The First Year of Driving

Can an In-Vehicle Data Recorder and Parental Involvement Make It Safer?

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This study examines the impact of the provision of feedback and guidance about parental monitoring on the safety performance of young male drivers during their first year of driving. The research used an in-vehicle data recorder (IVDR), which documented events of extreme gravitational forces measured in the vehicles that participated in the experiment. Two hundred forty-two families of young male drivers participated in the research. Participants were randomly allocated into four groups: (*a*) family feedback, no guidance, in which all members of a family were exposed to feedback on their own driving and on that of other family members; (*b*) family feedback, parental guidance, in which, in addition to the family feedback, parents received personal guidance on ways to enhance their involvement with and monitor their sons' driving; (*c*) individual feedback, no guidance, in which family members received feedback only on their own driving behavior and not that of other family members; and (*d*) a control group, which received no feedback at all. IVDRs were installed in family cars for 12 months, starting from the time that the young driver received his driver's license. This period included the initial 3 months of the accompanied driving phase and 9 months of independent driving. The driving exposure of young drivers increased significantly during the solo period compared with that during the accompanied period. The results indicate substantial differences in behavior between young drivers in the control group and the group that received both feedback and guidance on parental involvement.

Young drivers in Israel, as in many other countries all over the world, experience higher road crash rates than any other age group. Their overrepresentation in crashes is especially substantial in severe and fatal crashes (*1*). This problem has received considerable public and media attention, which has led, among other efforts, to modifications in the process of licensing Israeli drivers. Starting in November 2004, new young drivers were required to drive only when accompanied by an experienced driver for the first 3 month after licensure. The accompanying driver must be older than age 24 years and have had a driver's license for at least 5 years or be over the age of 30 years with at least 3 years of driving experience. During the first 2 years of driving, the new driver is limited to driving with no more than two passengers, unless when he or she is accompanied by an experienced driver. Another limitation that was introduced in 2011 is a lower tolerance for the blood alcohol content, which is 0.01% for novice drivers and those who are under 24 years old and 0.05% for other drivers. The law does not mandate a minimal amount of driving during the driving period when the novice driver must be accompanied by an experienced driver, nor does it include any limitations on nighttime driving.

A previous study showed that throughout the period when the novice driver must be accompanied by an experienced driver, the involvement of novice drivers in crashes is extremely low (*2*). However, immediately after it ends and the solo unsupervised driving phase begins, crash rates rise drastically. Afterward, the crash rate gradually declines with time. Similar trends in crash involvement statistics have been observed in other countries around the world (*3, 4*). At the individual level, Simons-Morton et al. equipped vehicles driven by teens with an advanced data acquisition system (*5*). They observed a general decrease in crash and near-crash involvement during the first 18 months of driving. They also found changes in specific behaviors over time (a decline in rapid starts and an increase in hard turns). The results of these studies indicate that the problem of crash involvement by novice drivers is most acute during the transition from supervised to independent driving.

The literature also shows substantial differences in the rates of involvement in road crashes between young males and females. Male drivers and drivers in the group from 16 to 18 years of age are more often involved in fatal crashes per number of miles driven (*4, 6*). This difference may be partly explained by more aggressive driving behaviors; a stronger inclination toward risk taking, sensation seeking, and antisocial behaviors; a greater tendency to overestimate their driving abilities; and the higher susceptibility of young male drivers than young female drivers to the influence of peers (*6–8*).

Significant advances in sensing and communication technologies have been made in recent years. These have led to considerable growth in the development and use of in-vehicle data recorders (IVDRs) to monitor and influence drivers' behavior not only in the context of postcrash analyses but also as a tool to assist with crash prevention. As a measurement tool, IVDRs facilitate the observation of natural driving behavior. As a tool for intervention, they support reductions in risky behaviors through the provision of feedback to drivers or those who are responsible for their driving. The 100-Car Naturalistic Driving Study was a major research effort in this direction that used elaborate and expensive monitoring equipment (*9, 10*). It

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involved the use of vehicles equipped with IVDRs that continuously measured and recorded the location, speed, and acceleration of the vehicle through the use of the Global Positioning System (GPS) and accelerometers.

