesting that this is mostly a matter of learning, or that learning overwhelms other forces that might predispose young drivers to speed more often as they age. The seeming inconsistency of this with other reports that speed is particularly common for young drivers may result from the fact that we examined crashes of all severity levels, whereas other studies typically focus only on fatal crashes, which are more likely to result from speeding. About 31% of fatal crashes consistently involve speeding for the full driving population; the rate is slightly higher among teenage drivers (cf., NHTSA, 2011).

"Experienced" beginning drivers

It is noteworthy that the crashes during the early months of driving examined here do not represent the initial driving experiences of the involved drivers. Every driver included in the analyses had been licensed as a learner for at least 12 months, during which they were expected to drive only with an experienced adult driver in the vehicle.

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One Australian study found that teenagers with a learner permit rarely drove, averaging about two trips, 50 minutes and 30 miles driving per month (Harrison, 2004). Were that the case in the present sample, drivers could fairly be considered beginners as they began their intermediate license period. However, in a recently completed intensive study of a small sample of true beginning drivers in North Carolina (those with a learner license), we found that teens seem to be driving about 90 minutes a week during this initial license stage (Goodwin et al., 2010). Another self-report study of North Carolina teens, using less detailed measurement, suggested that novices do drive substantially more than reported in the Australian study (Goodwin et al., 2006). About four months into the 12-month learner period, both teens with a learner permit and their parents reported the teen had driven a median of 3.5 days in the previous week.

The results reported by Goodwin et al. (2010) suggest that novices learn a substantial amount during the learner period. Anecdotal reports of driver license examiners following the introduction of GDL in North Carolina suggested this as well. Nonetheless, the dramatic and immediate increase in crash rates in the transition from supervised to unsupervised driving (Lewis-Evans, 2010; Mayhew et al., 2003), as well as the trajectory over the next few years shown here, suggests a great deal more is learned following the learner period. It seems likely that learning during unsupervised driving is less about vehicle handling, actions of other drivers, or the roadway environment, and more about self-regulation and, perhaps, the need for self-reliance. A great deal can be learned from the practical experience of driving while supervised, but a teenager cannot learn self-regulation, the meaning of full responsibility for the vehicle, or how to manage the internal vehicle environment (e.g., interaction with passengers, passenger behavior) while a parent/adult is present. All of these are potentially important in avoiding collisions.

The high crash rate when unsupervised driving begins, however, may indicate that there is a good deal more that parents can and should do during the supervised driving period of the licensing process. That was one of the primary conclusions of Goodwin et al. (2010), based on direct observation of supervised driving and extensive interviews with parents throughout the 12-month learner period. The present results may provide some general guidance about the sorts of things teens appear not yet to have grasped during the learner license period. The high rate of running off the road during the first months of unsupervised driving, often hitting something or overturning, suggests a continuing lack of “savvy” or wisdom about driving that ought to have developed during a year of practice. It may be that more varied driving practice is needed, exposing novices repeatedly to a broad range of situations and conditions, which parents seem not to be doing (Goodwin et al., 2010). Or it may simply be that more driving is needed. However, this is merely speculation. The rapid decline in the propensity to run off the road may also represent learning to self-regulate while driving, rather than driving-specific behaviors such as vehicle-handling and hazard identification.

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Effects of graduated driver licensing

Experts in adolescent behavior who have addressed driving note that many of the worrisome behaviors of young teenage drivers cannot realistically be modified to any great degree by direct intervention to train, educate or threaten punishments (Keating, 2007; Steinberg, 2007). GDL, with its carefully integrated elements designed to protect teenagers from the consequences of impulsive behaviors, is considered the best hope for preventing crash-related injury.

The North Carolina GDL system has long been recognized as one of the most comprehensive in the U.S. (IIHS, 1997). Interestingly, there is clear evidence of the effect of the 6-month intermediate license period in many of the crash trajectories. The overall crash pattern, and that of many individual crash characteristics as well, depart from their overall trend in the 7th month. This is the point when the intermediate license period – with limits on driving after 9 pm and carrying more than one young passenger – expire for most young drivers. Whether this merely represents increased overall exposure as a result of being allowed to drive after 9 pm, changes in driving behavior, or the added exposure to high risk driving conditions cannot be determined from the information available here.

