Status Report

Insurance Institute for Highway Safety | Highway Loss Data Institute

Left behind

Rear-seat occupant protection hasn't kept pace with the front

ALSO IN THIS ISSUE

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- Developing new crash tests
- Better belt reminders could save 1,500 lives a year
- Speed limit increases cost 37,000 lives over 25 years

A new IIHS study of frontal crashes in which belted rear-seat passengers were killed or seriously injured suggests that more sophisticated restraint systems are needed in the back.

Front-seat occupants have benefited greatly from advancements in restraints — the umbrella term for airbags and seat belts, which work together during a crash to keep a person in the proper position and manage forces on the body. Back-seat occupants haven't benefited from this technology to the same extent.

IIHS first looked at rear-seat injuries and fatalities in 2014 (see *Status Report*, Dec. 23, 2014). Failing to buckle up was a big factor, but many older adults and children over age 9 suffered injuries even when belted.

The new study takes a closer look at the specific types of injuries belted back-seat passengers age 6 or older sustained in front crashes. IIHS is using the information to develop a new front crash test that will evaluate occupant protection in the rear as well as the front. The Institute is currently conducting a series of research crash tests as part of this project (see p. 4).

Most of the rear-seat fatalities in the new study were in crashes considered survivable. That suggests that better restraints in the back seat could save many lives.

"Manufacturers have put a lot of work into improving protection for drivers and front-seat passengers. Our moderate overlap front crash test and, more recently, our driver-side and passenger-side small overlap front tests are a big reason why," IIHS President David Harkey says. "We hope a new evaluation will spur similar progress in the back seat."

As soon as a frontal collision starts, seat belts in the front seat tighten around the occupants, thanks to embedded devices called crash tensioners. At the same time, the front airbags deploy within a fraction of a second. Depending on the crash configuration, the side airbags may deploy too.

The tightened belts and deployed airbags keep the front-seat occupants safely away from the steering wheel, instrument panel and other structure when the vehicle stops abruptly, even if the force of the crash pushes that structure inward. To reduce the risk of chest injuries, these belts also have force limiters, which allow some webbing to spool out before forces from the belt get too high.

In the rear seat, side airbags protect passengers in a side crash, but there are no front airbags, and the seat belts generally lack crash tensioners and force limiters.

Although intruding structure is usually not an issue in the back seat during a frontal collision, crash forces can cause a back-seat passenger to collide with the vehicle interior. Seat belts can prevent that, but, as the new study shows, seat belts without force limiters can inflict chest injuries.

For the study, IIHS researchers used two national databases to find 117 crashes in which rear-seat occupants were killed or seriously injured. The most common type of injury, found in 22 of the injured occupants and 17 of the 37 fatalities with documented injuries, was to the chest.

Of the fatal cases, most were considered survivable, meaning there was sufficient

space in the vehicle for the passenger after the crash. This contrasts with a 2003 IIHS study of fatally injured children in child restraints. In that study, the crashes in which child restraints were properly used were generally unsurvivable (see *Status Report*, June 11, 2003).

"Child restraints are so effective that when young children in properly used restraints die, it's usually because the crash was so severe that improving the restraints wouldn't have made a difference," says IIHS Senior Research Engineer Jessica Jermakian, the lead author of the new paper. "The fact that our sample had mostly survivable crashes tells us that we need to do a better job restraining adults and older children in the back seat."

In many of the cases in the new study, the back-seat passengers were injured more severely than the front-seat occupants, suggesting the restraints in the rear didn't perform as well as the ones in the front.

Using information in the case records — including things like photographs, police and medical records, and crash investigation »

Back seat solutions

Seat belts have to hold occupants tightly in a crash. In doing so, they sometimes cause chest injuries. One solution is a force limiter (right). The small metal rod is built into a seat belt retractor. It twists during a crash to allow a bit of webbing to spool out before forces get too high. An inflatable seat belt can help by spreading forces across the torso. A rear-seat frontal airbag also would allow for a more forgiving seat belt and would protect the head.

Ford Motor Company

ZF Friedrichshafen AG

Using real-world crash data to develop new crash tests

Crash tests at the IIHS Vehicle Research Center normally follow the same procedures day in and day out to produce comparable results for vehicle ratings. Lately, however, IIHS engineers and technicians have been mixing it up as they try out new test configurations — not for current ratings but for the evaluations of the future.