DriveAtlanta is another study in which vehicles were equipped with multiple sensors (*11*). One hundred seventy-two vehicles were instrumented with IVDRs that included a GPS and connected to the vehicle's computer. The data collected in this experiment included high-resolution vehicle locations, speeds, and accelerations and data on parameters for the engine and vehicle systems, such as the use of seatbelts, emissions, and the positions of the gas and brake pedals.

At the same time, more affordable commercial IVDR systems have also been introduced. Lotan and Toledo (*2*) and Lotan et al. (*12*) used an IVDR system that measures gravitational forces (*g* forces) and the vehicle's GPS location in various experiments. This system analyzes the raw measurements to identify various maneuvers that the vehicle has made, such as hard braking, accelerations, turns, and lane changes. Toledo and Lotan (*13*) and Toledo et al. (*14*) showed that the rates of these maneuvers can be used as indicators of the risk involved in road crashes. Lerner et al. also found a connection between aggressive driving maneuvers and involvement in crashes and near crashes (*15*). Toledo and Lotan (*13*) and Prato et al. (*7*) used these *g* force–based maneuvers to study the driving behavior of novice drivers in the system of graduated licensing of drivers.

As noted above, IVDRs may be used not only for measurement but also as a tool to provide feedback to drivers and others (e.g., parents and fleet managers) about individuals' driving. Several studies have provided empirical evidence about the positive effect of monitoring through the use of IVDR systems on the driving behavior and the safety of all drivers (*16*). In the context of young drivers, McGehee et al. (*17*) and Carney et al. (*18*) conducted a study in which video recordings were triggered by safety-relevant events. Teen drivers and their parents reviewed these videos together weekly. It was found that the review process and parental feedback resulted in a significant decrease in the number of events that the young drivers generated. Farmer et al. (*19*) and Prato et al. (*7*) also reported that the provision of young drivers and their parents with feedback generated by use of an IVDR installed in their vehicle could reduce the incidence of risky behaviors.

A large body of literature links various aspects of parental monitoring to the prevention of risky behaviors among children and adolescents (*20*). Parenting style was shown to play a role in risky driving behavior and crash risk. Teens with authoritative or authoritarian parents were found to be less likely to be involved in unsafe behaviors and less involved in road crashes than teens with permissive or uninvolved parents (*21*). However, many parents who were offered the opportunity to monitor the young drivers using IVDR technology did not make full use of it or even rejected it completely (*19, 22*). Parents explained these choices by saying that they trusted the young driver or were concerned about damaging their relationship with their child. Parents in these studies also said that they needed guidance on how to motivate the young driver to use the feedback effectively and on how to avoid conflicts with them on the basis of the feedback.

The New Authority (NA) is an approach used to help parents handle the difficulties described above (*23, 24*). It aims to help parents increase their involvement and monitoring ability, enable them to better resist the child's risk activities, and prevent escalation. These parental activities are subsumed under the term "vigilant care," which is better able to connote the attitude of parental watchfulness and positive involvement than the more current but rather mechanical term "monitoring."

Parental counseling in NA has been shown to be effective as a means to reduce aggressive and risk behaviors, as well as reduce parental helplessness, prevent parental outbursts, and increase positive interactions (*25, 26*). The counseling program in NA has also been shown to be helpful for the parents of highly demanding and dysfunctional young adults (*27*). These findings suggest that this approach might allow the development of a brief counseling intervention geared toward enhancement of parental involvement in a child's driving and provision of parents with an increased ability to make use of IVDR feedback and also enable parents to cope better with conflicts that might arise.

