SPECIAL ARTICLE

Distracted Driving and Risk of Road Crashes among Novice and Experienced Drivers

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ABSTRACT

BACKGROUND

Distracted driving attributable to the performance of secondary tasks is a major cause of motor vehicle crashes both among teenagers who are novice drivers and among adults who are experienced drivers.

METHODS

We conducted two studies on the relationship between the performance of secondary tasks, including cell-phone use, and the risk of crashes and near-crashes. To facilitate objective assessment, accelerometers, cameras, global positioning systems, and other sensors were installed in the vehicles of 42 newly licensed drivers (16.3 to 17.0 years of age) and 109 adults with more driving experience.

RESULTS

During the study periods, 167 crashes and near-crashes among novice drivers and 518 crashes and near-crashes among experienced drivers were identified. The risk of a crash or near-crash among novice drivers increased significantly if they were dialing a cell phone (odds ratio, 8.32; 95% confidence interval [CI], 2.83 to 24.42), reaching for a cell phone (odds ratio, 7.05; 95% CI, 2.64 to 18.83), sending or receiving text messages (odds ratio, 3.87; 95% CI, 1.62 to 9.25), reaching for an object other than a cell phone (odds ratio, 8.00; 95% CI, 3.67 to 17.50), looking at a roadside object (odds ratio, 3.90; 95% CI, 1.72 to 8.81), or eating (odds ratio, 2.99; 95% CI, 1.30 to 6.91). Among experienced drivers, dialing a cell phone was associated with a significantly increased risk of a crash or near-crash (odds ratio, 2.49; 95% CI, 1.38 to 4.54); the risk associated with texting or accessing the Internet was not assessed in this population. The prevalence of high-risk attention to secondary tasks increased over time among novice drivers but not among experienced drivers.

CONCLUSIONS

The risk of a crash or near-crash among novice drivers increased with the performance of many secondary tasks, including texting and dialing cell phones. (Funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development and the National Highway Traffic Safety Administration.)

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DRIVERS WHO ARE 15 TO 20 YEARS OF AGE constitute 6.4% of all drivers, but they account for 10.0% of all motor vehicle traffic deaths and 14.0% of all police-reported crashes resulting in injuries.[1] These rates are thought to result from a combination of young age, inexperience, and risky driving behaviors.[2]

One of the riskiest driving behaviors is the performance of a secondary task, and novice drivers appear to be particularly prone to this distraction.[3] Distracted driving has been defined as the "diversion of attention away from activities critical for safe driving toward a competing activity."[4] Drivers engage in many competing tasks (including eating, adjusting the radio, and talking to passengers) that are not related to operating the vehicle in traffic, but the use of electronic devices such as cell phones while driving has garnered the most public and mass-media interest. An estimated 9% of all persons who drive during the day do so while dialing or talking on a cell phone or sending or receiving text messages.[3]

Estimates based on cell-phone records indicate that cell-phone use among all drivers increases the risk of a crash by a factor of 4.[5,6] Likewise, simulator studies involving adolescent drivers indicate that texting while driving increases the frequency of deviations in a lane relative to the position from the centerline.[7] Adolescents who were using a cell phone on a test track were more likely than experienced adult drivers who were using a cell phone to enter an intersection at a red or yellow light.[8] Simulation and test-track research on distraction among experienced drivers indicates that cell-phone use delays reaction to potential hazards,[9-11] increases following distances,[12] and decreases the driver's visual scanning of the environment.[13,14] Performance of a secondary task can increase the risk of a crash because it is cognitively demanding (preventing the driver from devoting full attention to driving) and because it takes the driver's eyes off the road ahead so that he or she cannot see and respond to unexpected hazards.[15]

Both the 100-Car Naturalistic Driving Study (hereinafter called the 100-Car Study),[14] which involved experienced drivers, and the Naturalistic Teenage Driving Study (NTDS),[16] which involved novice drivers, used data-recording devices installed in the participants' vehicles to assess their behaviors while driving and during a crash or near-crash. In previous analyses of NTDS data, we reported that among newly licensed drivers, the rates of crashes or near-crashes were 3.9 times as high as the corresponding rates among their parents when they drove the same vehicles, and the rates of a gravitational-force event (e.g., hard braking or making sharp turns or an overcorrection) were 5.1 times as high.[15] Here we report the results of our analysis of both studies with respect to the prevalence of engagement in a secondary task and the associated risk of a crash or near-crash among novice and experienced drivers.

