Using an Event-Triggered Video Intervention System to Expand the Supervised Learning of Newly Licensed Adolescent Drivers

Cher Carney, MS, Daniel V. McGehee, PhD, John D. Lee, PhD, Michelle L. Reyes, BSE, and Mireille Raby, MS

Objectives. We examined whether feedback from an event-triggered video intervention system reduced the number of safety-relevant driving errors made by newly licensed adolescents.

Methods. We used a 1-group pretest–posttest quasi-experimental design to compare the rate of coachable error events per 1000 miles for 18 drivers who were aged 16 years. The intervention consisted of immediate visual feedback provided to the drivers and weekly event reports and videos provided to the drivers and their parents.

Results. The number of coachable events was reduced by 61% overall during the intervention ($\chi^2 = 11.42$; $P = .001$) and did not significantly increase during the second baseline, which was assessed after the intervention ended ($\chi^2 = 1.49$; $P = .223$). The greatest reduction was seen in the category of improper turns or curves and for drivers identified at the first baseline as ''high-event'' drivers.

Conclusions. Our results show that immediate visual feedback for adolescents and cumulative video feedback for parents and adolescents during the early period of independent driving can have a dramatic influence on the rate of safety-relevant driving events. To the extent that such events are a proxy for crash risk, we suggest that feedback can enhance adolescent driving safety. (*Am J Public Health.* 2010;100:1101–1106. doi:10.2105/AJPH.2009.165829)

In 2005, motor-vehicle crashes accounted for more adolescent deaths in the United States (5253) than did homicide (2219), suicide (1809), and all forms of cancer (981) combined.[1] Fatal crashes occur more frequently for adolescents—especially for newly licensed adolescents—than they do for any other segment of the population. In fact, the crash rate per mile driven for 16-year-old drivers is roughly 4 times the crash rate for all drivers (61.4 per 1000 drivers vs. 16.8 per 1000 drivers).[1] Inexperience, immaturity, and risky driving all contribute to the disproportionate number of adolescents involved in motor-vehicle crashes.[2]

Parents generally play an important role in their adolescents' driving development by mentoring and monitoring them during the supervised-learning phase of driver licensing. However, once adolescents receive their independent driver's license, parental involvement wanes.[3,4] This occurs at the worst possible time, because research shows that the first 6 months of independent driving are the most dangerous. In fact, the crash rate per mile driven for newly licensed drivers aged 16 years is twice that of drivers aged 18 to 19 years.[1]

Experts on the issue of adolescent driving advocate a dual approach for helping adolescents become independent drivers: the adoption of a graduated driver licensing policy and an increase in parental supervision.[5] Most graduated driver licensing policies restrict exposure of newly licensed adolescents to the riskiest conditions, extend training periods, and require drivers to pass tests in order to progress to the next levels. Doing so increases new drivers' experience and allows additional time for them to develop maturity and driving skills. Recent research has shown graduated driver licensing to be successful in reducing crashes among beginning drivers by 7% to 37%.[6–8] In addition, parental monitoring can reduce intentionally risky driving behaviors, and parental mentoring can fill the gaps left by standard driver education by helping adolescents become more aware of roadway hazards.

The crash risk for adolescent drivers is the lowest during the supervised-learner period because of parental involvement.[9] Several new technologies are designed to extend this "low-risk" period by allowing parents to continue in their supervisory role even after independent driving has begun. Data recorders and global positioning systems can provide data to parents on general driving behavior (e.g., speed, acceleration, location). Although there is a lack of research on these more traditional monitoring technologies, our recent study of adolescents aged 16 to 17 years in rural Iowa found that event-triggered video-based interventions may have the potential to improve driving safety among adolescents.[10,11] Parents can use such systems to monitor adolescents and enforce restrictions on driving behavior. Alternatively, the systems can be used to mentor adolescents and train them to detect hazards.