With the exception of the "7-month bump," and the fact they are not so high in the first few months, the overall crash trajectory of young North Carolina drivers licensed under GDL is quite similar – although about 10% lower – to that in the mid-1990s before GDL was implemented (Masten & Foss, 2010). However, trajectories for particular crash types/characteristics following introduction of GDL may be substantially different, reflecting the variety of effects GDL can have on novice driver crashes. We were unable to address that issue in the present study, but it seems worth pursuing, especially in a state where GDL has been introduced more recently. Comparisons of post-GDL crash rates to pre-GDL rates from a previous era entail substantial difficulties in disentangling GDL effects from historical trends.

Teenagers and the mistakes of other drivers

Although the fact that no contributing driver action was listed in nearly a third of young driver crashes may seem surprising, it is a reminder that novice drivers can be innocent victims – of other drivers and unavoidable circumstances. An obvious example of this occurs when a stopped vehicle is hit from the rear by another driver who fails to stop in time. There are many other possible instances of driver involvement in crashes to which they did not directly contribute. Most of these are less clear cut than being hit while stopped. For instance, a vehicle being hit from the side after another driver runs a stop sign or red light is clearly the other driver's fault. Experienced drivers sometimes avoid "faultless involvement" in such crashes, by understanding that other drivers make mistakes and being particularly alert to those, especially at intersections. Inexperienced drivers are often poorly equipped to do this, whereas experienced drivers often do so without conscious effort or even awareness. Consequently, novice drivers may often be involved in crashes resulting not from their own

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driving mistakes, but from their underdeveloped ability to avoid problems resulting from the mistakes or deliberate misbehaviors of other drivers. Improvement in this ability is probably one of the reasons for the overall decrease in crash involvement by novices. Unfortunately, these instances are exceedingly difficult to identify in crash data.

Study limitations

Analysis of crash data entails several difficulties that limit the conclusions that can reasonably be reached. By trying to infer information about the reasons for drivers' actions, the present study may have sought to elicit more insight than can reasonably be expected from crash data. The following briefly summarize some of the particular problems.

Unclear meaning of some crash data file elements

Crash report data often are insensitive indicators of what crash-involved drivers did, what they saw, what they were thinking, or what judgments they made. Crash reports can generally describe physical aspects of a crash – what happened, where, when – but are not well-suited to determining the precursors, hence the "causes," in many cases (Waller, 1985, Ch. 3 & Ch. 6, p. 76). Consequently, although it was possible to identify crash types or characteristics that declined particularly quickly with increasing experience it was rarely possible to clearly attribute these to a particular underlying phenomenon (e.g., learning, maturation, changes in exposure, etc.).

Measures confounded by exposure

Some measures (crash types/characteristics) are heavily influenced by exposure – both the amount and type. To the extent that the amount of driving, or the amount in particular conditions, changes with experience (age), it is difficult to separate the effects of this from changes in driver knowledge or driving demeanor.

Skewed crash characteristic distributions

Another limitation was the relative infrequency of many crash types/characteristics. For relatively rare crash characteristics, monthly incidences were too rare to exhibit a clear pattern. Tables 2-5 show how heavily crash traits are concentrated in a few categories. In each of those tables, at least 60% of crashes fell into the four most commonly recorded characteristics.

Some crash characteristics seem to be relatively clear indicators of an erroneous driver action, but in the absence of contextual information it is not clear why such actions occurred. To identify context in a quantitative analysis of crash data requires examining joint distributions (co-occurrence of multiple crash attributes). Because of the skewed distribution of crash characteristics we were not able to identify clear trajectories for combinations of

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crash characteristics. The detailed combinations that might be informative were simply not sufficiently common.

