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16. Abstract

This study introduced a new methodology for evaluating the relative contributions of the changes in the frequency of crashes and the severity of the outcome of crashes to the recent large improvement in road safety in the U.S. The approach is based on a parallel examination of changes in variables for all crashes and for fatal crashes only. The change for all crashes provides an index of the change in the frequency of crashes; the difference between the change in the frequency of fatal crashes and the change in the frequency of all crashes provides an index of the change in the severity of the outcome of crashes. The specific analysis that was performed using this new methodology involved examining the changes from 2005 to 2009 in 11 selected variables common to both the GES database (all crashes) and the FARS database (fatal crashes only).

The main result is that from 2005 to 2009 there were reductions in both the frequency of crashes and the severity of the outcome of crashes. The obtained patterns of change for the 11 examined variables are consistent with the known changes in factors such as the economic conditions (resulting in less driving, and different proportions of leisure and nighttime driving), installation of active-safety technology (e.g., electronic stability control), installation and quality of passive-safety technology (e.g., airbags), licensing of young drivers, and driver distractions.

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Contents

Introduction

Road safety in many countries has improved greatly over the past five years. For example, in the U.S., road fatalities dropped from 43,510 in 2005 to 32,788 in 2010—a reduction of 25% (NHTSA, 2011a). Our previous research began an examination of factors that have contributed to this unprecedented reduction. That research suggested that a large part of the improvement is likely a consequence of the current economic downturn that has affected both the amount and the type of driving in the U.S. (Sivak, 2009; Sivak and Schoettle, 2010).

In this study, we are posing the following fundamental question: Is the recent improvement in road safety due to a reduced frequency of crashes, decreased severity of the outcome of crashes, or both? Understanding the roles of these two aspects of crashes is important because the two aspects are dependent on different mechanisms. For example, active-safety interventions influence primarily (but not exclusively) the frequency of crashes, while passive-safety interventions influence primarily the severity of the outcome of crashes.

To answer the question posed above, we will simultaneously examine two databases: one that includes crashes of all severities (GES[1]), and another that includes fatal crashes only (FARS[2]). Data for two years will be analyzed: 2005 (the recent peak in fatal crashes), and 2009 (the latest year for which both GES and FARS data are currently available.) Possible outcomes of the analysis, given the improvements in road safety from 2005 to 2009, are conceptually outlined in Table 1.

[1] GES (General Estimates System) provides weighted estimates of crash frequencies for the entire country that are based on a nationally representative sample of police-reported crashes of all types, ranging from minor to fatal.

[2] FARS (Fatal Analysis Reporting System) is a census of all police-reported crashes in which at least one person dies within 30 days as a result of the crash.

Table 1
Possible outcomes of GES and FARS analyses, given the improvements in road safety from 2005 to 2009.

Parameter change from 2005 to 2009		Expected pattern of change from 2005 to 2009	
Frequency of crashes	Severity of the outcome	GES	FARS
Reduction	No change	Fewer crashes	Fewer fatal crashes; a reduction of the same magnitude as in GES
No change	Reduction	No change	Fewer fatal crashes
Reduction	Reduction	Fewer crashes	Fewer fatal crashes; a reduction of a greater magnitude than in GES
Reduction	Increase	Fewer crashes	Fewer fatal crashes; a reduction of a smaller magnitude than in GES, *or*… No change in fatal crashes, *or*… More fatal crashes
Increase	Reduction	More crashes	More fatal crashes; an increase of a smaller magnitude than in GES, *or*… No change in fatal crashes, *or*… Fewer fatal crashes

We will use the change from 2005 to 2009 in all crashes (ΔGES) as an index of the changes in the frequency of crashes. The difference between the change from 2005 to 2009 in fatal crashes and the change in all crashes (ΔFARS minus ΔGES) will be used as an index of the change in the severity of the outcome of crashes. For example, let us assume that for a given variable, the change in all crashes (ΔGES) is -10%, and the change in fatal crashes (ΔFARS) is -15%. In this case, the change in the frequency of crashes is -10%, and the change in the severity of the outcome of crashes is -5%.

This research is a follow up to Sivak and Schoettle (2010). In that study, we examined the changes in the distributions of all variables in FARS from 2005 to 2008. In this study, we analyzed the changes in several variables that have identical or similar descriptions in both the FARS and GES databases. We compared crashes in 2005 and 2009.

