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Naturalistic Teenage Driving Study: Findings and Lessons Learned

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Abstract

Problem—This paper summarizes the findings on novice teenage driving outcomes (e.g., crashes and risky driving behaviors) from the Naturalistic Teenage Driving Study.

Method—Survey and driving data from a data acquisition system (Global Positioning System, accelerometers, cameras) were collected from 42 newly-licensed teenage drivers and their parents during the first 18 months of teenage licensure; stress responsivity was also measured in teenagers.

Result—Overall teenage crash and near crash (CNC) rates declined over time, but were >4 times higher among teenagers than adults. Contributing factors to teenage CNC rates included secondary task engagement (e.g., distraction), kinematic risky driving, low stress responsivity, and risky social norms.

Conclusion—The data support the contention that the high novice teenage CNC risk is due both to inexperience and risky driving behavior, particularly kinematic risky driving and secondary task engagement.

Practical Applications—Graduated driver licensing policy and other prevention efforts should focus on kinematic risky driving, secondary task engagement, and risky social norms.

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Keywords

adolescence; risk taking; accidents; speeding; learning to drive; kinematic; expertise

INTRODUCTION

Crash rates are particularly high early in licensure, due mainly to inexperience and risky driving behavior (Simons-Morton et al., 2011a; Williams, 2003), and decline rapidly for about six months (about 1000 miles) and then slowly over a period of years (Mayhew et al., 2003). While novices of all ages have high crash risk, younger age at licensure is associated with higher initial risk and slower declines (Twisk & Stacy, 2007; NHTSA, 2012). This is particularly problematic in the United States where the age of licensure is relatively young, 16 in most states and as old as 17 in only one state (Insurance Institute for Highway Safety, 2015).

Relative to older drivers, crashes among teenagers are more likely to involve speeding and hitting stationary objects (NHTSA, 2012), which could reflect both risk taking and poor judgment. Adolescents take more risks than adults in general (Steinberg, 2008), and with respect to driving in particular (Williams, 2003). Novice drivers of any age make many mistakes when first learning but over time learn to process information quickly, resolve problems, and better judge their abilities (Elvik, 2006; Keating & Halpern-Felsher, 2008; McKnight & McKnight, 2003).

A variety of methods have been employed to document the problems associated with teenage driving. For example, analyses of crash databases have demonstrated problems associated with teenage driving, such as that younger drivers have higher fatal crash rates per mile driven and per licensed driver (Williams, 2003), particularly in the presence of teenage drivers (Ouimet et al., 2010), and nearly half of serious teenage crashes involve driving too fast for conditions, inadequate surveillance, and distraction (Curry et al., 2011). Test track studies have demonstrated that novices relative to adults are more highly distracted by secondary task (e.g., cell phone dialing) engagement (Lee et al., 2006) and less able to detect road hazards (Pradhan et al., 2011). Simulation studies have demonstrated that novice teenagers are not as good as experienced adults at intersection management, hazard anticipation, and other complex driving tasks (Pradhan et al., 2005). Analyses of crash databases have demonstrated that novices make a lot of mistakes (McKnight & McKnight, 2003; Curry et al., 2011). An observational study reported that teenagers drove faster and maintained shorter headway than other drivers, particularly in the presence of male teenage passengers (Simons-Morton, Lerner, & Singer, 2005). Survey research has provided additional information about the psycho-social predictors of self-reported driving risk (e.g., Fernandes et al., 2010; Mirman et al., 2012).

While each of these methods has provided useful information, the development of advanced naturalistic driving measurement methods provides an important and relatively new approach to the study of driving risk. By instrumenting vehicles with a variety of sensors it is possible to evaluate driving performance over long periods of time, providing objective measures of driving risks and contributing factors. The Naturalistic Teenage Driving Study

(NTDS) included continuous assessment of mileage, elevated g-force events, speeding, and crash experience in a sample of teenage drivers and their parents driving the same vehicles over the same time period and geographic area. The study has provided new information about the variability and predictors of teenage driving performance and risk. The purpose of this paper is to provide a summary of NTDS findings, describe lessons learned, and note the implications of the findings for policy, practice, and future research.

Study Aims

The purpose of the study was to examine over time novice teenage driving performance and risk, including crash and near crash rates, kinematic risky driving, speeding, and distraction due to secondary task engagement, with respect to the following issues:

1) Changes in driving outcomes (e.g., crash experience, speeding, kinematic risky driving) over time among novice teenage drivers relative to adults driving the same vehicles over the same period of time and roads.

