U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

DOT HS 812 819 March 2020

Analysis of Pedestrian Injuries by Passenger Vehicle Model Year

Suggested APA Format Citation:

Pfeiffer. M. R. (2020, March). *Analysis of pedestrian injuries by passenger vehicle model year* (Report No. DOT HS 812 819). Washington, DC: National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No. DOT HS 812 819	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Analysis of Pedestrian Injuries by Passenger Vehicle Model Year		**5. Report Date** March 2020 **6. Performing Organization Code**
7. Authors Melissa R. Pfeiffer, MRP Consulting		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Melissa R. Pfeiffer MRP Consulting Santa Fe, NM		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.**
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 1200 New Jersey Avenue SE Washington, DC 20590		**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code**
15. Supplementary Notes		

16. Abstract

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17. Key Words		**18. Distribution Statement** Document is available to the public from the National Technical Information Service, www.ntis.gov.	
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 18	**22. Price**

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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Summary

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Background

Starting in 2005, pedestrian crashworthiness standards went into effect in Europe. The correlation between the European New Car Assessment Program (Euro NCAP) pedestrian test scores and the injury rate among those particular vehicles seen in the German In-Depth Accident Study (GIDAS) suggests that a good pedestrian assessment can lead to reductions in pedestrian injuries. However, no such standard pedestrian assessment exists in the United States. Nevertheless, it is possible that the benefits being seen in Europe are being realized in the United States despite the lack of regulation or NCAP assessment. Since many U.S. passenger cars and sport utility vehicles (SUVs) share the same basic design underpinnings as model variants sold in Europe or are built on global passenger car platforms, as vehicle front ends have become more pedestrian friendly on European models, so too have they become more pedestrian friendly on U.S. models. European and U.S. variants are especially similar in the hood and windshield, the sources of most pedestrian head and upper thorax injuries. Unfortunately, although the number of pedestrian fatalities has been decreasing in Europe and Japan, the number has remained steady or increased in the United States. We sought to investigate whether pedestrians struck by newer passenger vehicles—those more likely to have the pedestrian protection features—were less likely to be injured or killed than pedestrians struck by earlier-model-year passenger vehicles that may not have such pedestrian protection features.

Objective

Our objective was to determine if the latest generation of passenger vehicles offers better safety to pedestrians than previous generations.

Methods

Data source

Reportable crashes included in the NHTSA State Data System (SDS) data sets were used for analysis. For each State included in the SDS, relational data sets for crashes, vehicles, and people were provided for each crash year. These data sets can be linked by a variable for the ID numbers for the crashes. The SDS data sets use a common file structure with common variable names, although the meanings for the same value of a common variable may differ between States.

Selection of States

To identify States in which pedestrians were likely to be involved in crashes, we selected the States that ranked in the top 10 for the number of pedestrian fatalities for crashes from 2015 (Table 1). We also selected the States that ranked in the top 10 for the proportion of traffic fatalities who were pedestrians. Data on the number of pedestrian fatalities and all traffic fatalities were obtained from the NHTSA Traffic Safety Facts 2015 .[1] Note that some States were identified both by the number and the proportion of pedestrian fatalities. We also included two States that did not meet the criteria above but had been used in preliminary analyses. However, in order to ensure that later-model-year vehicles would be included in the SDS data sets, crash data for 2012 or later had to be available for the States selected. For each State selected, we included crash data from 2006 until the most recent year available, unless there was a change in the criteria for a reportable crash in that State during the time period; in those instances, data was limited to the years with consistent criteria. This ensured that the types of crashes did not differ for more recent model year vehicles simply because of the change in reporting criteria (e.g., that uninjured pedestrians are not more likely to appear in earlier crashes because of the lower threshold for property damage). Our analysis included 12 States: Delaware, Florida, Illinois, Indiana, Maryland, Michigan, New Jersey, New Mexico, New York, North Carolina, Pennsylvania, and Virginia.

Identification and preparation of pedestrian records

For each State, pedestrian records were identified from the "persons" file; duplicate records for the same pedestrian were removed. New variables for sex and injury status were created with standardized values across States. Three variables for injury status were made: fatality (yes/fatality, no/non-fatal injury or no injury, and null/unknown injury status), major injury or fatality (yes/fatality or incapacitating, serious, or major injury; no/injury of lesser severity or no injury; and null/unknown injury status), and any injury (yes/any fatal or non-fatal injury, no/uninjured, and null/unknown injury status). We also captured or calculated age at the time of the crash and the number of pedestrians involved in the crash.