Method

The analysis involved evaluating the changes in crashes from 2005 to 2009 for 11 selected variables that have either identical or similar descriptions in GES (NHTSA, 2011c) and in FARS (NHTSA, 2011b). The specific variables examined are listed in Table 2. (Not all levels of each variable were examined.)

Table 2
Variables examined in the analysis. The entries correspond to the variable numbers in the respective database.

Variable	GES		FARS	
	2005	2009	2005	2009
Time of day	A02	A02	A9	C9
Lighting condition	A19	A19	A31	C31
Vehicle body type	V05	V05	V10	V10
Speed limit	A07	A07	A23	C23
Atmospheric condition	A20	A20	A32	C32
Driver age	P07	P07	P6	P6
Avoidance maneuver	V27	V27	V18	V18
Manner of collision	A07	A07	A18	C18
Driver drinking	P11	P11	P16	P16
Work/construction zone	A25	A25	A28	C28
Airbag availability and deployment	P21	P21	P11	P11

Results and Discussion

Overall changes

Overall, there was a 10.6% reduction in all crashes, and a 21.4% reduction in fatal crashes (see Table 3). These results indicate that the change from 2005 to 2009 involved comparable reductions in both the frequency of crashes (-10.6%) and in the severity of the outcome of crashes (-10.8%). These overall changes, each of about -11%, should be kept in mind when interpreting the changes in the 11 variables that will be documented in Tables 4 through 14.

Table 3
Overall changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), and the resulting changes in the frequency of crashes and the severity of the outcome of crashes.

ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
-10.6%	-21.4%	-10.8%

Time of day

Table 4 lists the changes from 2005 to 2009 by time of day. As indicated in Table 4, the reductions in both the frequency of crashes and the severity of the outcome of crashes were present at all times of the day. The reductions in the frequency of crashes reflect, in part, the overall decrease in driving due to the current economic downturn (FHWA, 2011). The reduction in the frequency of crashes was greatest for the morning rush hours (-14.2%), consistent with decreased employment. On the other hand, the reduction in the severity of the outcome of crashes was greatest for early afternoon (-15.1%), possibly due to a disproportionate reduction in pedestrian crashes (generally very serious crashes) during the lunch hour and at the end of the school day.

Table 4
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by time of day.

Time of day	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
12:00 - 2:59 a.m.	-12.3%	-20.8%	-8.5%
3:00 - 5:59 a.m.	-12.6%	-15.9%	-3.3%
6:00 - 8:59 a.m.	-14.2%	-28.0%	-13.8%
9:00 - 11:59 a.m.	-10.4%	-21.6%	-11.2%
12:00 - 2:59 p.m.	-6.3%	-21.4%	-15.1%
3:00 - 5:59 p.m.	-11.3%	-25.4%	-14.1%
6:00 - 8:59 p.m.	-10.2%	-18.9%	-8.7%
9:00 - 11:59 p.m.	-12.9%	-19.3%	-6.4%

The possible mechanisms mentioned in this section, and in the sections to come, are listed only as examples of mechanisms that could contribute to the observed changes in the frequency and/or the severity of the outcome of crashes. No attempt was made to comprehensively identify all possible mechanisms that underlie all observed changes.

Lighting condition

Changes by lighting condition are documented in Table 5. The largest reduction in the frequency of crashes was for crashes in dark (-20.6%). It is likely that this effect is a consequence of the reduced amount of leisure driving because of the current economic conditions. (Leisure driving is done more often at night than is commuter driving.) On the other hand, the largest reduction in the severity of the outcome was for crashes in daylight (-12.6%).

Table 5
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by lighting condition.

Lighting condition	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
Daylight	-10.2%	-22.8%	-12.6%
Dark	-20.6%	-25.5%	-4.9%
Dark but lighted	-7.3%	-12.2%	-4.9%
Dawn/Dusk	-15.8%	-24.2%	-8.4%

Vehicle body type

Changes by vehicle body type are summarized in Table 6. All major types showed decreases in both the frequency of crashes and the severity of the outcome of crashes. However, for motorcycles, these reductions were small (-1.0% and -2.2%, respectively). The reductions in the frequency of crashes involving heavy trucks (single-unit and truck-tractor) were greater than the reductions for light-duty vehicles (automobiles, pickups, SUVs, and minivans), likely reflecting less truck shipping because of the economic downturn. However, the reductions in the severity of the outcome of crashes were greater for light-duty vehicles than for heavy trucks. This is likely because of more improvements in both active and passive safety recently in light-duty vehicles than in heavy vehicles. Furthermore, given that in 2009 there were fewer crashes involving heavy trucks (which tend to be more severe, and they generally involve light-duty vehicles too), the remaining crashes involving light-duty vehicles would be expected to be less severe in 2009.

