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Abstract
A previous NHTSA study in 2013 reported that females have a higher estimated fatality risk than males in comparable crashes (i.e., from similar physical impacts) as front row occupants when the full history of all fatal crashes are considered. This report updates NHTSA's previous analysis to examine the effect of sex on driver-side or right-front passenger-side occupant fatalities in fatal crashes, focusing on recent model year (MY) vehicles with advanced occupant protection technologies for various vehicle types and impact types. Key findings are:

- Incremental female fatality risk estimates versus males are reduced in newer MY vehicles. In this study, incremental risks for female front-row occupants (average of drivers and right-front passengers) age 16 to 96 are found to be 19.9 (± 1.3) percent in fatal crashes in MY 1960-1999 vehicles, and 9.4 (± 2.2) percent in MY 2000-2020 vehicles. The difference in fatality risk between females and males is further reduced when looking at MY 2010-2020 vehicles (6.3 ± 5.4%) compared to MY 1960-2009 vehicles (18.3 ± 1.2%).
- When extended to MY 2015-2020 vehicles, the estimated difference in fatality risk between females and males is further reduced to 2.9 (± 9.8) percent for the average of drivers and right-front passengers. The difference in fatality risk between female and male drivers is close to zero (0.5 ± 17.5%) while the risk between female and male right front passengers is 5.3 (± 16.4) percent.
- Incremental fatality risk estimates are reduced in vehicles with newer generations of occupant protection systems regardless of model year. When occupants are belted in vehicles with the latest generation of modern occupant protection systems (dual air bags, seat belt pretensioners, and load limiters), the estimated female fatality risk relative to males (average of drivers and right-front passengers) becomes 5.8 (± 3.8) percent, which is lower than for belted occupants in vehicles without those occupant protections.
- Differences in fatality risks vary across ages. The estimated fatality risk for females relative to males is highest in younger ages, and the relative risk decreases for older ages. In the oldest age groups (65-96), female drivers have lower fatality risk than male drivers.
- Other confounding factors exist: vehicle type and impact type affect the fatality risk level of females relative to males.

17. Key Words
relative fatality risk, logistic regression, double pair comparison, model year, impact type, occupant protection

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Executive Summary

This report updates part of a previous NHTSA study (Kahane, 2013) examining female fatality risk relative to males in driver-side or right-front (RF) passenger-side (front-row) fatal crashes with similar physical impacts. The purpose of this report is to present updated findings by focusing on trends in relative female fatality risk from older to newer vehicle model years (MY) and from older to newer generations of occupant protection systems in an attempt to capture the effects of recent vehicle safety improvements and to determine whether differentials in fatality outcome by sex remain. It should be noted that this study looked only at female fatality risk relative to males and did not look at absolute female fatality risk.

From the mid-1990s through the early 2010s, numerous regulatory and consumer metric-focused changes to crashworthiness testing programs were made. In combination, these changes required or encouraged automakers to make substantial crashworthiness improvements to their vehicles, including installing more-advanced seat belts and air bags. For example, NHTSA issued updates to Federal Motor Vehicle Safety Standard (FMVSS) Nos. 208 and 214, which are the occupant crash protection and side impact protection standards. The updates to both standards included the introduction of female crash test dummies, as well as new frontal and side crash testing protocols and performance requirements. Additionally, starting with MY 2011, NHTSA's New Car Assessment Program (NCAP) was updated to include an additional side impact pole test condition and, for the first time, female crash test dummies in all tests. Further, from 1995 to 2012, the Insurance Institute for Highway Safety (IIHS), which provides consumers crash safety ratings separate from, but similar to NCAP, also introduced three new crashworthiness testing protocols into its safety ratings program, including the use of a small female crash test dummy in its side impact protocol beginning in 2003.

This study focuses on whether newer vehicles affected by new regulations and consumer information programs continue to show different relative fatality risk for female front-row occupants in fatal crashes when compared to older vehicles without the safety updates. The 2013 study had reported that front-row female occupants were 17.0 percent more likely to be killed than front-row male occupants in passenger vehicles in comparable crashes when considering an overall analysis of passenger vehicles with MYs 1960 to 2011 from the Fatality Analysis Reporting System (FARS) 1975-2010. The overall finding in the Kahane 2013 report does not reflect sex-related fatality risk differences in modern vehicles involved in fatal crashes, given the majority of vehicles used to derive the 17.0-percent incremental risk finding were not equipped with the newer generations of seat belts and air bags. In the 2013 report, 120,460 out of 154,467 vehicles involved in fatal crashes (78%) did not have any form of air bags, let alone newer generation of air bags and seat belts.

The current study augments the data included in the 2013 study by adding vehicles from recent fatal crashes and vehicles with younger occupants. Therefore, this study uses data from FARS 1975-2019, with vehicle MYs 1960 to 2020 and an occupant age range of 16- to 96 years (the 2013 study used an age range of 21- to 96). For comparison, the current study presents case (i.e., vehicle) counts and associated differences in front-row occupant female fatality risk compared to males for both age ranges (21- to 96 and 16- to 96) in the Appendix. The body of the report and associated figures, however, focus on the results from the dataset that includes 16- to 20-year-old occupants.

Like the 2013 study, this study selects passenger vehicles with a driver and RF passenger, at least one of whom was fatally injured, and with identical seat belt use status and air bag availability between the driver and RF passenger. This study, like the 2013 study, also includes only cars, light trucks, and vans (LTVs). The full dataset after applying these criteria includes 255,566 vehicles (178,175 if limiting to occupant age range of 21 to 96). This full dataset was divided into various vehicle groups, based on factors including MY, vehicle type, occupant protection type, and crash type, depending on the analysis.

As in the 2013 study, Vehicle Identification Number (VIN) analysis programs were used to determine the occupant protection type for vehicles. This was possible in the majority of cases (242,258 cases). Many newer cases were added for vehicles equipped with seat belts and dual air bags (45,281 cases in the current study, compared to 20,508[1] cases in the 2013 study), which enabled improved MY and occupant protection equipment generation-based analyses. However, the majority of the cases with known occupant protection types were vehicles without air bags (180,851 out of 255,566 cases involving occupant ages 16 to 96 and 121,960 out of 178,715 cases involving occupant ages 21 to 96). Thus, as with the 2013 study, the overall results of the current study when including FARS crash years 1975 to 2019 and vehicle MYs 1960 to 2020 (Appendix – Table A: 15.5% increased risk for females for occupants 21 to 96 years old and 17.9% when adding 16- to 20-year-old occupants) present a long historical average and do not describe trends in risk differences over time that result from confounding factors such as modern crashworthiness improvements introduced in modern vehicles. For that reason, this report focuses on the analysis of how the estimated relative fatality risk for females versus males may have changed over time, looking at trends by MY and by occupant protection technology generation.

In this report, the term "female fatality risk relative to males" refers to the difference in the fatality risk estimated for front-row female occupants relative to front-row male occupants of vehicles involved in comparable fatal crashes. Further, the term "similar physical impacts" refers to comparable crashes where there was a high likelihood that the crash forces asserted on the front-row occupants were similar.

This study uses the same analysis method as the 2013 study to estimate female fatality risk relative to males.

The fatality risk for females relative to males was estimated for various groups of vehicles to find the effect of sex on different crash scenarios and restraint conditions, and a 95 percent confidence interval was constructed to determine if the difference in fatality risk between females and males is statistically significant (i.e., different from 0). To this end, logistic regression models were built on various groups of vehicle data defined by MY, vehicle types, occupant protection types, impact types, and the combination of these factors. Additionally, the estimates were computed by age groups (16-24, 25-44, 45-64, and 65-96) in each vehicle group

[1] The number of cases of 3-point belt plus dual air bags for cars and LTVs combined is not available in the 2013 study. The number (20,508) was recalculated from the data for the 2013 study.

to compare how female fatality risk relative to males differs between younger and older occupants. The vehicle groups are described below.

- Vehicle Type: cars + LTVs, cars only, and LTVs only.
- Model Year Ranges: 1960-2020, 1960-1999, 2000-2020, 1960-2009, 2010-2020, 10-year and 5-year blocks from 1960 to 2020.
- Occupant Protection Type: Combinations of belt use status (unbelted or belted) and occupant protection system (air bags availability and pretensioners and load limiters availability in seat belts).
- Impact Type: frontal impacts, nearside (left side for the driver and right side for the RF passenger), far-side (right side for the driver and left side for the RF passenger), first-event rollovers, and rear/other locations.

This report emphasizes trends or findings related to vehicle MYs or generations of occupant protection technologies. The authors investigated whether the newer vehicles with the modern occupant protection systems statistically significantly reduce the difference in fatality risk between females and males in comparison to older vehicles without those systems. Certain pairs of vehicle groups were compared, and 95-percent confidence intervals were estimated for the difference between two compared groups. The comparisons were done exclusively on vehicle groups where cars and LTVs are combined. Additionally, the comparisons were done on the average risk between drivers and RF passengers. The pairs of vehicle groups compared are listed below.

- Model years for cars + LTVs (belted, unbelted, and belted + unbelted):
    - 2010-2020 versus 1960-2009
    - 2010-2020 versus 1960-1999
    - 2010-2020 versus 1980-1989
    - 2010-2020 versus 1990-1999
    - 2000-2020 versus 1960-1999
    - 2000-2020 versus 1980-1989
    - 2000-2020 versus 1990-1999
- Generations of occupant protection types of cars + LTVs:
    - Unbelted with dual air bags (generation 3) versus unbelted without air bags (generation 1)
    - Belted with dual air bags (generation 4) versus belted without air bags (generation 2)
    - Belted with dual air bags, pretensioners and load limiters (generation 5) versus belted without air bags (generation 2)

The percentage of vehicles with belted occupants is higher in later MY vehicles than in earlier MY vehicles. For example, in MY 2010-2020 vehicles, the percentage of vehicles with belted occupants is 82.6 percent (5,869 out of 7,107 vehicles). Meanwhile, the percentage of vehicles with belted occupants in MY 1960-2009 vehicles is 31.4 percent (77,906 out of 248,459 vehicles). Differences in belt use rates may affect the comparison across MYs. Therefore, MY comparisons were performed for belted occupants and unbelted occupants separately as well as combining belted and unbelted occupants.

Key findings are described below. Any results statistically significantly different from zero are **highlighted in bold**. Note that the absence of statistical significance does not count as evidence that the true difference in fatality risk between males and females is zero. There may still be a difference in fatality risk that is too small to be detected given the sample size.

- Model Year
    - In general, the estimated difference in female fatality risk relative to males is statistically significantly reduced in recent MY (2010-2020 or 2000-2020) vehicles compared to older MY (prior to 2000) vehicles. For belted occupants, the estimated difference in female fatality risk relative to males for cases involving vehicle MYs 2010-2020 was statistically significantly reduced compared to cases involving vehicle MY 1960-2009 (**-9.8 ± 6.7** %). Statistically significant reductions are seen in all of the comparisons between recent MY vehicles and older MY vehicles for belted occupants. For unbelted occupants, vehicles involving MY 2010-2020 reduce the estimated difference in female fatality risk relative to males compared to the vehicle groups involving older MYs, but the reductions are not statistically significant. This is because the number of vehicles of MY 2010-2020 with unbelted occupants is small (1,238) compared to the number of MY 2010-2020 vehicles with belted occupants (5,869). Therefore, confidence intervals are wider for the unbelted comparisons. When vehicles involving MY 2000-2020 are compared to vehicles involving MY 1960-1999 for unbelted occupants, the estimated difference in female fatality risk relative to males is reduced by **-5.9 ± (4.9)** percent, which is statistically significant.
    - When broken down in smaller MY groups and occupant type, fatality risk for females relative to males is estimated to decrease in vehicles involving newer MYs. For example, female drivers have a **19.0 (± 5.0)** percent higher fatality risk than male drivers for MY 1975-1979 compared to a 0.5 (± 17.5) percent higher relative fatality risk for MY 2015-2020. Female RF passengers have a **27.9 (± 10.6)** percent higher fatality risk than males for MY 1960-1966, compared to a 5.3 (± 16.4) percent higher relative fatality risk for MY 2015-2020. When the estimates are averaged for drivers and RF passengers, females have a **21.8 (± 9.6)** percent higher fatality risk than males for MY 1960-1966, compared to a 2.9 (± 9.8) percent higher relative fatality risk for MY 2015-2020.
- Crash Year

  When considering front-row occupants age 16- to 96 of MY 1960-2020 vehicles involved in fatal crashes from 1975 to 2019, females have a **17.9 ± (1.1)** percent higher fatality risk compared to males. This represents a historical average over a long period of time and does not describe recent trends in fatality risk differences. When examining the crash data from the 2000s (2000 – 2019), the female fatality risk relative to males is **13.5 ± (1.4)** percent. Furthermore, when using data from more recent crash years (2015-2019), the fatality risk difference is **9.1 ± (3.3)** percent. Isolating to more recent crash years means having a higher proportion of newer vehicles in the sample. The reduction in relative female fatality risk when looking only at the more recent crash years is consistent with the findings of this study, which show a reduction in relative female fatality risk for recent MY vehicles with advanced occupant protection systems. As older MY vehicles are retired, and newer MY vehicles remain and are introduced, the disparity should lessen if current trends persist.

- Occupant Protection Type
    - In cars + LTVs, modern occupant protection technologies statistically reduce significantly the estimated difference in fatality risk for females relative to males. Dual air bags reduce the estimated difference in fatality risk by **-6.4 (± 4.0)** percent for unbelted occupants (unbelted without air bags: **20.8** ± **3.8**%, unbelted with dual air bags: **14.4** ± **3.5**%). Dual air bags further reduce the estimated difference in fatality risk by **-11.3 (± 4.1)** percent for belted occupants (belted without air bags: **21.0** ± **3.5**%, belted with dual air bags: **9.7** ± **2.1**%). The latest occupant protection technologies (dual air bags, pretensioners, and load limiters) reduce the estimated difference in fatality risk for females relative to males by **-15.2 (± 5.2)** percent for belted occupants (belted without air bags: **21.0** ± **3.5**%, belted with dual air bags, pretensioners and load limiters: **5.8** ± **3.8**%).
    - In cars, among occupant protection types considered, a two-point lap belt with automatic shoulder belt (the vast majority of which do not have pretensioners and load limiters) use without air bags has the highest estimated fatality risk for females relative to males (**31.1** ± **8.9**%). Air bags reduce the estimated difference in female fatality risk for both unbelted occupants (**15.1** ± **4.5**%) and belted occupants (**15.7** ± **5.9**%). When air bags are available and the occupants use advanced seat belts equipped with pretensioners and load limiters, the estimated fatality risk for females relative to males drops further to **6.1 (± 4.2)** percent. In LTVs, the estimated fatality risk for females compared to males is the highest for unbelted occupants without air bags (**24.2** ± **5.1**%) and is gradually reduced when the occupant protection type moves toward later generations. It drops to **6.9 (± 4.9)** percent for belted occupants in LTVs with air bags, then to 5.3 (± 8.5) percent when the belts are equipped with pretensioners and load limiters.
- Age Group by Occupant Protection Type
  In most generations of occupant protections, the estimated fatality risk for females relative to males is at the highest level in the younger ages (16 to 24), and the difference in fatality risk is reduced for older age groups, and becomes negative (i.e., males have a higher fatality risk than females) in the 65-to-96 age range for some generations. There are two main exceptions. The first is RF passengers in cars, where in the latest generation of occupant protection systems the estimated fatality risk for females relative to males is roughly 5 percent for all age groups. The other is for drivers in LTVs with the latest generation of occupant protection, which has a lower estimated fatality risk for females relative to males for all age groups.

- Occupant Protection Type in Frontal Impacts
  For cars and LTVs, females have the highest estimated fatality risk compared to males when the occupants use seat belts in vehicles not equipped with air bags (**22.1 ± 6.0**%). When the vehicles are equipped with air bags, the estimated relative fatality risk gradually decreases, especially when the occupants use advanced seat belts: **11.5 (± 4.8)** percent for unbelted occupants with air bags, **7.8 (± 3.7)** percent for belted occupants with air bags, and 5.4 (± 5.8) percent for belted occupants with air bags, pretensioners and load limiters. A similar pattern is shown for cars. The estimated female fatality risk relative to males is highest for belted occupants without air bags (**19.6 ± 6.8**%). When cars have air bags, the estimated female fatality risk relative to males drops to **13.2 (± 5.4)** percent for unbelted occupants and to **12.7 (± 8.5)** percent for belted occupants. The estimated relative fatality risk further drops to under 5 percent (4.4 ± 5.5%) when occupants use seat belts equipped with pretensioners and load limiters in vehicles with air bags. Additionally, this result does not show any statistically significant difference between females and males.

- Occupant Protection Type in Nearside and Far-Side Impacts
  In cars, the estimated female fatality risk relative to males stays at 20 percent or more for all occupant protection types for nearside impacts. However, dual air bags reduce the estimated female fatality risk relative to males to under 10 percent (**8.5 ± 7.8**%) for belted occupants in far-side impacts. When cars are equipped with curtain-plus-torso or combination bags, the estimated female fatality risk relative to males is further reduced to close to zero (1.8 ± 15.2%). In LTVs equipped with air bags, belt use lowers estimated female fatality risk relative to males for both nearside impacts and far-side impacts. Belt use decreases the estimated relative fatality risk from 14.5 (± 24.4) percent to 8.5 (± 16.2) percent for nearside and from 19.5 (± 24.8) percent to 4.3 (± 14.3) percent for far-side impacts. When belts are equipped with pretensioners and load limiters, the estimated female fatality risk relative to males becomes negative: -5.4 percent for nearside impacts and -3.3 percent for far-side impacts.

- Occupant Protection Type in First-Event Rollovers and Rear Impacts and Other Crashes
  Belt use reduces the estimated female fatality risk relative to males in first-event rollovers crashes from **36.1 (± 7.3)** percent to **14.7 (± 11.6)** percent when vehicles are not equipped with air bags. Additionally, belt use reduces female relative risk in first-event rollover crashes from **23.3 (± 11.6)** percent to 3.5 (± 7.5) percent when vehicles are equipped with air bags. For rear impact and other crashes, belt use reduces female fatality relative risk from **27.7 (± 8.0) percent** to 8.5 (± 13.5) percent when vehicles are not equipped with air bags, and from **24.2 (± 19.5)** percent to 2.4 (± 8.6) percent when vehicles are equipped with air bags.

Consistent with the results in Kahane (2013), the estimated female relative fatality risk, while still present, is found to be significantly reduced in more recent MY vehicles with current occupant protection technologies, such as air bags, pretensioners and load limiters, for belted occupants. When considering the effect of crash impact types in vehicles with current occupant protection technologies, nearside crashes have the highest estimated female relative fatality risk.

1. Introduction

In a previous NHTSA study of fatality risk for driver-side or right-front passenger-side female occupants in comparison to male occupants,[2] Kahane (2013) reported that females have higher estimated fatality risk compared to males given similar physical impacts when considering an overall analysis performed on MY 1960-2011 passenger vehicles involved in fatal crashes. The estimated female fatality risk relative to males was also shown to steadily drop for later MYs of vehicles equipped with modern technology for occupant protection. Changes in occupant protection technology are driven, in part, by changes in crashworthiness testing in recent years. Specifically, inclusion of a 5th percentile female crash dummy in both frontal and side barrier testing (FMVSS Nos. 208 and 214) began in 2003 and 2010, respectively. In addition, the New Car Assessment Program was updated beginning in MY 2011 to include use of the 5th percentile crash dummy for front and side crash test. Vehicles designed for these updated requirements were limited in the fatal crash population that was used in the 2013 study.

More specifically, in the previous study—

- Kahane used data from the Fatality Analysis Reporting System (FARS) 1975-2010 to investigate the difference in fatality risk for drivers and right-front (RF) passengers with varying ages and sexes for similar physical impacts;
- The data included passenger cars or light trucks and vans (LTVs) with a driver and an RF passenger, at least one of whom did not survive in the crash;
- Vehicle MYs ranged from 1960 to 2011; and
- Occupant ages ranged from 21 to 96.

Kahane's methodology involved two steps: a logistic regression analysis, and then a double-pair comparison analysis as developed by Evans (1986). Kahane first built two logistic regression models, one for drivers and one for RF passengers, using FARS 1975-2010. These models formulated the relations between the fatalities of a driver and a RF passenger and the ages and sexes of both in various crash scenarios. Then, the regression coefficients were applied to the representative set of vehicles in fatal crashes created from FARS 2001-2010 to estimate the fatalities of drivers and RF passengers given the ages and sexes of both. Based on those estimated fatalities, the relative fatality risk for females given similar physical impacts was estimated using double-pair comparison. The previous study and the current study looked only at female fatality risk relative to males and did not look at absolute female fatality risk.

[2] Throughout this report, a reference to "fatality" refers to "fatality for driver-side or right -front passenger side occupants" unless explicitly stated otherwise.

In the analysis of female fatality risk relative to males, Kahane found that the overall fatality risk for female drivers was as high as **17.3 (± 5.2)**[3] percent compared to males for MY 1975-1979 cars and LTVs, but decreased consistently until it was 6.9 (± 17.0) percent for MY 2005-2011. Female fatality risk relative to males was also higher for RF passengers, with a high of **25.7 (± 4.7)** percent for MY 1985-1989 and a low of **6.8 (± 6.3)** percent for MY 2000-2004. Female fatality risk relative to males was also higher on average for younger occupants (21- to 30 years old) than older occupants (65- to 74 years old) for both drivers and RF passengers. In addition to overall risk, Kahane explored the female fatality risk relative to males in various groups of vehicles confined by vehicle types (cars or LTVs), MYs, occupant protection types determined by belt use status and air bag availability, impact types, and combinations of these groups.