Identification and preparation of vehicle records

For vehicles in each State's "vehicle" file, we created indicators for whether the vehicle was noted to have struck a pedestrian and the model year of the vehicle. Duplicate records for the same vehicle were removed. Vehicles were excluded if they had a value for model year that was more than one year greater than the year of the crash (e.g., a vehicle was excluded if the model year was recorded as 2018 and the crash year was 2007); model years one year beyond the crash year were permitted, since model years are sold in the previous calendar year (e.g., a model year 2008 vehicle could be involved in a crash in 2007). Model years were then grouped into two categories: earlier-model-year vehicles (MY2001 – MY2005) and later-model-year vehicles (MY2011 – MY2016). We wanted the model year categories to be far enough apart to be fairly certain that they were separated by one generation in which pedestrian friendly design differences are likely but without big differences in body styles that could also influence pedestrian injuries. Model years 2006 through 2010 were excluded from analyses to help create a

[1] National Highway Traffic Safety Administration. (2017). *Traffic Safety Facts 2015: A compilation of motor vehicle crash data from the Fatality Analysis Reporting System and the General Estimates System* (Report No. DOT HS 812 384). Washington, DC: Author. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812384

clear distinction between pre- and post-pedestrian friendly designs. Three indicators were created for the vehicle type. The first indicated if the vehicle was a passenger vehicle (passenger car, SUVs, vans), the second indicated if the vehicle was a passenger car (excluding SUVs and vans) – vehicles that potentially have the greatest likeness to those in Europe, and the third (for comparison) indicated if the vehicle was a pickup truck.

Linkage of pedestrian records to the vehicles that struck them

In most instances, pedestrians could only be linked with vehicles that were noted to have hit pedestrians (without an indication of which pedestrian the vehicle struck). Since we could not determine which vehicle struck which pedestrian, we could only include a pedestrian who was the only pedestrian involved in a crash. Vehicle records included in the linkage were limited to those that were marked as involved in collisions with pedestrians. There could be multiple vehicles linked with the same pedestrian. While some of those instances may be data errors, in other instances the pedestrian could truly have been struck by more than one vehicle. Since being hit by more than one vehicle is likely to affect injury severity regardless of model year, pedestrians who were connected to more than one vehicle were excluded.

Analysis

We compared the proportion of pedestrians who were injured after being struck by later-model-year vehicles (MY2011 – MY2016) with the proportion of pedestrians who were injured after being struck by earlier-model-year vehicles (MY2001 – MY2005) using chi-square tests. We tested these comparisons in each of our three injury categories (fatality, major injury/fatality, and any injury) and each of our three vehicle categories (cars/SUVs/vans, cars only, and pickups). Resulting p-values generated by each test are reported as <0.05, <0.10, or not significant. We calculated the percent change in the proportion of pedestrians injured as the difference between the proportions injured in the two model year groups divided by the proportion injured by the earlier-model-year group (MY2001-MY2005). We also calculated the difference in proportions injured simply as the proportion injured by the later-model-year group subtracted by the proportion injured in the earlier-model-year group.

In addition to conducting the analyses with all pedestrian records, we conducted the comparisons for male and female pedestrians separately. We also replicated the primary analysis with the pedestrian population limited to those who were 18 to 65 years old at the time of the crash. This restriction was intended to adjust for the underlying health or vulnerability of the pedestrian population. For instance, some older pedestrians may have underlying frailty and/or medical conditions and consequently may be more likely to have a major injury regardless of the type of vehicle they were struck by. Additionally, injuries for child and adolescent pedestrians could be influenced by their shorter stature, lighter weight, or conditions of the crash, such as whether they were in a stroller.

For each State, we assessed the proportion of pedestrians involved in crashes who could be connected with vehicles, by crash year. We wanted to verify that we could connect each pedestrian with the vehicle that struck him or her similarly over time given different information available in different crash years. In some instances, we were concerned that pedestrians from some crash years may not have linked with vehicles as well as in other crash years due to limited information. We conducted a sensitivity analysis in which we excluded crash years that had less than 70 percent of pedestrians linked with vehicles; State-years excluded were Delaware, 2011 and 2012; New Jersey, all years; and Virginia, 2006 to 2008.

Results

Primary analysis

Our results showed that for the category of passenger vehicles (cars, SUVs, and vans), a significantly higher proportion of pedestrians struck by earlier-model-year vehicles were injured compared with pedestrians struck by later-model-year vehicles, although the difference was 0.6 percent (Table 2a, Figure 1a). When the analysis was limited to passenger cars, a significant decrease was seen for the "any injury" category (93.8% of pedestrians struck by earlier-model-year cars versus 93.0% struck by later-model-year cars, percentage point difference of -0.8), whereas there was a similar percentage point increase in the proportion of pedestrians with a major injury or fatality (15.6% versus 16.4%). For the comparison group of pickups, for which we would not expect to see a difference in the proportions injured by the different model year categories, the differences in proportions injured are not significantly different.