Table 6
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by vehicle body type.

Vehicle body type	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
Automobile	-13.0%	-26.3%	-13.3%
Pickup, SUV, or minivan	-8.0%	-21.2%	-13.2%
Motorcycle	-1.0%	-3.2%	-2.2%
Single-unit truck	-27.7%	-34.1%	-6.4%
Truck-tractor	-31.4%	-36.9%	-5.5%

Speed limit

Table 7 presents the changes by speed limit. The reductions in both the frequency of crashes and the severity of the outcome of crashes increased with speed limit. Both trends are consistent with a decrease in leisure driving due to economic factors: Leisure travel tends to occur at higher speeds than commuter travel, and leisure travel is more risky than commuter travel because of increased involvement of both alcohol and nighttime driving. However, the changes in the frequency of crashes did not vary greatly; they ranged from -10.7% for 5–25 mph to -12.7% for 50–75 mph. On the other hand, the changes in the severity of the outcome of crashes showed a greater range, from -2.6% for 5–25 mph to -11.0% for 50–75 mph. The large reduction in the severity of crashes at high speeds is consistent with the large reduction in the frequency of crashes involving heavy trucks (see Table 6). (Heavy trucks tend to accumulate a greater proportion of travel at high speeds than do light-duty vehicle, and heavy-truck crashes tend to be more severe.)

Table 7
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by speed limit.

Speed limit	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
5–25 mph	-10.7%	-13.3%	-2.6%
30–45 mph	-10.9%	-19.4%	-8.5%
50–75 mph	-12.7%	-23.7%	-11.0%

Atmospheric condition

Table 8 lists the changes by atmospheric condition. Crashes in snow showed the largest reduction in frequency (-31.5%), but their outcome became more severe (+4.9%). On the other hand, crashes in rain became more numerous (+6.3%), but their outcome showed the largest reduction in severity (-23.3%). Crashes in sleet and fog became less numerous (-15.1% and -29.5%, respectively), but the severity of their outcome stayed approximately the same (-1.2% and -1.3%, respectively). In no adverse weather, crashes became less numerous and with less severe outcomes (-12.1% and -9.2%, respectively).

The increase in the frequency of crashes in rain is consistent with the fact that rainfall throughout the country in 2009 was generally greater than in 2005 (NOAA, 2011a). Similarly, the large decrease in the frequency of crashes in snow is likely due to the fact that in 2009 a larger area of the country experienced no snow than was the case in 2005 (NOAA, 2011b).

Table 8
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by atmospheric condition.

Atmospheric condition	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
No adverse weather	-12.1%	-21.3%	-9.2%
Rain	+6.3%	-17.0%	-23.3%
Snow	-31.5%	-26.6%	+4.9%
Sleet	-15.1%	-16.3%	-1.2%
Fog	-29.5%	-30.8%	-1.3%

Driver age

In terms of the frequency of crashes by driver age (Table 9), the largest reduction was for those between 16 and 20 years of age (-19.6%), possibly as a consequence of (a) improved graduated-licensing programs (e.g., Fell, Jones, Romano, and Voas, 2011), and (b) the current economic downturn and higher gasoline prices reducing leisure driving by young people the most (because of their more limited discretionary budget). All age groups showed reductions in the severity of the outcome of crashes, with the largest reduction for those between 56 and 65 years of age (-16.0%).

Table 9
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by driver age.

Driver age*	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
16-20	-19.6%	-30.7%	-11.1%
21-25	-16.2%	-29.8%	-13.6%
26-35	-13.9%	-24.4%	-10.5%
36-45	-14.6%	-27.0%	-12.4%
46-55	-5.6%	-17.5%	-11.9%
56-65	+4.6%	-11.4%	-16.0%
66-75	+0.6%	-12.2%	-12.8%
76-85	-6.1%	-16.6%	-10.5%

* Drivers under 16 and over 85 were not included in the analysis because of their small numbers in both databases.