The new study of real-world crashes in which rear-seat occupants were killed or injured points to problems with rear-seat protection. Now research tests are being conducted to figure out what kind of evaluation will help distinguish vehicles that offer better protection in the rear seat from those that are lagging.

A second group of tests aims to solve another crash-testing puzzle: how to modify the successful IIHS side test to encourage even better protection in right-angle crashes.

For both research programs, the goal is to come up with a draft protocol for a new evaluation by the end of the year and incorporate a new test into IIHS ratings for 2022.

"All of our tests start with real-world crash data," says Joe Nolan, IIHS senior vice president for vehicle research. "We look for trends in the crashes that leave people with serious or fatal injuries. If those crashes have things in common that current ratings don't capture, we'll try to fill that gap in the ratings."

That was true of the very first IIHS evaluation, the moderate overlap front test. The Institute began the program in 1995 to complement the frontal evaluation that the National Highway Traffic Safety Administration (NHTSA) had been doing as part of the New Car Assessment Program started in the 1970s.

In the NHTSA frontal test, vehicles are crashed at 35 mph into a rigid barrier that covers the full width of the vehicle. This test spurred big improvements in occupant protection, but didn't reflect the full range of real-world frontal crashes. In the 1990s, IIHS researchers found that more than half of frontal crashes in which a vehicle was towed involved two-thirds or less of the front end (See *Status Report*, June 25, 1994).

In the IIHS moderate overlap test, 40 percent of the front of the vehicle strikes the barrier.

Once automakers mastered the moderate overlap test, IIHS researchers looked for other ways to raise the bar for frontal crash protection. In a 2009 study of vehicles with good ratings in the moderate overlap test, nearly a quarter of the frontal crashes in which front-seat occupants were seriously or fatally injured involved only a small portion of the vehicle's front end (see *Status Report*, March 7, 2009). This finding led to the development of the small overlap front test, in which 25 percent of the vehicle strikes the barrier.

The Institute's side crash test also came about because of a gap in existing evaluations. NHTSA's moving-barrier side test relies on a barrier developed in the early 1980s, when most of the vehicles on the road were cars, not SUVs and pickups. The NHTSA test doesn't account for the much greater risk of head injury from impacts with taller vehicles. In 2003, IIHS began its own testing with a barrier that mimicked the height and shape of the front end of the typical SUV or pickup on the road at the time (see *Status Report* special issue: side impact crashworthiness, June 28, 2003).

The current side-impact research tests build on a study of real-world side crashes in which people were seriously injured in vehicles with good side ratings from IIHS. In that study, many of the impacts occurred further forward on the vehicle than the spot where the barrier strikes in the current IIHS test. Many also occurred at higher speeds than the 31 mph used in the test.

IIHS engineers have also taken a closer look at the moving barrier and found that it may need to be redesigned to more closely approximate the front ends of SUVs and pickups.

The research tests for rear occupant protection in frontal crashes are looking at what size dummies to use in the rear seat. Engineers are also considering whether to simply add the rear-seat dummies to an existing frontal evaluation or modify other aspects of the test too. The latter route would provide an opportunity to learn something new about front-seat protection at the same time. ■

This 37 mph crash of a 2015 Ford F-150 into a 2018 Toyota Camry is part of a series of research tests investigating how the IIHS side crash evaluation might be improved.

(« *from p. 3)* and autopsy reports — the researchers determined that the rear-seat chest injuries were mostly due to excessive forces from the shoulder belt.

Force limiters like the ones in the front seat would be one way to reduce belt injuries. Another possible solution is an inflatable seat belt of the type introduced by Ford and Mercedes-Benz. These belts inflate in a crash to better distribute forces across the torso and chest.

Head injuries were the second-most common injury type in the study. They were present in nine injured passengers and 18 fatalities.

Many of the fatal head injuries occurred in crashes considered unsurvivable. In some nonfatal crashes, passengers hit their heads against the vehicle interior, but researchers couldn't confirm any such incidents in the fatal cases, which generally had less detailed information about injuries.