Among pedestrians with known sex, there were more males than females struck by passenger vehicles (54.3% males for the earlier-model-year group and 53.2% males for the later-model-year group). These proportions were similar when limited to cars (54.2% males for the earlier-model-year group and 53.5% males for the later-model-year group) and slightly higher for pickups (57.8% males for the earlier-model-year and 59.9% males for the later-model-year group). When the primary analysis was restricted to male pedestrians, none of the comparisons showed significant differences at the $p<0.05$ level (Table 2b, Figure 1b). The p-value testing the difference in pedestrians experiencing any injury after being struck by cars/SUVs/vans changed from $p<0.05$ to $p<0.10$. When the primary analysis was restricted to female pedestrians, the results were generally similar to those seen overall (Table 2c, Figure 1c). The only change was that the significance testing for the proportion of pedestrians with any injury after being struck by cars/SUVs/vans went from $p<0.05$ to $p<0.10$, as it did for males. Notably, for the two comparisons with significant differences—the proportion struck by cars with any injury and the proportion struck by cars with a major injury or fatality—one showed a lower proportion for later-model-year cars and the other a higher proportion for later-model-year cars.

Nearly two-thirds of pedestrians struck by vehicles included in this analysis (cars, SUVs, vans, pickups) were 18 to 65 years old (63.1% for earlier-model-year and 65.3% for later-model-year vehicles). When limited to these pedestrians, the median age of pedestrians struck by earlier-model-year vehicles (cars, SUVs, vans, and pickups) was 39; the median age was also 39 for pedestrians struck by later-model-year vehicles. Among adults 18 to 65, the comparison of fatal injuries for passenger vehicles became significantly different: 3.9 percent of pedestrians struck by earlier-model-year vehicles were killed compared with 3.4 percent of pedestrians struck by later-model-year vehicles, a 12 percent decrease (Table 2d, Figure 1d). As with all pedestrians, there was a significant decrease in pedestrians with any injury, either from passenger vehicles or cars only, however the decrease was 1 percent. The comparison of major injuries or fatalities for cars that was significant for all pedestrians was no longer significantly different when limited to adults 18 to 65.

Sensitivity analysis

We conducted a sensitivity analysis similar to the primary analysis (males and females combined, all ages) but excluded crash years that had less than 70 percent of pedestrians linked with a vehicle. In the sensitivity analysis, the comparison of pedestrian fatalities from passenger vehicles showed a significant difference (3.6% for earlier-model-year vehicles versus 3.2% for later-model-year vehicles, $p < 0.05$). This was the only comparison that resulted in a different significance testing outcome than what was found in the primary analysis. Additionally, when comparing the proportions of pedestrians injured in the 18 combinations of vehicle type, injury status, and model year of the primary analysis to the same combinations in the sensitivity analysis, none changed by more than 10 percent.

Discussion

This analysis showed moderate, inconsistent evidence for differences in proportions of pedestrians injured according to passenger vehicle model year. There was a significant difference in the proportion of pedestrians experiencing any injury after being struck by later-model-year passenger vehicles. However, half of the comparisons for passenger vehicles and cars only showed an increase in the proportion of pedestrians injured by later- versus earlier-model-year vehicles, although only one of these increases was significant. Further, although the proportions of pedestrians with any injury by model year for pickups were not significantly different, the percent change was also not very different—in magnitude or direction—than the significant difference observed for cars/SUVs/vans or for cars only.

In addition to the percent change in proportion from earlier-model-year to later-model-year, we also examined the difference in the proportions (that is, the difference in percentage points). Even when there was a large percent change—for instance a 7.6 percent decrease in fatalities for pedestrians struck by later versus earlier-model-year cars, SUVs, or vans—the difference in proportion was small (-0.3 in that example). Most of the differences in proportions were less than +/- 1; the greatest difference was an increase of 1.4 percentage points for pedestrians with a major injury or fatality after being struck by a later-model-year pickup.

When limited to males, none of the comparisons showed a significant difference in proportions. The direction and magnitude of changes in proportions were similar to what was seen overall, with the exception of fatalities among pedestrians struck by pickups, which showed a non-significant decrease among later model years. When restricted to females, the findings are similar to what was seen overall.