Reliability and validity issues with some crash report elements

Crash reports are retrospective accounts of an event, gleaned from whatever physical evidence and participant/observer reports may be available. Some crash characteristics can be determined fairly well from physical evidence at the scene. But many driver behaviors, and especially their unobservable cognitive states prior to the crash sequence, often leave no evidence. Hence the opportunity to extract useful information about driver knowledge, motivation, attention, etc. from the elements of crash data files depends on the consistency and accuracy with which police officers can identify and report driver behaviors during crash investigations. This is a particular problem with data elements that, of necessity, sometimes rely more on inference than on the availability of direct evidence. Unfortunately, it is just these kinds of elements that would be of greatest value for inquiries like the present one.

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Conclusions

The present descriptive findings should provide "food for thought" by young driver researchers and the traffic safety community more broadly. By examining a large number of crashes and their characteristics as a function of months licensed we were able to provide a highly detailed look at the rapidly changing nature of young driver crashes as a function of experience. No other study has provided so much detail about so many aspects of crashes. Although they do not provide direct, conclusive evidence, the crash patterns identified here do appear to suggest that experience-based learning, rather than age-related maturation, is the more important factor in the dramatic decline in crashes among young novice drivers.

The analyses clearly identified a few crash characteristics that decline sharply and quickly when teenagers begin driving unsupervised. These provide some suggestions for how parents might improve beginning teenage drivers' learning experience during their learner permit period. They also raise some intriguing questions about the potential differences in what is (or can be) learned during supervised driving as opposed to learning that occurs when one is the sole responsible person in the vehicle.

The nature of many of the crash patterns identified is highly consistent with learning and a few seem clearly to be the result of changing driving amount and patterns as young drivers age and gain experience. Unfortunately the results yielded less insight than had been hoped into the complex question of why and how beginning driver crash rates decline so steeply during the initial several months of licensure. Though continued rapid learning appears to be involved, it is not yet clear what is learned. Our inability to identify this was partly because of the substantial demands this question places on the data, along with the particular approach taken. The skewed distribution of crash attributes among young drivers and the inherent limitations of crash data reporting – a system better suited to thoroughly describing what happened than to documenting why – also limited our ability to glean greater understanding of what young drivers learn during the first few years of driving.

Because of the limitations of crash data, it seems likely that the primary question that motivated the present study and others like it may be addressed more successfully with data collected in naturalistic driving studies (Goodwin et al., 2010; Klauer et al., 2006; Lee et al., 2011; Prato et al., 2010). Fortunately, several such studies are now under way. These are not without their own limitations (Bingham & Foss, 2010), but they entail a dramatic increase in the amount, breadth, precision and relevance of information about driver behavior and its context. Technologic advances promise to render future studies less costly and more logistically feasible. We hope that the findings of the present study will guide the choice of questions to be addressed in naturalistic driving studies as well as other approaches that entail more precise measurement, but which are limited by small samples, logistic constraints and high deployment costs.

For most beginners, experience accumulates quickly in the early months of driving, whereas maturation occurs more slowly. Moreover, extra-individual factors associated with increasing

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age among teenagers – more driving, greater freedom from parental oversight, increased exposure to drinking environments – contribute to increasing crash risk, even as intra-individual changes tend to mitigate risk. In view of the strong influence of exposure on crash risk, the distinct declines in crash rates overall, in several specific crash characteristics, and in many driver behaviors/errors that contribute to crashes is fairly remarkable.

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Appendix A

List of all options for each of the crash report variables examined

Vehicle Maneuver/Action

1. Stopped in travel lane (driver still in vehicle)
2. Parked out of travel lanes
3. Parked in travel lanes
4. Going straight ahead
5. Changing lanes or merging
6. Passing
7. Making right turn
8. Making left turn
9. Making U turn
10. Backing (takes priority over other maneuvers)
11. Slowing or stopping
12. Starting in roadway (from driveways, public or private)
13. Parking
14. Leaving parked position
15. Avoiding object in road
16. Other

First Harmful Event and Most Harmful Event (use same codes)

The first harmful event is the first injury or damage producing event, while the most harmful event is the event, which caused the most severe injury or greatest amount of property damage to each vehicle.