2) The extent to which changes in novice teenage driving risk were due to improvements in measures of driving performance.

3) The extent to which teenage CNC risk varied by psycho-social and other predictors.

4) Statistical methods for evaluating CNC risk among novice teenage drivers.

METHOD

The NTDS study collected objective driving data over an 18-month period and collected survey data every 6 months to evaluate patterns and predictors of driving performance. Information about participants' inclusion criteria, vehicle instrumentation, and measures are provided below; additional detail was reported in Lee et al. (2011). The study was conducted between June 2006 and September 2008.

Participants

A volunteer sample of 42 newly-licensed teenagers (22 females and 20 males with an average age of 16.4 years ±0.3) and at least one of their parents was recruited through driving schools and local media in the metropolitan areas of Blacksburg and Roanoke, Virginia, USA, where a provisional driver's license could be obtained at the age of 16 years and three months (Lee et al., 2011). Consistent with the demographics of the area, the participants were 93% white and over 50% of the families reported annual incomes of > $100,000/year, well above the national average. Identical twins and teenagers with Attention Deficit Disorder or Attention Deficit Hyperactivity Disorder were among the exclusion criteria in this study. Study participants were provided up to $2000 for completion of all aspects of the study. The protocol was reviewed and approved by the Virginia Tech Institutional Review Board. Parent consent and teenage participant assent were obtained. Maintenance of participation was very high, with only one drop out (at 8 months).

Vehicle Instrumentation

Vehicle instrumentation included a sophisticated driving data acquisition system (DAS) designed at the Virginia Tech Transportation Institute (Dingus et al., 2006). It consisted of a computer that received and stored data from accelerometers that assessed kinematic data, a global positioning system (GPS), and video recorders. Cameras were installed strategically so that they could identify and continuously monitor the driver's face, hand and arm movements, dashboard, and forward and rearward roadway. Two other cameras provided periodic still shots of the vehicle interior (blurred to protect the anonymity of passengers) and the lap area of the rear passenger seat, allowing coders to determine passenger presence, gender, relative age, and seatbelt use. Vehicles (mostly sedans; no trucks) were instrumented within 3 weeks of provisional licensure allowing unsupervised driving and maintained for 18 months.

Measures

The video of every trip was viewed and the identification of the driver, the presence of passengers by age (adult, teen, youth) and sex, ambient light (day, dawn or dusk, night), and weather conditions were identified. A variety of kinematic measures were obtained from the data acquisition system, including crashes and near crashes (CNC), elevated gravitational force (g-force) events, and speeding, described fully elsewhere (Lee et al., 2011; Simons-Morton et al., 2011a). Very high g-force events were viewed to identify crashes (involving physical contact) and near crashes (close calls where physical contact was avoided by an evasive maneuver), which were combined in analyses as CNC (Guo, 2010). Rates of g-force events above determined thresholds, but excluding those associated with CNC, were included in the measure of KRD (Simons-Morton et al., 2011a). Driver exposure was identified by GPS.

Survey data were collected at baseline, 6, 12, and 18 months when the study participants brought their vehicles in for instrumentation. The survey measures are listed in Table 1 and fully described elsewhere (Simons-Morton et al., 2011a,b; Simons-Morton et al., 2012b,c; Ehsani et al, 2014a). Participants completed the >60-minute surveys separately according to procedures for honoring privacy.

Early in the study a standard stress-inducing test (a mathematical test) was administered and saliva swabs were collected for later analyses of the hormone, cortisol. These data were analyzed for stress responsivity by an experienced laboratory.

Distraction was assessed by trained technicians who coded the video of each CNC and randomly-sampled (baseline) road segment according to the presence of many common secondary tasks or task categories (e.g., reaching for object).

Speed was assessed by GPS as well as the on-board vehicle network and compared to the posted speed limits. The average number of speeding events 10+ miles over the speed limit per 100 miles and the percent of time over 10 mph over the speed limit was determined (Simons-Morton et al., 2012b).

Driving skill was assessed by an unsafe driving index for which technicians scored data from kinematic, secondary task, and eye movement sources to assess performance in selected merges and intersections, providing scores that were weighted by expert consensus to reflect their relationship to safety (Pradhan et al., 2011).