Still, head injuries are a concern, so it's important that anything done to reduce forces on the chest doesn't raise the danger that the passenger's head moves too far forward. Too much forward movement could allow a passenger's head to come into contact with the front seatback or other parts of the vehicle interior.

"This is a big reason why force limiters usually go hand in hand with crash tensioners," Jermakian says. "With a crash tensioner, a person is held firmly against the seat from the beginning of the crash, so a slight loosening of the belt from the force limiter isn't a big a problem."

Manufacturers might also find a way to equip rear seats with frontal airbags — for example, deploying from the roof — but so far that hasn't been done in any production vehicle.

IIHS isn't prescribing a particular solution for the back seat. Instead, the Institute believes a crash test that evaluates rear-seat protection will prompt automakers to figure out what combination of technologies works best.

"We're confident that vehicle manufacturers can find a way to solve this puzzle in the back seat just as they were able to do in the front," Harkey says.

For a copy of "Factors contributing to serious and fatal injuries in belted rear-seat occupants in frontal crashes" by J.S. Jermakian et al., email StatusReport@iihs.org. ■

Belt reminders can be just as effective as interlocks

Persistent audible belt reminders are no less effective at promoting belt use than interlocks, which drivers often circumvent, and may raise fewer concerns for drivers, new IIHS research suggests.

Encouraging belt use through this technology is a simple intervention that would help move the U.S. closer to the goal of zero fatalities. The researchers found that persistent reminders could save nearly 1,500 lives a year if all vehicles were equipped with them.

IIHS researchers conducted two studies that build off earlier research about the best ways to close the remaining belt use gaps. Seat belts reduce the risk of death among front-row occupants in crashes by 45 percent. About 90 percent of drivers and front passengers use seat belts, but nearly half of front-seat occupants killed in crashes weren't belted.

In the first of the new studies, 49 part-time belt users who had recently received a seat belt citation drove two vehicles with different seat-belt reminders or a speed-limiting interlock for one week each. The data were combined with data from an earlier study, also involving part-time belt users with recent citations, that compared a gear-shift interlock with an audible belt reminder from Chevrolet consisting of three seven-second periods of chiming, a minute or more apart (see *Status Report*, Nov. 21, 2017).

In the latest round of data collection, some participants first drove a Chevrolet with the same fairly minimal belt reminder as used in the first study. They then drove either a BMW with a 100-second audible reminder or a Subaru with an audible reminder that lasted indefinitely, until the person buckled. A third group drove BMWs with the 100-second reminder first and then a BMW equipped with a prototype speed-limiting interlock. This interlock restricted vehicle speed to 15 mph if either the driver or front passenger was unbelted.

Comparing belt use with these four different technologies, the researchers found that the speed-limiting interlock, the indefinite reminder from Subaru and the 100-second constant reminder from BMW all increased belt use by 30-34 percent compared with the intermittent reminder from Chevrolet. The gear-shift interlock increased belt use 16 percent relative to the intermittent reminder.

Increasing belt use by 34 percent in all vehicles on U.S. roads would save 1,489 lives each year, the researchers calculated.

"We expected the interlocks to be more effective than any type of belt reminder, but that didn't turn out to be the case," says HLDI Senior Research Scientist David Kidd, the study's lead author. "Many people simply forget to buckle up, so a persistent reminder works well for them. For those who are really averse to using the seat belt, an interlock doesn't always help »

(« *from p. 5)* because they can find a way to get around it, for example by buckling the belt behind their back or sitting on top of it."

In a complementary study, some participants were invited back to give their opinions about three different reminder systems and three different interlock systems after experiencing each during a short drive. Based on their experience, participants felt the interlocks were more effective for increasing belt use.

Surprisingly, when asked how acceptable each technology would be to them in their personal vehicle, interlocks were no less acceptable than belt reminders.

Interlocks were previously so hated that Congress passed a law banning them in the 1970s. That was after the National Highway Traffic Safety Administration required them on all vehicles without airbags. The law also limited how persistent seat belt reminders could be.

A 2012 highway reauthorization law relaxed these restrictions. Now NHTSA can permit automakers to equip vehicles with belt interlocks as an alternative means to comply with a federal safety standard. The agency also can require belt reminders with auditory warnings that last longer than the prior eight-second limit.