Non-Collision

1. Ran off Road Right
2. Ran off Road Left
3. Ran off Road Straight Ahead - vehicle runs through “Y” or “T” intersection.
4. Jackknife – (only used if vehicle is truck pulling a semi-trailer)
5. Overturn/Rollover - motor vehicle overturns for any reason *without antecedent collision.*
7. Downhill runaway
8. Cargo/Equipment Loss or Shift
9. Fire/Explosion
10. Immersion
11. Equipment Failure (tires, brakes, etc.)
12. Separation of Units
13. Other Non-Collision* (write in narrative) – any other event involving only the motor vehicle in transport, that is of a non-collision nature.

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Collision of Motor Vehicle With

14. Pedestrian – collision of motor vehicle and a pedestrian.
15. Pedalcyclist - collision of motor vehicle and a pedalcyclist (bicyclist)
16. Railway Train, Engine
17. Animal
18. Movable Object - collision of a motor vehicle and any other object which is movable or moving, but not fixed.
19. Fixed Object - collision of a motor vehicle and any object, which is fixed (not movable). More detailed codes available for vehicle level information.

Collision of Two or More Motor Vehicles

20. Parked Motor Vehicle - collision of motor vehicle and in transport and a motor vehicle not in transport.
21. Rear End, Slow, or Stop - rear end collision with one vehicle going at a slower speed, slowing down or stopping in traffic.
22. Rear End, Turn - rear end collision with front vehicle turning.

Collision of Two or More Motor Vehicles

23. Left Turn, Same Roadway - collision with both vehicles traveling on same roadway prior to one or both turning left; may occur in passing maneuver or vehicles may be meeting.
24. Left Turn, Different Roadways - collision of vehicles traveling on different roadways prior to one or both turning left.
25. Right Turn, Same Roadway - collision with both vehicles traveling on the same roadway prior to one or both turning right.
26. Right Turn, Different Roadways - collision of vehicles traveling on different roadways prior to one or both turning right.
27. Head On - head on collision of motor vehicles moving in opposite directions in which initial contact is on the fronts of both vehicles.
28. Sideswipe, Same Direction - the collision of motor vehicles, traveling in the same direction, in which contact usually results from attempting to pass too closely, skidding, or other side-to-side initial contact.
29. Sideswipe, Opposite Direction - the collision of motor vehicles, traveling in opposite directions, in which contact usually results from attempting to pass too closely, skidding, or other side-to-side initial contact.
30. Angle Collision - collision most often resulting in the vehicles hitting at or near right angles, with the front of one vehicle striking the side of the other vehicle.
31. Backing Up – collision in which one vehicle backs into another, generally stopped or parked vehicle
32. Other Collision with Vehicle

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Driver Contributing Circumstances

The actions of the driver which may have contributed to the crash. The importance is to record the cause of the crash, not necessarily the citation issued. Even though the citation issued is for a safe movement violation, it is better to record the specific contributing circumstances, e.g., improper turn or improper lane change, etc.

0. No contributing circumstances indicated
1. Disregarded yield sign
2. Disregarded stop sign
3. Disregarded other traffic signs
4. Disregarded traffic signals
5. Disregarded road markings
6. Exceeded authorized speed limit
7. Exceeded safe speed for conditions
8. Failure to reduce speed
9. Improper turn
10. Right turn on red
11. Crossed centerline/going wrong way
12. Improper lane change
13. Use of improper lane
14. Overcorrected/oversteered
15. Passed stopped school bus
16. Passed on hill
17. Passed on curve
18. Other improper passing
19. Failed to yield right of way
20. Inattention
21. Improper backing
22. Improper parking
23. Driver distracted
24. Improper or no signal
25. Followed too closely
26. Operated vehicle in erratic, reckless, careless, negligent or aggressive manner
27. Swerved or avoided due to wind, slippery surface, vehicle, object, non-motorist
28. Visibility obstructed
29. Operated defective equipment
30. Alcohol use
31. Drug use
32. Other* (Write in Narrative)
33. Unable to determine
34. Unknown

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