Analyses

A variety of analyses were employed. Poisson distributions were specified for the count data from CNC and KRD events, and rates were calculated with the logarithm of miles driven as an offset (which adjusts for mileage) and with subject-specific random effects to account for over-dispersion and correlation over time. Generalized linear mixed models were employed to calculate median incidence rates and odds ratios comparing teenage and adult drivers across time. The association of secondary task engagement with CNC was estimated by comparing the prevalence of the tasks observed in each CNC with the prevalence of the tasks in a random sample of non-CNC road segments. Prevalence of task engagement was further assessed over time by comparing scores for teenage and parent participants aggregated over 3-month periods and compared using repeated measures ANOVA. Psycho-social variables were treated as continuous, for example, as potential predictors of speeding using multivariate regression with random intercepts specified based on trip data, with driver sex as a covariate.

FINDINGS

Shown in Table 1 for each psycho-social variable (measured at baseline) are the prospective associations with the 18-month per mile rate for the driving outcomes of speeding, KRD, and CNC. Accordingly, having more friends who engaged in risky driving and other risky behavior (risky friends) was associated with the rate of speeding, KRD, and CNC. Sensation seeking was associated with speeding. No other psychosocial or personality variable was associated with any of the driving outcomes, although risk perception moderated the association between risky friends and speeding – perceived risk was negatively associated with speeding among teenage participants with more risky friends.

Table 2, organized by driving outcome, shows the main findings and predictors for that outcome.

Exposure

On average teenagers drove 367 miles (590 km) per month during the 18-month period, ranging from 315 miles (507 km) in the first month to 441 miles (710 km) in the last month, with substantial variability (Lee et al., 2011). Average mileage for the 18-month study period was 6384 miles (10274 km), of which 24% was at night and 62% with no passengers and about 38% of the time with passengers (29% with one passenger and about 8-9% with more than one passengers; Klauer et al., 2011). Participants drove with an adult less than 15% of the time during the first three months, and less than 10% thereafter, particularly among those with their own vehicle compared to those sharing a vehicle with their family. Average miles driven increased over time. Participants with exclusive vehicle access,

compared with those who shared a vehicle, drove more overall, at night, and with multiple passengers.

Crashes and Near-Crashes

Teenage CNC rates declined significantly, if unevenly, particularly over the first 6-9 months of driving, but were 3.9 times higher among novices than adult participants on average and remained significantly higher after 18 months, as shown in Figure 1A (Simons-Morton et al., 2011a). Three groups were identified with different CNC rates of 21.8 (high-risk), 8.2 (moderate-risk), and 2.1 (low-risk) per 10 000 kilometers traveled (Guo et al., 2013). CNC rates did not vary over time for the high- and low-risk groups, but declined for moderate-risk drivers from 8.8/10 000 kilometers in the first quarter to 0.7 in the fourth quarter, before increasing to 3.2 in the fifth quarter. The three groups were not distinguishable with respect to personality characteristics. The high-risk drivers did not improve with experience, with CNC rates consistently high throughout the 18-month study period. Analyses of the hormone, cortisol, revealed that teenager with a normal response to stress had lower CNC rates during the 18-month assessment and a significant decrease in CNC rate over time compared to those with a blunted response to stress (Ouimet et al., 2014). The best psychosocial predictor of CNC was friends' risk behavior (Simons-Morton et al., 2011b).

Distraction Due to Secondary Task Engagement

Secondary task engagement during the 5 seconds prior or 1 second after each at-fault crash and near-crash were identified by coders watching the video footage, and rates were compared with those in randomly-sampled, non-CNC road segments. The following secondary tasks were significantly associated with CNC: cell phone dialing (odds ratio (OR) = 8.3, 95% CI: 2.8-24.4); reaching for objects other than phone (OR = 8.0, CI: 3.7-17.5); reaching for a phone (OR = 7.1 CI: 2.6-18.8); texting (OR = 3.9 CI: 1.6-9.3); looking fixedly at an external object (OR = 3.9 CI, 1.7 – 8.8); and eating (OR = 3.0, CI 1.3-6.9). Similar analyses of data collected as part of the 100-Car Study (Dingus et al., 2006) on a group of 109 older, experienced drivers served as a comparison. Among experienced drivers only dialing was significantly associated with CNC (texting was not common at the time the 100-Car study was conducted from January 2003 to July 2004). The prevalence of high-risk secondary task engagement increased over time among novices but not among experienced drivers (Klauer et al., 2014). For secondary tasks associated with CNC, risk increased as a function of the single longest eye glance during task engagement (Simons-Morton et al., 2014).