This follow-up study builds on our previous research with rural Iowa drivers by examining 16-year-old adolescents with less than 6 months of driving experience who drive in an urban environment. Urban adolescents experience very different driving conditions from their rural counterparts and are at greater risk for being involved in a crash.[12] We assessed whether event-trigged video technology that provides feedback to newly licensed adolescents and their parents regarding potentially unsafe driving behaviors reduced the number of safety-relevant driving errors committed by the adolescents. We addressed the following questions: (1) Does the intervention reduce the frequency of safety-relevant driving errors? (2) What types of unsafe behaviors are most influenced by this type of intervention? (3) Does the intervention have a lasting effect? and (4) Does

Classification of Event Types Among Drivers Aged 16 Years Recorded by an Event-Triggered Video Intervention System: Eagan, Minnesota, 2007–2008

Safety-relevant events

- Incident: A threshold exceedance in which the driver's action, either intentional or unintentional, was responsible for a safety-relevant event.
- Invalid trigger with feedback: Activation of the system because of something other than unsafe driving behavior (e.g., the vehicle hitting a bump or pothole in the roadway or manual activation by someone in the vehicle). However, as the video was reviewed, a safety-relevant concern was revealed (e.g., unbelted driver or passenger, cell phone use, or traffic violations such as failing to stop for traffic signs or signals).
- Near crash: A threshold exceedance in which an evasive maneuver was performed to avoid a collision.
- Crash: A collision with an object or vehicle.
- Good response: A threshold exceedance in which the driver's action occurred in response to an external event.

Coachable events

- All safety-relevant events described above, excluding the "good responses."

Invalid events

- Invalid trigger: Activation of the system because of something other than unsafe driving behavior (e.g., the vehicle hitting a bump or pothole in the roadway).
- Manual: A trigger caused by the driver or passenger pressing a button on the device. This happened for a variety of reasons (e.g., weekly odometer readings, capturing the actions of other vehicles, recording passengers).
- Nonparticipant: A threshold exceedance or manual activation that occurred while someone other than the participant was driving the vehicle. These video events were not reviewed.

the intervention benefit drivers by enabling parental monitoring or mentoring?

To the extent that such technology enables parental monitoring, we hypothesized that the benefit would be immediate but that it would not last once the intervention was complete. Such a benefit would also be greater for intentional behaviors that are unsafe. On the other hand, if the technology enables parental mentoring, we hypothesized that the benefit would emerge over time, would not be greater for intentional behaviors that are unsafe, and would persist beyond the intervention.

METHODS

Thirty-six 16-year-old drivers (19 males and 17 females) were recruited from Eagan High School in Eagan, Minnesota, a suburb of Minneapolis. All of the participants were newly licensed adolescents and had less than 5 months of unsupervised driving experience before taking part in the study (52% had less than 2 months of experience). The adolescents were required to be the primary driver of their vehicle, in order to ensure that all of the miles driven were their own. Participants were paid $25 per month to participate, and they received a $75 bonus for completing all 12 months.

Each participant's vehicle was equipped with an event-triggered video recording system manufactured by DriveCam, Inc. (San Diego, CA). The system is a palm-sized device that integrates 2 video cameras (forward and interior view), a microphone, a 2-axis accelerometer, a 20-second data buffer, an infrared illuminator for lighting the vehicle's interior at night, and a wireless transmitter. The device is mounted on the windshield behind the rear-view mirror and is wired into the vehicle's electrical system. Data are continuously buffered 24 hours a day but are written to internal memory only when an acceleration threshold is exceeded or if the camera is manually activated. Each video clip written to internal memory captures the 10 seconds preceding and the 10 seconds following an accelerometer-based trigger.

There were 3 types of accelerometer-based triggers: shock, longitudinal, and lateral. Individual threshold levels were determined for each trigger, measured in g-force accelerations. The shock trigger threshold was 1.5 g. This type of trigger is most often caused by severe impacts. The longitudinal trigger threshold, most often exceeded because of hard braking, was set at 0.50 g. Lateral triggers are most often caused by hard cornering or swerving. The threshold setting used for this trigger was 0.55 g.