A Quick Take animation is available at NEJM.org

METHODS

STUDY DESIGN AND OVERSIGHT

The NTDS data were collected from June 2006 through September 2008, and the 100-Car Study data were collected from January 2003 through July 2004. The two studies used similar experimental methods, detailed descriptions of which have been reported previously.[14,16]

We used a case–cohort approach to compare the prevalence of each task in the seconds before a crash or near-crash with the prevalence of the task during randomly sampled control periods of driving. We conducted separate analyses involving novice drivers and experienced drivers.

In both studies, adults provided written informed consent, and adolescents (i.e., those under the age of 18 years) provided written informed assent. Both studies were approved by the institutional review board of Virginia Polytechnic Institute and State University.

PARTICIPANTS

In the NTDS, 42 newly licensed drivers (22 females and 20 males) from southwestern Virginia were recruited, and instruments were installed in their personal vehicles. At the initiation of the study, the mean (±SD) age of the participants was 16.4±0.3 years of age, and they had had a driver's license for 3 weeks or less. They received a total of $1,800 in monthly and end-of-study compensation for participation in the 18-month study.

In the 100-Car Study, 109 participants (43 women and 66 men) between the ages of 18 and 72 years (mean age, 36.2±14.4 years) from the Washington, D.C., area were recruited. The mean length of time that participants had been driving was 20.0±14.5 years. A total of 22 participants were compensated with the use of a leased ve-

Table 1. Secondary Tasks Observed in the Studies.*

Talking on a cell phone (either a handheld or a hands-free device)
Dialing a cell phone or other handheld device (includes the use of shortcut keys)
Reaching for a cell phone (includes locating and answering)
Reaching for an inanimate object inside the vehicle
Sending text messages or using the Internet to read e-mail or Web content
Adjusting the radio, HVAC, or other internal vehicle system with controls on the dashboard
Adjusting controls other than those for the radio or HVAC (e.g., windows, seat belt, rearview mirror, or sun visor)
Looking at a roadside object (e.g., a previous crash or highway incident, a construction zone, a pedestrian, an animal, or other known or unknown object)
Eating (with or without utensils)
Drinking a nonalcoholic beverage from an open container with or without a lid, straw, or both†

* HVAC denotes heating, ventilation, and air conditioning.
† Cases in which alcohol consumption was suspected were not included in the current analysis.

hicle, and 87 participants drove their own vehicles; the latter group received a total of $1,800 ($125 per month plus $300 at the end of the 12-month study).

EQUIPMENT

Instruments with the same data-acquisition systems (developed at the Virginia Tech Transportation Institute) were installed in vehicles in both studies. These systems included four cameras (forward view, rear view, view of the driver's face, and view over the driver's right shoulder) and a suite of vehicle sensors that included a multiaxis accelerometer, forward radar, a global positioning system, and a machine-vision lane tracker. Video and driving-performance data were collected continuously for the duration of the studies.[15,17]

DATA CODING AND ANALYSIS

Highly trained analysts used threshold values obtained through a sensitivity analysis of the vehicle-sensor data (e.g., braking at more than 65 gravitational units)[16] to identify potential crashes and near-crashes. The operational definition of a crash was any physical contact between the vehicle and another object for which the driver was at fault or partially at fault. (None of the crashes involved a death or serious injury.) The operational definition of a near-crash was any circumstance requiring a last-moment physical maneuver that challenged the physical limitations of the vehicle to avoid a crash for which the driver was at fault or partially at fault.

On the basis of prespecified criteria, we excluded events in which the driver was considered to be not at fault (108 events in the NTDS and 190 events in the 100-Car Study) and in which the driver was observed to be drowsy or under the potential influence of drugs or alcohol (7 events in the NTDS and 113 events in the 100-Car Study). The analyses included 31 crashes and 136 near-crashes among novice drivers and 42 crashes and 476 near-crashes among experienced drivers. Previous analyses have shown that near-crashes are reliable surrogates for crashes.[18]

Randomly sampled control periods that consisted of 6-second time segments during which the vehicle was moving faster than 5 mph were selected to represent typical or "normal" daily driving conditions. For each driver, sampling for control periods was stratified according to the number of miles the vehicle had traveled (in the NTDS) or the number of hours the person had driven (in the 100-Car Study). Thus, the number of control periods for each driver was proportional to either the distance of travel (e.g., one sample per 50 vehicle miles traveled) or the duration of travel (e.g., two samples per hour driven).[17]

Two analysts viewed the video footage before each confirmed crash or near-crash and identified and coded secondary tasks. Analysts also viewed the video footage of the randomly sampled control periods and recorded the performance of secondary tasks. The identified secondary tasks were organized according to the 10 categories listed in Table 1.[15] Operational definitions of the tasks were identical in the two studies; texting was assessed only in the NTDS, since the 100-Car Study was performed before this activity was widely used.

