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Will the light truck bumper height-matching standard reduce deaths in cars?

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ABSTRACT

Background: In a collision between a car and a sport utility vehicle (SUV) or pickup truck, car occupants are more likely to be killed than if they crashed with another car. Some of the excess risk may be due to the propensity of SUVs and pickups with high bumpers to override the lower bumpers in cars. To reduce this incompatibility, particularly in head-on collisions, in 2003 automobile manufacturers voluntarily established a bumper height-matching standard for pickups and SUVs.
Objective: To assess whether height-matching bumpers in pickups and SUVs were associated with the risk of death in either car occupants or pickup and SUV occupants.
Methods: Case–control study of collisions between one car and one SUV or pickup in the US during 2000–2008, in which the SUV or pickup was model year 2000–2006. Cases were all decedents in fatal crashes; one control was selected from each crash in a national probability sample of crashes.
Findings: Occupants of cars that crashed with SUVs or pickups with height-matching bumpers may be at slightly reduced risk of death compared to those that crashed with other SUVs or pickups (adjusted odds ratio: 0.83 (95% confidence interval 0.61–1.13)). There was no evidence of a reduction in risk in head-on crashes (1.09 (0.66–1.79)). In crashes in which the SUV or pickup struck the car on the side, height-matched bumpers were associated with a reduced risk of death (0.68 (0.48–0.97)). Occupants of SUVs and pickups with height-matching bumpers may also be at slightly reduced risk of death (0.91 (0.64–1.28)).
Conclusions: Height-matching bumpers were associated with a reduced risk of death among car occupants in crashes in which SUVs or pickups struck cars in the side, but there was little evidence of an effect in head-on crashes. The new bumper height-matching standard may not achieve its primary goal of reducing deaths in head-on crashes, but may modestly reduce overall deaths in crashes between cars and SUVs or pickups because of unanticipated benefits to car occupants in side crashes, and a possible beneficial effect to SUV and pickup occupants.

1. Introduction

As the proportion of SUVs and pickup trucks on U.S. roads rose during the 1990s, the problem of the increased danger they posed to car occupants gained more attention (Bradsher, 2002; Summers et al., 2001). It was noted that light trucks and vans (LTVs) were particularly dangerous to car occupants in head-on collisions and in angle collisions in which the LTV struck the car in the side (Summers et al., 2001; Joksch, 2000). Bumpers in many LTVs are higher than car bumpers, and studies suggested that a major cause of the excess deaths in cars was the tendency of LTVs to override the front bumper of cars in head-on collisions, or to override the door sill in angle collisions (Acierno et al., 2004).

In response to these concerns, in 2003 the Alliance of Automobile Manufacturers (AAM) convened two workgroups to develop strategies for enhancing compatibility in crashes between cars and light trucks (Alliance of Automobile Manufacturers, 2003). One workgroup was assigned to work on side-impact crashes (in which light trucks strike cars in the side). This work group recommended improving self-protection in cars by increasing side structure strength and installing side airbags. Another workgroup was assigned to work on head-on crashes, and recommended that compatibility between light trucks and cars be improved by requiring that the front energy-absorbing structure in light trucks be installed at a height that would match the front bumper of cars. On cars and light trucks, the bumper is the primary energy-absorbing structure. Manufacturers of light trucks could meet this standard by having the light truck bumper match car bumpers (known as Option 1), or by installing a secondary energy-absorbing structure

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below the light truck bumper to match car bumpers (known as Option 2). This standard was intended to reduce intrusion into the passenger cabin of cars and thereby reduce fatalities to car occupants. Although the purpose of the standard was to reduce fatalities in head-on crashes, the workgroup thought it might also provide some benefit in side-impact crashes. All major auto manufacturers, except Porsche, agreed to implement this standard in all light trucks sold in the U.S. by September 1, 2009 (although Porsche did not sign the agreement, all current Porsche models meet the standard).

The Insurance Institute for Highway Safety (IIHS) evaluated the effect of LTVs that met the standard (Baker et al., 2008). They found that in crashes in which LTVs met the standard, there was a 19% reduction in risk of death to car occupants in both head-on and side-impact crashes. The IIHS study was conducted by tabulating the deaths recorded in NHTSA's Fatality Analysis Recording System (FARS) in head-on or side-impact crashes between cars and SUVs or pickups, and dividing those numbers by the number of registered light trucks. This method does not allow for control of a variety of potential confounders, including some which influence the risk of death given a crash, such as vehicle speed or seatbelt use, and some which influence the chance of a crash occurring, such as miles driven or the crash propensity of the driver.