The proportion of pedestrians 18 to 65 only who experienced any injury was significantly lower for those struck by later-model-year passenger vehicles (and cars only), as it was overall. However, when analyses were limited to these pedestrians, the increase in the proportion of pedestrians with major injury or fatality after being struck by a car was no longer significant. In contrast, this group had a significant decrease in the proportion of pedestrians killed by later-model-year vehicles.

Limitations

This analysis has several limitations. First, crashes involving pedestrians were not included if there was no injury (to anyone involved in the crash) and little property damage. However, most pedestrians (93% or more) reported some level of injury. Further, whether a crash is reportable is not likely to be systematically associated with the model year of the vehicle involved and therefore the exclusion of crashes with no injuries is unlikely to influence this comparison of model years. Second, we generally could not include crashes in which more than one pedestrian was involved, since it was not usually possible to distinguish which vehicle struck which pedestrian. Consequently, we omitted situations in which a single vehicle hit more than one pedestrian as well as those in which several vehicles each struck one or more pedestrians. However, we again would not expect there to be differences in the model years of vehicles involved in those types of crashes. Third, each State has its own coding scheme for vehicles, which had to be collapsed into smaller, uniform categories of passenger vehicles (cars, SUVs, vans). Coding was checked to ensure uniformity, and the more common values in the group were clear members (e.g., "passenger car," "4-door sedan," "automobile," "passenger car/station wagon/minivan," "automobile/passenger car"). However, misclassification could have occurred. Misclassification was less likely to occur for the more restrictive category of cars only. Finally, it is possible that, due to regulations and standards already in place, many vehicles included in the earlier-model-year category already had pedestrian friendly designs, and the incremental improvements were not sufficient to demonstrate changes reaching statistical significance. However, this analysis showed increases in proportions as well as decreases. If the trends were indicative of improvements to pedestrian safety that were meaningful if not statistically significant, we would have expected the changes in proportions to be in the same direction.

It is also important to note that this analysis focused on injuries experienced by pedestrians *who were struck* by vehicles and did not examine factors related to the *likelihood* of being struck, such as time of day or pedestrian exposure (e.g., duration near roadway). Those factors may be relevant to other analyses related to trends in pedestrian fatalities. Additionally, we did not adjust for potential covariates such as the speed at which the pedestrian was struck or pedestrian toxicology information nor did we further stratify by pedestrian age. While these factors may influence the severity of injury, they are not expected to be influenced by the model year of the vehicle striking the pedestrian. However, additional analyses could delve into these considerations if there are enough people in each group to detect differences.

Conclusions

In contrast to experimental vehicle impact testing, where reduced injury measurements in later-model-year vehicles were observed, the current study showed little evidence that later-model-year vehicles in the United States are more pedestrian friendly than earlier-model-year vehicles. Although other factors may be influencing pedestrian injury and fatality rates, such as speed, location of injuries, and pedestrian exposure, the results suggest that any pedestrian safety improvements in later-model-year U.S. vehicles are either not substantial or that such improvements are being offset by other factors.

Table 1. Data used for selection of States to include in analysis: rank by number and proportion of pedestrian fatalities, years of data availability

State	Rank by Number of Pedestrian Fatalities	Rank by Proportion of Pedestrian Fatalities	Available Crash Years	Included or Exclusion Reason
California	1	4	2006 – 2010	No data after 2010
Florida*	2	5	2012 – 2014	Rank by Number and Proportion
Texas	3	10	2006 – 2010	No data after 2010
New York	4	3	2006 – 2013	Rank by Number and Proportion
Georgia	5	14	2006 – 2010	No data after 2010
North Carolina	6	15	2006 – 2012	Rank by Number
New Jersey	7	1	2006 – 2014	Rank by Number and Proportion
Michigan	8	8	2006 – 2013	Rank by Number and Proportion, Preliminary Analysis
Pennsylvania	9	16	2006 – 2012	Rank by Number, Preliminary Analysis
Illinois*	10	11	2009 – 2014	Rank by Number
Delaware	26	2	2007 – 2014	Rank by Proportion
Maryland	17	7	2006 – 2015	Rank by Proportion
New Mexico	22	6	2006 – 2013	Rank by Proportion
Connecticut	23	9	2006 – 2013	Model year not available
Indiana	16	19	2006 – 2014	Preliminary Analysis
Virginia	19	22	2006 – 2015	Preliminary Analysis

* Crash years included were limited to those with consistent reportable criteria for crashes.

Table 2a. Number and proportion of pedestrians injured by grouped model year and vehicle type.