A secondary task was included if it occurred within the 6-second duration of each sampled control period or within 5 seconds before or 1 second after the onset of the crash or near-crash. Coding continued for 1 second after the onset of the crash or near-crash to capture behaviors that continued because the driver was not aware of the onset of the crash or near-crash.

It was not considered feasible for analysts to be unaware of whether a crash or near-crash occurred, but they were unaware of the purpose of the analyses and recorded many variables in addition to performance of secondary tasks. Any disagreements among analysts were adjudicated by a senior researcher. Interrater reliability, which was determined by comparing the analysts' assessments of the performance of secondary tasks during control periods with the assessments of a senior researcher, was 88.4% in the 100-Car Study[17] and 93.3% in the NTDS (see Tables S1 and S2 of Appendix 1 in the Supplementary Appendix, available with the full text of this article at NEJM.org).

STATISTICAL ANALYSIS

We used a mixed-effects logistic-regression analysis to estimate odds ratios for a crash or near-crash associated with each category of distracting task. We conducted separate regression analyses involving novice drivers and experienced drivers. A random intercept was assigned to each driver to incorporate within-driver correlations.

The prevalence of engagement in a secondary task was calculated per 3-month interval as the percentage of control conditions in which any recorded secondary task was observed. A mixed-effects linear-regression model was used to assess trends for performance of a secondary task over time by both novice and experienced drivers.

Table 2. Odds Ratio for a Motor Vehicle Crash or Near-Crash Associated with Performance of a Secondary Task.*

Task	Novice Drivers	Experienced Drivers
	Odds Ratio (95% CI)	
Using cell phone		
Texting or using Internet	3.87 (1.62–9.25)	NA†
Dialing	8.32 (2.83–24.42)	2.49 (1.38–4.54)
Talking	0.61 (0.24–1.57)	0.76 (0.51–1.13)
Reaching for phone	7.05 (2.64–18.83)	1.37 (0.31–6.14)
Reaching for object other than cell phone	8.00 (3.67–17.50)	1.19 (0.61–2.31)
Looking at roadside object	3.90 (1.72–8.81)	0.67 (0.37–1.22)
Adjusting controls for radio or HVAC	1.37 (0.72–2.61)	0.53 (0.30–0.94)
Adjusting controls other than those for radio or HVAC	2.60 (0.89–7.65)	0.64 (0.15–2.65)
Eating	2.99 (1.30–6.91)	1.26 (0.74–2.15)
Drinking nonalcoholic beverage	1.36 (0.31–5.88)	0.44 (0.16–1.22)

* The analysis of the 100-Car Naturalistic Driving Study involving experienced adult drivers was based on 518 crashes and near-crashes for which the driver was at fault or partially at fault and 16,614 control periods. The analysis of the Naturalistic Teenage Driving Study was based on 167 crashes and near-crashes for which the driver was at fault or partially at fault and 5238 control periods. CI denotes confidence interval, and NA not applicable.

† Texting, accessing the Internet, or both rarely occurred during the data-collection period in the 100-Car Study, so this task could not be appropriately evaluated with the use of the data from this study.

RESULTS

RISK OF A CRASH OR NEAR-CRASH

The odds ratios and corresponding confidence intervals for a crash or near-crash associated with each secondary task are shown in Table 2. Among novice drivers, dialing or reaching for a cell phone, texting, reaching for an object other than a cell phone, looking at a roadside object such as a vehicle in a previous crash, and eating were all associated with a significantly increased risk of a crash or near-crash. Among experienced drivers, only cell-phone dialing was associated with an increased risk. Table 1 of Appendix 2 in the Supplementary Appendix shows the prevalence of engagement in secondary tasks as a percentage of crashes and near-crashes and as a percentage of control periods.

PREVALENCE OF ENGAGEMENT IN SECONDARY TASKS

As shown in Figure 1, the prevalence of engagement in a secondary task was estimated as the percentage of randomly sampled control periods in which they occurred. The incidence of high-risk performance of secondary tasks did not change significantly over time among the experienced drivers ($P=0.61$ for trend). Novice drivers engaged in secondary tasks more frequently over time ($P<0.05$ for trend). However, overall mean rates of performance of secondary tasks were similar among novice and experienced drivers (9.9% and 10.9%, respectively).