Kinematic Risky Driving

The correlation between CNC and KRD was r=0.60 (p>0.001). Higher KRD rates in the past month significantly increased the risk of a crash in subsequent months (OR=1.07; 95% CI = 1.02-1.12), particularly during the first 6 months of licensure (Simons-Morton, Zhang, Jackson, & Albert, 2012a). Operating characteristic curve models showed relatively high predictive accuracy, with an area under the curve of 0.74, or about 74% accuracy between KRD at any level and CNC.

Shown in Figure 1B, KRD rates were much higher over time (Simons-Morton et al., 2012b). On average KRD rates were 5.08 times higher than for adults (parents). Rates varied considerably within the sample (data not shown) Simons-Morton et al., (2012c). KRD rates were lower at night than during the day, highest when the driver had no passengers, lowest in the presence of adult passengers, and somewhat lower in the presence of a teenage passenger (Simons-Morton et al., 2011b). Friends' risky behavior was the best predictor of higher KRD rates (Simons-Morton et al., 2011b).

Speeding Over-Time

While speeding 10+ mph over the speed limit was not more prevalent among teenagers than adults, it increased about 50% over time among teenagers (Simons-Morton et al., 2012b). Speeding was correlated with CNC rates (r=0.23, ns) and KRD rates (r=0.37, $p < 0.05$). Speeding was less common at night. Speeding was more prevalent among teenagers who reported more risky friends, particularly among those who reported lower perceived risk for risky driving ($p < 0.001$). Those with exclusive access to a vehicle were more likely to speed than those who shared a vehicle and more likely to speed at night and with passengers (Klauer et al., 2011).

Safe Driving Skill

Safe driving skill is notoriously difficult to measure and there are few if any longitudinal analyses of changes in driving skills related to safety. Because many errors would be expected for novices when encountering complex driving situations, common merges and intersections were identified and the video footage was examined by coders. An unsafe driving index measured left turn and merge ramp skills such as use of turn signals, lane management, eye glances away from the forward roadway and at mirrors, and secondary task engagement. Teenagers had better scores (made fewer errors) than adults, particularly during the first 6 months, but teenage drivers' scores declined over time (Pradhan et al., 2013). Novice drivers tended to rigorously apply the safety skills they were taught as learners, often making multiple eye glances toward mirrors or blind spot even when there were no following vehicles, while adults applied these safety behaviors in a more contextual way, often not signaling or looking in the blind spot when there was no following vehicle.

Predictors of Risk

The study assessed a range of possible risk predictors for the several driving outcomes of interest. A summary of the findings is provided in Table 1.

Psycho-Social Predictors—While many of the psycho-social variables assessed at baseline were associated with risk in bivariate analyses, in adjusted analyses typically only the measure of social norms, friends' risky behavior, was consistently associated with risk, including CNC, KRD, (Simons-Morton et al., 2011b), and speeding (Simons-Morton et al., 2012b). Risk perception was not directly associated with risk, but did moderate the association between risky friends and speeding. None of the other variables, including tolerance of deviance, sensation seeking, and the five personality traits assessed by the NEO Five-Factor Inventory, were related to risk outcomes (see Table 1).

Teenage-Parent Correlations in Risk—It is logical that teenagers would drive like their parents, given how much they share common experiences, have similar values, drive on the same roads in the same cars, and the like. Parents and teenagers are also likely to share similarities in personality and other psychological characteristics. Because parents and teenagers shared the same instrumented-vehicle in many cases, we were able to assess teenage-parent associations. During the first six months of driving, teenage-parent correlation in KRD was significantly, positively correlated (Ehsani et al., 2014b). The overall correlation between teenage and parent kinematic risky driving for the 18-month study period was positive, but weak and not significant (r=0.18). When the association between parent and teenagers' risky driving was adjusted for shared personality characteristics, the correlation reduced to 0.09. Although interesting, the 95% confidence intervals on the difference between these two estimates overlapped zero, suggesting that the weak similarity in parent-teenage kinematic risky driving was partly explained by shared personality characteristics.