All data were automatically downloaded from the device via a secure wireless network whenever participants parked in their high school parking lot. Once downloaded, the encrypted data were classified according to event type, as shown in the box on this page.

Additional coding was conducted for each of the safety-relevant events. Information regarding the nature of the event, its cause, the number of vehicles involved, and the action of the driver that caused the event were recorded. Safety-relevant data were also recorded, including information about safety-belt use, the presence of loud music, and aggressive or reckless driving. Information about the number, location, and age of passengers and whether they were wearing a seat belt was also entered into the database. Also recorded were environmental factors (such as weather, light, road conditions, road geometry, and road type) and driver-related factors (such as distraction, fatigue, and social influence of passengers).

Participants were asked to self-report their mileage each week by manually triggering the system and reading their odometer. In addition, project staff took odometer readings at the beginning and end of each of the 3 project phases (first baseline, intervention, and second baseline). Mileage traveled during each 8-week intervention phase was estimated by interpolating between odometer readings. Teens reported days when their car was not in use (e.g., gone on vacation, in for repairs, etc.); these days were not counted when interpolating or calculating miles per day.

A 1-group pretest–posttest quasi-experimental design was used for this study.[13] Table 1 describes the 3 phases of the design, including the duration of each and the type of feedback provided. The 6-week first baseline phase came first, followed by a 40-week intervention

TABLE 1—Design of Study Examining Whether an Event-Triggered Video Intervention Can Reduce the Number of Coachable Driving Errors Among Drivers Aged 16 Years: Eagan, Minnesota, 2007–2008

Phase	Duration	Feedback Provided
First baseline	6 weeks	None
Intervention	40 weeks (in 5 8-week segments[a])	Real-time blinking of the LED on the recording unit immediately after an event was triggered.
		A report card showing weekly and cumulative event frequency relative to the other adolescents in the study.
		A DVD containing the adolescent's safety-relevant video clips for the week.
Second baseline	6 weeks	None

[a]Dates for the intervention segments were July 26, 2007–September 19, 2007; September 20, 2007–November 14, 2007; November 15, 2007–January 9, 2008; January 10, 2008–March 5, 2008; and March 6, 2008–April 30, 2008.

divided into 5 equal segments of 8 weeks each. The intervention was divided into segments to enable us to examine how long it took for the intervention to cause change and whether the changes would persist throughout the entire 40 weeks. The 6-week second baseline phase came last.

During the intervention phase, feedback took 2 forms: immediate and delayed. Immediate feedback was provided to the adolescent via a blinking LED on the in-vehicle system. Delayed feedback consisted of a weekly mailing to the adolescent driver's parents containing both a written report of safety-relevant events, including seatbelt compliance and cell phone use, and a DVD containing the video clips of those safety-relevant events. Parents were asked to review this information with their adolescent each week.

Upon completion of the study, adolescents and parents were asked to complete a brief online survey regarding their experiences during the study. The survey asked questions about the amount of time spent reviewing the weekly feedback, the way in which the parent used the feedback, the adolescent's impression of the effectiveness of the system, and the adolescent's acceptance of the technology.

The primary dependent measure was the number of coachable events per 1000 miles driven. Negative binomial regression of the number of coachable events on study phase was conducted, with log of phase mileage as the offset variable and participant as the repeated measure. Two contrasts were calculated to compare the 5 segments of the intervention phase to both the first and second baseline phases. The analyses were completed using the PROC GENMOD command in SAS version 9.1 (SAS Institute, Inc, Chicago, IL).