Injury level	Vehicle type	MY2001-MY2005		MY2011-MY2016		p-value	Proportion injured	
		Number injured	Percent injured (Confidence Interval)	Number injured	Percent injured (Confidence Interval)		Percent change	Percentage point difference
Any injury	Car/SUV/Van	56689	93.96 (93.77, 94.15)	11666	93.38 (92.94, 93.82)	<0.05	-0.6	-0.6
	Car	43597	93.82 (93.60, 94.04)	8788	93.04 (92.53, 93.56)	<0.05	-0.8	-0.8
	Pickup	5947	95.23 (94.70, 95.76)	843	95.04 (93.61, 96.47)	NS	-0.2	-0.2
Major injury or fatality	Car/SUV/Van	9844	16.32 (16.02, 16.61)	2063	16.51 (15.86, 17.16)	NS	1.2	0.2
	Car	7260	15.62 (15.29, 15.95)	1552	16.43 (15.68, 17.18)	<0.05	5.2	0.8
	Pickup	1343	21.51 (20.49, 22.52)	203	22.89 (20.12, 25.65)	NS	6.4	1.4
Fatality	Car/SUV/Van	2097	3.48 (3.33, 3.62)	401	3.21 (2.90, 3.52)	NS	-7.6	-0.3
	Car	1446	3.11 (2.95, 3.27)	308	3.26 (2.90, 3.62)	NS	4.8	0.1
	Pickup	377	6.04 (5.45, 6.63)	58	6.54 (4.91, 8.17)	NS	8.3	0.5

Table 2b. Number and proportion of male pedestrians injured by grouped model year and vehicle type.

Injury level	Vehicle type	MY2001-MY2005		MY2011-MY2016		p-value	Proportion injured	
		Number injured	Percent injured (Confidence Interval)	Number injured	Percent injured (Confidence Interval)		Percent change	Percentage point difference
Any injury	Car/SUV/Van	30330	93.94 (93.68, 94.20)	6043	93.31 (92.71, 93.92)	<0.10	-0.7	-0.6
	Car	23248	93.78 (93.48, 94.08)	4589	93.23 (92.53, 93.94)	NS	-0.6	-0.5
	Pickup	3380	94.97 (94.25, 95.69)	485	93.63 (91.53, 95.73)	NS	-1.4	-1.3
Major injury or fatality	Car/SUV/Van	6033	18.69 (18.26, 19.11)	1211	18.70 (17.75, 19.65)	NS	0.1	0.0
	Car	4463	18.00 (17.52, 18.48)	917	18.63 (17.54, 19.72)	NS	3.5	0.6
	Pickup	845	23.74 (22.34, 25.14)	128	24.71 (21.00, 28.42)	NS	4.1	1.0
Fatality	Car/SUV/Van	1457	4.51 (4.29, 4.74)	277	4.28 (3.78, 4.77)	NS	-5.2	-0.2
	Car	1010	4.07 (3.83, 4.32)	214	4.35 (3.78, 4.92)	NS	6.7	0.3
	Pickup	257	7.22 (6.37, 8.07)	36	6.95 (4.76, 9.14)	NS	-3.8	-0.3