Methods Research

Given the unusual data structure, with relatively few study participants, but frequent observations on each, standard statistical methods for longitudinal data analysis have poor statistical properties (such as providing biased association estimates). For count data like CNC, Poisson distributions were assumed, and for prevalence estimates data were aggregated over 1, 3, or 6 month periods as a form of "smoothing" the distributions. The research generated a number of important methods and statistical papers. One paper demonstrated that KRD rates in a month predicted the likelihood of a CNC in the following month, with good diagnostic accuracy (area under the Receiver Operating Curve = 0.76; Simons-Morton, Zhang, & Albert, 2012a). KRD rates declined immediately but briefly after a CNC, and did not alter the prediction of CNC.

Other methods research focused on the variability in the distribution on risk variables. As noted earlier, using a k-sort cluster analyses, Guo et al. (2013) reported three CNC groups, one with persistently high CNC rates, one with persistently low CNC rates, and one with initially high rates that declined after 6 months. Some novices may have been better judges of their driving abilities initially, while others seemed to learn from their driving experience, and others did not seem to learn from experience.

One paper examined the KRD trajectories (Simons-Morton et al., 2012c). Using latent class models, KRD over the 18-month period was best characterized as two classes, over the entire study period. However, there was substantial variability in KRD rates within groups.

Another set of analyses examined the utility of ordinal latent variable models for jointly modeling the association of CNC and KRD, allowing to make inference about the dependence between these two processes across time (Jackson et al., 2012). These models were also used to formulate a predictor of CNC from KRD and other subject-specific covariates. Another set of analyses used the NTDS data to explore marginal analyses of count data in long sequences, taking into account both subject-level covariates (e.g., gender) and trip-level or time-dependent covariates (e.g., time since licensure, presence of passengers; Zhang, Albert, & Simons-Morton, 2012). Lastly, Kim et al. (2013) proposed a

Poisson regression model with stochastic random effects to examine the between- and within-subject variation in KRD for these trip-level count data. The analyses showed that the within-subject variation is approximately the same as the between-subject variation, suggesting large individual variation in KRD behavior across time for the same subjects; an observation that is not possible with standard statistical procedures.

DISCUSSION

The potential of naturalistic driving, first suggested in the 100 Car Study (Dingus et al., 2006; Klauer et al., 2014) for identifying proximal contributing causes of CNC among adult drivers, was demonstrated by the NTDS for the first time with novice teenage drivers. Analyses of data from the Naturalistic Teenage Driving Study confirmed the following: (a) CNC rates were highest early in licensure, but on average (despite substantial variability) declined rapidly over the course of the study, suggesting that teenagers learned from driving experience how to avoid crashing or experiencing near misses; (b) KRD and secondary task engagement were significantly associated with CNC, suggesting the potential of a convenient way to identify and notify individuals at high risk for CNC using accelerometers in routine driving; (c) However, over time safe driving behaviors declined, KRD rates remained high, and the prevalence of secondary task engagement and speeding increased.

These findings suggest the following: (a) risky driving behaviors contributed but did not fully explain CNC risk; (b) novice teenagers appeared to maintain or increase dangerous driving practices despite CNC experience or increased risky driving behavior as they gained experience, consistent with theories of risk homeostasis (Wilde, 1998). That is, rather than learning from experience to reduce risky driving behavior, novice teenagers learned how to engage in relatively high risk driving behaviors while managing to moderate CNC risk (Wilde, 1998).

The study found substantial inter-individual variability in measures of driving outcomes and contributing factors, indicating that some novices experienced greater risk than others, with perceived social norms and cortisol responsivity the best personal predictors of CNC. Curiously, two important risk factors for fatal crashes, teenage passenger presence and night driving, were negatively associated with CNC rates.

The findings are consistent with the contention that novice teenage driving risk is due both to inexperience and risky driving behavior and suggest that the high crash risk among novice teenage drivers may be due in part to the driving conditions in which they engage in risky driving behavior such as speeding, KRD, and secondary tasks.

Summary of New or Confirmatory Findings

The study also reported the following new findings, not previously reported or emphasized in previous literature.

1. Crashes and near crashes declined over time but remained nearly four times higher than adults over the first 18 months of licensure.