This report updates a portion of Kahane's analysis to include more recent crash years and vehicle MYs in the FARS data.

- The analyses in this report specifically focus on trends over time based on vehicle MY and occupant protection system generation given recent improvements in vehicle safety.
- This analysis adds crash years 2011-2019 and MY 2012-2020.[4]
- The data used also include occupants 16- to 20 years old in addition to the occupants used in Kahane's 2013 analysis (21- to 96 years old).
- Finally, this analysis includes a wider range of vehicle groups based on MY ranges, vehicle type, occupant protection type, and impact type than the previous analysis.

Section 2 of this report describes the data used and changes made compared to Kahane's analysis. Section 3 describes the methodology used. Section 4 describes the set of vehicle groups used in this analysis compared to Kahane's analysis. Section 5 describes the results and meaningful findings. Finally, Section 6 discusses the implications and limitations of the analysis.

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[3] Throughout this report, a statistical result of this notation describes a point estimate of the relative female fatality risk to males and the 95-percent confidence interval in parentheses. If a confidence interval does not include zero, the difference in fatality risk between female and male is statistically significant. If a confidence interval includes zero, the difference is not statistically significant. In this specific case, the point estimate is 17.3, and the 95-percent confidence interval is (12.1, 22.5). Since the interval does not include zero, the estimate shows a statistically significant difference. All results in this report that are statistically significantly different from zero are **highlighted in bold**. Note that the absence of statistical significance does not count as evidence that the true difference in fatality risk between males and females is zero. There may still be a difference in fatality risk that is too small to be detected given the sample size.

[4] Since the crash year ends December 31, 2019, MY 2020 represents vehicles built before December 31, 2019.

2. Data

FARS

NHTSA began collecting fatal crash data through FARS in 1975 and has continued to release data annually ever since. FARS is a census of all fatal crashes that occur within the United States and Puerto Rico on public traffic ways. A motor vehicle traffic crash is included in FARS if it directly resulted in a fatality of a vehicle occupant or nonoccupant within 30 days of the crash. After receiving information on each fatal crash from State agencies, analysts code many elements at the crash, vehicle, and person level for each crash and store them in data files. Some of these elements include the number and occupancy level of people in a vehicle during the crash; the age, sex,[5] and seating position of each occupant; and whether the occupants were wearing restraints at the crash time. FARS specifically indicates an occupant's sex as either male, female, or unreported/unknown. See National Center for Statistics and Analysis (2021) for more details. This analysis includes the most recent set of FARS crashes augmenting the data that Kahane used. The data used for both the logistic regression analysis and the double-pair comparison are described below.

Data for Logistic Regression

This analysis included FARS crash years 1975-2019 and vehicle MYs 1960-2020, while Kahane used crash years 1975-2010 and MY 1960-2011. As Kahane did, this analysis selected passenger vehicles (passenger cars or LTVs) where there was a driver and a right-front passenger,[6] and at least one of those two occupants died. Additionally, each selected vehicle needed to have the same seat belt use status for both the driver and RF passenger (i.e., both using or not using), as well as the same air bag availability for the driver and RF passenger.

In addition to expanding the crash years and MYs, the current analysis also extended the occupant age range from 21-to-96 to 16-to-96. In the previous analysis, Kahane investigated age effects as well as the effect of sex on fatalities. When deciding the minimum age to set the data for the analysis, Kahane performed an empirical analysis that showed inconsistent trends for age variables in the younger ages. Kahane therefore used an occupant age range of 21- to 96. The current study focuses only on the effect of sex on fatalities, and the empirical study in Kahane's analysis did not show inconsistent trends for sex variables in younger ages. Therefore, drivers and RF passengers 16- to 20 years old were included in this study to increase the sample size.

The final dataset used for building the logistic regression model includes 255,566 vehicles compared with 154,467 for Kahane. The increase in vehicles is due both to including recent MY vehicles with advanced occupant protection systems and including vehicles with younger occupants. For example, the addition of the newer cases added 24,773 cases that include lap/shoulder (i.e., 3-point) belts plus dual air bags (45,281 cases in current study, compared to 20,508 cases in the 2013 study).

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[5] FARS primarily sourced this information from police crash reports or driver's license records. The variable in FARS is defined to capture biological sex.

[6] When there are two or more occupants in the same seat, that vehicle is not included in the data.

Data for Double-Pair Comparison

As in Kahane’s analysis, a set of vehicles were used for the double-pair comparison step. These vehicles served as a representative sample of vehicles involved in fatal crashes. Kahane used this dataset from FARS crash years 2001-2010 by selecting cars or LTVs each with a driver and an RF passenger 21- to 96 years old, at least one of whom died in the crash.

As in the data used for logistic regression, the data in this step includes crash years 2011-2019. Additionally, younger ages 16- to 20 are included for both drivers and RF passengers (i.e., FARS 2001-2019, ages 16- to 96). The dataset includes 131,067 vehicles in the current analysis compared with 58,438 vehicles in Kahane’s analysis.

3. Methodology

Relative fatality risk for females refers to the fatality risk for females relative to males. For example, if the relative fatality risk is estimated to be 13 percent, the interpretation is that females have an absolute increase of 13 percent fatality risk compared to males. Evans (1986) used the double-pair comparison technique to estimate the relative fatality risk for females from similar physical impacts. The double-pair comparison method estimates the effect of sex separately from the other effects on fatalities such as crash severity, risky driving behavior, and so on. Evans described the concept of double-pair comparison with the following example. There are two sets of crashes with a driver and an RF passenger where at least one of them was killed. One set contains cars with female drivers and male RF passengers. From these crashes the ratio of female driver fatalities to male RF passenger fatalities is r1. The other set of crashes has cars with male drivers and male RF passengers. The ratio of male driver fatalities to male RF passenger fatalities is r2. The sex of the RF passenger is the same for both sets as the control characteristics. Therefore, the ratio of these two ratios r1/r2 measures the relative fatality risk of female driver to male driver.

In Evans (1986), the estimate of the female fatality risk relative to males is computed directly using double-pair comparison by counting fatalities of drivers and RF passengers, calculating the ratios of driver to RF passenger fatalities, and comparing those ratios. The estimates are separate and discrete for non-overlapping intervals of age. On the other hand, Kahane (2013) used the logistic regression analysis and double-pair comparison together to obtain continuous estimates for ages. Two logistic regression models relate the ages and sexes of the driver and RF passenger to the driver fatality (i.e., driver model) and to the RF passenger fatality (i.e., RF passenger model) in a certain crash scenario.

With the regression coefficients, the probabilities of a driver fatality and an RF passenger fatality in the specified crash scenario can be predicted given the ages and sexes of the driver and RF passenger for a vehicle in any fatal crash. By predicting the probabilities of a driver fatality and an RF passenger fatality for each vehicle in a representative set of vehicles in fatal crashes and aggregating those probabilities, fatalities of drivers and RF passengers are estimated. Then the double-pair comparison is used to estimate the female fatality risk relative to males by calculating expected ratios of the driver to the RF passenger fatalities and comparing the expected ratios. Kahane started from “simple models” that used four independent variables: driver’s sex and age, and RF passenger’s sex and age. The empirical study, which was based on many separate simple models fitted on subsets of data divided by the driver’s and RF passenger’s ages, showed the effects of sex (i.e., coefficients of sex variables) are stable until the age of 35. After age 35, the effect trends downward. Based on results from the empirical study, Kahane built “principal models,” which are piecewise linear with breakpoints at age 35 to estimate the non-constant effects with two models: the driver model and the RF passenger model. The “principal models” have additional independent variables: second terms of driver’s sex and age, and the RF passenger’s sex and age, all applying when the driver or RF passenger is at least 35 years old. These models are described in the next section.

The current analysis used the same “principal models” Kahane used (see additional information in the limitations section). The following sections describe building the logistic regression models, performing double-pair comparison to estimate the female fatality risk relative to males using the model coefficients, and estimating confidence intervals. See Kahane (2013) for more details about these methodologies.

Logistic Regression

Two logistic regression models were built using the data from FARS 1975-2019: 255,566 vehicles where the driver's and RF passenger's ages were 16- to 96. The following variables were used in the models.

- Response Variables:
  - FATAL1 = 1 if the driver was killed; = 2 if the driver survived.
  - FATAL3 = 1 if the RF passenger was killed; = 2 if the RF passenger survived.
- Independent Variables
  - AGE1 = Driver's age.
  - AGE3 = RF passenger's age.
  - FEM1 = 1 if the driver was female; = 0 if the driver was male.
  - FEM3 = 1 if the RF passenger was female; = 0 if the RF passenger was male.
  - AGE1_35 = $(\mathrm{AGE1} - 35)^2$ for drivers 35 or older; = 0 otherwise.
  - AGE3_35 = $(\mathrm{AGE3} - 35)^2$ for RF passengers 35 or older; = 0 otherwise.
  - FEM1_35 = (AGE1−35) for female drivers 35 or older; = 0 for female drivers < 35 or all male drivers.
  - FEM3_35 = (AGE3−35) for female RF passengers 35 or older; = 0 for female RF passengers < 35 or all male RF passengers.

Table 1 and Table 2 show the regression coefficients of two models when the full dataset (255,566 vehicles) created from FARS 1975-2019 (NCSA, 2021) is used. The driver model is used to predict the log-odds of the driver fatality while the RF passenger model is used to predict the log-odds of the RF passenger fatality for MY 1960-2020 cars or LTVs. To predict log-odds of fatalities of the driver and RF passenger for a specific group of vehicles (e.g., cars, MY ≥ 2000), regression models should be based on the corresponding subset of vehicles from the full dataset.

Table 1. Driver Model

Response Variable: Fatal1 (Driver Fatality), 146,895 killed; 108,671 survived					
Parameter	**Degrees of Freedom**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.2957	0.015	389.1137	<.0001
AGE1	1	0.0366	0.000648	3190.8723	<.0001
AGE3	1	-0.0316	0.000623	2566.2718	<.0001
FEM1	1	0.2871	0.012	571.6189	<.0001
FEM3	1	-0.2872	0.0103	774.1709	<.0001
AGE1_35	1	0.00016	0.000018	78.8729	<.0001
AGE3_35	1	-0.0004	0.000018	522.7556	<.0001
FEM1_35	1	-0.0096	0.000662	210.536	<.0001
FEM3_35	1	0.00404	0.000594	46.2865	<.0001

Table 2. Right Front Passenger Model

Response Variable: Fatal3 (RF Passenger Fatality), 54,565 killed; 101,001 survived					
Parameter	**Degrees of Freedom**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.2599	0.0151	294.9741	<.0001
AGE1	1	-0.0335	0.000645	2700.388	<.0001
AGE3	1	0.0342	0.000643	2830.987	<.0001
FEM1	1	-0.2952	0.0119	610.5374	<.0001
FEM3	1	0.3181	0.0103	952.4957	<.0001
AGE1_35	1	-0.00021	0.000019	118.5171	<.0001
AGE3_35	1	0.000445	0.00002	498.6742	<.0001
FEM1_35	1	0.00895	0.00069	168.3679	<.0001
FEM3_35	1	-0.00517	0.000664	60.6589	<.0001

Double-Pair Comparison

From the coefficients in Table 1 and Table 2, the log-odds of a driver fatality ($Z1$) and log-odds of an RF passenger fatality ($Z3$) are predicted as follows.

$$Z1 = 0.2957 + 0.0366\text{ AGE1} - 0.0316\text{ AGE3} + 0.2871\text{ FEM1} - 0.2872\text{ FEM3} + 0.00016\text{ AGE1\_35} - 0.0004\text{ AGE3\_35} - 0.0096\text{ FEM1\_35} + 0.00404\text{ FEM3\_35}$$

$$Z3 = 0.2599 - 0.0335\text{ AGE1} + 0.0342\text{ AGE3} - 0.2952\text{ FEM1} + 0.3181\text{ FEM3} - 0.00021\text{ AGE1\_35} + 0.000445\text{ AGE3\_35} + 0.00895\text{ FEM1\_35} - 0.00517\text{ FEM3\_35}$$

The probability of a driver fatality (E_FATAL1) is calculated as

$$E\_FATAL1 = \frac{exp(Z1)}{1 + exp(Z1)}$$

and the probability of an RF passenger fatality (E_FATAL3) is calculated as follows.

$$E\_FATAL3 = \frac{exp(Z3)}{1 + exp(Z3)}$$

The probabilities of occupant fatalities above can be calculated for any pair of a driver and an RF passenger of a vehicle involved in a fatal crash by plugging in the values of a driver's and an RF passenger's ages and sexes. The following example describes how the percentage difference in fatality risk for female drivers relative to male drivers is estimated based on the dataset of 131,067 vehicles created from FARS 2001-2019.

1) For each vehicle in the dataset, the driver is assumed as a female, but the driver's age and RF passenger's age and sex are not changed. Therefore, the values of independent variables become the following.
   - FEM1 = 1
   - FEM1_35 = AGE1−35 if AGE1 >=35, 0 otherwise
   - Other variables: the values in the dataset
2) By plugging the values of variables into the regression models, the predicted log-odds of the driver fatality ($FZ1$) and RF passenger fatality ($FZ3$) are calculated as the following.

$$FZ1 = 0.2957 + 0.0366\ \mathrm{AGE1} - 0.0316\ \mathrm{AGE3} + 0.2871\ \mathrm{FEM1} - 0.2872\ \mathrm{FEM3} + 0.00016\ \mathrm{AGE1\_35} - 0.0004\ \mathrm{AGE3\_35} - 0.0096\ \mathrm{FEM1\_35} + 0.00404\ \mathrm{FEM3\_35}$$

$$FZ3 = 0.2599 - 0.0335\ \mathrm{AGE1} + 0.0342\ \mathrm{AGE3} - 0.2952\ \mathrm{FEM1} + 0.3181\ \mathrm{FEM3} - 0.00021\ \mathrm{AGE1\_35} + 0.000445\ \mathrm{AGE3\_35} + 0.00895\ \mathrm{FEM1\_35} - 0.00517\ \mathrm{FEM3\_35}$$

3) Then, the probability of a driver fatality ($F1\_FATAL1$) is calculated as

$$F1\_FATAL1 = \frac{exp(FZ1)}{1 + exp(FZ1)}$$

and the probability of an RF passenger fatality ($F1\_FATAL3$) is calculated as the following.

$$F1\_FATAL3 = \frac{exp(FZ3)}{1 + exp(FZ3)}$$

4) The numbers of driver fatalities and RF passenger fatalities are estimated by summing up the estimated probabilities across all cases in the dataset. Therefore, when the driver is assumed as a female, the average fatality risk ratio of the driver to RF passenger becomes the following.

$$r1 = \frac{\sum F1\_FATAL1}{\sum F1\_FATAL3}$$

5) Now, to compare with the male drivers, for each vehicle in the dataset, the driver is assumed as a male, but the driver's age and RF passenger's age and sex are not changed. Therefore, the values of independent variables become the following.
   - FEM1 = 0
   - FEM1_35 = 0
   - Other variables: the values in the dataset

6) The predicted log-odds of the driver fatality ($MZ1$) and the RF passenger fatality ($MZ3$) are calculated by plugging in the above values of variables into the regression model in the same way as the driver is assumed as a female.

7) Then, the probability of a driver fatality ($M1\_FATAL1$) is calculated as

$$M1\_FATAL1 = \frac{exp(MZ1)}{1 + exp(MZ1)}$$

and the probability of an RF passenger fatality ($M1\_FATAL3$) is calculated as the following.

$$M1\_FATAL3 = \frac{exp(MZ3)}{1 + exp(MZ3)}$$

8) The numbers of driver fatalities and RF passenger fatalities are estimated by summing up the estimated probabilities across all records in the dataset. Therefore, when the driver is assumed as a male, the average fatality risk ratio of the driver to RF passenger is calculated as the following.

$$r2 = \frac{\sum M1\_FATAL1}{\sum M1\_FATAL3}$$

9) Finally, the relative fatality risk for female drivers to male drivers is the ratio of these two fatality risk ratios (i.e., double-pair comparison)

$$R = \frac{r1}{r2}$$

and the percentage difference in the fatality risk for female drivers relative to male drivers is computed as the following.

$$R(\%) = \left(\frac{r1}{r2} - 1\right) \times 100$$

This is the process to estimate the percentage difference in fatality risk for female drivers relative to male drivers from similar physical impacts for all cars and LTVs with MY 1960-2020. The same process is used for RF passengers. To estimate the relative fatality risk for females in a specific group of vehicles (e.g., cars, MY ≥ 2000), the above process should be performed using the coefficients from the regression models fitted based on the corresponding subset of vehicles from the full dataset.

Confidence Interval

All estimates in this analysis are computed from FARS data, which is a census. However, the FARS cases can be treated as one realization (i.e., a sample) from a superpopulation, and the estimates can have sampling errors. Ninety-five percent confidence intervals are constructed for the percentage difference estimates in female fatality risk relative to males for drivers, RF passengers, and the average of the drivers and the RF passengers. The complex nature of the female relative risk statistic means that there is no simple formula for calculating the 95-percent confidence interval. Kahane (2013) calculated the confidence interval using the "jackknife technique," a resampling method employed in circumstances where the confidence interval cannot be calculated with a straightforward formula. See Efron (1982) for more information on the jackknife estimate of variance. This report uses the same technique as Kahane because the confidence interval formula for the female relative risk statistic remains intractable. The jackknife technique used in this report is described below.

The dataset used for the regression analysis is randomly divided into 10 equal size subsamples. Ten jackknife samples are then created by deleting one subsample from the dataset (i.e., it consists of 9 subsamples). For each jackknife sample, the percentage difference in female fatality risk relative to males is estimated by building regression models and performing double-pair comparison as described above. Let the original estimate be x and the estimate from the jackknife sample be $x + h$. Then, a pseudo-estimate is calculated as $x - 9h$, and it is considered as an estimate from the deleted subsample. In this way, 10 pseudo-estimates are calculated from the 10 jackknife samples. The standard error of these 10 pseudo-estimates serves as the standard deviation of the original estimate, and a t-distribution with 9 degrees of freedom is used for the 95-percent confidence intervals. To avoid unstable variance estimate, this process is repeated 11 times and produces 11 standard errors. The median of these 11 standard errors is taken as the final standard error (SE) of the estimate x. Finally, confidence intervals are calculated by multiplying the standard error and 2.262, which is the 97.5th percentile of t-distribution with 9 degrees of freedom (i.e., $t_{(9,\ \alpha/2)} = 2.262,\ \alpha = 0.05$), and presented as

$$(x - 2.262 \times SE,\ x + 2.262 \times SE).$$

This formula is a conventional method for calculating a 95-percent confidence interval for an estimate given the standard error. The t-distribution is an alternative to the normal distribution with larger probabilities of the more extreme ends.

If a confidence interval does not include zero, the difference in fatality risk between females and males is statistically significant. If a confidence interval includes zero, the difference in fatality risk is not statistically significant. Note that the absence of statistical significance does not count as evidence that the true difference in fatality risk between males and females is zero. There may still be a difference in fatality risk that is too small to be detected given the sample size.

Confidence Interval of the Difference Estimate Between Two Groups

In order to determine if there is a statistical evidence of a change (i.e. reduction) in female fatality risk relative to males in later MY vehicles with more advanced occupant protections compared to the older MY vehicles, 95-percent confidence intervals were estimated for the difference estimates between selected pairs of vehicle groups. The following steps were used.

1) Let R_{G1} be the estimate of relative fatality risk for females to males for group 1, and R_{G2} be for group 2. Then the difference estimate between two groups is calculated as

$$D_{G1G2} = R_{G1} - R_{G2}$$

2) Let the variance estimates of R_{G1} be V_{G1}, and the 95-percent confidence interval be $(R_{G1} - C_{G1},\ R_{G1} + C_{G1})$ for the first group, where $C_{G1} = 2.262 \times \sqrt{V_{G1}}$. In the same way, let the variance estimates of R_{G2} be V_{G2s}, and the 95-percent confidence interval be $(R_{G2} - C_{G2},\ R_{G2} + C_{G2})$ for the second group, where $C_{G2} = 2.262 \times \sqrt{V_{G2}}$. Then The variance of the difference estimate (D_{G1G2}) is estimated as follows.

$$V_D = V_{G1} + V_{G2} = \left(\frac{1}{2.262} * C_{G1}\right)^2 + \left(\frac{1}{2.262} * C_{G2}\right)^2$$

3) The 95-percent confidence interval of the difference estimate (D_{G1G2}) is estimated as

$$(D_{G1G2} - C_D,\ D_{G1G2} + C_D),$$

where $C_D = 2.262 * \sqrt{V_D}$

4) The difference in fatality risk for females relative to males between vehicle groups G_1 and G_2 is statistically significant at the $\alpha = 0.05$ level if $|D_{G1G2}| \geq C_D$, in which case the 95-percent confidence interval does not include zero, and is not statistically significant otherwise.

The estimation of 95-percent confidence intervals were computed for the pairs of vehicle groups listed below.