RESULTS

Of the 36 adolescent participants, 2 were unable to participate because of licensing issues; 1 other adolescent began the study but had difficulties with her vehicle and was thus unable to continue. Of the remaining 33 participants, 10 had at least 20% of their total events triggered while someone else was driving their vehicle. For these 10 adolescents, it is possible that the other driver(s) drove the study vehicle infrequently, despite causing a sizable proportion of the triggers; but it could also be that the other driver(s) simply drove the study vehicle more frequently than did the adolescent participant. Because we were examining the number of events triggered per 1000 miles driven, and we were unable to determine with any reasonable certainty the number of miles driven by those 10 participants, their data were not included in the analysis.

Five of the 23 remaining participants did not agree to continue their participation in the project for the full year of data collection. Their intervention lasted only for 16 weeks. A comparison of the 5 participants who discontinued the study with the 18 who continued showed no significant differences in the number of coachable events triggered per 1000 miles for the first baseline phase and for the first 2 8-week segments of the intervention phase. Therefore, only the data from the 18 participants who were considered the primary drivers of their vehicles *and* who completed the entire year of data collection were used for the subsequent analyses.

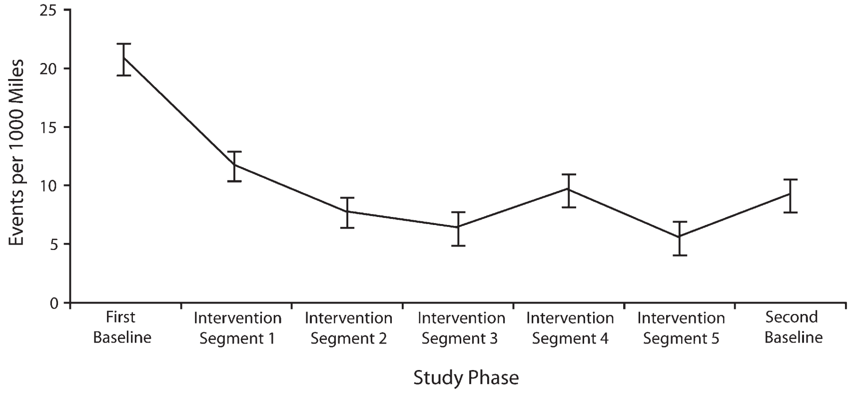
The 18 adolescent drivers (7 males, 11 females) averaged 6904 miles annually. Their mileage remained relatively constant throughout the year, ranging on average from 17 to 26 miles daily, with the lowest mileage occurring during the months of January and February. Overall, 3792 events were triggered for these 18 drivers, and 1416 of these events were coded as coachable events.

Effectiveness of the Intervention

The number of coachable events per 1000 miles driven was calculated for each participant for each segment of the study. Results of the initial data analysis showed a 61% reduction in the number of coachable events during the intervention, from an average of 21 per 1000 miles at first baseline to 8 per 1000 miles at second baseline (Figure 1). The number of coachable events decreased significantly with intervention relative to the first baseline (χ^2=11.42; P=.001) and did not significantly increase during the second baseline after the intervention ended (χ^2=1.49; P=.223).

During weeks 25 through 32 of the intervention (January 10 through March 5), there was a small but significant increase in the number of coachable events triggered compared with the 8-week segments before the intervention (χ^2=7.11; P=.008) and after the intervention (χ^2=9.23; P=.002). The rise in the number of events corresponds to an increase in inclement weather (e.g., snow and ice).

Further analysis of the events coded as incidents, near crashes, or crashes found that most were caused by the driver making improper turns or curves (41%), braking abruptly (30%), or accelerating abruptly (7%). The intervention had different effects on different



Note. Figures derived from least squares means. Error bars reflect standard error.

FIGURE 1—Number of coachable driving error events recorded by an event-triggered video intervention system among drivers aged 16 years, by study phase: Eagan, Minnesota, 2007–2008.

driver actions. The intervention had an almost immediate effect on the way in which the drivers negotiated turns and curves. Compared with first baseline, the frequency of coachable events for this category fell 59% in the first 8-week segment of the intervention (χ^2=11.54; P=.001). Turn and curve events did rebound slightly in second baseline after feedback ended; however, there were still fewer events than there were during first baseline, for an overall reduction of 78% over the course of the study.