2. Kinematic risky driving, the rate of elevated gravitational-force events, was more than five times higher among novices than adults over the first 18 months of licensure.
3. Contributing factors to teenage Crash/Near Crash rates included secondary task engagement (e.g., distraction), kinematic risky driving, low stress responsivity, and risky social norms.
4. Secondary task engagement was riskier for novice teenagers than adults, despite little difference in prevalence. Risky non-driving tasks for teenagers included dialing, answering, and locating a phone; texting; reaching for objects; eating; and staring fixedly at outside objects. The longer teenage drivers glanced away from the forward roadway, the greater the CNC risk. These findings result indicates that CNC risk increases when drivers take their eyes off the forward road while engaging in visual-manual tasks.
5. Perceived risk behavior of close friends was the best psycho-social predictor of risk, including CNC, KRD, and speeding, indicating the importance of social norms on driving behavior.
6. CNC risk was persistently high for one group of participants, persistently low for another group, and initially high but declined for a third group, suggesting that some participants drove within their limits, some learned from driving experience, while others were insensitive to experience.
7. CNC and KRD risk was greatest when driving alone and lower when driving with other teenage or adult passengers, but teenagers drove most of the time alone and parents seldom rode with their teenage children after licensure.
8. KRD did not decline over time. There were two KRD trajectory groups, one higher and one lower, with wide variability between and within groups.
9. Teenagers drove somewhat like their parents. The modest shared variance in parent-teenage driving contributed little to overall teenage driving risk.
10. Safe driving behaviors (as taught in driving school) were higher among novices than experienced adults early in licensure, but declined over time. Novice teenage drivers appeared to have adequate vehicle management skill, but lacked judgment consistent with driving safety.

Practical Implications For Practice, Policy, and Research

The NTDS findings are relevant for policy and practice in the following ways:

1. 1. Training
    A. Pre-license training and practice seemed to prepare teenagers to engage in many appropriate safety-related behaviors, and novices tended to apply them diligently initially, but less so over times and not always as needed to improve safety.

B. Research is needed on how best to provide training that better generalizes to independent driving safety.

2. Graduate Driver Licensing programs

A. Secondary task engagement by novice teenagers is strongly associated with crash risk and should be a major focus of efforts to increase Graduate Driver Licensing programs and foster greater parental limit setting.

B. Passengers

○ Adult passenger presence is associated with lower teenage driving risk and parents should be encouraged to more frequently accompany their newly licensed teenage children and encourage and reinforce safe driving behavior.

○ The findings provided no evidence that teenage passengers are associated with increased CNC risk.

○ Research is needed to determine if teenage passenger risk varies by driver and passenger characteristics and driving conditions.

3. Risk Factors

A. Both inexperience and risk taking were associated with risk measured by CNC, KRD, and speeding rates.

B. Variability was high in all measures of risk.

○ CNC and KRD risk was minimal for some teenagers and high for others. It may be possible and desirable to identify and intervene with higher-risk teenager drivers.

○ Predictors of CNC risk included KRD, secondary task engagement, insensitivity to stress, and social norms, indicating the presence of higher-risk groups.

○ Research is needed to determine the extent to which the variability in risky driving behavior and driving outcomes vary by driving conditions.

Study Strengths and Limitations

The NTDS provided a wealth of new information about teenage driving performance and risk. However, given the small regional sample and the lack of other naturalistic studies of novice teenage driving for comparison, these findings must be considered tentative, pending verification in future research.

The Future of Naturalistic Driving Research

For decades archival crash databases provided a foundational understanding of predictors of crash risk that informed policy and prevention efforts. The advent of objective, naturalistic driving methods represents a significant new research approach for the study of road safety. The NTDS is an early naturalistic driving study that has provided new insights into the nature of novice teenage driving risk, predictors, and individual variability that can inform a

new generation of prevention efforts. The NTDS has showcased the potential of naturalistic methods for studying driving performance, providing a rich and powerful dataset and objective confirmation of previous research findings and identifying important contributing factors.

The costs of naturalistic driving studies have continually declined and a number of naturalistic studies have since been conducted or are underway employing advances in naturalistic technology, including smaller and less obtrusive data acquisition systems; remote downloading capabilities; new sensor measures; and substantially greater potential for automated data reduction and coding. Larger studies, such as the recently completed SHRP2 (Transportation Research Board, 2015), will provide more generalizable findings and allow subgroup and interaction analyses not possible with small samples.