The current study addresses three main questions: (*a*) Does the provision of young male drivers with feedback about their driving affect their driving safety? (*b*) Does the provision of parents with feedback on their male teen's driving affect his driving more than self-regulated feedback? (*c*) Does the provision of parents with guidance on how to be more involved and to exercise vigilant care with the help of IVDR increase the benefits of its use?

The rest of the paper is organized as follows: the next section presents the study methodology and describes the IVDR, the experimental design, the guidance provided to parents within the experiment, the participants, and the recruitment process. The subsequent section describes the data that were collected in the experiment and provides summary statistics. Then, the results of the analysis within this study are presented, followed by a discussion and summary.

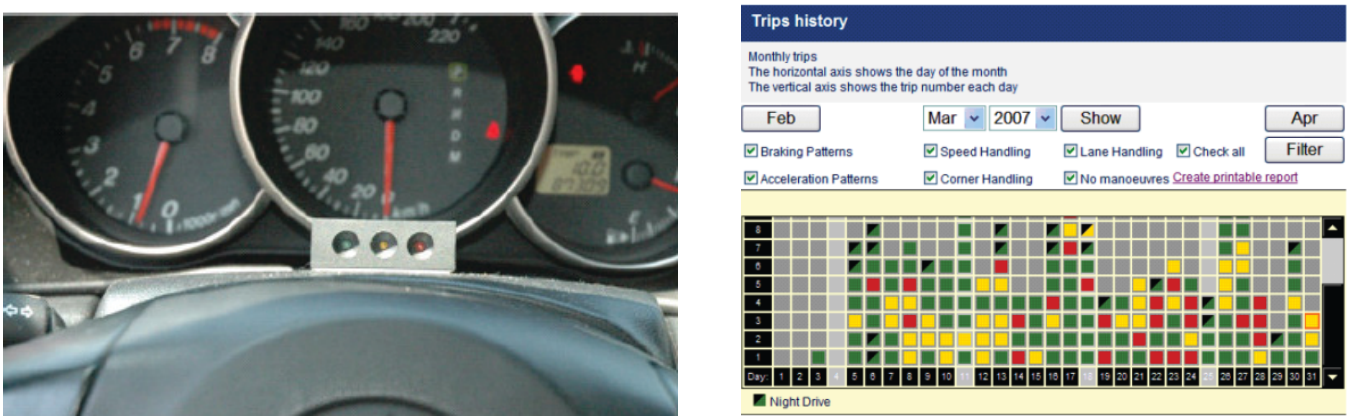
METHODOLOGY

IVDR System

The IVDR system used in this study was the GreenRoad technology (*7*). It is a *g* force–based system that tracks all trips made by the vehicle and records the following information:

- Trip start and end times,
- Driver identification,
- Vehicle location, and
- Events of excessive maneuvers defined by patterns of *g* forces measured in the vehicle. These events are classified into severity groups, according to the intensity of the *g* forces. The system can identify 20 types of excessive maneuvers in the raw measurements. These maneuvers are classified into five major categories: braking, accelerating, turn handling, lane handling, and speeding.

Drivers were requested to identify themselves at the beginning of each trip through the use of Dallas keys. Overall, drivers did not identify themselves on about one-third of the trips. Models for identification of the driver were developed to allocate the unidentified trips among the family members probabilistically. These models were developed for each family separately. The variables that were most often useful in these models were the driver in the previous or subsequent trip, destination of the trip, time of day, duration of the trip, events rate (number of events in a trip divided by its duration), and the period in the graduated system of licensing of drivers that the young driver was in (i.e., accompanied or independent driving).



(a) (b)

FIGURE 1 Feedback media: (*a*) in-vehicle display and (*b*) web-based application.

Feedback from the IVDR can be provided in multiple ways. The collected data are transmitted in real time and can be instantaneously conveyed. In the current study, participants in experimental groups that received feedback got it through a specialized web-based application and through an in-vehicle display, as shown in Figure 1.