- Model years for cars + LTVs (belted, unbelted, and belted + unbelted):
  - 2010-2020 versus 1960-2009
  - 2010-2020 versus 1960-1999
  - 2010-2020 versus 1980-1989
  - 2010-2020 versus 1990-1999
  - 2000-2020 versus 1960-1999
  - 2000-2020 versus 1980-1989
  - 2000-2020 versus 1990-1999

- Generations of occupant protection types of cars + LTVs:
  - Unbelted with dual air bags (generation 3) versus unbelted without air bags (generation 1)
  - Belted with dual air bags (generation 4) versus belted without air bags (generation 2)
  - Belted with dual air bags, pretensioners and load limiters (generation 5) versus belted without air bags (generation 2)

Vehicle groups are described further in the next section.

4. Vehicle Groups

Kahane estimated the percentage difference in fatality risk for females relative to males for various groups of vehicles to find the effect of sex on different crash scenarios and vehicle circumstances. The vehicle groups were defined by the vehicle MY, vehicle type (cars or LTVs), occupant protection type, and impact type. This analysis updated the vehicle groups by adding more MY groups, occupant protection types, and combinations of the groups. All estimates by the vehicle groups and the numbers of cases used for the logistic regression analysis are presented in the tables in the Appendix.

For each vehicle group, point estimates and confidence intervals were estimated for drivers, RF passengers, and the average of drivers and RF passengers 16- to 96 years old. In addition, point estimates were computed for the drivers and RF passengers in the following age groups: 16-24, 25-44, 45-64, and 65-96.

Although this report explains the key findings from the expanded dataset (including occupants 16- to 96 years old in the following section), the tables in the Appendix also include estimates from the dataset including occupants 21- to 96 years old for comparison to the Kahane study. Table 3 summarizes the updates of the current study compared to Kahane's study.

Table 3. Summary of Table Updates

<table>
<tr><th colspan="2">Updates</th><th>Kahane's Study</th><th>Current Study</th></tr>
<tr><td rowspan="2">Vehicle Group Updates</td><td>Overall and
By Model Year</td><td>Table 3-1 d
• Overall (All cars and LTVs, MY 1960-2011)
• Cars only and LTVs only
• MY ≥ 2000 for Cars only and LTVs only
• MY ranges for Cars and LTVs combined
• 1960-1966, 1967-1974, 1975-1979,1980-1984, 1985-1989, 1990-1994, 1995-1999, 2000-2004, 2005-2011.</td><td>Table A
• Overall (All cars and LTVs, MY 1960-2020)
• Overall (all cars and LTVs, MY 1960-obtainable year) by crash years: 2000-2019, 2000-2009, 2010-2019, 2000-2004, 2005-2009, 2010-2014, and 2015-2019
• Cars only and LTVs only
• MY ≥ 2000 and MY ≥ 2010 for Cars only and LTVs only
• MY ranges for Cars and LTVs combined
• All previous MY groupings, plus: 1960-1999, 2000-2020, 1960-2009, 2010-2020, 1980-1989, 1990-1999, and 2000-2009, 2010-2014 and 2015-2020.</td></tr>
<tr><td>By Occupant Protection Type[7]</td><td>Table 3-2 d
• Eight generations of car occupants
• Four generations of LTV occupants</td><td>Table B
• Eight generations of car occupants
• Five generations of LTV occupants – the fifth generation (belted, dual air bags, pretensioners/load limiters) was added
• Five generations of car and LTV occupants</td></tr>
</table>

[7] Occupant protection types were differently defined for car occupants and LTV occupants because of the limitation in data and coding.

	By Impact Type and Model Year	Table 3-3 d • All impacts and five impact types (Frontal Impacts, Nearside Impacts, Far-Side Impacts, First-Event Rollovers, and Rear Impacts & Other Crashes) for Cars and LTV combined and Cars only	Table C • All Impacts and Frontal Impact by MY groups (1960-1999, 2000-2020, 1960-2009, and 2010-2020, 1990-1999, and 2000-2009) for Cars Only, LTVs Only, and Cars and LTVs combined. • Nearside Impact, Far-Side Impact, First-Event Rollovers, Rear Impact & Other Crashes by MY groups (1960-1999, 2000-2020, 1960-2009, and 2010-2020) for Cars and LTVs combined
	By Impact Type and Occupant Protection Type[8]	Table 3-4 d • Frontal Impacts by five occupant protection types for car occupants • Nearside Impacts and Far-Side Impacts by two occupant protection types for car occupants • All side impact, one occupant protection type for cars and LTV occupants • First-Event Rollovers and Rear Impact & Other Crashes by two occupant protection types of car occupants	Table D (1) • From Table 3-4 d, two occupant protection types (Belted with dual air bags and Belted with curtain+torso or combo bags) were added for car occupants of Nearside Impacts and Far-Side Impacts. • From Table 3-4 d, two occupant protection types were broken down to four types (Unbelted without dual air bags, belted without dual air bags, unbelted with dual air bags, and belted with dual air bags) for car occupants of First-Event Rollovers and Rear Impact & Other Crashes. Table D (2) • Five impact types and five generations of occupant protection types for LTV occupants (defined in Table B) Table D (3) • Five impact types and five generations of occupant protection types of car and LTV occupants (defined in Table B)
Age Group Updates		Drivers and RF Passengers: • 21-96 (with confidence intervals) • 21-30, 65-74 Average of Drivers and RF passengers: • 21-96 (with confidence intervals)	Drivers and RF Passengers: • 16-96 (with confidence intervals) • 16-24, 25-44, 45-64, and 65-96 Average of Drivers and RF Passengers: • 16-96 (with confidence intervals) Drivers, RF Passengers, and Average of Drivers and RF Passengers: • 21-96 (with confidence intervals)
Number of Cases Used in the Regression Analysis		Number of cases used in regression is not in the tables. It is presented in the Appendix separately.	Number of cases used in the regression analysis is added for each vehicle group of age ranges 16-96 and 21-96.

[8] Occupant protection types for car occupants in Table 3-4d/Table D (1) were defined differently by impact type, and those definitions are also different from the eight generations in Table 3-2d/Table B. On the other hand, occupant protection types for LTV occupants in Table D (2) were defined the same for all impact types, and those definitions are the same as the five generations in Table B because of the limitation in data and coding.

5. Results

As previously described, the aim of this study was to present trends in female versus male fatality risk differences while emphasizing vehicle vintage (MY groupings) or the generation of occupant protection system that was present. These MY or occupant protection groupings are used in combination with vehicle type, occupant age and crash type in presenting the results of this study. All estimates that are statistically significantly different from zero are **highlighted in bold**. As stated previously the absence of statistical significance does not count as evidence that the true difference in fatality risk between males and females is zero. There may still be a difference in fatality risk that is too small to be detected given the sample size. Note that different groups can be statistically compared even if the groups individually are not statistically different from zero.

5.1 Trends by Model Years

The estimated difference in fatality risk for females (age 16- to 96) compared to males has steadily decreased over vehicle MY. For drivers of cars and LTVs, the peak female fatality risk relative to males is for MY 1975-1979, at **19 (± 5.0)** percent. For RF passengers, the peak female fatality risk relative to males is for MY 1960-1966, at **27.9 (± 10.6)** percent. For MY 2015-2020, the female fatality risk relative to males is estimated as 0.5 (± 17.5) percent for drivers and 5.3 (± 16.4) percent for RF passengers, respectively. Note that the relatively small number of vehicles for most recent MY (2,182 for MY 2015-2020, compared to 40,396 for MY 1975-1979) accounts for the larger confidence intervals for later MYs. Figure 1 below shows the difference in fatality risk for female occupants by groups of MYs. Table A in the Appendix shows additional estimates and the number of cases used in the regression analysis.

Figure 1. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Model Years (Cars and LTVs)

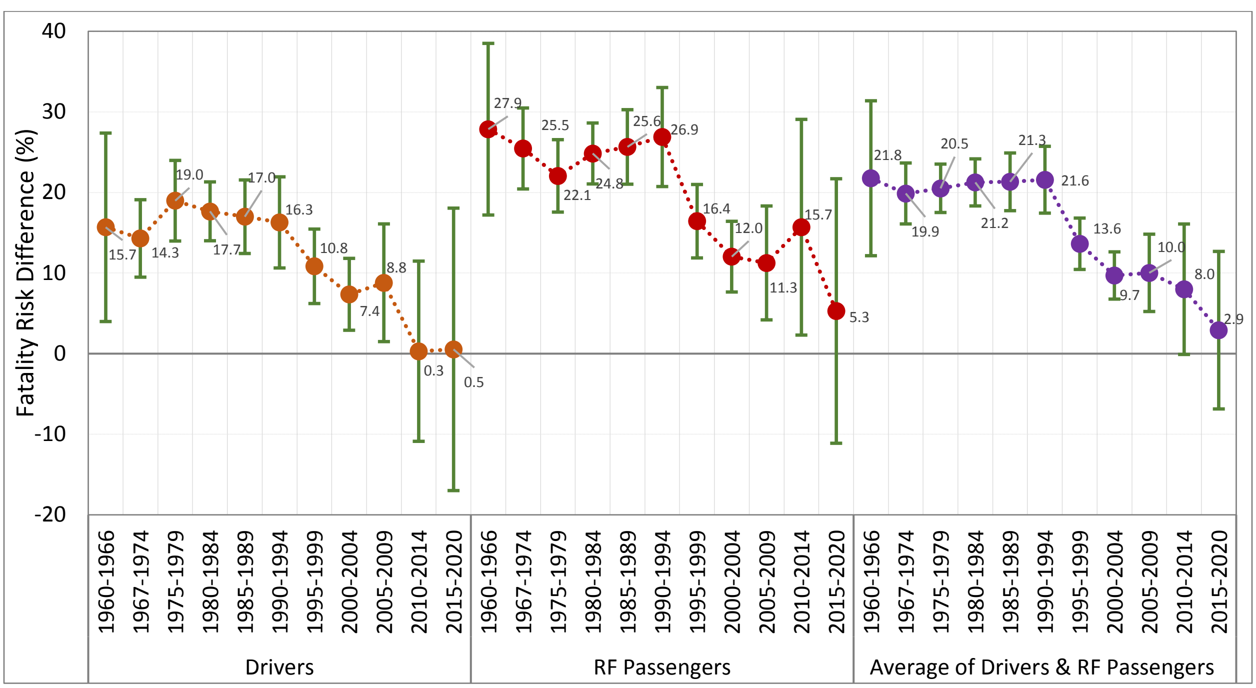


Table 4 shows the comparisons of estimated female fatality risk relative to males between recent MYs (2010-2020 or 2000-2020) and older MYs (prior to 2000) of vehicles (cars + LTVs) by occupant belt use status. The estimated difference in female fatality risk relative to males for cases involving vehicle MY 2010-2020 was statistically significantly reduced compared to cases involving vehicle MY 1960-2009 when occupants are belted (**-9.8 ± 6.7**%) and when combining belted and unbelted occupants (**-12.0 ± 5.5**%). Statistically significant reductions are seen in all of comparisons between recent MY vehicles and older MY vehicles when occupants are belted, or when belted and unbelted occupants are combined. Given the smaller case count for 2010-2020 unbelted cases, none of the differences found in comparisons versus other unbelted MY ranges was found to be statistically significant. When vehicles involving MY 2000-2020 are compared to vehicles involving MY 1960-1999 for unbelted occupants, the estimated difference in female fatality risk relative to males is reduced by **-5.9 ± (4.9)** percent, which is statistically significant.

Table 4. Comparison of Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males Between Model Years of Vehicles (Cars + LTVs), Grouped by Occupant Belt Use

	Unbelted		Belted		All (Unbelted + Belted)	
Model Years	**Drivers & RFP**	**Number of Cases**	**Drivers & RFP**	**Number of Cases**	**Drivers & RFP**	**Number of Cases**
1960-1999	**20.3 ± 1.8**	159,706	**19.4 ± 2.8**	54,274	**19.9 ± 1.3**	213,980
2000-2020	**14.4 ± 4.6**	12,085	**7.1 ± 2.6**	29,501	**9.4 ± 2.2**	41,586
1960-2009	**19.9 ± 1.7**	170,553	**15.6 ± 2.0**	77,906	**18.3 ± 1.2**	248,459
2010-2020	8.0 ± 14.0	1,238	5.8 ± 6.5	5,869	**6.3 ± 5.4**	7,107
1980-1989	**21.8 ± 2.7**	52,136	**19.6 ± 4.9**	22,553	**21.3 ± 2.5**	74,689
1990-1999	**16.9 ± 3.8**	20,534	**18.3 ± 2.9**	27,146	**17.5 ± 2.3**	47,680
Comparison of Model Years						
2010-2020 vs. 1960-2009	-11.9 ± 14.1		**-9.8 ± 6.7**		**-12.0 ± 5.5**	
2010-2020 vs. 1960-1999	-12.3 ± 14.2		**-13.6 ± 7.0**		**-13.6 ± 5.6**	
2010-2020 vs. 1980-1989	-13.8 ± 14.3		**-13.8 ± 8.1**		**-15.0 ± 6.0**	
2010-2020 vs. 1990-1999	-8.9 ± 14.6		**-12.5 ± 7.1**		**-11.2 ± 5.9**	
2000-2020 vs. 1960-1999	**-5.9 ± 4.9**		**-12.3 ± 3.8**		**-10.6 ± 2.5**	
2000-2020 vs. 1980-1989	**-7.4 ± 5.4**		**-12.5 ± 5.6**		**-12.0 ± 3.3**	
2000-2020 vs. 1990-1999	-2.5 ± 6.0		**-11.2 ± 3.9**		**-8.2 ± 3.2**	

Note: The estimates **highlighted in bold** indicate that they are statistically significant. Comparison estimates were computed using the unrounded estimates in each model year group. Differences between groups may be statistically significant even if groups taken individually are not statistically significant.

5.2 Overall Fatality Risk by Crash Years

Table 5 shows the estimated overall difference in fatality risk for females compared to males by crash years. When considering front-row occupants age 16- to 96 of MY 1960-2020 vehicles involved in fatal crashes from 1975 to 2019, females have a **17.9 ± (1.1)** percent higher fatality risk compared to males. This represents a historical average over a long period of time and does not describe recent trends in fatality risk differences. When examining the crash data from the 2000s (2000 – 2019), the female fatality risk relative to males is **13.5 ± (1.4)** percent. Furthermore, when using data from more recent years (2015-2019), the fatality risk difference is **9.1 ± (3.3)** percent. Isolating to more recent crash years means having a higher proportion of newer vehicles in the sample. The reduction in relative female fatality risk when looking only at the more recent crash years is consistent with the findings of this study, which show a reduction in relative female fatality risk for recent MY vehicles with advanced occupant protection systems. Table A in the Appendix shows additional estimates.

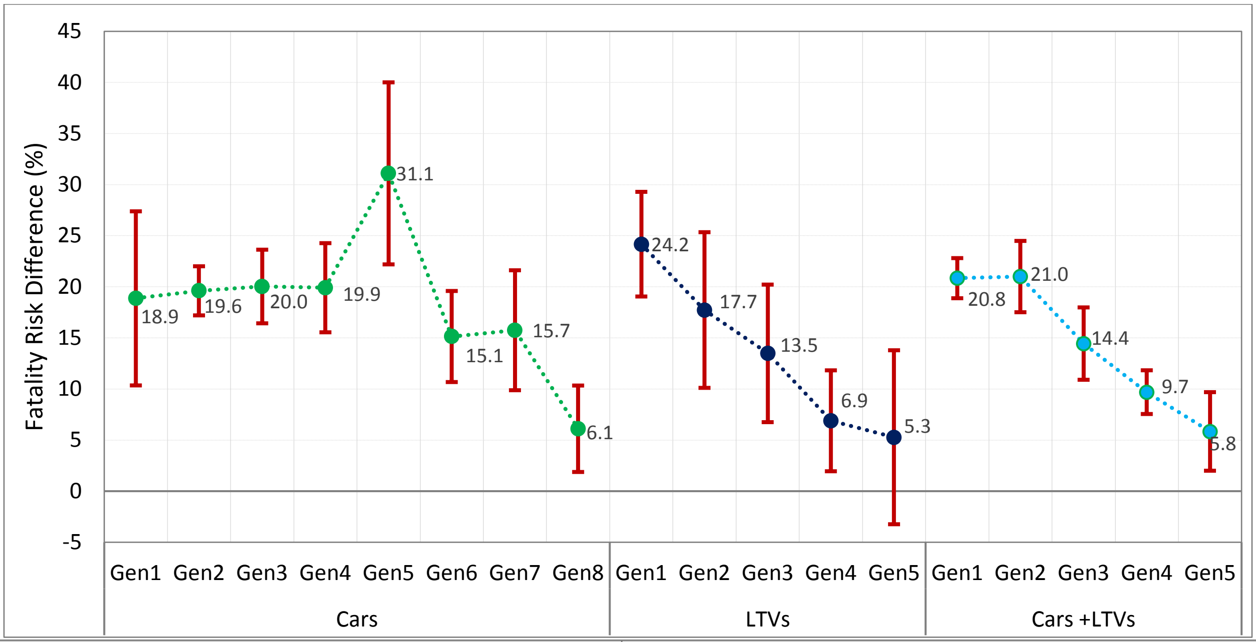
Table 5. Overall Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Crash Years

All cars and LTVs	Drivers			RFPs			Average of Drivers & RFPs			Number of Cases
Model Year 1960-2020 in Crash Year 1975-2019	**14.3**	±	**1.4**	**21.5**	±	**1.6**	**17.9**	±	**1.1**	255,566
Model Year 1960-2020 in Crash Year 2000-2019	**10.5**	±	**2.6**	**16.5**	±	**2.7**	**13.5**	±	**1.4**	82,023
Model Year 1960-2005 in Crash Year 2000-2004	**10.4**	±	**4.6**	**19.8**	±	**4.9**	**15.1**	±	**3.2**	26,539
Model Year 1960-2010 in Crash Year 2005-2009	**10.8**	±	**5.6**	**19.6**	±	**5.4**	**15.2**	±	**3.3**	22,236
Model Year 1960-2015 in Crash Year 2010-2014	**16.4**	±	**6.4**	**10.5**	±	**6.3**	**13.5**	±	**4.8**	16,221
Model Year 1960-2020 in Crash Year 2015-2019	4.2	±	5.5	**13.9**	±	**4.4**	**9.1**	±	**3.3**	17,027

5.3 Fatality Risk by Occupant Protection Type

Figure 2 shows that the estimated average fatality risk of drivers and RF passengers (16- to 96 years old) differs between females and males for most generations of cars and LTVs. Because of limitations in data and coding, generations of occupant protection types for cars and LTVs are defined differently. In cars, two-point lap belt with automatic shoulder belt use has the highest estimate of fatality risk for females relative to males (**31.1 ± 8.9**%). The last three generations of cars, which are equipped with dual air bags reduce the estimated fatality risk for females relative to males. When car occupants use seat belts equipped with pretensioners and load limiters, the estimated fatality risk for females relative to males drops to **6.1 (± 4.2)** percent. In LTVs, the estimated fatality risk for females relative to males is the highest for unbelted occupants without air bags (**24.2 ± 5.1**%) and gradually decreases with later generations of occupant protection. It drops to **6.9 (± 4.9)** percent for belted occupants in LTVs with air bags, then to 5.3 (± 8.5) percent when the belts are equipped with pretensioners and load limiters. For cars and LTVs combined, the estimated female fatality risk relative to males is higher than 20 percent for vehicles without air bags, but it drops to **14.4 (± 3.5)** percent for unbelted occupants with dual air bags, **9.7 (± 2.1)** percent for belted occupants with air bags, and **5.8 (± 3.8)** percent for belted occupants with dual air bags, pretensioners and load limiters. Table B in the Appendix shows additional estimates and the number of cases used in the regression analysis.

Figure 2. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Occupant Protection Type



Generations of Car Occupants	Generations of LTV or Car+ LTV Occupants
Gen1: Unbelted, pre-MY 1968, no energy-absorbing (EA) steering columns	Gen1: Unbelted, without air bags
Gen2: Unbelted, MY 1969-1982 cars	Gen2: Belted, without air bags
Gen3: Unbelted, MY 1983-1996, no air bags	Gen3: Unbelted, with dual air bags (no on-off switches for LTVs)
Gen4: 3-point belted occupants of cars without air bags	Gen4: Belted, with dual air bags (no on-off switches for LTVs)
Gen5: 2-point lap/automatic shoulder belted occupants of cars without air bags	Gen5: Belted, with dual air bags, pretensioners, load limiters (LTV MY ≥ 2007)
Gen6: Unbelted occupants of cars with dual air bags	
Gen7: Belted, with dual air bags, no pretensioners/load limiters	
Gen8: Belted, with dual air bags, pretensioners, load limiters	

Table 6 shows the comparisons of estimated female fatality risk relative to males between occupant protection types of vehicles (cars + LTVs). Modern occupant protection technologies statistically significantly reduce the estimated difference in fatality risk for females relative to males. Dual air bags reduce the estimated difference in fatality risk by **-6.4 (± 4.0)** percent for unbelted occupants (unbelted without air bags: 20.8 ± 3.8%, unbelted with dual air bags: **14.4 ± 3.5**%). Dual air bags also reduce the estimated difference in fatality risk by **-11.3 (± 4.1)** percent for belted occupants (belted without air bags: **21.0 ± 3.5**%, belted with dual air bags: **9.7 ± 2.1**%). The latest occupant protection technologies (dual air bags, pretensioners, and load limiters) statistically significantly reduce the estimated difference in fatality risk for females relative males by **-15.2 (± 5.2)** percent for belted occupants (belted without air bags: **21.0 ± 3.5**%, belted with dual air bags, pretensioners and load limiters: **5.8 ± 3.8**%).