We conducted two analyses of crashes involving SUVs and pickups. The first analysis assessed the effectiveness of lowered front energy-absorbing structures in SUVs and pickups in reducing deaths in cars (the *car-occupant analysis*). Our method allowed us to estimate this effect given that a crash occurred, and allowed us to control for a variety of characteristics of the crash, the vehicles, and the persons involved in the crash. We also evaluated the difference in effectiveness between front bumpers on LTVs which met the standard through Option 1 and LTVs with secondary energy-absorbing structures that met the standard through Option 2. The second analysis assessed whether bumper configuration affected the risk of death of occupants of SUVs and pickups (the *LTV-occupant analysis*).

2. Materials and methods

Both analyses used case–control designs and drew data from two large US crash databases. We drew cases from the Fatality Analysis Reporting System (Tessmer, 2007) (FARS), and controls from the General Estimates System (NHTSA, 2007; Shelton, 1991) (GES), both of which are maintained by the National Highway Traffic Safety Administration (NHTSA). FARS includes reports of all motor vehicle crashes occurring on public roads in the U.S. that result in a death within 30 days of the crash. The GES includes a probability sample that is designed to be representative of all police-reported crashes occurring in the U.S. If there was a fatality in the GES crash, that crash was still eligible, but a surviving occupant was selected as the control.

From each eligible fatal crash, all fatalities were selected as cases, and from each eligible GES crash, one person was selected as a control. The selected case or control was termed the *index person*. The vehicle the index person was riding in was termed the *index vehicle*, and the vehicle that they crashed with was termed the *opposing vehicle*. For the car-occupant analysis we used crashes in which the index vehicle was a car, and the opposing vehicle was an SUV or pickup truck. In this analysis, the exposure of primary interest was the bumper configuration of the opposing vehicle. In the LTV-occupant analysis, we used crashes in which the index vehicle was an SUV or pickup, and the opposing vehicle was another passenger vehicle. Here, the exposure of interest was the bumper configuration of the index vehicle.

In both analyses, we restricted the analysis to the consideration of bumper configuration in SUVs and pickups of model year 2000–2006. We did not have data on bumper configuration for models before 2000, and could not classify light trucks into NHTSA vehicle families after model year 2006. In both analyses, we restricted the other vehicle (the index car in the car-occupant analysis, or the opposing passenger vehicle in the LTV-occupant analysis) to model year 1980 or newer. Older vehicles are likely to differ enough in design and crash characteristics from newer vehicles that including them would make the results less generalizable to current vehicles.

2.1. Case and control selection

For the car-occupant analysis, we selected as cases all car occupants who died in collisions occurring between 2000 and 2008 in which one car and one SUV or pickup and no pedestrians were involved, the SUV or pickup was of model year 2000–2006 and the car was of model year 1980 or newer. For controls, we included surviving car occupants from GES crashes that otherwise met the same criteria. If there was more than one surviving occupant in the index control vehicle, we randomly selected one as the control.

For the LTV-occupant analysis, we selected as cases all SUV or pickup occupants who died in crashes occurring between 2000 and 2008 in which one SUV or pickup and one other passenger vehicle (which could also be an SUV or pickup) and no pedestrians were involved, the index SUV or pickup was of model year 2000–2006 and the other vehicle was model year 1980 or newer. For controls, we included SUV or pickup occupants from control crashes that otherwise met the same criteria. If the GES crash involved two SUVs or pickups of model year 2000–2006, then we randomly selected one of them as the index vehicle. If the index vehicle had more than one surviving occupant, we randomly selected one as the control.

2.2. Vehicle classification

We classified vehicle types as passenger cars, compact SUVs, full-size SUVs, compact pickups, and full-size pickups, using the body type codes in FARS and GES, and the FARS and GES instructions for grouping body types into vehicle types (Tessmer, 2007; NHTSA, 2007). We included light trucks with a gross vehicle weight rating (GVWR) up to 10,000 pounds, if they were a type likely to be used for personal transportation. We excluded light trucks with a body type code denoting commercial use, such as panel trucks.

For some LTVs, the body type information was complete enough to classify vehicles as SUVs or pickups, but not to classify them as compact versus full-size SUVs or pickups (Table 1). For these, we used multiple imputation to classify the size (see below).

2.3. Bumper configuration

We classified vehicles into "vehicle families", consisting of models of the same design, using the vehicle identification number (VIN) and SAS programs developed by NHTSA for that purpose (Kahane, 2007). Each member of a vehicle family was made by the same manufacturer but may have been marketed under different nameplates, for example, Ford Taurus and Mercury Sable. We categorized vehicles from each model year for each vehicle family into one of three categories: the bumper height matched car bumper heights (i.e. the vehicle met the standard through Option 1), the vehicle had a secondary energy-absorbing structure installed below the bumper (met Option 2), or the vehicle did not meet the standard. For model years 2000–2003, we obtained bumper configuration data from a report by Baker and colleagues (Baker et al., 2008). For model years 2004–2006, we obtained bumper configuration from the reports submitted to NHTSA by each auto manufacturer (Docket NHTSA-2003-14623 at http://www.regulations.gov/search/index.jsp (accessed 02.09.09).