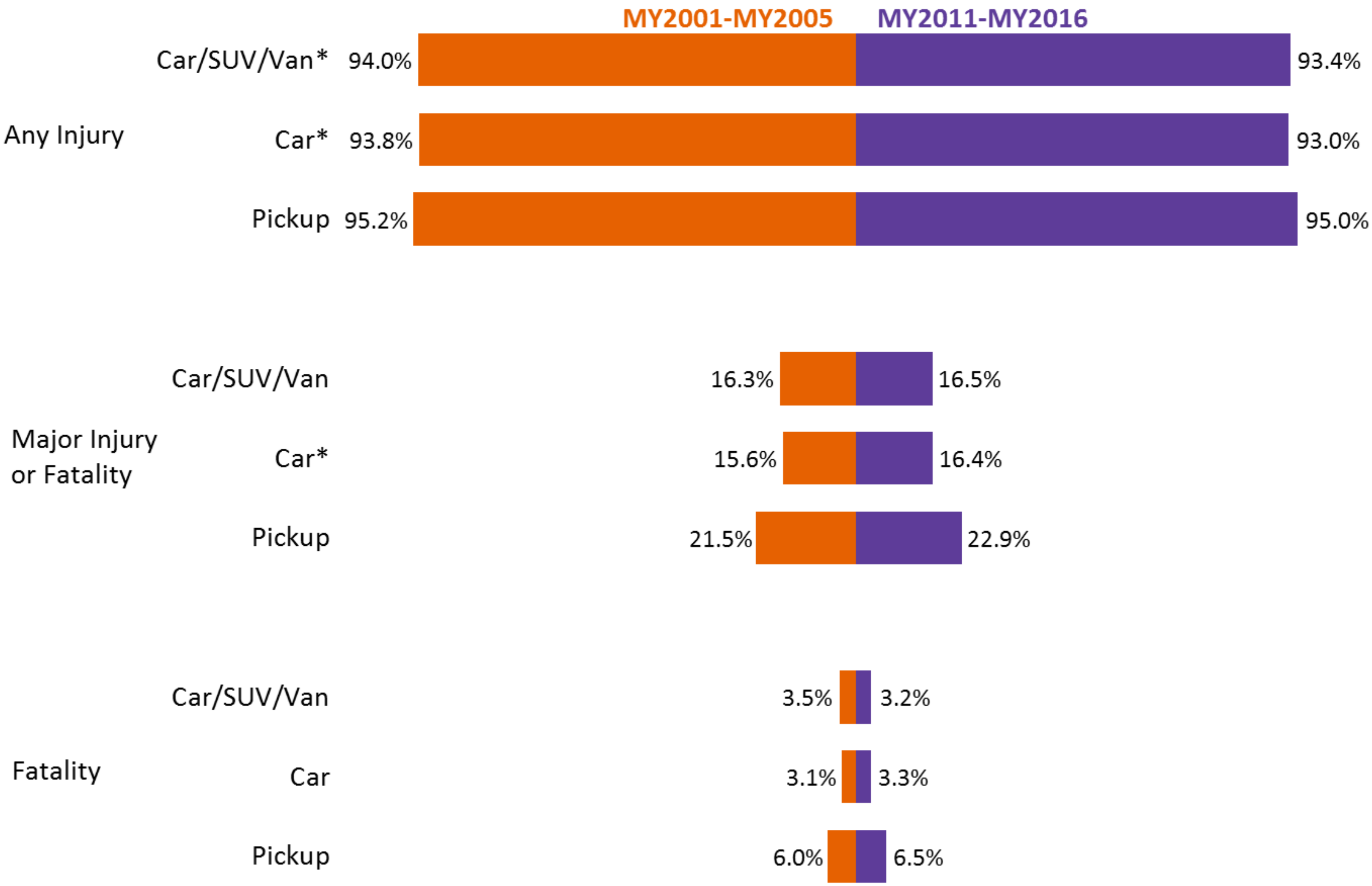
Table 2c. Number and proportion of female pedestrians injured by grouped model year and vehicle type.

Injury level	Vehicle type	MY2001-MY2005		MY2011-MY2016		p-value	Proportion injured	
		Number injured	Percent injured (Confidence Interval)	Number injured	Percent injured (Confidence Interval)		Percent change	Percentage point difference
Any injury	Car/SUV/Van	25832	94.92 (94.66, 95.18)	5385	94.36 (93.76, 94.96)	<0.10	-0.6	-0.6
	Car	19947	94.90 (94.61, 95.20)	4020	93.82 (93.09, 94.54)	<0.05	-1.1	-1.1
	Pickup	2502	96.27 (95.54, 97.00)	340	97.70 (96.13, 99.28)	NS	1.5	1.4
Major injury or fatality	Car/SUV/Van	3691	13.56 (13.16, 13.97)	806	14.12 (13.22, 15.03)	NS	4.1	0.6
	Car	2706	12.87 (12.42, 13.33)	603	14.07 (13.03, 15.11)	<0.05	9.3	1.2
	Pickup	478	18.39 (16.90, 19.88)	71	20.40 (16.17, 24.64)	NS	10.9	2.0
Fatality	Car/SUV/Van	623	2.29 (2.11, 2.47)	118	2.07 (1.70, 2.44)	NS	-9.7	-0.2
	Car	424	2.02 (1.83, 2.21)	90	2.10 (1.67, 2.53)	NS	4.1	0.1
	Pickup	118	4.54 (3.74, 5.34)	20	5.75 (3.30, 8.19)	NS	26.6	1.2

Table 2d. Number and proportion of 18- to 65-year-old pedestrians injured by grouped model year and vehicle type.