In the IVDR real-time feedback unit (Figure 1*a*), the driver continuously receives feedback on his driving aggressiveness level, which is color coded with green, yellow, and red lights for moderate, intermediate, and high levels of aggressiveness, respectively. The web-based application provides drivers with reports that summarize the information for the driver. An example of a monthly driver report is presented in Figure 1*b*. The chart shows the various trips that the driver undertook during the month; each square in the chart represents a trip. The *x*-axis indicates the day of the month, and the *y*-axis indicates the number of trips performed during each day. Trips are color coded according to their aggressiveness classification, which is based on the rate of aggressive maneuvers that were recorded during the trip. Drivers are classified as moderate, intermediate, or aggressive drivers if they recorded less than 20, 20 to 50, or more than 50 maneuvers per 10 driving hours, respectively. Black triangles indicate nighttime trips. A more detailed description of the system and previous studies that have used it are presented elsewhere (*7*, *14*).

Participants and Recruitment

A rolling recruitment procedure in which recruitment was continued for several months was used. The entire process took place between July 2009 and November 2010.

To be eligible to participate in the study, candidates who expressed an interest in it were required to meet the following screening criteria:

1. The candidate had to be a male young driver.
2. The candidate had to have been licensed as a driver less than 1.5 month earlier, which means that the new driver was still within the period of accompanied driving.
3. The parents had to have access to the Internet.
4. The family had to live in the central part of Israel (between Haifa in the north and Ashdod in the south).
5. The candidate had to drive the family car (i.e., he could not have his own car).
6. The candidate could not have untreated attention deficit hyperactivity disorder.

In total, 6,290 phone calls to potential candidates were made. A potential candidate was defined as a young male driver who was newly licensed. After preliminary screening according to the screening criteria outlined above, 2,380 candidates were asked to fill out the web-based questionnaire, and 872 actually did. Two hundred forty-two families started participation in the experiment. Of these, 217 completed the 1-year experiment. This represents a dropout rate of 10.3%. The young participants were between 17 and 22 years old; the average age was 17.5 years, and the standard deviation was 0.8 year.

Participants received 1,000 Israeli new shekels (approximately $250) for their participation.

Experimental Design

The families that participated in the experiment were randomly allocated into one of four groups. The participants were not aware of the various study groups that existed in the study. The four groups were defined on the basis of the type of feedback that the family members received from the IVDR and the guidance that parents received on ways to enhance their involvement and monitor their sons' driving:

- Individual feedback, no guidance, group. In the individual feedback, no guidance, group, family members were provided feedback on their own driving but not on that of other family members. Thus, parents did not have access to the driving records of their teens and vice versa.
- Family feedback, no guidance, group. In the family feedback, no guidance, group, family members were exposed to their own driving record and to the driving records of other members of the family. Thus, parents had access to the driving records of their teens and vice versa.
- Family feedback, parental guidance, group. In the family feedback, parental guidance, group, family members had access to the driving data for all other family members, as in the previous group.

In addition, parents received personal guidance on ways to enhance their involvement and monitor their sons' driving. The guidance intervention, which is described in more detail in the next section, is based on the NA approach and was developed specifically for this study.

- Control group. None of the drivers (neither parents nor teens) in the control group received any feedback or guidance throughout the duration of the study.

Family members in the three experimental groups received feedback starting from the end of the accompanied driving period.

Guidance to Parents

In the NA approach, the parents were guided to link their level of parental involvement to the three levels of driving aggressiveness that were introduced above: moderate (green), intermediate (yellow), and aggressive (red). Thus, when the young driver drove moderately, parental involvement was kept to a minimum. This level of involvement is termed "open attention" in the NA. When the aggressiveness of driving of the young driver was classified as intermediate, the parents' level of vigilance was intensified. This level is termed "focused alertness." Finally, if the young driver drove aggressively, parental involvement was the highest. This level is termed "protective action."