Avoidance maneuver

Table 10 presents the changes by avoidance maneuver. The frequency of crashes with no avoidance maneuver increased (+8.5%), possibly reflecting an increase in driver distractions. However, the severity of the outcome of these types of crashes decreased (-38.4%). A similar pattern was evident for crashes with braking only (+2.9% and -26.3%, respectively). On the other hand, for crashes when steering was performed, both the frequency of crashes and the severity of the outcome of crashes were reduced (-23.0% and -3.6%, respectively). A similar pattern was present for crashes with both steering and braking (-23.9% and -6.3%, respectively). The findings of a reduced frequency of crashes and a reduced severity of the outcome of crashes with steering (with or without braking) are consistent with the increased penetration of electronic stability control (ESC) on new vehicles.

Table 10
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by avoidance maneuver.

Avoidance maneuver	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
None	+8.5%	-29.9%	-38.4%
Steering	-23.0%	-26.6%	-3.6%
Braking	+2.9%	-23.4%	-26.3%
Steering and braking	-23.9%	-30.2%	-6.3%

Manner of collision

Crash changes by manner of collision are listed in Table 11. Front-to-front crashes became more numerous (+4.3%), possibly due to an increase in driver distractions. However, the severity of the outcome of these types of crashes decreased (-28.7%), possibly because of lower speeds (see Table 7) and improved occupant protection. For the remaining types of crashes, both the frequency and the severity of the outcome decreased.

Table 11
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by manner of collision.

Manner of collision	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
Not a collision (single vehicle)	-8.3%	-17.1%	-8.8%
Front-to-rear	-5.0%	-23.3%	-18.3%
Front-to-front	+4.3%	-24.4%	-28.7%
Angle	-20.3%	-30.5%	-10.2%
Sideswipe	-8.3%	-20.4%	-12.1%

Driver drinking

Table 12 presents information on the changes in the role of alcohol in crashes. Drivers in crashes who were reported to be drinking were less numerous in 2009 than in 2005 (-18.5%), but the severity of the outcome of crashes with drivers reported to be drinking increased (+4.4%).

Table 12
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by driver drinking.

Driver drinking	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
Yes	-18.5%	-14.1%	+4.4%
No	-13.5%	-25.8%	-12.3%
Unknown	+10.0%	n/a	n/a

Work/construction zone

As shown in Table 13, crashes in work/construction zones were less numerous in 2009 than in 2005 (-42.7%), likely reflecting the decrease in road maintenance due to economic factors. However, the severity of the outcome of these types of crashes increased (+4.0%).

Table 13
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by work zone.

Work zone	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
Yes	-42.7%	-38.7%	+4.0%
No	-9.8%	-21.0%	-11.2%

Airbag availability and deployment

As shown in Table 14, crashes in which no airbags were available were fewer in 2009 than in 2005 (-47.2%), and with less severe outcome (-7.4%). On the other hand, crashes in which an airbag deployed increased in frequency (+3.8%), but the severity of their outcome decreased (-12.0%). This pattern is consistent with the increased availability of airbags (and especially of side-impact airbags) and their improvement. Finally, crashes in which an available airbag did not deploy increased in frequency, but the severity of their outcome decreased (+42.3% and -16.0%, respectively), consistent with a decreased frequency of crashes at high speeds (see Table 7).

Table 14
Changes from 2005 to 2009 for all crashes (GES) and for fatal crashes (FARS), by airbag availability and deployment.

Airbag	ΔGES (change in frequency)	ΔFARS	ΔFARS minus ΔGES (change in severity)
Not available	-47.2%	-54.6%	-7.4%
Deployed	+3.8%	-8.2%	-12.0%
Available but did not deploy	+42.3%	+26.3%	-16.0%

Summary

This study introduced a new methodology for evaluating the relative contributions of the changes in the frequency of crashes and the severity of the outcome of crashes to the recent large improvement in road safety in the U.S. The approach is based on a parallel examination of changes in variables for all crashes and for fatal crashes only. The change for all crashes provides an index of the change in the frequency of crashes; the difference between the change in the frequency of fatal crashes and the change in the frequency of all crashes provides an index of the change in the severity of the outcome of crashes. The specific analysis that was performed using this new methodology involved examining the changes from 2005 to 2009 in 11 selected variables common to both the GES database (all crashes) and the FARS database (fatal crashes only).

The main result is that from 2005 to 2009 there were reductions in both the frequency of crashes and the severity of the outcome of crashes. The obtained patterns of change for the 11 examined variables are consistent with the known changes in factors such as the economic conditions (resulting in less driving, and different proportions of leisure and nighttime driving), installation of active-safety technology (e.g., electronic stability control), installation and quality of passive-safety technology (e.g., airbags), licensing of young drivers, and driver distractions.

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