In contrast, drivers took longer (i.e., until the second 8-week segment of the intervention) to significantly reduce the frequency of abrupt braking (χ^2=6.00; P=.014 for the second 8-week segment, compared with χ^2=3.40; P=.065 for the first 8-week segment). Overall, abrupt braking was reduced by 43% during the study. The frequency of abrupt accelerations decreased significantly during the intervention (χ^2=10.68; P=.001) but somewhat increased (χ^2=2.91; P=.088) during second baseline, such that the 2 baseline periods were not significantly different for this category of event (χ^2=0.07; P=.785).

High-Event Drivers Versus Low-Event Drivers

To examine whether there were any differences between participants who had a higher rate of events and those who had a lower rate, we formed a group of "high-event" adolescents (3 males, 3 females) from the 6 participants with the highest number of coachable events (25 or more) during first baseline, and we formed a group of "low-event" adolescents (3 males, 3 females) from the 6 participants with the fewest coachable events (fewer than 10) during first baseline. Figure 2 shows the distinction between the high-event group and the low-event group on the basis of the number of coachable events per 1000 miles. During the first baseline period, the high-event group triggered more than 40 coachable events per 1000 miles, whereas the low-event group triggered fewer than 4 coachable events per 1000 miles. Over the course of the entire study, the 6 high-event adolescents triggered 73% of all coachable events, and the 6 low-event adolescents triggered 7% of all coachable events.

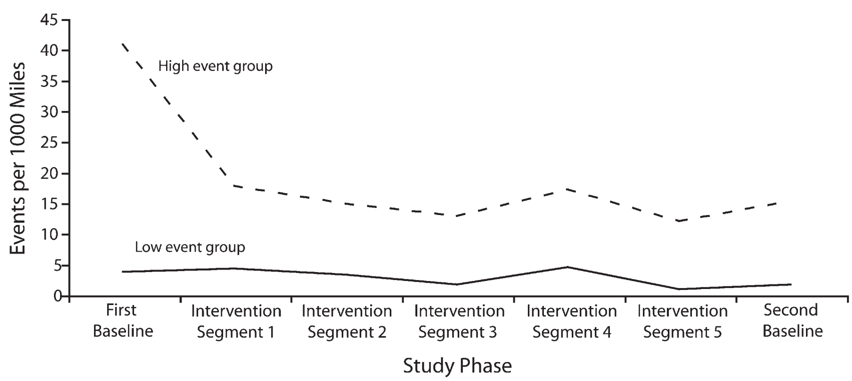


FIGURE 2—Number of coachable driving error events recorded by an event-triggered video intervention system among drivers aged 16 years, by high- and low-event group and study phase: Eagan, Minnesota, 2007–2008.

Although there was a 64% decline in the number of events triggered by the high-event group during the intervention phase, the high-event group's mean number of events never declined to the level of the low-event group. Compared with the last 8 weeks of the intervention phase, the frequency of coachable events in second baseline significantly increased for the high-event group (χ^2=5.74; P=.017) but did not for the low-event group.

Additional analyses were conducted on the types of events triggered by the high- and low-event groups. Results showed that the adolescents in the high-event group tended to accumulate events related to more aggressive driving, such as taking turns and curves too fast (41% of the total events for this group) and accelerating abruptly (8%). The driving errors of the adolescents in the low-event group tended to include events that were more likely to be caused by a lack of hazard awareness, such as braking abruptly (42% of the total events for this group), suggesting that they simply may not have acquired the skills or experience necessary to judge where or how far ahead to look for potential hazards.