For each of the levels of vigilant care, specific parental tools were developed. A general guideline that was valid in all cases was for the parents to check the driving record on the experiment IVDR website on a routine basis. Specific guidelines were then provided to help the parents react appropriately to information indicating the young driver's risk level. When the driving aggressiveness of the young driver was moderate (green), the parents were to react by conveying to him that he is deservedly earning the privileges of driving independence. Thus, even at this lowest aggressive level, the parents were involved and present in a supportive and confirming way. When the driving aggressiveness of the young driver was intermediate (yellow), the parents were to tighten their involvement, sit together with the child to examine the feedback, and set goals for improvement for the coming week. If the goals for improvement were not met, the parents were to limit driving under risky conditions (e.g., at night) until they were. Parents were trained on ways to present to the young driver the restrictions that they enforced in a constructive way and to avoid escalation. When the driving aggressiveness of the child was aggressive (red), the parents were to intensify their involvement, taking away more driving privileges, such as driving on weekends, on highways, or with friends, until the records showed improvement.

The guidance program was administered in a 90-min meeting at the family's home. Both parents and the young driver were invited to attend. In the current experiment, both parents attended in most cases; in only 12 families did only one parent attend. The parents were also given written material with instructions on how to implement the guidelines in ways that would increase effectiveness and minimize escalation.

Later, three to four biweekly phone conversations were conducted. These were initiated by the counselors. These contacts were bolster sessions devised to help the parents better cope with the difficulties that they faced in implementing the program. An e-mail summarizing the main messages for the parents was sent after each contact. The parents were also given the option of calling on their own, if they felt the need to get immediate support. Only a small number of parents used this option.

TABLE 1 Summary Statistics for Four Research Groups

Factor	Family Feedback, No Guidance	Family Feedback, Parental Guidance	Individual Feedback, No Guidance	Control
Number of young drivers	55	54	53	55
Total number of accompanied trips	2,491	2,513	2,680	3,196
Total number of solo trips	33,846	32,623	33,146	33,872
Total accompanied driving time (hours)	945.7	907.2	993.2	1,072.5
Total solo driving time (hours)	10,655.0	10,612.2	9,860.9	10,248.4

DATA

The data collected in the experiment covered 45,295 driving hours in 144,367 trips that were made by young drivers. Table 1 presents summary statistics for the four groups of the young drivers.

Table 1 shows that the four groups were roughly balanced according to various characteristics. Drivers in the four groups undertook similar numbers of trips during the accompanied and solo periods. The random allocation of the participants to the four groups was also examined according to their age and driving behavior during the accompanied driving period, during which none of the four groups received any interventions. No significant differences were found among the groups; for example, the average age and standard deviation for the four groups were almost similar, with the average age ranging from 17.4 to 17.5 years and the standard deviation ranging from 0.6 to 0.8 year. Also, no significant difference in event rates was found among the different groups during the accompanied driving period (detailed results are presented in Table 2). Thus, any further

TABLE 2 Event Rates

	Event Rates (events per hour)	
Group	Accompanied	Solo
Control	1.38 (2.03)	3.83 (4.74)
Individual feedback, no guidance	1.05 (1.15)	2.61 (1.94)
Family feedback, parental guidance	1.42 (1.89)	2.10 (2.29)
Family feedback, no guidance	0.99 (1.38)	2.48 (2.69)
Overall sample	1.21 (1.65)	2.76 (3.17)

NOTE: Data represent averages (standard deviations).

