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

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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).2

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.3

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.4 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

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.

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 (χ²=11.42; P=.001) and did not significantly increase during the second baseline, which was assessed after the intervention ended (χ²=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)
less than 2 months of experience). The
before taking part in the study (52% had
months of unsupervised driving experience
neapolis. All of the participants were newly
17 females) were recruited from Eagan High

METHODS

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 interpo-
lating 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.

There were 3 types of accelerometer-based
triggers: shock, longitudinal, and lateral. Indi-
vidual 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 re-
garding 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 pas-
sengers 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 geome-
try, and road type) and driver-related factors
(such as distraction, fatigue, and social influ-
ence of passengers).

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A 1-group pretest–posttest quasi-experi-
mental 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
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 ($\chi^2=11.42; P=.001$) and did not significantly increase during the second baseline after the intervention ended ($\chi^2=1.49; P=.223$).

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 ($\chi^2=7.11; P=.008$) and after the intervention ($\chi^2=9.23; P=.002$). 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

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**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**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Duration</th>
<th>Feedback Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>First baseline</td>
<td>6 weeks</td>
<td>None</td>
</tr>
<tr>
<td>Intervention</td>
<td>40 weeks (in 5 8-week segments&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>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.</td>
</tr>
<tr>
<td>Second baseline</td>
<td>6 weeks</td>
<td>None</td>
</tr>
</tbody>
</table>

<sup>a</sup>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.
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 ($\chi^2=1.154; P=.001$). 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 ($\chi^2=6.00; P=.014$ for the second 8-week segment, compared with $\chi^2=3.40; P=.065$ 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 ($\chi^2=10.68; P=.001$) but somewhat increased ($\chi^2=2.91; P=.088$) during second baseline, such that the 2 baseline periods were not significantly different for this category of event ($\chi^2=0.07; P=.785$).

### 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.

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 ($\chi^2=5.74; P=.017$) 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. 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. 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.

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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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