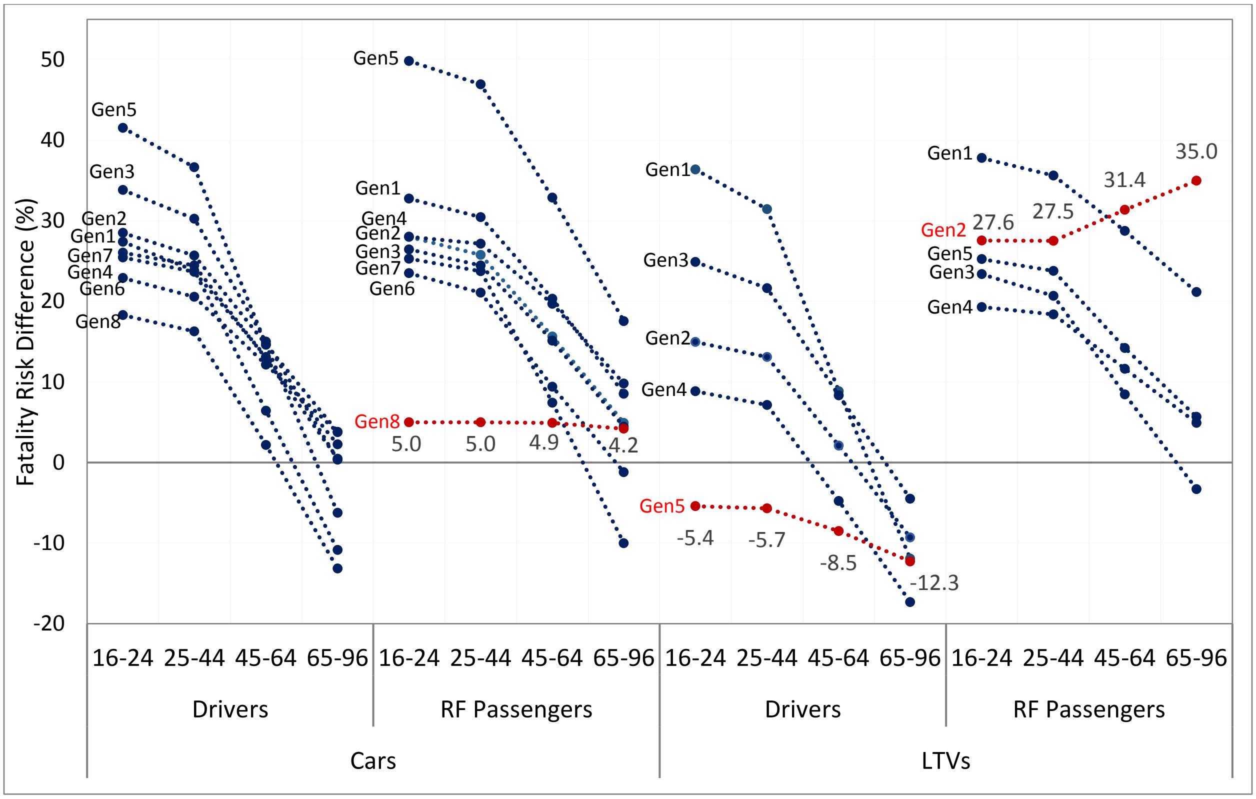
Table 6. Comparison of Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males Between Occupant Protection Types

Occupant Protection Types for Cars + LTVs	Drivers & RFP	Number of Cases
Unbelted without air bags (generation 1)	**20.8 ± 2.0**	137,036
Belted without air bags (generation 2)	**21.0 ± 3.5**	36,598
Unbelted with dual air bags (generation 3)	**14.4 ± 3.5**	22,328
Belted with dual air bags (generation 4)	**9.7 ± 2.1**	45,281
Belted with dual air bags, pretensioners and load limiters (generation 5)	**5.8 ± 3.8**	17,978
Comparison of Occupant Protection Types		
Unbelted with dual air bags (gen 3) vs. Unbelted without air bags (gen 1)	**-6.4 ± 4.0**	
Belted with dual air bags (gen 4) vs. Belted without air bags (gen 2)	**-11.3 ± 4.1**	
Belted with dual air bags, pretensioners and load limiters (gen 5) vs. Belted without air bags (gen 2)	**-15.2 ± 5.2**	

Note: The estimates **highlighted in bold** indicate that they are statistically significant. Comparison estimates were computed using the unrounded estimates in each occupant protection type. Differences between groups may be statistically significant even if groups taken individually are not statistically significant.

Figure 3 displays the estimated fatality risk difference for females relative to males by age group and occupant protection type for drivers and RF passengers and for cars and LTVs. In most generations of occupant protection systems, the estimated fatality risk for females relative to males is at the highest level in the younger ages (16- to 24), and the estimated difference in fatality risk is reduced for older age groups, and is even negative (i.e., males have a higher estimated fatality risk than females) in the ages (65-96) for some generations. As exceptions (red lines in Figure 5), for belted RF passengers in cars equipped with air bags, pretensioners and load limiters, the point estimates of fatality risk for females relative to males are 4- to 5 percent for all age groups (5.0% for ages 16-24, 5.0% for ages 25-44, 4.9% for ages 45-64, and 4.2% for ages 65-96). For belted drivers in LTVs with air bags, pretensioners and load limiters, the estimated fatality risk for females is lower than males for all age groups (-5.4% for ages 16-24, -5.7% for ages 25-44, -8.5% for ages 45-64, and -12.3% for ages 65-96). On the other hand, the estimated fatality risk for females relative to males shows a slightly rising trend for belted RF passengers in LTVs without air bags (27.6% for ages 16-24, 27.5% for ages 25-44, 31.4% for ages 45-64, and 35.0% for ages 65-96). Table B in the Appendix shows additional estimates and the number of cases used in the regression analysis.

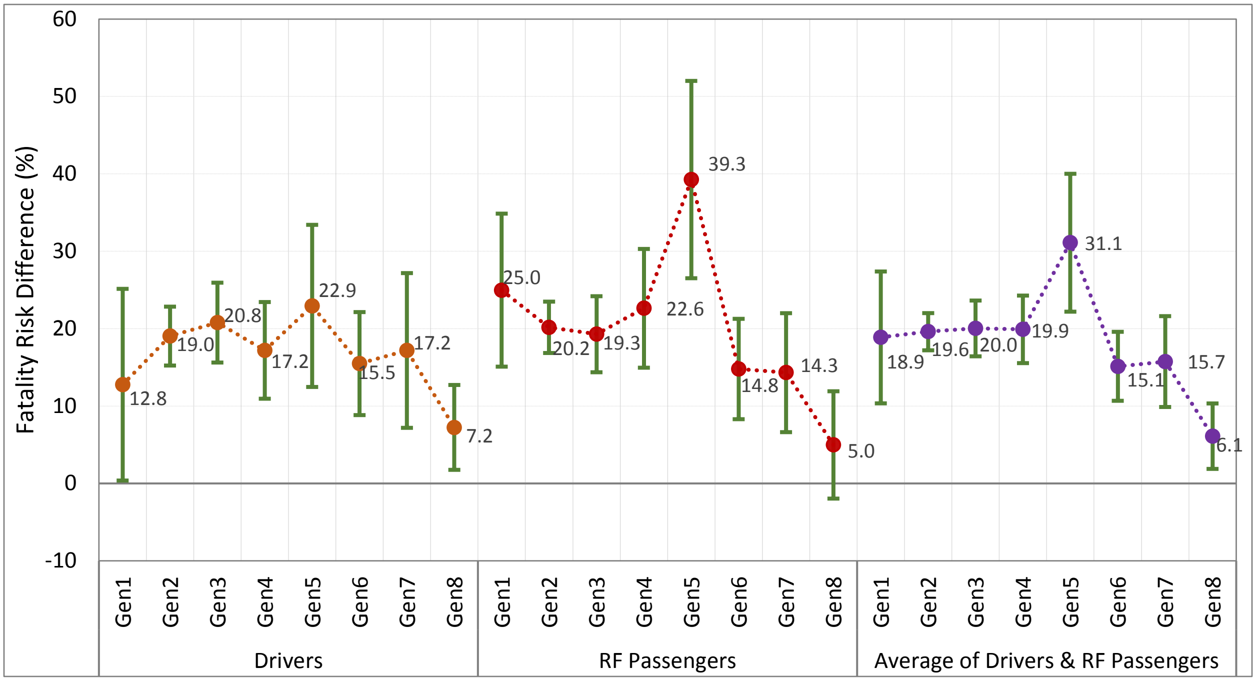
Figure 3. Fatality Risk Difference for Females Relative to Males by Age Group and Occupant Protection Type



Generations of Car Occupants	Generations of LTV Occupants
Gen1: Unbelted, pre-MY 1968, no EA columns	Gen1: Unbelted, without air bags
Gen2: Unbelted, MY 1969-1982 cars	Gen2: Belted, without air bags
Gen3: Unbelted, MY 1983-1996, no air bags	Gen3: Unbelted, with dual air bags (no on-off switches for LTVs)
Gen4: 3-point belted occupants of cars without air bags	Gen4: Belted, with dual air bags (no on-off switches for LTVs)
Gen5: 2-point lap/automatic shoulder belted occupants of cars without air bags	Gen5: Belted, with dual air bags, pretensioners, load limiters (LTV MY ≥ 2007)
Gen6: Unbelted occupants of cars with dual air bags	
Gen7: Belted, with dual air bags, no pretensioners/load limiters	
Gen8: Belted, with dual air bags, pretensioners, load limiters	

Figure 4 shows the estimated fatality risk difference for females (age 16- to 96) relative to males by the occupant protection type for drivers, RF passengers, and average of drivers and RF passengers in cars. For drivers, the estimated female fatality risk relative to males is highest at **22.9 (± 10.5)** percent when a two-point lap belt with automatic shoulder belt is used. Air bags reduce the estimated relative fatality risk difference to **15.5 (± 6.7)** percent for unbelted occupants and to **17.2 (± 10.0)** percent for belted occupants. When belts are equipped with pretensioners and load limiters, the estimated fatality risk for female drivers relative to male drivers drops to **7.2 (± 5.5)** percent. RF passengers show a similar pattern as drivers, but the effect of advanced occupant protection systems is larger: **39.3 (± 12.7)** percent for two-point lap belt with automatic shoulder belt use, **14.8 (± 6.5)** percent for unbelted occupants with air bags, **14.3 (± 7.7)** percent for belted occupants with air bags, and 5.0 (± 6.9) percent for belted occupants with air bags, pretensioners and load limiters. Table B in the Appendix shows additional estimates and the number of cases used in the regression analysis.

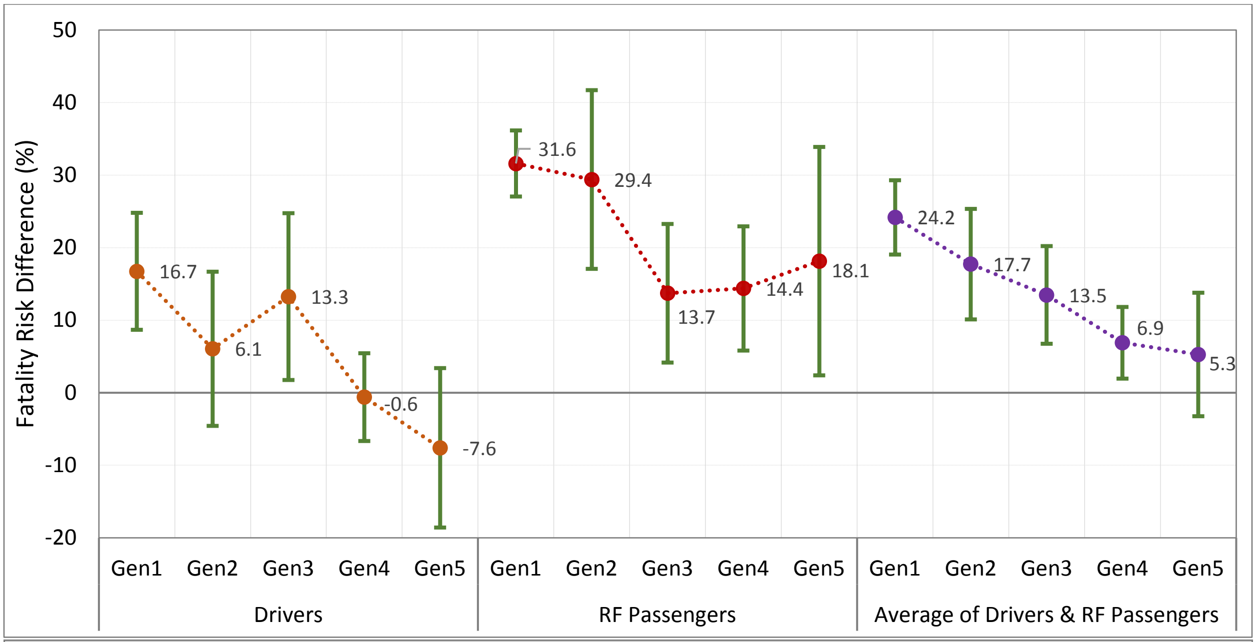
Figure 4. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Occupant Protection Type (Cars Only)



Generations of Car Occupants
Gen1: Unbelted, pre-MY 1968, no EA columns
Gen2: Unbelted, MY 1969-1982 cars
Gen3: Unbelted, MY 1983-1996, no air bags
Gen4: 3-point belted occupants of cars without air bags
Gen5: 2-point lap/automatic shoulder belted occupants of cars without air bags
Gen6: Unbelted occupants of cars with dual air bags
Gen7: Belted, with dual air bags, no pretensioners/load limiters
Gen8: Belted, with dual air bags, pretensioners, load limiters

Figure 5 shows the estimated fatality risk difference for females (16- to 96 years old) relative to males by occupant protection type for drivers, RF passengers, and the average of drivers and RF passengers in LTVs. Belt use reduces the estimated relative female fatality risk for drivers. When LTVs are not equipped with air bags, the estimated relative female fatality risk drops from **16.7 (± 8.1)** percent for unbelted drivers to 6.1 (± 10.6) percent for belted drivers. Similarly, when LTVs are equipped with air bags, the estimated female fatality risk relative to males is reduced from **13.3 (± 11.5)** percent for unbelted drivers to -0.6 (± 6.0) percent for belted drivers. When belts are equipped with pretensioners and load limiters, the estimated female driver fatality risk relative to males is negative (-7.6 ± 11.0%) even for younger age drivers (-5.4% for ages 16-24 in Figure 3). On the other hand, belt use slightly increases the estimated relative female fatality risk for RF passengers in LTVs equipped with air bags. The estimated fatality risk difference is **13.7 (± 9.6)** percent for unbelted occupants, **14.4 (± 8.6)** percent for belted occupants, and **18.1 (± 15.7)** percent for belted occupants with pretensioners and load limiters. Table B in the Appendix shows additional estimates and the number of cases used in the regression analysis.

Figure 5. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Occupant Protection Type (LTVs Only)



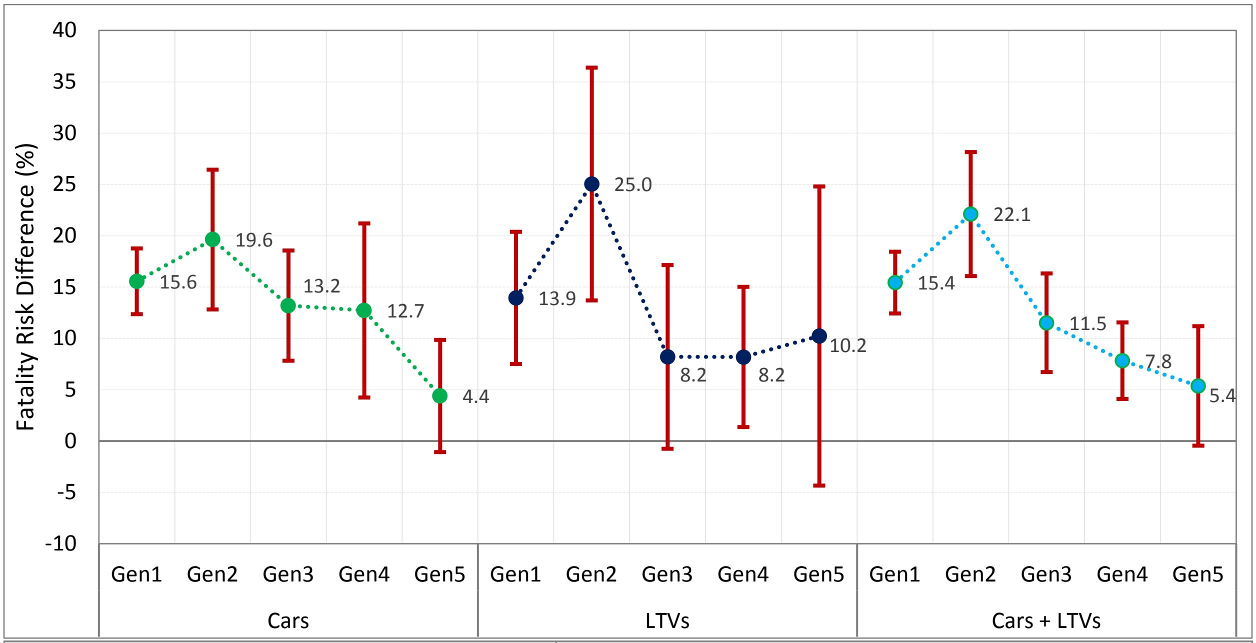
Generations of LTV Occupants
Gen1: Unbelted occupants of LTVs without air bags
Gen2: Belted occupants of LTVs without air bags
Gen3: Unbelted occupants of LTVs with dual air bags (no on-off switches)
Gen4: Belted occupants of LTVs with dual air bags (no on-off switches)
Gen5: Belted occupants of LTVs with dual air bags, pretensioners/load limiters (MY ≥ 2007)

5.4 Fatality Risk by Occupant Protection Type and Impact Type

Frontal Impacts

Figure 6 shows the estimated fatality risk difference for females (16- to 96 years old) relative to males by occupant protection type in frontal impact crashes. From the FARS data, impact (or crash) type was defined by a combination of first harmful event, most harmful event, and area of impact. Estimates for drivers and RF passengers were averaged in the figure. For cars and LTVs combined, the estimated female fatality risk relative to males is highest when the occupants use belts in vehicles not equipped with air bags (**22.1 ± 6.0**%). The estimated relative fatality risk for females gradually decreases when vehicles have air bags, occupants use seat belts, and seat belts are equipped with pretensioners and load limiters (**11.5 ± 4.8**% for unbelted occupants with air bags, **7.8 ± 3.7**% for belted occupants with air bags; and 5.4 ± 5.8% for belted occupants with air bags, pretensioners and load limiters). A similar pattern is shown for cars. The estimated female fatality risk relative to males is highest for belted occupants without air bags (**19.6 ± 6.8**%). When cars have air bags, the estimated relative female fatality risk drops to **13.2 (± 5.4)** percent for unbelted occupants and to **12.7 (± 8.5)** percent for belted occupants. The estimated risk further drops to under 5 percent (4.4 ± 5.5%) and does not show any statistically significant difference compared to males for occupants who use seat belts equipped with pretensioners and load limiters in vehicles with air bags. However, for LTVs with air bags, the estimated relative fatality risk remains around 8-10 percent regardless of whether occupants are belted or unbelted, or the pretensioners and load limiters are present or not. Tables D (1) – D (3) in the Appendix show additional estimates and the number of vehicles used in the regression analysis.