TABLE 3 Amount of Driving During Accompanied Period and After

	Driving Time (h/week)		Number of Trips (trips/week)		Average Trip Length (min)	
Statistic	Accompanied	Solo	Accompanied	Solo	Accompanied	Solo
Overall Sample						
Mean	2.47	4.31	6.91	14.02	22.11	19.36
(SD)	(2.27)	(3.05)	(6.36)	(9.70)	(6.76)	(4.79)
Control						
Mean	2.61	4.69	7.73	15.25	21.11	19.31
(SD)	(2.21)	(3.47)	(6.88)	(12.37)	(6.52)	(5.11)
Individual Feedback, No Guidance						
Mean	2.54	3.99	6.80	13.38	23.14	18.92
(SD)	(2.47)	(1.85)	(7.19)	(6.82)	(6.88)	(5.66)
Family Feedback, Parental Guidance						
Mean	2.01	4.23	5.67	12.92	22.14	20.12
(SD)	(1.50)	(2.95)	(4.16)	(8.52)	(7.20)	(4.82)
Family Feedback, No Guidance						
Mean	2.22	4.33	6.04	13.74	21.97	19.08
(SD)	(2.75)	(3.60)	(6.81)	(10.48)	(6.44)	(3.29)

NOTE: Data represent averages [standard deviations (SD)].

differences during the solo period can be attributed to the intervention and the feedback type provided to the drivers.

RESULTS

Amount of Driving

Earlier research indicated the importance of the amount of supervised driving experience on the crash risk for novice drivers in the graduated program of licensing of drivers (*28*).

Table 3 presents summary statistics for the amount of driving during the accompanied and solo periods for each of the four groups as well as for the entire sample. The results are shown as the number of hours driven weekly to account for the differences in the period of collection (especially at the beginning of the experiment during the accompanied driving period) among the drivers. Data for the first month of accompanied driving were not included in the analysis, as the limited data were available for that month.

The results in Table 3 show a sharp increase in the mean weekly amount of driving (74% in driving time and 103% in the number of trips for all groups) during the solo driving period compared with that during the accompanied driving period. This increase was statistically significant ($p < .001$ in both statistics). The increase was even larger for the numbers of trips that drivers undertook. The reason was not only that drivers drove more hours but also that they made shorter trips. These trends were similar for the four groups.

Figure 2 illustrates the distribution of the weekly driving time during the accompanied and solo periods for the overall sample.

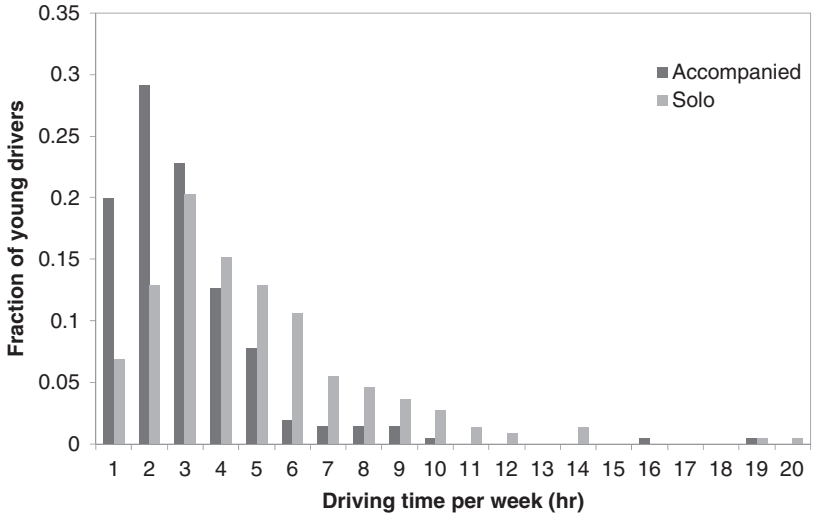


FIGURE 2 Distribution of weekly driving time of young drivers.

The fraction of young drivers who drove up to 3 h per week during the accompanied driving period was higher than that during the solo period, and the fraction of drivers who drove 4 h and more per week was higher during the solo period than during the accompanied period. In other words, young drivers drove more hours per week during the solo period than during the accompanied period. A paired-sample *t*-test between the weekly driving times during the two periods for each young driver revealed that the differences were statistically significant ($p < .0001$).