People who are determined to evade seat belt interlocks usually find a way, for example, by buckling the belt behind them.

"Attitudes toward belt interlocks seem to have softened as the culture surrounding seat belts has evolved," Kidd says. "However, participants in the study raised safety concerns about interlocks that were not expressed for reminders."

The main concerns people voiced were that interlocks could prevent someone from operating a vehicle in an emergency or that limited vehicle function could increase crash risk.

Some of these concerns are well-founded. In survey responses from the two-week on-road study, two participants described how the speed-limiting interlock suddenly slowed the vehicle because groceries or other objects were mistaken for an unbelted front-seat passenger. Another two participants felt that a sudden slowdown caused by the speed-limiting interlock almost resulted in a crash.

For copies of "The effects of persistent audible seat belt reminders and a speed-limiting interlock on the seat belt use of drivers who do not always use a seat belt" and "Consumer acceptance of enhanced seat belt reminders, a gearshift interlock, or different speed-limiting interlocks to encourage seat belt use following a brief hands-on experience," both by D.G. Kidd and J. Singer, email StatusReport@iihs.org. ■

Speed limit increases are tied to 37,000 deaths over 25 years

Rising speed limits over the past 25 years have cost nearly 37,000 lives, including more than 1,900 in 2017 alone, a new IIHS study shows.

The research, an update of a 2016 analysis, calls attention to the trade-off between a few minutes of saved travel time and the increased risk of fatalities (see *Status Report*, April 12, 2016).

Maximum speed limits are set by the states, and they have been rising since the mid-1990s. Proponents of raising the speed limit often argue that such increases simply bring the law in line with reality, since most drivers exceed the limit. Once the limit is raised, however, drivers go even faster.

Today, 41 states have maximum speed limits of 70 mph or higher. Six states have 80 mph limits, and drivers in Texas can legally drive 85 mph on some roads.

For the new study, Charles Farmer, IIHS vice president for research and statistical services, analyzed the effect of changes in the maximum posted limit in every state from 1993 to 2017. Looking at annual traffic fatalities per mile traveled for each state and taking into account other factors that affect fatality rates — including changes in unemployment, the number of potential young drivers (ages 16-24) and the seat belt use rate — he calculated the effect of speed limit increases.

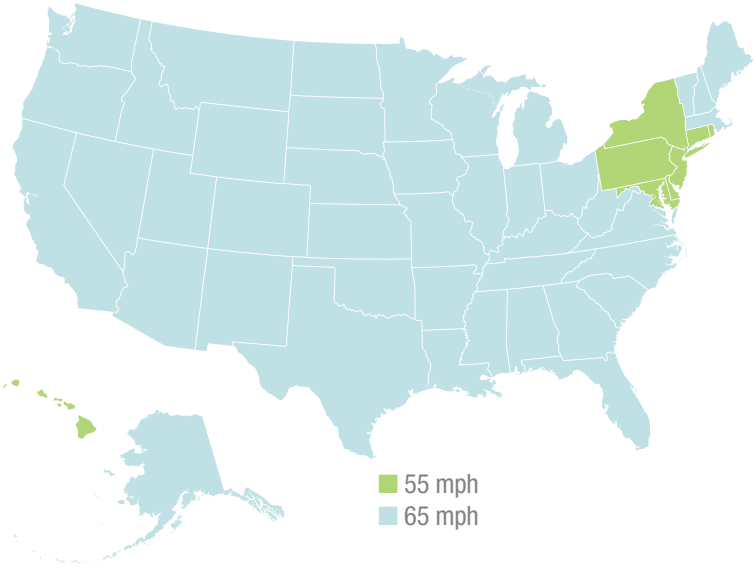
Farmer found that a 5 mph increase in the maximum speed limit was associated with an 8 percent increase in the fatality rate on interstates and freeways — the roads most directly affected by changes to the maximum speed limit — and a 3 percent increase on other roads. In total, over the 25-year study period, there were 36,760 more deaths — 13,638 on interstates and freeways — and 23,122 on other roads — than would have been expected if maximum speed limits hadn't changed over that time.