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Highlights

1. Crashes and near crashes declined over time but remained nearly four times higher than adults over the first 18 months of licensure.
2. Kinematic risky driving, the rate of elevated gravitational-force events, was more than five times higher among novices than adults over the first 18 months of licensure.
3. Contributing factors to teenage Crash/Near Crash rates included secondary task engagement (e.g., distraction), kinematic risky driving, low stress responsivity, and risky social norms.
4. Secondary task engagement was riskier for novice teenagers than adults, despite little difference in prevalence. Risky non-driving tasks for teenagers included dialing, answering, and locating a phone; texting; reaching for objects; eating; and staring fixedly at outside objects.
5. The best predictor of risky driving outcomes was having friends who engaged in risky driving and other risky behaviors.

Note: MIR = median incident rate; IRR = incident rate ratio

Figure 1A.
Teenage and parent crash/near crash median incident rate ratios per 3-month period.

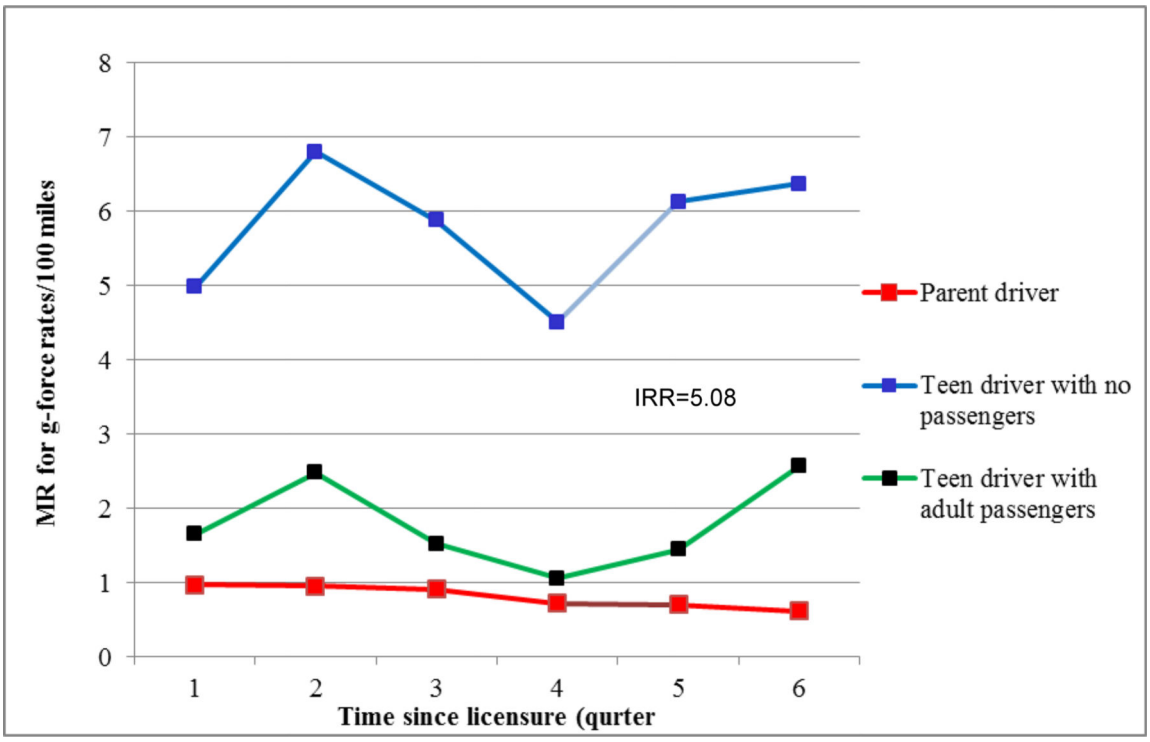

Figure 1B.
Teenage and parent kinematic risky driving median incident rate ratios per 3-month period.

Table 1

Properties of baseline psychosocial variables for teenage participants & significant associations with driving outcomes.