On the basis of these results, the average driving time for the 3 months during the accompanied period was estimated to be 32 h. This is expected to raise the experience level of young drivers in Israel, who may obtain their driver's license with as little as 28 h of driving instruction. However, it is far less than the minimum of 50 h of accompanied driving that will soon be required by law in Israel. It is also far shorter than the required driving times in most states in the United States, where 50 h or more is required (*29*), or in the different states in Australia, where the range is from 50 to 120 h (*30*).

Driving Behavior

This section presents a comparison of the four groups according to their driving behavior and the impact of the feedback and parental guidance treatments. Driving behavior was measured by the rate of maneuver events recorded for the driver, normalized by the number of driving hours. Table 2 presents the average and standard deviation of the event rates in each of the four groups during the accompanied and solo driving periods and for the overall sample.

Table 2 shows that in all four groups, the average event rates were higher during the solo period. To examine whether the difference in the event rate between the accompanied and the solo periods for the entire sample (1.55) was significant, a paired *t*-test was conducted. This difference was found to be statistically significant ($p < .0001$).

For novice drivers, event rates changed over time during the first driving period. Figure 3 presents the average event rates and standard deviations for the four groups for each of the 11 months corresponding to the first driving period for the young drivers participating in the study. In Figure 3, month 0 corresponds to the first month of solo driving. Accompanied driving months are indicated with negative values. Figure 3 does not include the first month of the accompanied driving period, as limited data were available for that month.

Figure 3 demonstrates the differences among the groups. From Figure 3 it is apparent that the control group was consistently the worst group according to the event rates from the start of the solo phase. The family feedback, parental guidance, group, which received the most elaborate form of feedback and parental guidance, performed best according to event rates. This group had lower event rates than its control group for parental guidance (the family feedback, no guidance, group). One-way analysis of variance tests for the average event rates over the entire accompanied period among the four groups did not find statistically significant differences ($p = .451$); however, over the entire solo period, with the rates for months 0 to 8 pooled, the differences in the average event rates among the groups were found to be statistically significant ($p = .026$). This finding indicates that initially, during the accompanied period, the groups were similar according to the event rates. In contrast, a significant difference among the groups was found during the solo period.

A further examination of the differences between the four groups according to the event rates during the solo period by the Tukey honestly significant difference post hoc analysis revealed that the mean difference between the control group and the family feedback, parental guidance, group was significant. The means for the three groups that received feedback did not differ significantly. The results for the mean differences between the individual feedback, no guidance, and family feedback, no guidance, groups and the control group are inconclusive. Detailed results of this analysis are presented in Table 4.