DISCUSSION

Our analysis showed that the performance of secondary tasks, including dialing or reaching for a cell phone, texting, reaching for an object other than a cell phone, looking at a roadside object, and eating, was associated with a significantly increased risk of a crash or near-crash among novice drivers. Among experienced drivers, only dialing a cell phone was associated with an increased risk; data on secondary tasks performed by experienced drivers were collected before the widespread use of texting. The secondary tasks associated with the risk of a crash or near-crash all required the driver to look away from the road ahead. The

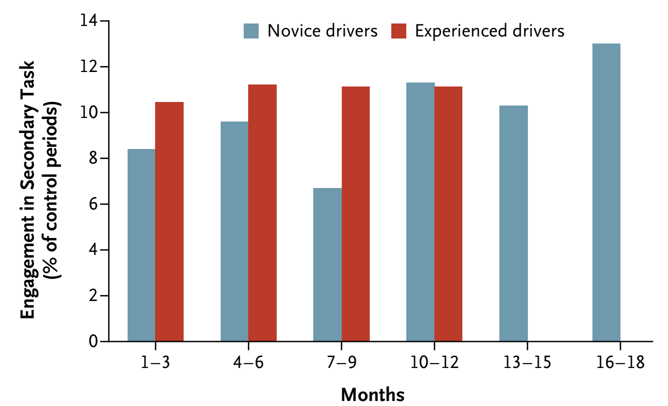

Figure 1. Performance of High-Risk Secondary Tasks among Novice and Experienced Drivers.

The prevalence of engagement in a secondary task was estimated as the percentage of randomly sampled control periods in which these tasks occurred. In the 100-Car Naturalistic Driving Study (red bars), the data-collection period was 12 months, so no data are shown for months 13 through 18. The blue bars represent data from the Naturalistic Teenage Driving Study.

prevalence of high-risk performance of secondary tasks was similar overall in the two groups, although it increased among young drivers over the 18-month study period, possibly because of increased confidence in driving over time.

Previous research[5,6] involving experienced drivers indicated that cell-phone use (both dialing and talking) was associated with an increase in the risk of a crash by a factor of 4. Our analysis, which separated talking and dialing tasks, showed that talking on a cell phone was not associated with a significant increase in the risk of a crash among novice or experienced drivers, whereas dialing was associated with an increased risk in both groups. In contrast to dialing and other high-risk tasks such as texting and reaching for a cell phone or other object, talking on a cell phone does not require the driver to look away from the road ahead. However, our findings should not be interpreted to suggest that there is no risk associated with this activity, since previous simulation and test-track research has shown that talking on a cell phone reduces attention to visible road hazards and degrades driving performance.[10-12] Also, talking on a cell phone can rarely be accomplished without reaching for it and dialing the phone or answering calls, all of which are likely to take the driver's eyes off the road.

The limitations of our analysis included the relatively small regional samples of study participants. Although the same data-collection methods were used in the two studies, the 100-Car Study data were collected in 2003–2004 in the Washington, D.C., area (where traffic density and crash rates are relatively high) and the NTDS data were collected in 2006–2008 in southwestern Virginia. The methods for sampling the control conditions in the NTDS and 100-Car Study were very similar, but they were not identical. Also, in both studies, the majority of events were near-crashes rather than crashes. In addition, the coding of secondary tasks was subject to possible human error and bias. However, the coding procedures and reliability tests were designed to ensure the most accurate data possible, and the standard for coding secondary tasks before a crash or near-crash required 100% accuracy between two expert analysts, thereby minimizing inconsistencies. Another limitation is that actual crashes were relatively rare and the samples were small; thus, confidence intervals were relatively wide, even with the combination of crashes and near-crashes. Previous research has indicated that combining crash and near-crash events, as compared with the use of crash events alone, produces conservative estimates of risk associated with various behaviors.[19]

Considerable policy attention that has been directed toward young drivers has primarily resulted in graduated driver licensing. Graduated licensing has been adopted in all 50 states, but there is considerable variation in these state programs. Our finding of the association of several secondary tasks with a significantly increased risk of a crash or near-crash among young drivers provides support for policies limiting the performance of these tasks through graduated licensing requirements or other policy initiatives.

In conclusion, our findings indicate that secondary tasks requiring drivers to look away from the road ahead, such as dialing and texting, are significant risk factors for crashes and near-crashes, particularly among novice drivers.

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