Injury level	Vehicle type	MY2001-MY2005		MY2011-MY2016		p-value	Proportion injured	
		Number injured	Percent injured (Confidence Interval)	Number injured	Percent injured (Confidence Interval)		Percent change	Percentage point difference
Any injury	Car/SUV/Van	35817	94.53 (94.30, 94.76)	7662	93.86 (93.34, 94.38)	<0.05	-0.7	-0.7
	Car	27457	94.51 (94.25, 94.77)	5784	93.62 (93.01, 94.23)	<0.05	-0.9	-0.9
	Pickup	3997	95.76 (95.15, 96.37)	559	95.88 (94.27, 97.50)	NS	0.1	0.1
Major injury or fatality	Car/SUV/Van	6376	16.83 (16.45, 17.20)	1358	16.64 (15.83, 17.44)	NS	-1.1	-0.2
	Car	4724	16.26 (15.84, 16.69)	1032	16.70 (15.77, 17.63)	NS	2.7	0.4
	Pickup	882	21.13 (19.89, 22.37)	126	21.61 (18.27, 24.95)	NS	2.3	0.5
Fatality	Car/SUV/Van	1459	3.85 (3.66, 4.04)	277	3.39 (3.00, 3.79)	<0.05	-11.9	-0.5
	Car	1010	3.48 (3.27, 3.69)	215	3.48 (3.02, 3.94)	NS	0.1	0.0
	Pickup	236	5.65 (4.95, 6.35)	33	5.66 (3.78, 7.54)	NS	0.1	0.0

Figure 1a. There were some significant model year group differences in the proportion of pedestrians injured by Car/SUV/Vans and Cars, but decreases for any injury and an increase for major injury or fatality



* These proportions are statistically different ($p < 0.05$)

Figure 1b. The proportion of male pedestrians injured were similar in model year groups, regardless of the type of vehicle or injury level

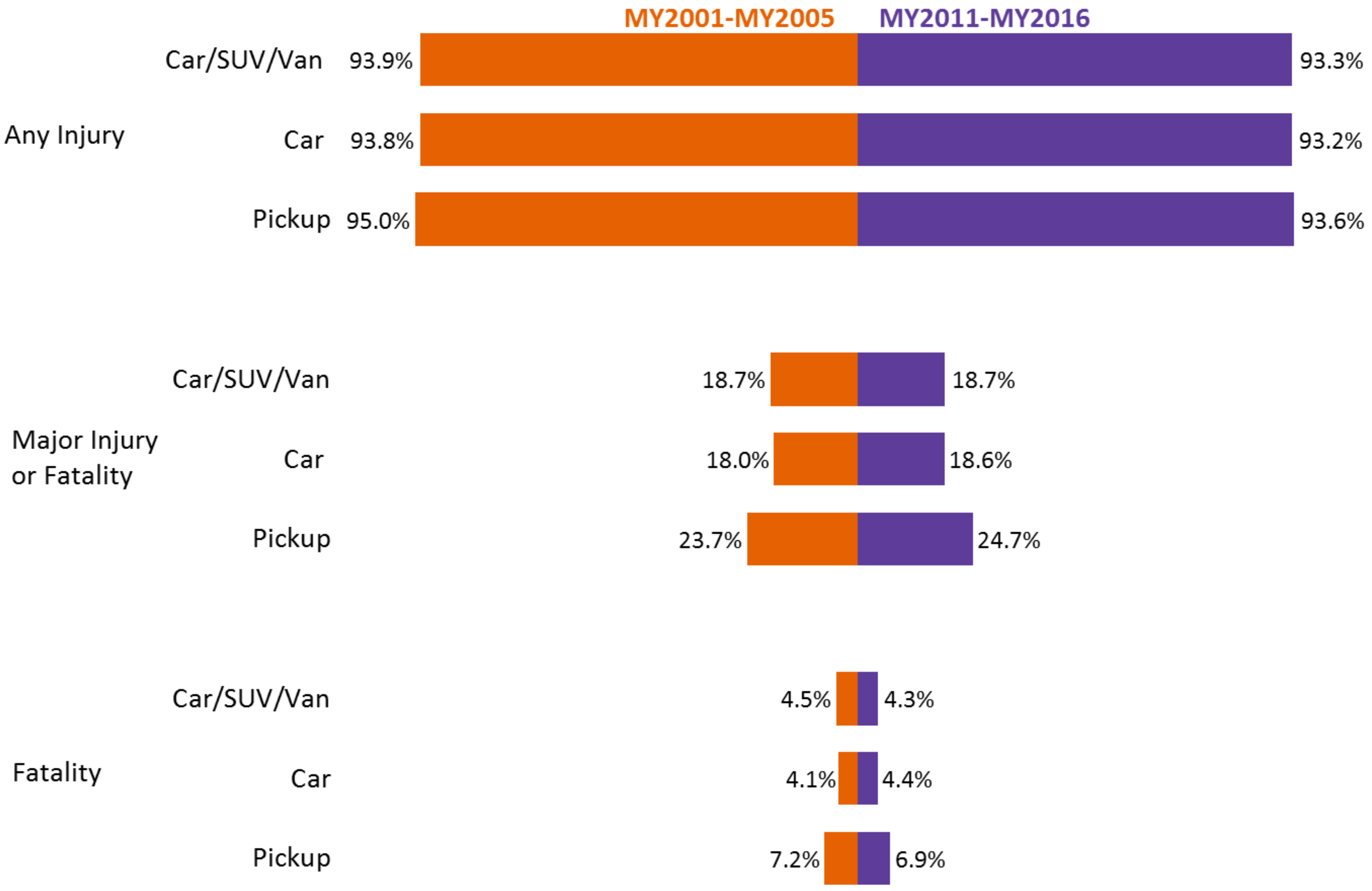


Figure 1c. There were some significant model year group differences in the proportions of female pedestrians injured by Cars, but a decrease for any injury and an increase for major injury or fatality