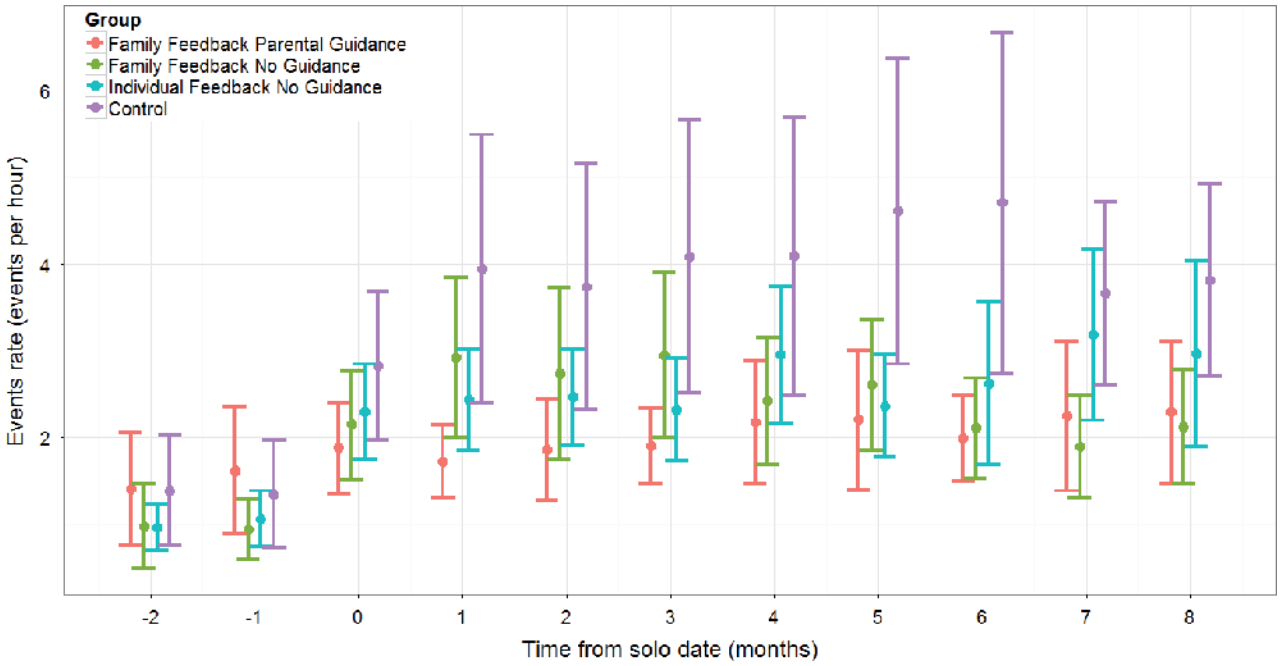


FIGURE 3 Average event rate per group and month.

TABLE 4 Results of Tukey Honestly Significant Difference Post Hoc Analysis of Differences in Event Rates Among Groups During Solo Period

Group I	Group J	Mean Difference	Standard Error	Significance
Individual feedback, no guidance	Control	−1.223	0.602	0.180
	Family feedback, parental guidance	0.509	0.605	0.834
	Family feedback, no guidance	0.125	0.602	0.997
Control	Family feedback, parental guidance	1.733	0.599	0.022[a]
	Family feedback, no guidance	1.348	0.596	0.111
Family feedback, parental guidance	Family feedback, no guidance	−0.385	0.599	0.918

[a]Significant at 95% confidence level.

SUMMARY AND CONCLUSIONS

The research described in this paper investigated the effects of various forms of feedback from an IVDR and parental guidance to help young male drivers and their parents improve the young male drivers' driving performance during their first year of driving. Participants were randomly allocated into four groups: (*a*) family feedback, no guidance, in which all family members were exposed to the driving records of all drivers in the family; (*b*) family feedback, parental guidance, in which, in addition to the feedback, parents received personal guidance on ways to enhance their involvement and monitor their sons' driving; (*c*) individual feedback, no guidance, in which the feedback to family members was on their own driving but not on that of other family members; and (*d*) a control group, in which drivers in the family did not receive any feedback or guidance.

Analysis of the driving exposure of young drivers during their first year of driving indicated significant differences in the numbers of trips that they made between the accompanied and solo periods. Young drivers more than doubled the weekly number of hours that they drove during the solo period compared with the number during the accompanied period.

The effect of the feedback and parental guidance was measured through the event rates that the young drivers recorded. The results showed differences in event rates among the four groups during the solo period, especially between the control group and the family feedback, parental guidance, group. The control group recorded the highest event rates throughout the solo period. The family feedback, parental guidance, group, which received the most elaborate feedback and guidance, consistently recorded the lowest event rates. The difference between the two groups was more noticeable during the first 3 months of the solo period, when the parents received guidance on parental monitoring; afterward, this difference diminished slightly. Still, because those first 3 months are considered the most critical time because of the rates of involvement of novice drivers in crashes, the impact of the intervention is the most important during this period.

The results suggest that the combined effect of feedback and parental involvement leads to statistically significant improvements relative to the performance of the control group.

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