Figure 6. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Occupant Protection Type (Frontal Impacts)



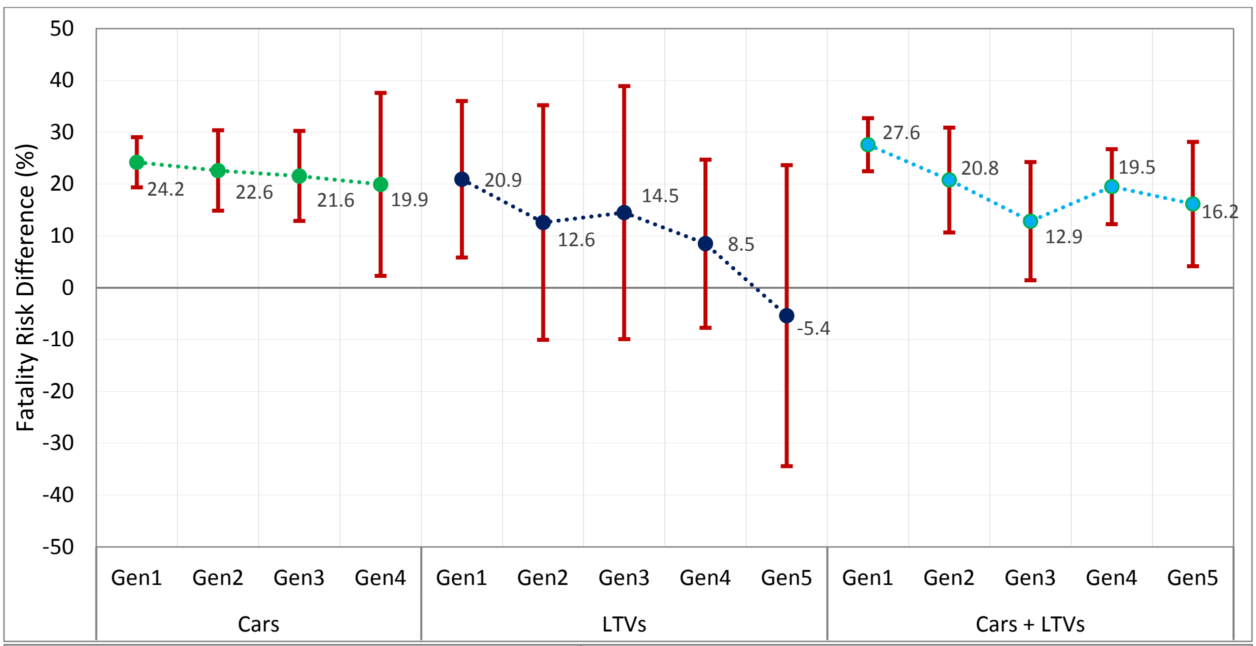
Generations of Car Occupants	Generations of LTV or Car+LTV Occupants
Gen1: Unbelted, without air bags	Gen1: Unbelted, without air bags
Gen2: 3-point belted, without air bags	Gen2: Belted, without air bags
Gen3: Unbelted, with dual air bags	Gen3: Unbelted, dual air bags (no on-off switches for LTVs)
Gen4: Belted, dual air bags, no pretensioners/load limiters	Gen4: Belted, dual air bags (no on-off switches for LTVs)
Gen5: Belted, dual air bags, pretensioners, load limiters	Gen5: Belted, dual air bags, pretensioners/load limiters (LTV MY ≥ 2007)

Nearside and Far-Side Impacts

In this study, nearside and far-side impacts are defined by the distance from the occupant seating position to crash impact location on the vehicle. Therefore, the nearside is the left side for drivers and the right side for RF passengers. On the other hand, the far side is the right side for drivers and the left-side for RF passengers. Some of the occupant protection types considered for side impacts are the same as those used for frontal impacts. While frontal air bags may not deploy in a side impact crash and may not be directly associated with side impact protection, they are indicative of overall changes in vehicle safety countermeasures, including improvements in vehicle structural design as well as padding of interior surfaces.

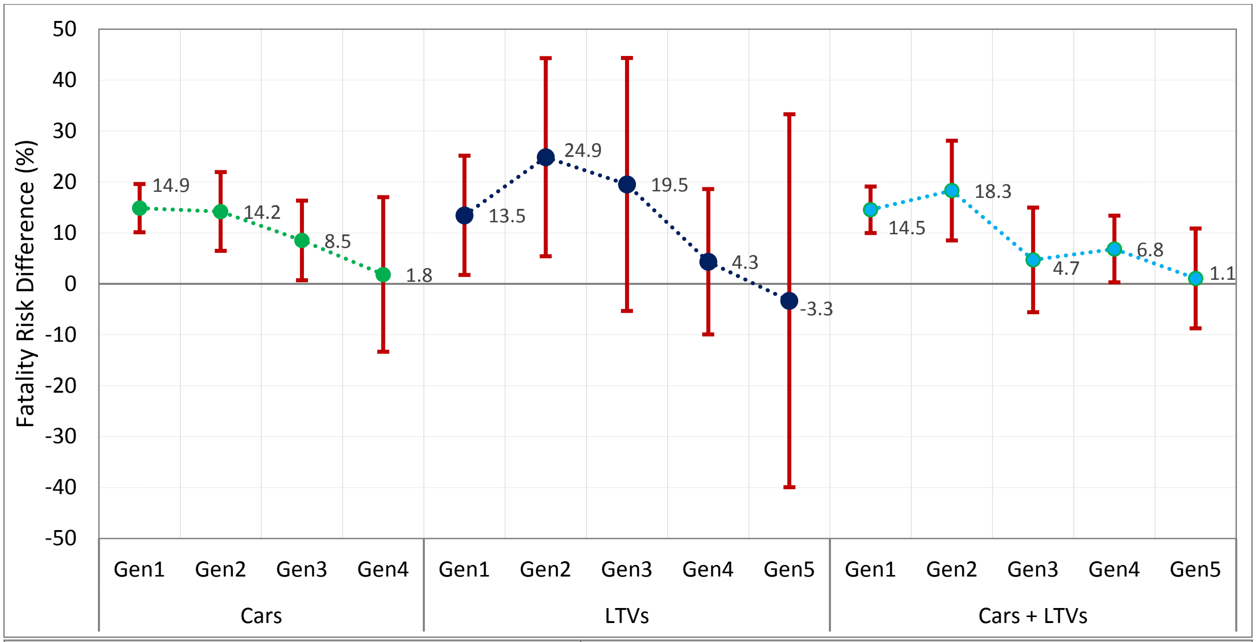
Figure 7 and Figure 8 show the estimated fatality risk difference for females (age 16- to 96) relative to males by occupant protection type in nearside and far-side impact crashes. Estimates for divers and RF passengers were averaged in the figure. In nearside impacts of cars, the estimated female fatality risk relative to males stays at around 20 percent or more for all occupant protection types even when the cars are equipped with frontal air bags or curtain-plus-torso or combination bags. However, the study found that the presence of dual air bags reduces the estimated relative female fatality risk to under 10 percent (**8.5 ± 7.8**%) for belted occupants in far-side impacts of cars. When cars are equipped with curtain-plus-torso or combination bags, the estimated female fatality risk relative to males is further reduced to near zero (1.8 ± 15.2%) for belted occupants in far-side impacts. In LTVs not equipped with air bags, belt use decreases the estimated female fatality risk relative to males from **20.9 (± 15.1)** percent to 12.6 (± 22.6) percent for nearside impacts but increases from **13.5 (± 11.7)** percent to **24.9 (± 19.5)** percent for far-side impacts. On the other hand, in LTVs with air bags, belt use lowers the estimated female fatality risk relative to males for both nearside impacts and far-side impacts. Belt use decreases the estimated relative female fatality risk from 14.5 (± 24.4) percent to 8.5 (± 16.2) percent for the nearside and from 19.5 (± 24.8) percent to 4.3 (± 14.3) percent for far-side impacts. When LTVs are equipped with pretensioners and load limiters, the estimated female fatality risk relative to males becomes negative: -5.4 (± 29.0) percent for nearside impacts and -3.3 (± 36.6) percent for far-side impacts. Tables D (1) – D (3) in the Appendix show additional estimates and the number of cases used in the regression analysis.

Figure 7. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Occupant Protection Type (Nearside Impacts)



Generations of Car Occupants	Generations of LTV or Car+LTV Occupants
Gen1: Unbelted, without side/curtain bags	Gen1: Unbelted, without air bags
Gen2: 3-point belted, without side/curtain bags	Gen2: Belted, without air bags
Gen3: Belted, dual air bags	Gen3: Unbelted, dual air bags (no on-off switches for LTVs)
Gen4: Belted, with curtain+torso or combo bags	Gen4: Belted, dual air bags (no on-off switches for LTVs)
	Gen5: Belted, dual air bags, pretensioners, load limiters (LTV MY ≥ 2007)

Figure 8. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Occupant Protection Type (Far-Side Impacts)



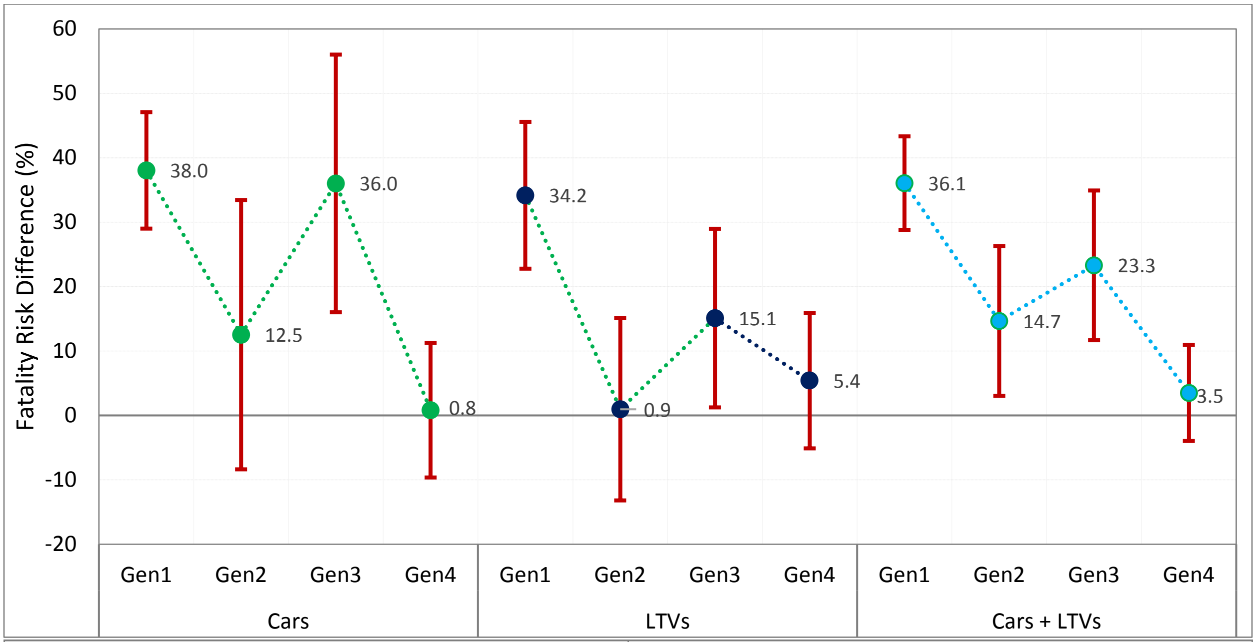
Generations of Car Occupants	Generations of LTV or Car+LTV Occupants
Gen1: Unbelted, without side/curtain bags	Gen1: Unbelted, without air bags
Gen2: 3-point belted, without side/curtain bags	Gen2: Belted, without air bags
Gen3: Belted, dual air bags	Gen3: Unbelted, dual air bags (no on-off switches for LTVs)
Gen4: Belted, with curtain+torso or combo bags	Gen4: Belted, dual air bags (no on-off switches for LTVs)
	Gen5: Belted, dual air bags, pretensioners, load limiters (LTV MY ≥ 2007)

First-Event Rollovers

The occupant protection types considered for first-event rollovers are the same as those used for frontal impacts. While frontal air bag generations may not be directly associated with rollover, they are indicative of overall changes in vehicle safety countermeasures, including improvements in vehicle structural design as well as padding of interior surfaces.

Figure 9 shows the estimated difference in female fatality risk relative to males by occupant protection type in first-event rollover crashes. Estimates for drivers and RF passengers were averaged in the figure. The estimated female fatality risk relative to males differs greatly depending on the belt use status in both cars and LTVs. In cars not equipped with air bags, unbelted female occupants have an estimated **38.0 (± 9.0)** percent difference in fatality risk relative to unbelted male occupants. But the estimated relative female fatality risk drops to 12.5 (± 20.9) percent when the occupants use 3-point belts. When cars are equipped with air bags, belt use reduces the estimated relative female fatality risk from **36.0 (± 20.0)** percent to 0.8 (± 10.4) percent. Belt use also reduces the estimated female fatality risk relative to males in LTVs. When LTVs are not equipped with air bags, belt use drops the estimated female fatality risk relative to males from **34.2 (± 11.4)** percent to 0.9 (± 14.1) percent. When LTVs are equipped with air bags, the estimated relative female fatality risk decreases from **15.1 (± 13.9)** percent to 5.4 (± 10.5) percent. Tables D (1) – D (3) in the Appendix show additional estimates and the number of cases used in the regression analysis.

Figure 9. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Occupant Protection Type (First-Event Rollovers)



Generations of Car Occupants	Generations of LTV or Car+LTV Occupants
Gen1: Unbelted, without air bags	Gen1: Unbelted, without air bags
Gen2: 3-point belted, without air bags	Gen2: Belted, without air bags
Gen3: Unbelted, with dual air bags	Gen3: Unbelted, dual air bags (no on-off switches for LTVs)
Gen4: Belted, with dual air bags	Gen4: Belted, dual air bags (no on-off switches for LTVs)

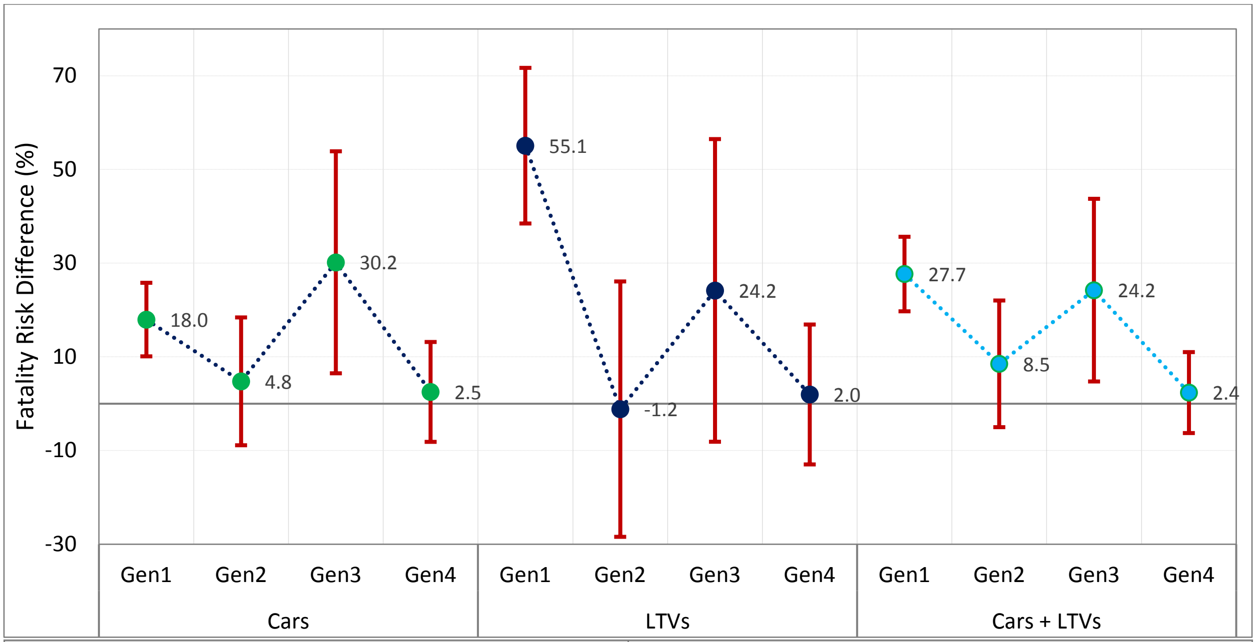
Rear Impacts and Other Crashes

The occupant protection types considered for rear impacts and other crashes are the same as those used for frontal impacts. While frontal air bag generations may not be directly associated with rear impacts and other crashes, they are indicative of overall changes in vehicle safety countermeasures, including improvements in vehicle structural design as well as padding of interior surfaces.

Figure 10 shows the estimated fatality risk difference for females relative to males by occupant protection type in rear impact and other crashes.[9] Estimates for drivers and RF passengers were averaged in the figure. Rear impact and other crashes show a similar pattern as first-event rollover crashes in Figure 9. Belt use reduces the estimated relative female fatality risk from **18.0 (± 7.9)** percent to 4.8 (± 13.6) percent in cars not equipped with air bags, and from **30.2 (± 23.7)** percent to 2.5 (± 10.7) percent in cars equipped with air bags. In LTVs, belt use drops the estimated relative female fatality risk from **55.1 (± 16.6)** percent to -1.2 (± 27.3) percent when air bags are not equipped, and from 24.2 (± 32.3) percent to 2.0 (± 14.9) percent when air bags are equipped. Tables D (1) – D (3) in the Appendix show additional estimates and the number of cases used in the regression analysis.

[9] It includes crashes in which first harmful event is fire/explosion, immersion, gas inhalation, fell/jumped from vehicle, injured in vehicle, etc., or area of impact is top.

Figure 10. Fatality Risk Difference for Females (16- to 96 Years Old) Relative to Males by Occupant Protection Type (Rear Impacts/Other Crashes)



Generations of Car Occupants	Generations of LTV or Car+LTV Occupants
Gen1: Unbelted, without air bags	Gen1: Unbelted, without air bags
Gen2: 3-point belted, without air bags	Gen2: Belted, without air bags
Gen3: Unbelted, with dual air bags	Gen3: Unbelted, dual air bags (no on-off switches for LTVS)
Gen4: Belted, with dual air bags	Gen4: Belted, dual air bags (no on-off switches for LTVs)

6. Conclusion

This study presented updated findings related to estimated female fatality risk relative to males. It focused on trends that include the newest case data and associated vehicle MYs and occupant protection technologies given recent improvements in vehicle safety. Results demonstrated that the incremental female fatality risk relative to males reduces steadily for later MYs, dropping to 2.9 percent for occupants in MY 2015-2020 vehicles. Although the number of vehicles for the later MYs are relatively small, the female fatality risk relative to males follows the overall decreasing trends for recent MYs. In particular, the reduction of the incremental fatality risk for females relative to males is statistically significant in comparison between MY 2010-2020 and MY 1960-2009 when occupants are belted. The reduction is also statistically significant when occupants are unbelted when comparing MY 2000-2020 to MY 1960-1999. Given that more safety technologies have been added to vehicles over the years, the results suggest that safety protections examined in this study may have reduced the difference in fatality risk between males and females, although there may be other technologies or factors as well.

The relative female fatality risk for the latest MY group (2015-2020) was higher for RF passengers (5.3%) than drivers (0.5%), although testing for statistical significance between drivers and RF passengers was beyond the scope of this paper. Further research is needed to understand how these occupant types compare in terms of their female relative fatality risk.

The estimated fatality risk for females relative to males is generally higher for younger occupants than older occupants when considering different occupant protection types. For both drivers and RF passengers, the estimated relative fatality risk for females is generally highest for 16- to 24-year-olds and decreases steadily until reaching its low for 65- to 96-year-olds.

Current occupant protection resulting from advances in crash testing regulations has the most effect at lowering female fatality risk relative to males. Air bags statistically significantly reduce the estimated difference in female fatality risk relative to males for both belted and unbelted occupants. Belted occupants in vehicles with the latest occupant protection technologies such as dual air bags and seat belts with pretensioners and load limiters have the lowest estimated relative female fatality risk, and the reduction of estimated relative female fatality risk compared to belted occupants in vehicles without those protection technologies is highest and statistically significant. Belt use and air bags together reduce the estimated female fatality risk relative to males in front and far-side impact crashes the most. Belt use also reduces the estimated female fatality risk relative to males in first-event rollovers, rear impact and other crashes.

7. Limitations

This study is subject to several limitations that are listed below.

As previously noted, occupant protection types were not always identified similarly for car and LTV occupants because of limitations in the FARS data and coding. As such, a few analyses, such as for side and rear impacts, relied on the presence of various frontal restraints to indicate updates to safety systems that would be applicable to those crash modes, such as side air bags, structural improvements, head restraints, etc. The assumption is that safety advancements across all crash modes will be present in newer MY vehicles, so vehicle generations based on updates to safety systems in one crash mode (i.e., frontal) will adequately reflect updates applicable to other crash modes.

Some of the vehicle groups in this analysis have a small number of vehicles, resulting in large confidence intervals. Thus, care should be taken to interpret point estimates of female fatality risk relative to males in conjunction with large confidence intervals. The vehicle group with the lowest number of vehicles is LTVs of which crash type is first-event rollovers, and which have belted occupants, air bags, pretensioners, and load limiters. This group has only 165 vehicles, and a confidence interval length of 123.9. The range of the estimate is too wide to make any firm conclusions. (See Table D (2) in the Appendix).

A small number of vehicles within a vehicle group also affected the statistical significance in comparisons between vehicle groups. For example, when occupants are unbelted, the MY 2010-2020 group has only 1,238 vehicles and female fatality risk relative to males is estimated as 8.0 (± 14.0) percent. Because of the wide confidence interval, the comparisons of this vehicle group with the other vehicle groups involving older MYs also have wide confidence intervals (i.e., the length of one side of the confidence intervals are greater than 14). Therefore, none of the comparisons are statistically significant although they estimated more than 11 percent reduction in the female fatality risk relative to males (See Table 4 in section 5.1).

Since female relative fatality risk estimates based on a small number of vehicles have big uncertainty, adding more vehicles to the analysis may change the relative risk estimate. For example, in the previous study, Kahane found that in all side impacts of vehicles (cars and LTVs) equipped with curtain-plus-torso or combination bags, the estimated average fatality risk difference for female drivers and RF passengers relative to males was close to zero, 2.6 (± 21.5) percent, although there was uncertainty due to the small number of vehicles. In that analysis, only 744 vehicles were used in the estimation. In the current analysis, the number of vehicles for this vehicle group increases to 4,206 (ages 16- to 96) and 3,424 (ages 21- to 96) by adding the recent FARS data. The updated estimates of relative fatality risk increased while the confidence intervals narrowed: **9.9 (± 8.7)** percent from the data with ages 16- to 96 and 9.3 (± 9.5) percent from the data with ages 21- to 96 (See Table D (1) in the Appendix).

The analysis assumes that the effect of sex on the logistic regression model remains constant until age 35 and then changes at a linear rate after age 35. The assumption with breakpoints at age 35 is based on Kahane's empirical study for the full data set (i.e., for all cars and vehicles with occupant age range 21- to 96). Although the relationship between fatality, age and the sex coefficient might be much more complex, and the relationship can differ for different groups of vehicles, this analysis maintained the simple relationship used by Kahane because low cases for some of the vehicle groups makes fitting more complex models difficult.