Psychosocial and Personality Variables*	# Items	Range	Mean (SD)	Cronbach's Alpha	Significant Associations with Driving Outcomes (column 1)
Risky Friends[a]	7	0-4	0.81 (0.54)	0.80	CNC, KRD, Speeding
Tolerance of deviance	8	0-3	0.89 (0.53)	0.86	None
Non-driving subscale	5	0-3	0.87 (0.75)	0.73	None
Driving Subscale	3	0-3	0.64 (0.56)	0.78	None
Susceptibility to peer pressure	11	0-3	0.53 (0.40)	0.77	Trend for speeding
Risk Perception	14	1-5	3.82 (0.47)	0.85	Moderation: speeding, risky friends
Personality Traits					
SS[b] Scale (Form V)	40	1-2	1.38 (0.17)	0.87	Speeding
NEO-FFI[c]					
Agreeableness	12	12-60	31.59 (5.97)	0.74	None
Conscientiousness	12	12-60	29.78 (6.51)	0.81	None
Extraversion	12	12-60	30.24 (5.65)	0.74	None
Neuroticism	12	12-60	18.93 (8.07)	0.88	None
Open to experience	12	12-60	27.62 (6.28)	0.74	None

*Measures described elsewhere (Simons-Morton et al., 2011a,b; Ehsani et al. 2014)

[a]How many of 5 closest friends drive in risky manner, smoke, drink, etc.

[b]SS = sensation seeking

[c]NEO-FFI = NEO Five-Factor Inventory.

Table 2

Summary of the Naturalistic Teenage Driving Study findings

Measures/Outcomes	Findings	Predictors[1]
Exposure Miles/km/month	Teen mileage increased over time Month 1 = 315 miles/507 km Month 18 = 441 miles/710 km/mo Average per month: 367 miles (590 km): - 24% at night - 62% with no passengers - 29% with 1 passenger (teen or adult) - 17% with adult passenger(s) - 10% with multiple passengers (teen or adult)	Teen miles driven: - Increased over time - Exclusive vs shared vehicle • Drove more on average • Drove more at night • Drove more with multiple passengers
Crash and near crash (CNC)	Teen: 37 crashes; 242 near crashes - CNC highest during first 6 mo - CNC declined rapidly for 6-9 months Adults: 2 crashes; 34 near crashes Teen vs adult CNC (OR=3.91) Teen CNC groups: - persistently high (n=13) - persistently low (n=13) - high then declining (n=16)	Association with higher teen CNC: - Adult passengers (OR=0.26) - More risky friends (OR=1.87) - Higher cortisol response (OR=0.93) - TA passengers (ns) - Night vs day (ns) - 2nd Task Engagement (see next row)
Distraction Odds ratios = (prevalence/CNC// prevalence/non-CNC road segments)	Higher CNC w/ 2nd task among TA than adults TA: longer eye glances off the forward road way for >2 seconds = greater CNC risk (OR= 3.8)[2]	Association with higher teen CNC rate: - Phone dialing (OR=8.3) - Texting (OR=3.9) - Phone reaching (OR=7.1) - Reaching for other object (OR=8.0) - Staring fixedly outside vehicle (OR=3.9) - Eating (OR=3.0) - Phone talking (ns) - Vehicle operations (ns) Association with higher adult CNC rate: - Phone dialing (OR=2.5)
KRD - composite measure (internal consistency r=0.78): - Stops ≥ −0.45*g* - Starts ≥ −0.35*g* - Turns ≥ −.50*g* - Yaw = *delta v* of turn & correction	KRD higher among TA than adults (OR=5.08) TA: 2 trajectory classes w/ high variability - Higher at night, w/ risky friends - Lower w/ teen or adult passengers	Association with KRD: - More vs fewer risky friends (OR=1.97) - Teen vs no passengers (OR=0.81) - Adult vs no passengers (OR=0.32) - Night vs day (OR=0.81)
Speeding 10 miles over the speed limit for 0.1 seconds in selected road segments	Increased over time Correlations: CNC *r*=0.23 (ns) KRD *r*=0.37 (p < 0.05)	Greater teen speeding 10 MPH+ over limit: - Over time - Exclusive vs shared vehicle - Substance use - Risky friends - Sensation seeking - Deviance acceptance - Susceptibility to peer pressure
Driving Skill Index of safe driving errors in merges & intersections	Compared to experienced adults, novice TA had fewer average errors, which increased over time.	Experience was associated with more errors.

KRD= Kinematic Risky Driving;

[1] Only significant odds ratios presented; in all reported ORs the 95% intervals did not overlap 1.0

[2] Analyses of associations between 2nd task and CNC included only at fault or partially at fault CNC; other analyses included all CNC