Of the 37,133 people who died on U.S. roads in 2017, Farmer estimates that 1,934, or 5 percent, would still be alive if speed limits hadn't changed since 1993. "Driving 70 instead of 65 saves a driver at best 6½ minutes on a 100-mile trip," Farmer says. "Before raising speed limits, state lawmakers should consider whether that potential time savings is worth the additional risk to lives."

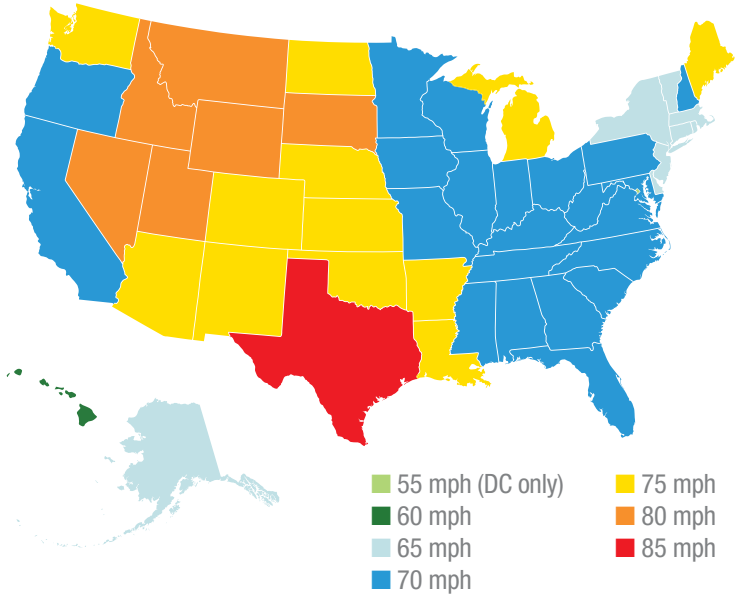
For a copy of "The effects of higher speed limits on traffic fatalities in the United States, 1993-2017" by C.M. Farmer, email StatusReport@iihs.org ■

Rising speed limits and deaths

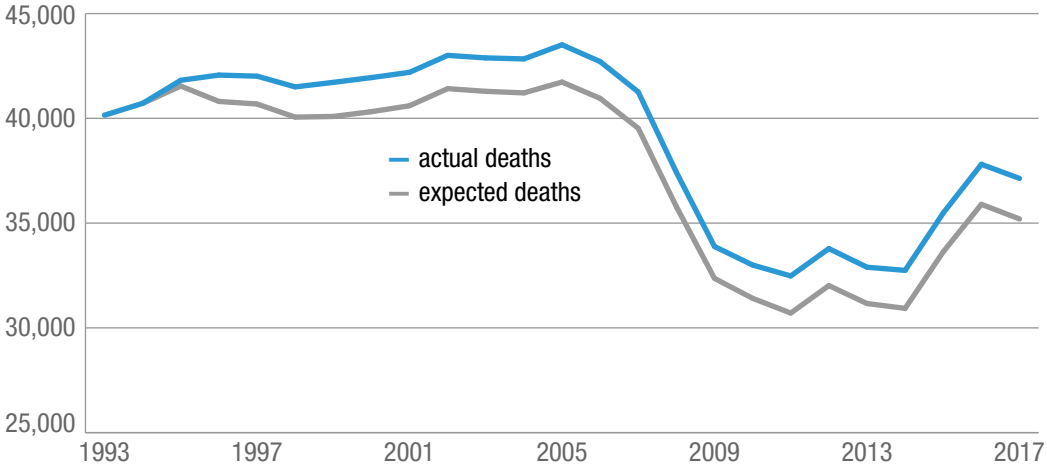
Maximum speed limits, January 1993



Maximum speed limits, December 2017



Deaths and expected deaths if maximum speed limits had not increased, 1993-2017



A 5 mph increase in the maximum posted speed limit is associated with an 8 percent increase in the fatality rate on interstates and freeways and a 3 percent increase on other roads, the study found. That adds up to 36,760 additional deaths over 25 years.

Insurance Institute for Highway Safety
Highway Loss Data Institute

Status Report

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HLDI shares and supports this mission through scientific studies of insurance data representing the human and economic losses resulting from the ownership and operation of different types of vehicles and by publishing insurance loss results by vehicle make and model.

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