Parental Monitoring

Survey data were analyzed to understand the extent of monitoring and mentoring that occurred during the intervention phase. Thirty-nine percent of adolescents (7 of 18) reported that they reviewed 100% of their safety-relevant events with at least 1 of their parents. Of these adolescents, all but 1 said that reviewing this information with their parent influenced the way they drove. Sixty-seven percent of adolescents reported having conversations with their parents regarding their driving and the reports at least once per month, and 22% reported talking on a weekly basis.

When asked whether they felt that the camera was an invasion of privacy, 77% of adolescents reported that they did not. Fifty-two percent said that the weekly reports never caused conflicts between them and their parents, and 90% reported that they never experienced privileges being taken away because of something that was in a weekly report. In fact, 97% of adolescents reported feeling like they knew what would trigger the recording of a coachable event, and 94% felt that they were able to keep the trigger from being activated. More than 90% of the adolescents reported that they were glad they chose to participate in the program and that they would recommend this program to other adolescents.

DISCUSSION

Our findings show that an intervention consisting of immediate visual feedback provided to adolescent drivers combined with weekly event reports and videos provided to drivers and their parents was successful in reducing the number of coachable events by 61%. Overall, the number of events was reduced from an average of 21 per 1000 miles during first baseline to an average of 8 per 1000 miles during second baseline, averaged across all drivers. These findings are similar to those demonstrated in a cohort study of rural adolescent drivers.[10,11]

The intervention was most successful in reducing the frequency of improper turns. In this category, adolescents went from triggering the system an average of 12 times per 1000 miles in the first baseline to fewer than 2 times per 1000 miles in the second baseline, a 78% reduction. The importance of these results is highlighted by previous data indicating that 22% of all fatal crashes occur at intersections and junctions.[14] High-speed turning and cornering has also been linked to rollover crashes, one of the most injurious and fatal types of crash.[15] There was also a 43% overall reduction in the frequency of abrupt braking events, although it took several weeks longer to achieve this benefit.

Results also showed that the frequency of coachable events at second baseline, after the intervention phase was complete, was significantly lower than at first baseline, suggesting that the intervention may have a lasting effect. However, abrupt accelerations did increase once the intervention had been removed.

Technology like that evaluated in this study can influence adolescent drivers in a number of ways. For instance, this kind of technology extends parental monitoring and inhibits adolescents' tendency to engage in intentionally risky behavior. It also extends parental mentoring and helps adolescents learn to recognize roadway hazards. The data suggest that the intervention in this study had both effects but that its predominant effect on safety was caused by parental mentoring. Consistent with a mentoring effect, certain benefits of the feedback emerged over time and persisted beyond the intervention. If participants in this study had simply reduced their events because they did not want their parents to see their behavior, we would expect a significant rebound in the number of events once the intervention was stopped. The lack of a significant rebound suggests that the intervention was successful in training young drivers to be better able to assess and react to hazardous situations.

The data also show a pattern consistent with a monitoring effect: other benefits were immediate, particularly for events associated with unsafe behavior that is committed on purpose (e.g., abrupt acceleration). For those behaviors, the benefit diminished after the feedback was removed.

The high-risk drivers engaged more often in improper turns and abrupt accelerations, which rebounded after the intervention was complete, suggesting that it was simply the parental monitoring that had reduced their frequency. Low-risk drivers had the majority of their events coded as abrupt braking. These events did not rebound after the feedback was removed, suggesting that for this group the intervention may have trained them to be more aware of hazards.