The results in this paper come from analysis of fatality outcomes in like crashes and show that the female relative fatality risk decreases for newer vehicles. This study did not examine factors that relate to drivers of older vehicles that do not have the latest safety countermeasures. This study also did not examine demographic data, such as race and ethnicity. NHTSA has a separate study that aims to assess disparities with respect to traffic fatalities based on race, ethnicity, and income.

8. References

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Appendix

Table A. Difference in Fatality Risk for Females Relative to Males of the Same Age,
***Overall and By Model Year** - Cars and LTVs, Drivers and Right Front Passengers*
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses	Relative Fatality Risk Difference for Females (%)			N of Cases Used in Regression Analyses
Seat Position ++>	**Drivers**					**Right Front Passengers**					**Drivers & RFPs**		**Drivers**	**RFPs**	**Drivers & RFPs**	
Occupant Age Group ++>	**16-96**	**16-24**	**25-44**	**45-64**	**65-96**	**16-96**	**16-24**	**25-44**	**45-64**	**65-96**	**16-96**		**21-96**	**21-96**	**21-96**	
Overall (by Crash Years)																
All Cars and LTVs, MY 1960-2020 in CY 1975-2019	**14.3 ± 1.4**	26.7	23.7	8.8	-6.5	**21.5 ± 1.6**	27.9	26.3	17.7	8.7	**17.9 ± 1.1**	255,566	**11.9 ± 1.8**	**19.2 ± 1.9**	**15.5 ± 1.3**	178,175
All Cars and LTVs, MY 1960-2020 in CY 2000-2019	**10.5 ± 2.6**	22.2	19.8	5.2	-10.3	**16.5 ± 2.7**	22.1	20.9	13.1	5.0	**13.5 ± 1.4**	82,023	**7.6 ± 2.5**	**14.0 ± 2.8**	**10.8 ± 1.5**	62,035
All Cars and LTVs, MY 1960-2010 in CY 2000-2009	**10.6 ± 3.6**	24.9	22.0	4.4	-14.1	**19.7 ± 3.9**	26.4	25.1	15.7	5.9	**15.2 ± 2.0**	48,775	**8.1 ± 4.0**	**16.3 ± 4.2**	**12.2 ± 2.1**	35,311
All Cars and LTVs, MY 1960-2020 in CY 2010-2019	**10.0 ± 4.0**	18.6	16.8	5.9	-5.9	**12.2 ± 4.5**	16.2	15.4	9.7	4.2	**11.1 ± 2.3**	33,248	**6.6 ± 4.4**	**11.2 ± 5.4**	**8.9 ± 2.6**	26,724
All Cars and LTVs, MY 1960-2005 in CY 2000-2004	**10.4 ± 4.6**	24.4	21.5	4.3	-13.8	**19.8 ± 4.9**	27.9	26.3	14.9	2.6	**15.1 ± 3.2**	26,539	**7.5 ± 4.6**	**17.4 ± 5.9**	**12.4 ± 3.5**	18,979
All Cars and LTVs, MY 1960-2010 in CY 2005-2009	**10.8 ± 5.6**	25.5	22.6	4.4	-14.6	**19.6 ± 5.4**	24.7	23.7	16.6	9.4	**15.2 ± 3.3**	22,236	**8.7 ± 6.3**	**15.0 ± 6.3**	**11.9 ± 4.5**	16,332
All Cars and LTVs, MY 1960-2015 in CY 2010-2014	**16.4 ± 6.4**	21.4	20.3	13.8	7.3	**10.5 ± 6.3**	15.0	14.2	7.7	0.7	**13.5 ± 4.8**	16,221	**13.6 ± 7.3**	**8.3 ± 7.4**	**10.9 ± 4.8**	12,761
All Cars and LTVs, MY 1960-2020 in CY 2015-2019	4.2 ± 5.5	15.8	13.5	-1.0	-16.6	**13.9 ± 4.4**	17.3	16.5	11.8	7.9	**9.1 ± 3.3**	17,027	0.4 ± 5.9	**14.1 ± 5.2**	**7.3 ± 3.6**	13,963
Vehicle Type and Model Years																
Cars only	**16.7 ± 1.7**	28.0	25.1	11.5	-2.4	**19.5 ± 1.8**	26.3	24.6	15.4	5.5	**18.1 ± 1.3**	187,094	**14.5 ± 2.2**	**17.1 ± 2.4**	**15.8 ± 1.6**	127,185
LTVs only	**9.8 ± 4.4**	26.2	22.5	3.0	-16.1	**24.5 ± 3.8**	30.7	28.9	21.1	13.8	**17.1 ± 2.5**	68,472	**7.5 ± 4.4**	**21.6 ± 3.7**	**14.6 ± 2.7**	50,990
Cars only, MY ≥ 2000	**9.4 ± 4.1**	20.2	18.0	4.5	-10.3	**11.1 ± 3.9**	14.0	13.4	9.2	4.7	**10.3 ± 2.9**	25,555	**7.1 ± 5.4**	**8.8 ± 4.6**	**8.0 ± 3.1**	19,559
LTVs only, MY ≥ 2000	3.7 ± 5.7	12.7	10.9	-0.3	-12.6	**12.5 ± 6.3**	18.6	17.3	8.8	1.4	**8.1 ± 3.2**	16,031	2.8 ± 6.4	**9.4 ± 7.0**	**6.1 ± 3.5**	13,529
Cars only, MY ≥ 2010	4.4 ± 11.9	10.7	9.4	1.5	-7.5	**13.6 ± 11.3**	16.9	16.3	11.4	6.0	**9.0 ± 6.3**	4,408	-0.6 ± 12.7	**14.6 ± 13.3**	7.0 ± 8.0	3,699
LTVs only, MY ≥ 2010	-6.8 ± 13.7	-3.7	-4.1	-8.1	-13.4	8.8 ± 16.3	13.6	12.2	6.3	3.4	1.0 ± 10.6	2,699	-7.9 ± 15.7	6.2 ± 16.2	-0.9 ± 11.0	2,482
Cars and LTVs, by Model Year Range																
1960-1999	**16.2 ± 1.5**	28.6	25.5	10.6	-4.4	**23.7 ± 1.8**	30.4	28.5	19.8	10.5	**19.9 ± 1.3**	213,980	**13.7 ± 2.0**	**21.6 ± 2.3**	**17.7 ± 1.5**	145,087
2000-2020	**6.9 ± 3.4**	17.2	15.3	2.2	-12.1	**11.9 ± 3.2**	15.5	14.8	9.6	4.3	**9.4 ± 2.2**	41,586	**4.9 ± 3.7**	**9.4 ± 3.5**	**7.2 ± 2.5**	33,088
1960-2009	**14.8 ± 1.4**	27.2	24.2	9.2	-6.1	**21.8 ± 1.6**	28.3	26.6	18.1	9.0	**18.3 ± 1.2**	248,459	**12.5 ± 1.8**	**19.5 ± 1.8**	**16.0 ± 1.3**	171,994
2010-2020	0.3 ± 9.2	6.0	5.0	-2.3	-10.9	**12.3 ± 10.4**	15.9	15.2	10.1	5.4	**6.3 ± 5.4**	7,107	-3.8 ± 9.4	**12.0 ± 9.7**	4.1 ± 6.8	6,181
1980-1989	**17.3 ± 3.2**	30.9	27.5	11.3	-4.8	**25.3 ± 3.0**	30.9	29.2	22.3	14.9	**21.3 ± 2.5**	74,689	**15.9 ± 4.0**	**24.6 ± 3.3**	**20.2 ± 2.6**	52,888
1990-1999	**13.7 ± 2.7**	25.4	22.8	8.4	-6.7	**21.4 ± 3.8**	29.9	28.2	16.2	3.4	**17.5 ± 2.3**	47,680	**10.7 ± 3.7**	**18.2 ± 4.3**	**14.5 ± 2.7**	34,428
2000-2009	**8.0 ± 3.4**	19.2	17.0	2.9	-12.3	**11.8 ± 4.1**	15.4	14.7	9.4	4.0	**9.9 ± 2.5**	34,479	**6.6 ± 3.4**	**8.8 ± 4.2**	**7.7 ± 2.7**	26,907
1960-1966	**15.7 ± 11.7**	31.6	27.6	8.8	-9.1	**27.9 ± 10.6**	35.3	32.9	23.7	13.5	**21.8 ± 9.6**	8,029	7.3 ± 13.2	**25.5 ± 12.7**	**16.4 ± 9.4**	5,045
1967-1974	**14.3 ± 4.8**	24.0	21.4	10.0	-2.0	**25.5 ± 5.0**	31.0	29.1	22.3	15.8	**19.9 ± 3.8**	43,186	**10.6 ± 6.3**	**24.4 ± 6.1**	**17.5 ± 4.5**	25,735

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

Table A (Continued). Difference in Fatality Risk for Females Relative to Males of the Same Age,
***Overall and By Model Year** - Cars and LTVs, Drivers and Right Front Passengers*
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses	Relative Fatality Risk Difference for Females (%)			N of Cases Used in Regression Analyses
Seat Position ++>	Drivers					Right Front Passengers					Drivers & RFPs		Drivers	RFPs	Drivers & RFPs	
Occupant Age Group ++>	16-96	16-24	25-44	45-64	65-96	16-96	16-24	25-44	45-64	65-96	16-96		21-96	21-96	21-96	
Cars and LTVs, by Model Year Range																
1975-1979	**19.0 ± 5.0**	29.9	26.9	13.9	1.5	**22.1 ± 4.5**	29.7	27.9	17.8	5.7	**20.5 ± 3.0**	40,396	**17.2 ± 5.7**	**18.0 ± 5.3**	**17.6 ± 3.7**	26,991
1980-1984	**17.7 ± 3.7**	32.7	28.8	11.1	-6.5	**24.8 ± 3.8**	32.6	30.3	20.5	10.3	**21.2 ± 2.9**	33,404	**16.4 ± 4.9**	**22.8 ± 4.3**	**19.6 ± 2.9**	23,337
1985-1989	**17.0 ± 4.6**	29.6	26.5	11.3	-3.9	**25.6 ± 4.6**	29.6	28.4	23.6	18.3	**21.3 ± 3.6**	41,285	**15.4 ± 5.1**	**26.0 ± 4.8**	**20.7 ± 3.8**	29,551
1990-1994	**16.3 ± 5.7**	28.6	25.5	10.7	-4.5	**26.9 ± 6.1**	34.9	33.0	22.2	10.2	**21.6 ± 4.1**	23,879	**13.8 ± 6.7**	**23.2 ± 7.5**	**18.5 ± 4.9**	17,244
1995-1999	**10.8 ± 4.6**	21.7	19.5	5.9	-8.7	**16.4 ± 4.6**	25.4	23.7	10.9	-2.5	**13.6 ± 3.2**	23,801	**7.3 ± 5.3**	**13.9 ± 5.0**	**10.6 ± 3.2**	17,184
2000-2004	**7.4 ± 4.5**	19.2	17.0	2.1	-13.8	**12.0 ± 4.4**	15.4	14.8	9.9	4.8	**9.7 ± 2.9**	22,217	**6.6 ± 5.0**	**7.2 ± 4.4**	**6.9 ± 3.0**	17,004
2005-2009	**8.8 ± 7.3**	19.0	17.1	4.1	-10.2	**11.3 ± 7.1**	15.2	14.5	8.7	3.0	**10.0 ± 4.8**	12,262	6.2 ± 8.2	**12.0 ± 7.4**	**9.1 ± 5.1**	9,903
2010-2014	0.3 ± 11.2	2.7	2.3	-0.8	-4.7	**15.7 ± 13.4**	21.2	20.1	12.1	4.6	8.0 ± 8.1	4,925	-3.8 ± 10.7	**15.6 ± 14.8**	5.9 ± 8.6	4,282
2015-2020	0.5 ± 17.5	15.6	12.6	-5.8	-25.3	5.3 ± 16.4	4.6	4.7	6.0	8.5	2.9 ± 9.8	2,182	-3.7 ± 16.5	4.8 ± 17.2	0.5 ± 10.7	1,899

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

Table B. Difference in Fatality Risk for Females Relative to Males of the Same Age,
***By Type of Occupant Protection** - Cars and LTVs, Drivers and Right Front Passengers*
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses	Relative Fatality Risk Difference for Females (%)			N of Cases Used in Regression Analyses
Seat Position ++>	Drivers					Right Front Passengers					Drivers & RFPs		Drivers	RFPs	Drivers & RFPs	
Occupant Age Group ++>	16-96	16-24	25-44	45-64	65-96	16-96	16-24	25-44	45-64	65-96	16-96		21-96	21-96	21-96	
Eight "Generations" of Car Occupants																
Unbelted, pre-MY 1968, no EA columns	**12.8 ± 12.4**	27.4	23.8	6.4	-10.9	**25.0 ± 9.9**	32.8	30.5	20.3	8.5	**18.9 ± 8.5**	7,217	4.7 ± 13.3	**25.0 ± 12.5**	**14.8 ± 9.3**	4,281
Unbelted occupants of MY 1969-1982 cars	**19.0 ± 3.8**	28.5	25.7	14.7	3.8	**20.2 ± 3.3**	28.0	25.8	15.6	4.9	**19.6 ± 2.4**	69,840	**16.5 ± 4.4**	**17.2 ± 4.2**	**16.9 ± 3.0**	43,548
Unbelted, MY 1983-1996, no air bags	**20.8 ± 5.2**	33.8	30.2	15.0	0.4	**19.3 ± 4.9**	26.5	24.4	15.1	4.4	**20.0 ± 3.6**	27,979	**19.9 ± 6.0**	**19.0 ± 4.7**	**19.5 ± 4.2**	18,305
3-point belted occupants of cars w/o air bags	**17.2 ± 6.2**	25.5	23.6	13.1	2.2	**22.6 ± 7.7**	28.0	27.1	19.7	9.8	**19.9 ± 4.4**	22,034	**16.5 ± 6.9**	**19.0 ± 7.0**	**17.7 ± 4.3**	17,629
2-point lap/automatic shoulder belted occupants of cars w/o air bags	**22.9 ± 10.5**	41.5	36.6	14.6	-6.2	**39.3 ± 12.7**	49.8	46.9	32.9	17.5	**31.1 ± 8.9**	6,877	**20.7 ± 13.7**	**34.7 ± 17.1**	**27.7 ± 9.7**	5,098
Unbelted occupant of cars with dual air bags	**15.5 ± 6.7**	22.9	20.6	12.1	3.8	**14.8 ± 6.5**	23.5	21.1	9.4	-1.2	**15.1 ± 4.5**	14,856	**14.8 ± 8.1**	**10.2 ± 7.8**	**12.5 ± 5.0**	9,452
Belted, dual air bags, no pretensioners/load limiters	**17.2 ± 10.0**	26.0	24.4	12.9	0.5	**14.3 ± 7.7**	25.3	23.7	7.4	-10.0	**15.7 ± 5.9**	10,790	**13.8 ± 8.4**	**10.5 ± 10.4**	**12.1 ± 6.6**	8,405
Belted, dual air bags, pretensioners, load limiters	**7.2 ± 5.5**	18.3	16.3	2.2	-13.2	5.0 ± 6.9	5.0	5.0	4.9	4.2	**6.1 ± 4.2**	14,269	5.4 ± 6.3	4.2 ± 6.7	4.8 ± 4.8	11,571
Five "Generations" of LTV Occupants																
Unbelted occupants of LTVs w/o air bags	**16.7 ± 8.1**	36.3	31.4	8.9	-11.9	**31.6 ± 4.6**	37.8	35.6	28.7	21.2	**24.2 ± 5.1**	39,217	**14.8 ± 9.0**	**29.4 ± 6.2**	**22.1 ± 5.5**	26,862
Belted occupants of LTVs w/o air bags	6.1 ± 10.6	15.0	13.1	2.1	-9.3	**29.4 ± 12.3**	27.6	27.5	31.4	35.0	**17.7 ± 7.6**	7,687	3.5 ± 11.4	**30.9 ± 14.4**	**17.2 ± 9.0**	6,237
Unbelted, dual air bags (no on-off switches)	**13.3 ± 11.5**	24.9	21.6	8.3	-4.5	**13.7 ± 9.6**	23.4	20.7	8.4	-3.3	**13.5 ± 6.7**	7,472	**10.5 ± 10.4**	**11.9 ± 11.0**	**11.2 ± 7.0**	5,627
Belted, dual air bags (no on-off switches)	-0.6 ± 6.0	8.8	7.1	-4.8	-17.3	**14.4 ± 8.6**	19.3	18.4	11.6	4.9	**6.9 ± 4.9**	14,020	-1.1 ± 6.6	**8.8 ± 8.1**	3.9 ± 4.6	12,207
Belted, dual air bags, pretens/load limiters (MY ≥ 2007)	-7.6 ± 11.0	-5.4	-5.7	-8.5	-12.3	**18.1 ± 15.7**	25.2	23.8	14.2	5.7	5.3 ± 8.5	3,709	-10.3 ± 12.1	13.0 ± 16.0	1.3 ± 8.5	3,412
Five "Generations" of Car and LTV Occupants																
Unbelted occupants of cars and LTVs, w/o air bags[1]	**18.1 ± 2.8**	30.5	27.2	12.6	-1.7	**23.6 ± 2.4**	30.7	28.6	19.8	10.2	**20.8 ± 2.0**	137,036	**15.9 ± 3.1**	**21.7 ± 3.2**	**18.8 ± 2.1**	88,715
Belted occupants of cars and LTVs, w/o air bags[2]	**14.5 ± 4.8**	24.7	22.4	9.7	-3.3	**27.5 ± 5.1**	32.7	31.6	24.7	15.7	**21.0 ± 3.5**	36,598	**12.4 ± 4.8**	**25.0 ± 5.1**	**18.7 ± 3.2**	28,964
Unbelted occupants of cars and LTVs with dual air bags	**14.2 ± 6.9**	23.2	20.8	10.2	-0.3	**14.7 ± 4.9**	23.3	21.1	9.6	-1.4	**14.4 ± 3.5**	22,328	**12.7 ± 7.2**	**11.1 ± 6.3**	**11.9 ± 3.6**	15,079
Belted occupants of cars and LTVs with dual air bags[3]	**8.1 ± 3.4**	18.7	16.8	3.2	-11.4	**11.3 ± 3.5**	15.5	14.9	8.5	1.4	**9.7 ± 2.1**	45,281	**5.6 ± 3.6**	**8.3 ± 3.9**	**7.0 ± 2.1**	36,798
Belted, dual air bags, pretens/load lim (LTV MY ≥2007)	4.7 ± 5.0	14.6	12.8	0.1	-13.9	**7.0 ± 5.5**	7.6	7.5	6.6	5.3	**5.8 ± 3.8**	17,978	2.1 ± 5.5	**5.9 ± 5.9**	4.0 ± 4.1	14,983

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

[1] MY<1969 cars are not included.

[2] It includes cars of 3-point and 2-point lap/automatic shoulder belted occupants without air bags and LTVs of belted occupants without air bags.

[3] It includes cars of belted occupants with dual air bags (with or without pretensioners/load limiters, or unknown pretensioners/load limiters status) and LTVs of belted occupants with dual air bags.

Table C. Difference in Fatality Risk for Females Relative to Males of the Same Age,
***By Impact Type and Model Year** - Cars and LTVs, Drivers and Right Front Passengers*
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses	Relative Fatality Risk Difference for Females (%)			N of Cases Used in Regression Analyses
Seat Position ++>	Drivers					Right Front Passengers					Drivers & RFPs		Drivers	RFPs	Drivers & RFPs	
Occupant Age Group ++>	16-96	16-24	25-44	45-64	65-96	16-96	16-24	25-44	45-64	65-96	16-96		21-96	21-96	21-96	
All Impacts (Cars and LTVs)																
MY 1960-1999	**16.2 ± 1.5**	28.6	25.5	10.6	-4.4	**23.7 ± 1.8**	30.4	28.5	19.8	10.5	**19.9 ± 1.3**	213,980	**13.7 ± 2.0**	**21.6 ± 2.3**	**17.7 ± 1.5**	145,087
MY 2000-2020	**6.9 ± 3.4**	17.2	15.3	2.2	-12.1	**11.9 ± 3.2**	15.5	14.8	9.6	4.3	**9.4 ± 2.2**	41,586	**4.9 ± 3.7**	**9.4 ± 3.5**	**7.2 ± 2.5**	33,088
MY 1960-2009	**14.8 ± 1.4**	27.2	24.2	9.2	-6.1	**21.8 ± 1.6**	28.3	26.6	18.1	9.0	**18.3 ± 1.2**	248,459	**12.5 ± 1.8**	**19.5 ± 1.8**	**16.0 ± 1.3**	171,994
MY 2010-2020	0.3 ± 9.2	6.0	5.0	-2.3	-10.9	**12.3 ± 10.4**	15.9	15.2	10.1	5.4	**6.3 ± 5.4**	7,107	-3.8 ± 9.4	**12.0 ± 9.7**	4.1 ± 6.8	6,181
MY 1990-1999	**13.7 ± 2.7**	25.4	22.8	8.4	-6.7	**21.4 ± 3.8**	29.9	28.2	16.2	3.4	**17.5 ± 2.3**	47,680	**10.7 ± 3.7**	**18.2 ± 4.3**	**14.5 ± 2.7**	34,428
MY 2000-2009	**8.0 ± 3.4**	19.2	17.0	2.9	-12.3	**11.8 ± 4.1**	15.4	14.7	9.4	4.0	**9.9 ± 2.5**	34,479	**6.6 ± 3.4**	**8.8 ± 4.2**	**7.7 ± 2.7**	26,907
All Impacts (Cars Only)																
MY 1960-1999	**18.1 ± 2.0**	29.3	26.3	13.0	-0.4	**20.9 ± 2.0**	28.3	26.3	16.5	6.0	**19.5 ± 1.4**	161,539	**16.0 ± 2.6**	**18.6 ± 2.7**	**17.3 ± 1.7**	107,626
MY 2000-2020	**9.4 ± 4.1**	20.2	18.0	4.5	-10.3	**11.1 ± 3.9**	14.0	13.4	9.2	4.7	**10.3 ± 2.9**	25,555	**7.1 ± 5.4**	**8.8 ± 4.6**	**8.0 ± 3.1**	19,559
MY 1960-2009	**17.0 ± 1.7**	28.4	25.5	11.8	-2.1	**19.7 ± 1.9**	26.6	24.8	15.5	5.5	**18.4 ± 1.3**	182,686	**15.0 ± 2.3**	**17.2 ± 2.5**	**16.1 ± 1.6**	123,486
MY 2010-2020	4.4 ± 11.9	10.7	9.4	1.5	-7.5	**13.6 ± 11.3**	16.9	16.3	11.4	6.0	**9.0 ± 6.3**	4,408	-0.6 ± 12.7	**14.6 ± 13.3**	7.0 ± 8.0	3,699
MY 1990-1999	**16.5 ± 4.4**	27.5	25.0	11.4	-3.0	**20.0 ± 4.7**	29.5	27.5	14.0	-0.4	**18.2 ± 3.0**	33,158	**14.2 ± 5.2**	**17.1 ± 6.3**	**15.7 ± 3.6**	23,467
MY 2000-2009	**10.3 ± 4.4**	22.0	19.7	4.9	-11.0	**10.7 ± 5.3**	13.5	12.9	8.9	4.5	**10.5 ± 3.2**	21,147	**8.8 ± 5.6**	**7.6 ± 5.4**	**8.2 ± 3.7**	15,860
All Impacts (LTVs Only)																
MY 1960-1999	**12.1 ± 4.9**	30.9	26.5	4.5	-16.3	**30.1 ± 5.0**	34.5	32.9	28.0	22.9	**21.1 ± 3.5**	52,441	**9.5 ± 5.3**	**28.1 ± 6.2**	**18.8 ± 3.6**	37,461
MY 2000-2020	3.7 ± 5.7	12.7	10.9	-0.3	-12.6	**12.5 ± 6.3**	18.6	17.3	8.8	1.4	**8.1 ± 3.2**	16,031	2.8 ± 6.4	**9.4 ± 7.0**	**6.1 ± 3.5**	13,529
MY 1960-2009	**10.6 ± 4.3**	27.3	23.4	3.8	-15.7	**25.2 ± 3.8**	31.2	29.4	22.0	14.9	**17.9 ± 2.5**	65,773	**8.5 ± 4.1**	**22.5 ± 4.0**	**15.5 ± 2.8**	48,508
MY 2010-2020	-6.8 ± 13.7	-3.7	-4.1	-8.1	-13.4	8.8 ± 16.3	13.6	12.2	6.3	3.4	1.0 ± 10.6	2,699	-7.9 ± 15.7	6.2 ± 16.2	-0.9 ± 11.0	2,482
MY 1990-1999	**10.7 ± 8.8**	24.4	21.3	4.8	-11.3	**22.4 ± 6.9**	28.8	27.2	19.1	9.9	**16.6 ± 5.2**	14,522	7.1 ± 9.3	**18.9 ± 8.2**	**13.0 ± 5.6**	10,961
MY 2000-2009	5.3 ± 6.0	15.0	13.0	1.0	-12.0	**12.8 ± 7.0**	19.3	18.0	8.8	0.4	**9.0 ± 4.0**	13,332	4.6 ± 6.9	**9.6 ± 7.7**	**7.1 ± 4.5**	11,047

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

Table C (Continued). Difference in Fatality Risk for Females Relative to Males of the Same Age
By Impact Type and Model Year *- Cars and LTVs, Drivers and Right Front Passengers*
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses	Relative Fatality Risk for Females (%)			N of Cases Used in Regression Analyses
Seat Position ++>	Drivers					Right Front Passengers					Drivers & RFPs		Drivers	RFPs	Drivers & RFPs	
Occupant Age Group ++>	16-96	16-24	25-44	45-64	65-96	16-96	16-24	25-44	45-64	65-96	16-96		21-96	21-96	21-96	
Frontal Impacts (Cars and LTVs)																
MY 1960-1999	**13.9 ± 2.1**	28.3	24.9	7.6	-9.4	**18.5 ± 3.1**	22.3	21.2	16.5	11.8	**16.2 ± 2.0**	100,899	**11.1 ± 2.9**	**17.3 ± 3.6**	**14.2 ± 2.4**	70,637
MY 2000-2020	**6.8 ± 5.6**	18.2	16.0	1.7	-14.2	**9.7 ± 5.6**	10.2	10.0	9.4	10.4	**8.2 ± 3.7**	19,700	4.3 ± 5.7	**8.4 ± 6.0**	**6.4 ± 4.2**	16,157
MY 1960-2009	**13.1 ± 2.1**	27.3	24.0	6.9	-10.4	**17.2 ± 2.5**	20.5	19.5	15.4	11.5	**15.1 ± 1.9**	116,397	**10.4 ± 2.6**	**15.9 ± 2.8**	**13.1 ± 2.0**	83,108
MY 2010-2020	2.1 ± 11.0	7.9	6.8	-0.5	-9.5	12.6 ± 13.9	15.9	15.2	10.8	6.7	7.4 ± 8.2	4,202	-3.3 ± 11.1	10.9 ± 14.9	3.8 ± 8.9	3,686
MY 1990-1999	**11.2 ± 4.8**	25.5	22.3	5.0	-12.7	**19.8 ± 6.5**	24.7	23.6	17.0	9.8	**15.5 ± 3.6**	21,188	**6.8 ± 6.8**	**18.3 ± 6.2**	**12.5 ± 4.3**	15,870
MY 2000-2009	**7.7 ± 6.2**	20.5	18.0	2.1	-15.5	**8.9 ± 6.9**	8.7	8.6	9.0	11.4	**8.3 ± 4.2**	15,498	6.1 ± 6.8	**7.5 ± 6.9**	**6.8 ± 4.8**	12,471
Frontal Impacts (Cars Only)																
MY 1960-1999	**16.8 ± 2.6**	30.7	27.2	10.6	-5.6	**16.1 ± 3.2**	20.9	19.6	13.3	6.9	**16.5 ± 2.1**	77,108	**14.1 ± 3.5**	**14.8 ± 4.1**	**14.4 ± 2.4**	52,924
MY 2000-2020	6.6 ± 6.7	16.9	14.7	2.1	-12.7	**8.3 ± 6.6**	7.4	7.4	8.9	12.5	**7.4 ± 3.5**	12,038	3.5 ± 7.5	**8.4 ± 7.2**	**5.9 ± 3.8**	9,513
MY 1960-2009	**15.6 ± 2.7**	29.2	25.8	9.6	-6.8	**15.1 ± 2.8**	19.2	18.0	12.7	7.4	**15.4 ± 2.0**	86,659	**12.9 ± 3.1**	**13.9 ± 3.3**	**13.4 ± 2.2**	60,338
MY 2010-2020	7.4 ± 14.9	12.9	11.6	4.8	-3.3	13.9 ± 15.9	14.7	14.4	13.5	13.2	**10.6 ± 10.3**	2,487	-0.1 ± 13.7	14.6 ± 18.6	7.2 ± 11.0	2,099
MY 1990-1999	**16.2 ± 7.5**	32.0	28.4	9.2	-10.3	**20.3 ± 7.0**	27.3	25.8	16.1	5.3	**18.3 ± 4.4**	14,820	**11.9 ± 9.2**	**19.4 ± 7.0**	**15.6 ± 4.9**	10,893
MY 2000-2009	6.2 ± 7.8	17.7	15.3	1.2	-15.0	6.8 ± 7.4	5.4	5.5	7.7	12.4	**6.5 ± 4.0**	9,551	4.4 ± 8.9	6.6 ± 8.9	**5.5 ± 4.4**	7,414
Frontal Impacts (LTVs Only)																
MY 1960-1999	5.9 ± 7.0	20.4	17.2	-0.3	-17.1	**24.9 ± 5.9**	26.0	25.2	24.8	25.4	**15.4 ± 4.3**	23,791	4.7 ± 8.0	**23.0 ± 6.7**	**13.9 ± 5.6**	17,713
MY 2000-2020	8.4 ± 9.8	21.9	19.3	2.5	-15.1	**12.0 ± 9.7**	15.8	15.0	9.7	5.7	**10.2 ± 5.9**	7,662	7.0 ± 9.4	7.9 ± 10.2	**7.5 ± 6.0**	6,644
MY 1960-2009	**7.9 ± 6.2**	23.2	19.8	1.5	-16.9	**21.4 ± 5.5**	23.8	22.9	20.4	19.2	**14.7 ± 4.1**	29,738	**6.9 ± 6.0**	**18.7 ± 5.4**	**12.8 ± 3.8**	22,770
MY 2010-2020	-4.0 ± 17.9	1.3	0.4	-6.5	-14.2	11.3 ± 24.9	18.9	17.5	7.2	-1.2	3.7 ± 15.2	1,715	-4.9 ± 17.8	6.0 ± 24.9	0.5 ± 15.9	1,587
MY 1990-1999	4.5 ± 11.7	11.6	10.1	1.2	-7.9	**16.2 ± 15.4**	17.3	16.8	15.9	15.2	**10.3 ± 8.3**	6,368	2.6 ± 13.2	13.2 ± 16.5	7.9 ± 8.4	4,977
MY 2000-2009	**11.4 ± 10.8**	26.7	23.7	4.7	-15.0	12.2 ± 12.7	15.0	14.4	10.3	7.7	**11.8 ± 7.2**	5,947	9.9 ± 11.2	8.1 ± 12.4	**9.0 ± 7.7**	5,057

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

Table C (Continued). Difference in Fatality Risk for Females Relative to Males of the Same Age
By Impact Type and Model Year - Cars and LTVs, Drivers and Right Front Passengers
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses[1]	Relative Fatality Risk Difference for Females (%)			N of Cases Used in Regression Analyses[1]
Seat Position ++>	Drivers					Right Front Passengers					Drivers & RFPs		Drivers	RFPs	Drivers & RFPs	
Occupant Age Group ++>	16-96	16-24	25-44	45-64	65-96	16-96	16-24	25-44	45-64	65-96	16-96		21-96	21-96	21-96	
Nearside Impacts (Cars and LTVs)																
MY 1960-1999	**22.6 ± 5.4**	35.5	32.2	16.7	1.6	**33.4 ± 5.1**	40.3	38.7	27.6	15.3	**28.0 ± 3.7**	28,448	**19.1 ± 7.0**	**32.1 ± 6.6**	**25.6 ± 4.8**	19,782
MY 2000-2020	**16.8 ± 9.7**	27.1	25.1	12.0	-1.3	**24.5 ± 11.5**	29.1	28.6	20.4	10.8	**20.6 ± 7.5**	6,230	11.2 ± 12.7	**21.2 ± 13.5**	**16.2 ± 9.3**	4,932
MY 1960-2009	**21.8 ± 5.5**	34.3	31.2	16.1	1.1	**31.1 ± 5.0**	37.9	36.4	25.2	12.5	**26.4 ± 3.7**	33,696	**17.6 ± 6.7**	**28.9 ± 6.3**	**23.2 ± 4.6**	23,870
MY 2010-2020	3.6 ± 21.4	8.3	7.2	1.6	-3.8	**50.3 ± 37.1**	54.3	51.7	47.5	46.5	**26.9 ± 21.4**	982	6.9 ± 26.7	**59.6 ± 48.2**	**33.2 ± 27.5**	844
Far-Side Impacts (Cars and LTVs)																
MY 1960-1999	**13.3 ± 4.9**	21.3	19.6	9.1	-2.3	**13.1 ± 4.6**	18.6	17.3	10.9	3.7	**13.2 ± 3.4**	36,653	**15.8 ± 6.3**	**11.2 ± 6.1**	**13.5 ± 4.4**	25,256
MY 2000-2020	-1.0 ± 9.5	0.6	0.4	-1.8	-4.6	-1.1 ± 9.4	3.7	2.9	-3.4	-10.5	-1.0 ± 6.7	7,022	2.0 ± 12.3	-2.4 ± 8.7	-0.2 ± 7.5	5,467
MY 1960-2009	**11.1 ± 4.2**	18.6	17.0	7.1	-3.6	**10.3 ± 4.3**	16.3	15.0	7.8	-0.2	**10.7 ± 3.0**	42,686	**13.8 ± 5.7**	**8.4 ± 5.2**	**11.1 ± 3.9**	29,864
MY 2010-2020	-7.7 ± 24.8	-13.3	-11.5	-5.0	3.1	10.7 ± 25.9	16.7	15.8	8.6	-0.6	1.5 ± 17.9	989	-7.4 ± 28.7	3.5 ± 22.9	-2.0 ± 18.4	859
First-Event Rollovers (Cars and LTVs)																
MY 1960-1999	**17.7 ± 7.1**	36.6	32.0	10.3	-12.5	**38.4 ± 9.3**	42.1	40.4	36.9	34.0	**28.0 ± 4.9**	31,387	**13.8 ± 8.2**	**35.9 ± 11.4**	**24.9 ± 5.1**	18,511
MY 2000-2020	3.6 ± 9.6	21.5	17.9	-3.7	-26.2	**12.6 ± 8.9**	23.6	21.5	6.4	-8.9	**8.1 ± 5.5**	5,516	1.0 ± 10.8	8.1 ± 9.3	4.6 ± 6.1	3,970
MY 1960-2009	**13.9 ± 6.4**	33.7	29.1	6.1	-17.5	**32.9 ± 8.1**	39.6	37.5	29.6	21.5	**23.4 ± 4.5**	36,627	**10.3 ± 6.9**	**29.5 ± 9.3**	**19.9 ± 4.4**	22,271
MY 2010-2020	-30.9 ± 32.5	6.6	-1.1	-48.2	-75.9	3.6 ± 47.1	-5.4	-4.6	9.6	48.6	-13.7 ± 23.1	276	**-43.0 ± 33.0**	11.4 ± 55.9	-15.8 ± 26.7	210
Rear Impact & Other Crashes (Cars and LTVs)																
MY 1960-1999	**13.3 ± 8.0**	22.2	20.2	9.2	-2.8	**27.3 ± 6.9**	35.8	33.7	22.2	8.3	**20.3 ± 5.6**	16,593	**11.0 ± 9.8**	**25.6 ± 9.5**	**18.3 ± 5.8**	10,901
MY 2000-2020	-3.5 ± 11.4	8.5	6.4	-8.7	-24.9	15.8 ± 16.8	24.2	22.7	10.3	-4.1	6.1 ± 10.6	3,118	-3.5 ± 13.2	13.9 ± 16.6	5.2 ± 11.3	2,562
MY 1960-2009	**10.3 ± 7.1**	20.3	18.1	5.8	-7.4	**26.1 ± 6.7**	34.8	32.6	20.8	6.9	**18.2 ± 4.6**	19,053	8.3 ± 8.4	**24.3 ± 7.1**	**16.3 ± 4.9**	12,881
MY 2010-2020	-5.2 ± 26.1	7.0	4.9	-10.2	-27.7	-1.3 ± 34.7	7.4	5.9	-7.4	-22.0	-3.3 ± 22.6	658	-6.5 ± 29.0	-0.2 ± 35.4	-3.3 ± 20.6	582

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

[1] The number in Nearside Impacts (Cars and LTVs) is the number of cases for Left-Side Impacts (Cars and LTVs), and the number in Far-Side Impact (Cars and LTVs) is the number of cases for Right-Side Impacts (Cars and LTVs).

Table D (1). Difference in Fatality Risk for Females Relative to Males of the Same Age
By Type of Impact and Occupant Protection - *Cars Only, Drivers and Right Front Passengers*
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses[2]	Relative Fatality Risk Difference for Females (%)			N of Cases Used in Regression Analyses[2]
Seat Position ++>	Drivers					Right Front Passengers					Drivers & RFPs		Drivers	RFPs	Drivers & RFPs	
Occupant Age Group ++>	16-96	16-24	25-44	45-64	65-96	16-96	16-24	25-44	45-64	65-96	16-96		21-96	21-96	21-96	
Frontal Impacts (Cars)																
Unbelted, without air bags[1]	**17.6 ± 4.1**	30.9	27.4	11.6	-3.4	**13.5 ± 4.5**	19.9	18.2	9.8	0.8	**15.6 ± 3.2**	48,255	**15.0 ± 4.9**	**12.2 ± 5.8**	**13.6 ± 3.7**	31,560
3-point belted, without air bags	**23.2 ± 9.7**	34.9	32.0	17.7	3.6	**16.0 ± 9.6**	20.0	19.2	14.2	8.5	**19.6 ± 6.8**	9,730	**21.3 ± 9.3**	**12.2 ± 9.3**	**16.7 ± 6.3**	7,938
Unbelted, with dual air bags	**15.2 ± 10.5**	13.4	13.0	16.0	20.2	11.2 ± 11.7	27.6	23.5	1.0	-17.8	**13.2 ± 5.4**	6,959	**13.2 ± 11.7**	5.2 ± 12.9	**9.2 ± 5.9**	4,665
Belted, dual air bags, no pretensioners/load limiters	**13.2 ± 12.2**	29.7	26.5	6.0	-14.6	12.2 ± 12.8	14.1	13.8	11.3	7.5	**12.7 ± 8.5**	4,171	8.9 ± 15.7	11.0 ± 15.0	**10.0 ± 9.2**	3,346
Belted, dual air bags, pretensioners, load limiters	4.8 ± 8.2	15.5	13.5	0.1	-15.7	4.0 ± 8.2	-1.1	-0.4	7.7	19.1	4.4 ± 5.5	6,781	3.1 ± 9.8	6.3 ± 9.2	4.7 ± 6.4	5,668
Nearside Impacts (Cars)																
Unbelted, without side/curtain bags[1]	**20.6 ± 6.9**	26.4	24.7	17.8	11.1	**27.8 ± 6.8**	34.1	32.4	22.7	11.7	**24.2 ± 4.8**	14,528	**16.5 ± 9.3**	**25.5 ± 8.9**	**21.0 ± 6.4**	9,340
3-point belted, without side/curtain bags	**14.4 ± 10.4**	32.7	29.0	7.3	-14.6	**30.9 ± 11.5**	42.2	41.1	19.8	-5.4	**22.6 ± 7.8**	8,933	8.9 ± 14.0	**22.8 ± 13.7**	**15.9 ± 9.8**	6,988
Belted, dual air bags	**19.6 ± 11.9**	33.8	30.6	13.5	-3.1	**23.5 ± 12.7**	32.5	31.5	14.5	-5.5	**21.6 ± 8.7**	6,431	11.3 ± 16.1	**22.9 ± 14.5**	**17.1 ± 10.8**	4,992
Belted, with curtain+torso or combo bags	**25.0 ± 22.5**	34.1	31.5	20.2	12.8	14.9 ± 27.2	17.0	17.1	13.3	9.6	**19.9 ± 17.6**	1,347	19.3 ± 24.7	26.2 ± 30.3	**22.8 ± 19.5**	1,085
Far-Side Impacts (Cars)																
Unbelted, without side/curtain bags[1]	**17.7 ± 7.3**	23.9	22.2	14.5	6.9	**12.0 ± 6.0**	17.3	16.0	9.7	3.1	**14.9 ± 4.7**	19,242	**22.2 ± 9.1**	**10.5 ± 7.5**	**16.3 ± 5.9**	12,415
3-point belted, without side/curtain bags	**19.8 ± 9.8**	24.4	24.1	17.1	9.2	8.6 ± 12.0	11.8	11.3	7.5	2.9	**14.2 ± 7.7**	10,781	**23.7 ± 13.1**	7.5 ± 14.9	**15.6 ± 9.9**	8,363
Belted, dual air bags	**14.7 ± 10.1**	16.2	15.8	13.7	11.8	2.4 ± 11.9	11.9	10.3	-1.7	-13.7	**8.5 ± 7.8**	7,455	**23.0 ± 13.6**	-0.6 ± 12.3	**11.2 ± 9.2**	5,717
Belted, with curtain+torso or combo bags	2.1 ± 22.8	5.4	4.6	0.6	-4.8	1.5 ± 20.0	7.3	6.3	-0.8	-10.2	1.8 ± 15.2	1,452	6.4 ± 27.0	1.7 ± 25.2	4.0 ± 18.4	1,173
First-Event Rollovers (Cars)																
Unbelted, without air bags[1]	**25.5 ± 15.4**	40.0	36.0	19.7	2.6	**50.6 ± 16.6**	57.5	54.4	47.6	41.7	**38.0 ± 9.0**	11,729	**23.5 ± 18.3**	**47.1 ± 18.2**	**35.3 ± 10.2**	6,132
3-point belted, without air bags	-8.2 ± 26.9	-7.0	-7.3	-8.6	-10.7	33.3 ± 37.5	29.4	31.0	36.5	37.1	12.5 ± 20.9	1,058	-6.8 ± 32.3	**41.5 ± 37.3**	17.4 ± 20.3	696
Unbelted, with dual air bags	**27.9 ± 26.1**	59.7	50.1	16.2	-24.5	**44.1 ± 30.4**	36.6	36.1	48.8	70.7	**36.0 ± 20.0**	2,428	29.8 ± 31.5	36.6 ± 38.6	**33.2 ± 21.7**	1,403
Belted, with dual air bags	-3.5 ± 16.1	24.3	19.1	-13.9	-43.9	5.1 ± 21.2	10.9	9.9	1.6	-8.0	0.8 ± 10.4	1,630	-7.2 ± 23.3	0.1 ± 27.8	-3.6 ± 14.2	1,117
Rear Impact & Other Crashes (Cars)																
Unbelted, without air bags[1]	**18.6 ± 13.8**	28.8	25.7	14.2	1.2	**17.4 ± 8.9**	23.5	21.6	13.8	4.8	**18.0 ± 7.9**	7,779	13.0 ± 15.8	**16.5 ± 10.7**	**14.8 ± 9.0**	4,645
3-point belted, without air bags	-9.0 ± 17.0	-12.0	-11.3	-7.4	-2.8	18.5 ± 26.3	26.9	25.4	12.4	-2.5	4.8 ± 13.6	1,324	-12.5 ± 18.0	19.3 ± 28.8	3.4 ± 13.3	1,047
Unbelted, with dual air bags	28.2 ± 33.2	23.7	24.4	31.0	36.5	32.2 ± 37.7	24.8	25.0	37.9	53.2	**30.2 ± 23.7**	996	29.5 ± 45.3	36.8 ± 51.0	**33.2 ± 29.2**	623
Belted, with dual air bags	-7.5 ± 12.5	-2.9	-3.7	-9.5	-16.8	12.5 ± 18.3	22.0	20.3	6.4	-10.5	2.5 ± 10.7	2,304	-2.1 ± 15.0	5.1 ± 18.2	3.4 ± 11.7	1,825

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

[1] MY<1969 cars are not included.