Whether drivers see the system as enabling mentoring or as simply monitoring could have substantial implications for acceptance and long-term safety benefit. The positive response and high level of acceptance in this study suggest that mentoring systems can gain wide acceptance. Monitoring systems are less likely to be well-accepted by adolescents, causing the effect to be limited to the period when the device is in the car. However, even a poorly accepted monitoring system could have a substantial impact on the number of adolescent motor-vehicle deaths. Understanding the factors that cause adolescents and other drivers to perceive feedback-based systems as either monitoring or mentoring remains an important research issue.[16]

Limitations

The 1-group pretest–posttest quasi-experimental design has several important limitations, the most obvious of which is that there was no control group for comparison. As a consequence, it is difficult to conclude that history, maturation, and regression could not have accounted for the observed effects, which affects the study's internal validity.[11] Another limitation concerns the recruitment of newly licensed adolescent drivers to be in a video-feedback intervention study in which their parents will be informed of their safety-relevant behaviors. The population willing to take part in such a study is small, and the sample may have suffered from a self-selection bias.

Another limitation of this study concerns the imperfect estimates of exposure. Event frequency was linked to estimated mileage. However, this proved to be a challenge in that adolescent participants would sometimes neglect to report their weekly odometer reading. Therefore, mileage had to be interpolated over larger ranges for some of the participants. We also had to assume that the participant drove the miles they reported; however, we know there were instances when a driver other than the participant drove the vehicle. In addition, the system only afforded a glimpse into the vehicle when it was triggered. The safety effects of specific driving-related behaviors, such as cell phone use or passenger distractions, were difficult to quantify because the data only included events, not exposure to the behaviors when no events were triggered. In addition, information regarding the number of trips per day, length of trips, or specific route information was not available.

One of the biggest limitations is that we were unable to control the amount or type of interaction adolescents had with their parents during the intervention period. Especially for the riskiest drivers, it seems that parental engagement is necessary for the success of the intervention.[17] Without a parent to monitor or mentor, we may not have seen a significant reduction in any of the safety-relevant events.

Conclusions

Motor-vehicle crashes are the most common cause of injury and mortality in adolescents, and the first 6 to 12 months of independent driving is the most crash-prone period for all drivers.[9] This study showed that immediate visual feedback for adolescent drivers and cumulative video feedback shared with parents during the early months of independent driving can have a dramatic influence on the rate of safety-relevant driving events. To the extent that such events are a proxy for crash risk, this study suggests that feedback might enhance adolescent driving safety.

Whether this benefit will generalize to a broader population of adolescents and what mechanisms underlie the benefits are still unknown. Data from this study suggest that a device that enables parental monitoring can reduce adolescents' exposure to risky behavior during the critical first months of driving. This could have substantial safety benefits because of the high crash rate during this period. Data also suggest that a device that enables parental mentoring can make adolescents more aware of hazards, which could help adolescents forge good driving habits that will remain with them for the long term. By informing both adolescent drivers and their parents when driving errors are made, such an intervention allows for review and discussion. Even if a driver has no events in a given week, the simple acknowledgment of a good "report card" would make driving issues a regular part of the family discussion. Such communication is critical in helping parents to regulate the most dangerous activity they allow their children to do. ■

About the Authors

Cher Carney, Daniel V. McGehee, Michelle L. Reyes, and Mireille Raby are with the Human Factors and Vehicle Safety Research Division of the Public Policy Center, University of Iowa, Iowa City. At the time of the study, John D. Lee was with the Department of Mechanical and Industrial Engineering, University of Iowa, Iowa City.

Correspondence should be sent to Daniel V. McGehee, Human Factors and Vehicle Safety Research Division, Public Policy Center, University of Iowa, 227 South Quad, Iowa City, IA 52242-1192 (e-mail: daniel-mcgehee@uiowa.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints/Eprints" button.

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Contributors

C. Carney participated in study conceptualization and design, acquisition of data, data interpretation, and wrote the article. D.V. McGehee supervised the study and participated in the study conceptualization, design, data interpretation, and revision of the article. J.D. Lee assisted with study design, data analysis, data interpretation, and article revision. M.L. Reyes led data analysis and interpretation, and assisted with revising the article. M. Raby assisted with the study conceptualization and acquisition and analysis of data.

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Human Participant Protection

This study was approved by the University of Iowa's institutional review board.

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