[2] The number in Nearside Impacts (Cars) is the number of cases for Left-Side Impacts (Cars), and the number in Far-Side Impacts (Cars) is the number of cases for Right-Side Impacts (Cars).

Table D (2). Difference in Fatality Risk for Females Relative to Males of the Same Age,
***By Type of Impact and Occupant Protection** – LTVs Only, Drivers and Right Front Passengers*
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses[1]	Relative Fatality Risk Difference for Females (%)			N of Cases Used in Regression Analyses[1]
Seat Position ++>	Drivers					Right Front Passengers					Drivers & RFPs		Drivers	RFPs	Drivers & RFPs	
Occupant Age Group ++>	16-96	16-24	25-44	45-64	65-96	16-96	16-24	25-44	45-64	65-96	16-96		21-96	21-96	21-96	
Frontal Impacts (LTVs)																
Unbelted, without air bags	4.2 ± 9.1	20.9	17.2	-2.8	-20.9	**23.7 ± 6.2**	28.3	26.7	21.5	17.0	**13.9 ± 6.4**	17,712	3.1 ± 10.1	**20.9 ± 6.9**	**12.0 ± 7.3**	12,606
Belted, without air bags	10.7 ± 13.9	24.9	21.6	4.5	-11.9	**39.4 ± 18.4**	39.7	38.7	40.4	42.9	**25.0 ± 11.3**	4,019	10.3 ± 15.0	**40.0 ± 20.1**	**25.1 ± 12.6**	3,372
Unbelted, dual air bags (no on-off switches)	10.7 ± 18.7	20.6	18.1	6.3	-4.9	5.7 ± 13.6	10.9	9.8	2.5	-5.6	8.2 ± 8.9	2,918	7.2 ± 19.0	2.3 ± 15.9	4.8 ± 10.2	2,299
Belted, dual air bags (no on-off switches)	1.8 ± 9.0	14.8	12.6	-3.9	-20.3	**14.5 ± 12.9**	15.8	15.6	14.3	13.4	**8.2 ± 6.8**	6,768	0.9 ± 11.2	11.4 ± 12.1	6.1 ± 6.8	6,050
Belted, dual air bags, pretens/load limiters (MY ≥ 2007)	2.9 ± 16.5	7.9	6.9	0.4	-6.3	17.6 ± 23.7	26.6	24.9	12.6	1.8	10.2 ± 14.6	2,243	1.1 ± 17.0	10.8 ± 24.6	5.9 ± 14.2	2,072
Nearside Impacts (LTVs)																
Unbelted, without air bags	17.0 ± 25.5	31.7	27.6	11.6	-2.6	**24.9 ± 17.6**	23.1	23.2	27.1	31.1	**20.9 ± 15.1**	3,077	14.5 ± 29.1	**27.7 ± 18.8**	**21.1 ± 17.3**	2,185
Belted, without air bags	3.2 ± 34.2	-11.7	-9.1	10.4	42.6	22.0 ± 31.3	44.1	39.2	5.5	-22.6	12.6 ± 22.6	815	8.5 ± 36.3	21.0 ± 34.2	14.8 ± 24.9	658
Unbelted, dual air bags (no on-off switches)	9.1 ± 34.0	44.3	38.2	-3.5	-33.5	19.9 ± 32.5	45.9	37.7	-0.1	-17.3	14.5 ± 24.4	599	3.0 ± 37.5	12.1 ± 38.0	7.5 ± 26.7	452
Belted, dual air bags (no on-off switches)	-2.8 ± 24.8	-7.4	-6.9	-0.9	6.8	19.8 ± 21.3	16.5	16.3	22.6	34.6	8.5 ± 16.2	1,715	-11.1 ± 21.3	9.0 ± 22.0	-1.0 ± 15.3	1,493
Belted, dual air bags, pretens/load limiters (MY ≥ 2007)	-29.3 ± 29.4	-38.7	-37.3	-25.2	-9.8	18.6 ± 67.6	-1.1	2.3	32.5	88.5	-5.4 ± 29.0	464	**-38.2 ± 28.5**	9.9 ± 66.3	-14.2 ± 36.1	430
Far-Side Impacts (LTVs)																
Unbelted, without air bags	3.0 ± 20.3	50.3	40.0	-14.7	-55.0	**23.9 ± 15.9**	37.1	33.4	18.9	3.5	**13.5 ± 11.7**	3,704	0.9 ± 22.4	**19.5 ± 18.4**	10.2 ± 14.5	2,574
Belted, without air bags	30.7 ± 36.9	62.3	56.0	18.5	-14.0	19.0 ± 36.9	26.4	24.5	16.8	11.4	**24.9 ± 19.5**	889	17.2 ± 42.1	12.1 ± 37.7	14.6 ± 28.2	698
Unbelted, dual air bags (no on-off switches)	-0.2 ± 47.9	21.7	16.3	-9.7	-29.7	**39.2 ± 38.0**	22.9	24.0	44.6	96.9	19.5 ± 24.8	662	-0.5 ± 45.7	**51.5 ± 44.0**	25.5 ± 31.7	512
Belted, dual air bags (no on-off switches)	2.7 ± 21.3	2.6	2.5	2.7	3.0	6.0 ± 23.5	26.8	23.4	-0.9	-22.7	4.3 ± 14.3	1,894	2.1 ± 26.8	3.4 ± 22.3	2.7 ± 17.4	1,608
Belted, dual air bags, pretens/load limiters (MY ≥ 2007)	-12.0 ± 37.4	-15.4	-15.6	-11.6	-3.4	5.3 ± 45.9	6.8	5.7	5.0	5.4	-3.3 ± 36.6	452	-12.8 ± 40.6	10.9 ± 49.6	-0.9 ± 32.1	410
First-Event Rollovers (LTVs)																
Unbelted, without air bags	**29.2 ± 19.2**	48.7	43.0	21.6	-0.1	**39.1 ± 15.5**	36.9	36.3	41.9	48.3	**34.2 ± 11.4**	11,185	**24.6 ± 20.2**	**40.1 ± 19.4**	**32.3 ± 12.5**	7,006
Belted, without air bags	-8.6 ± 23.7	-3.0	-3.5	-11.0	-20.4	10.5 ± 28.2	-11.9	-8.7	27.2	89.8	0.9 ± 14.1	1,441	-14.4 ± 27.1	18.7 ± 36.5	2.2 ± 17.8	1,057
Unbelted, dual air bags (no on-off switches)	10.3 ± 24.9	18.6	16.3	7.7	-7.2	**20.0 ± 17.2**	26.5	24.0	16.9	15.2	**15.1 ± 13.9**	2,843	7.3 ± 24.9	**21.2 ± 21.1**	14.3 ± 16.0	2,003
Belted, dual air bags (no on-off switches)	0.1 ± 15.0	10.3	8.4	-4.2	-17.4	10.6 ± 16.7	24.4	21.9	2.9	-15.4	5.4 ± 10.5	2,481	4.6 ± 17.6	0.5 ± 17.1	2.5 ± 9.9	2,010
Belted, dual air bags, pretens/load limiters (MY ≥ 2007)	**-55.3 ± 24.7**	-59.7	-59.5	-53.9	-43.8	80.8 ± 123.9	105.0	112.4	71.4	36.8	12.7 ± 64.0	165	**-55.1 ± 29.6**	71.6 ± 117.1	8.3 ± 59.1	144
Rear Impact & Other Crashes (LTVs)																
Unbelted, without air bags	27.7 ± 33.3	19.6	20.6	31.5	48.7	**82.5 ± 25.5**	105.4	98.0	68.2	43.1	**55.1 ± 16.6**	3,539	32.8 ± 38.1	**81.4 ± 34.3**	**57.1 ± 21.6**	2,491
Belted, without air bags	-8.8 ± 40.2	-3.0	-4.0	-11.8	-18.3	6.5 ± 42.0	-10.0	-7.7	21.8	62.0	-1.2 ± 27.3	523	-18.8 ± 44.2	11.2 ± 44.4	-3.8 ± 29.2	452
Unbelted, dual air bags (no on-off switches)	36.3 ± 54.0	41.0	34.2	32.8	49.5	12.1 ± 39.5	15.3	12.3	10.3	10.1	24.2 ± 32.3	450	43.9 ± 64.0	4.4 ± 37.4	24.1 ± 34.3	361
Belted, dual air bags (no on-off switches)	-8.1 ± 19.9	6.2	3.3	-14.0	-32.3	12.0 ± 26.9	18.5	17.1	8.1	-0.9	2.0 ± 14.9	1,162	-10.3 ± 21.0	15.2 ± 29.1	2.4 ± 15.5	1,046
Belted, dual air bags, pretens/load limiters (MY ≥ 2007)	-1.8 ± 40.2	19.8	14.2	-10.0	-34.4	-2.5 ± 48.7	3.0	1.9	-5.8	-15.4	-2.2 ± 30.8	385	-10.5 ± 42.0	3.3 ± 52.0	-3.6 ± 33.6	356

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

[1] The number in Nearside Impacts (LTVs) is the number of cases for Left-Side Impacts (LTVs), and the number in Far-Side Impacts (LTVs) is the number of cases for Right-Side Impacts (LTVs).

Table D (3). Difference in Fatality Risk for Females Relative to Males of the Same Age,
***By Type of Impact and Occupant Protection –** Cars and LTVs, Drivers and Right Front Passengers*
(Given the same crash scenario, FARS 1975-2019)

	Average for Occupants 16 to 96												Average for Occupants 21 to 96			
	Relative Fatality Risk Difference for Females (Percent)											N of Cases Used in Regression Analyses[2]	Relative Fatality Risk Difference for Females (%)			N of Cases Used in Regression Analyses[2]
Seat Position ++>	Drivers					Right Front Passengers					Drivers & RFPs		Drivers	RFPs	Drivers & RFPs	
Occupant Age Group ++>	16-96	16-24	25-44	45-64	65-96	16-96	16-24	25-44	45-64	65-96	16-96		21-96	21-96	21-96	
Frontal Impacts (Cars and LTVs)																
Unbelted, without air bags[1]	**14.4 ± 3.8**	28.8	25.2	8.1	-8.1	**16.4 ± 3.9**	22.0	20.4	13.4	6.1	**15.4 ± 3.0**	65,967	**11.7 ± 4.2**	**15.0 ± 4.7**	**13.4 ± 3.5**	44,166
Belted, without air bags[3]	**19.4 ± 6.9**	34.9	31.2	12.3	-5.6	**24.8 ± 6.5**	29.1	28.0	23.0	17.0	**22.1 ± 6.0**	17,448	**16.5 ± 7.3**	**22.7 ± 7.8**	**19.6 ± 6.0**	14,183
Unbelted, dual air bags (no on-off switches for LTVs)	**13.0 ± 9.1**	14.5	13.7	12.3	11.3	**10.0 ± 9.2**	23.0	20.0	2.0	-14.3	**11.5 ± 4.8**	9,877	**10.6 ± 10.0**	4.5 ± 9.7	**7.6 ± 4.4**	6,964
Belted, dual air bags[4] (no on-off switches for LTVs)	**6.0 ± 5.3**	19.4	16.9	0.1	-17.8	**9.6 ± 5.7**	8.4	8.6	10.7	14.1	**7.8 ± 3.7**	20,209	3.0 ± 6.0	**9.0 ± 6.1**	**6.0 ± 3.9**	16,990
Belted, dual air bags, pretens/load lim (LTV MY ≥ 2007)	4.4 ± 7.7	14.1	12.4	0.0	-14.2	6.3 ± 8.4	3.5	3.8	8.5	15.3	5.4 ± 5.8	9,024	2.5 ± 8.3	7.2 ± 10.5	4.9 ± 6.9	7,740
Nearside Impacts (Cars and LTVs)																
Unbelted, without air bags[1]	**25.0 ± 7.8**	30.4	28.4	22.2	16.9	**30.2 ± 6.6**	36.0	34.6	25.8	15.8	**27.6 ± 5.1**	15,909	**21.3 ± 8.9**	**29.0 ± 7.9**	**25.2 ± 6.0**	10,491
Belted, without air bags[3]	10.1 ± 13.0	23.1	20.6	5.2	-11.5	**31.5 ± 15.5**	41.3	40.2	23.0	2.1	**20.8 ± 10.1**	6,279	13.7 ± 16.5	**23.9 ± 16.8**	**18.8 ± 11.8**	4,943
Unbelted, dual air bags (no on-off switches for LTVs)	8.2 ± 17.8	19.1	16.6	4.0	-8.8	**17.6 ± 14.3**	19.5	19.0	15.9	14.7	**12.9 ± 11.4**	2,631	8.6 ± 21.8	**18.5 ± 16.2**	13.6 ± 13.6	1,716
Belted, dual air bags[4] (no on-off switches for LTVs)	**16.1 ± 10.6**	25.9	23.8	11.7	-0.4	**23.0 ± 9.8**	29.0	28.3	17.2	4.0	**19.5 ± 7.2**	8,146	6.8 ± 12.7	**19.5 ± 12.9**	**13.2 ± 9.1**	6,485
Belted, dual air bags, pretens/load lim (LTV MY ≥ 2007)	12.9 ± 15.6	26.5	23.9	7.4	-9.4	**19.4 ± 18.2**	22.6	22.7	16.3	7.3	**16.2 ± 12.0**	3,141	2.5 ± 18.4	18.3 ± 21.1	10.4 ± 14.0	2,561
Far-Side Impacts (Cars and LTVs)																
Unbelted, without air bags[1]	**15.0 ± 6.1**	24.6	22.3	10.4	-1.6	**14.1 ± 6.8**	20.3	18.7	11.5	3.6	**14.5 ± 4.6**	20,928	**17.8 ± 7.1**	**13.0 ± 7.5**	**15.4 ± 5.2**	13,784
Belted, without air bags[3]	**19.5 ± 14.4**	29.7	28.2	14.4	-0.7	**17.1 ± 13.3**	15.1	15.1	18.4	22.0	**18.3 ± 9.8**	7,644	**20.0 ± 16.1**	**16.2 ± 15.7**	**18.1 ± 11.2**	6,016
Unbelted, dual air bags (no on-off switches for LTVs)	0.9 ± 14.8	15.1	12.2	-5.7	-22.1	8.5 ± 14.2	16.1	14.1	5.0	-3.6	4.7 ± 10.3	3,103	1.8 ± 17.5	3.6 ± 16.8	2.7 ± 12.1	2,009
Belted, dual air bags[4] (no on-off switches for LTVs)	**11.3 ± 8.6**	12.7	12.4	10.5	8.7	2.4 ± 9.9	13.5	11.8	-2.1	-16.2	**6.8 ± 6.5**	9,349	**16.6 ± 13.3**	-0.2 ± 9.6	**8.2 ± 8.2**	7,325
Belted, dual air bags, pretens/load lim (LTV MY ≥ 2007)	4.9 ± 14.3	7.1	6.7	3.7	0.2	-2.8 ± 13.4	-3.8	-3.6	-2.3	-2.2	1.1 ± 9.8	3,400	12.8 ± 19.3	1.6 ± 17.5	7.2 ± 13.0	2,752
All Side Impact (Cars and LTVs)																
Cars/LTVs with curtain+torso or combo bags	**14.1 ± 10.9**	21.2	19.8	10.6	0.9	5.7 ± 12.6	10.0	9.3	2.7	-4.4	**9.9 ± 8.7**	4,206	11.6 ± 13.6	7.0 ± 11.1	9.3 ± 9.5	3,424
First-Event Rollovers (Cars and LTVs)																
Unbelted, without air bags[1]	**27.2 ± 10.0**	43.5	38.9	20.8	2.0	**44.9 ± 11.0**	48.0	46.1	44.2	43.0	**36.1 ± 7.3**	22,914	**24.1 ± 11.7**	**43.3 ± 12.9**	**33.7 ± 7.9**	13,138
Belted, without air bags[3]	-3.3 ± 19.5	5.5	4.2	-7.0	-19.7	**32.6 ± 21.8**	18.8	21.1	43.0	69.8	**14.7 ± 11.6**	2,998	-8.4 ± 17.8	**35.8 ± 27.2**	**13.7 ± 12.7**	2,048
Unbelted, dual air bags (no on-off switches for LTVs)	18.6 ± 21.6	36.7	31.6	12.4	-15.0	**28.0 ± 16.6**	30.1	28.4	27.2	29.7	**23.3 ± 11.6**	5,271	16.1 ± 21.8	**25.2 ± 21.8**	**20.6 ± 14.0**	3,406
Belted, dual air bags[4] (no on-off switches for LTVs)	-1.1 ± 11.2	16.3	13.1	-8.2	-29.3	8.1 ± 12.5	17.9	16.3	2.3	-12.5	3.5 ± 7.5	4,111	-0.2 ± 12.6	0.7 ± 14.4	0.2 ± 7.4	3,127
Belted, dual air bags, pretens/load lim (LTV MY ≥ 2007)	-10.3 ± 22.5	17.3	11.5	-20.7	-49.1	**34.0 ± 33.7**	48.4	46.3	25.8	4.0	11.8 ± 21.6	870	**-27.4 ± 20.7**	34.5 ± 46.2	3.5 ± 23.0	630
Rear Impact & Other Crashes (Cars and LTVs)																
Unbelted, without air bags[1]	**23.2 ± 13.2**	32.9	30.3	18.8	7.1	**32.1 ± 9.0**	40.6	38.2	27.0	14.1	**27.7 ± 8.0**	11,318	**20.0 ± 15.1**	**32.6 ± 10.8**	**26.3 ± 9.1**	7,136
Belted, without air bags[3]	-9.9 ± 13.5	-13.9	-13.2	-7.8	-0.7	**26.9 ± 22.5**	30.7	30.3	24.7	16.9	8.5 ± 13.5	2,229	-14.1 ± 14.9	21.5 ± 27.3	3.7 ± 11.1	1,774
Unbelted, dual air bags (no on-off switches for LTVs)	26.1 ± 32.5	27.0	25.8	25.6	26.0	22.4 ± 27.5	21.1	20.7	23.6	26.4	**24.2 ± 19.5**	1,446	28.3 ± 39.3	21.5 ± 31.9	**24.9 ± 20.3**	984
Belted, dual air bags[4] (no on-off switches for LTVs)	-8.1 ± 8.9	-1.0	-2.2	-11.3	-21.8	12.9 ± 14.9	21.6	20.0	7.2	-8.0	2.4 ± 8.6	3,466	-5.2 ± 11.0	8.3 ± 14.9	1.5 ± 9.5	2,871
Belted, dual air bags, pretens/load lim (LTV MY ≥ 2007)	-10.2 ± 16.5	-0.6	-2.2	-14.4	-28.4	4.1 ± 20.9	9.2	8.4	0.5	-10.9	-3.1 ± 11.7	1,543	-11.7 ± 18.1	-4.2 ± 23.0	-8.0 ± 13.2	1,300

Note: Red fonts indicate negative point estimates, and bold fonts indicate the estimate is statistically significant (i.e., different from 0).

[1] MY<1969 cars are not included.

[2] The number in Nearside Impacts (Cars and LTVs) is the number of cases for Left-Side Impacts (Cars and LTVs), and the number in Far-Side Impacts (Cars and LTVs) is the number of cases for Right-Side Impacts (Cars and LTVs).

[3] It includes cars of 3-point and 2-point lap/automatic shoulder belted occupants without air bags and LTVs of belted occupants without air bags.

[4] It includes cars of belted occupants with dual air bags (with or without pretensioners/load limiters, or unknown pretensioners/load limiters status) and LTVs of belted occupants with dual air bags.

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