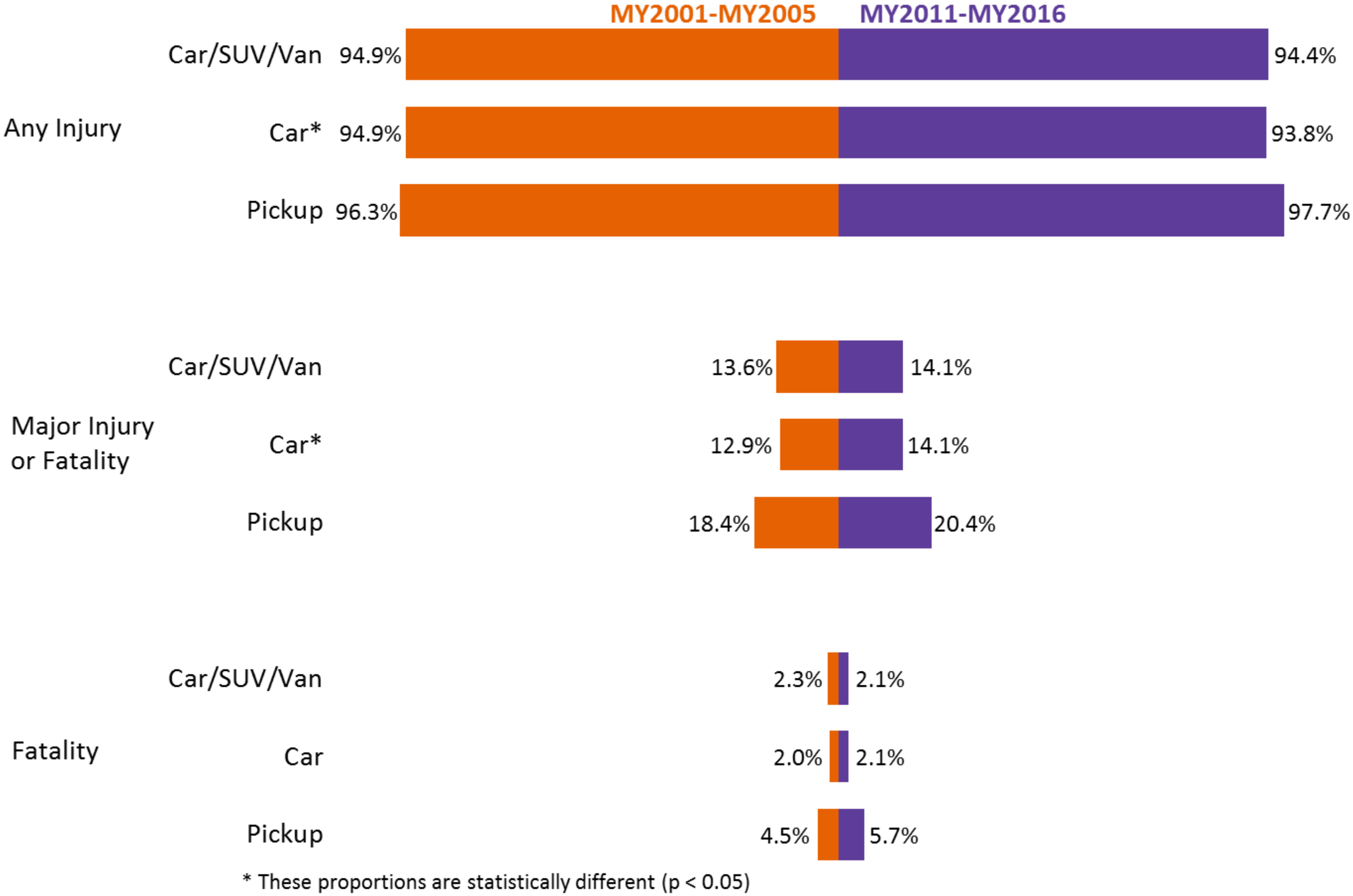
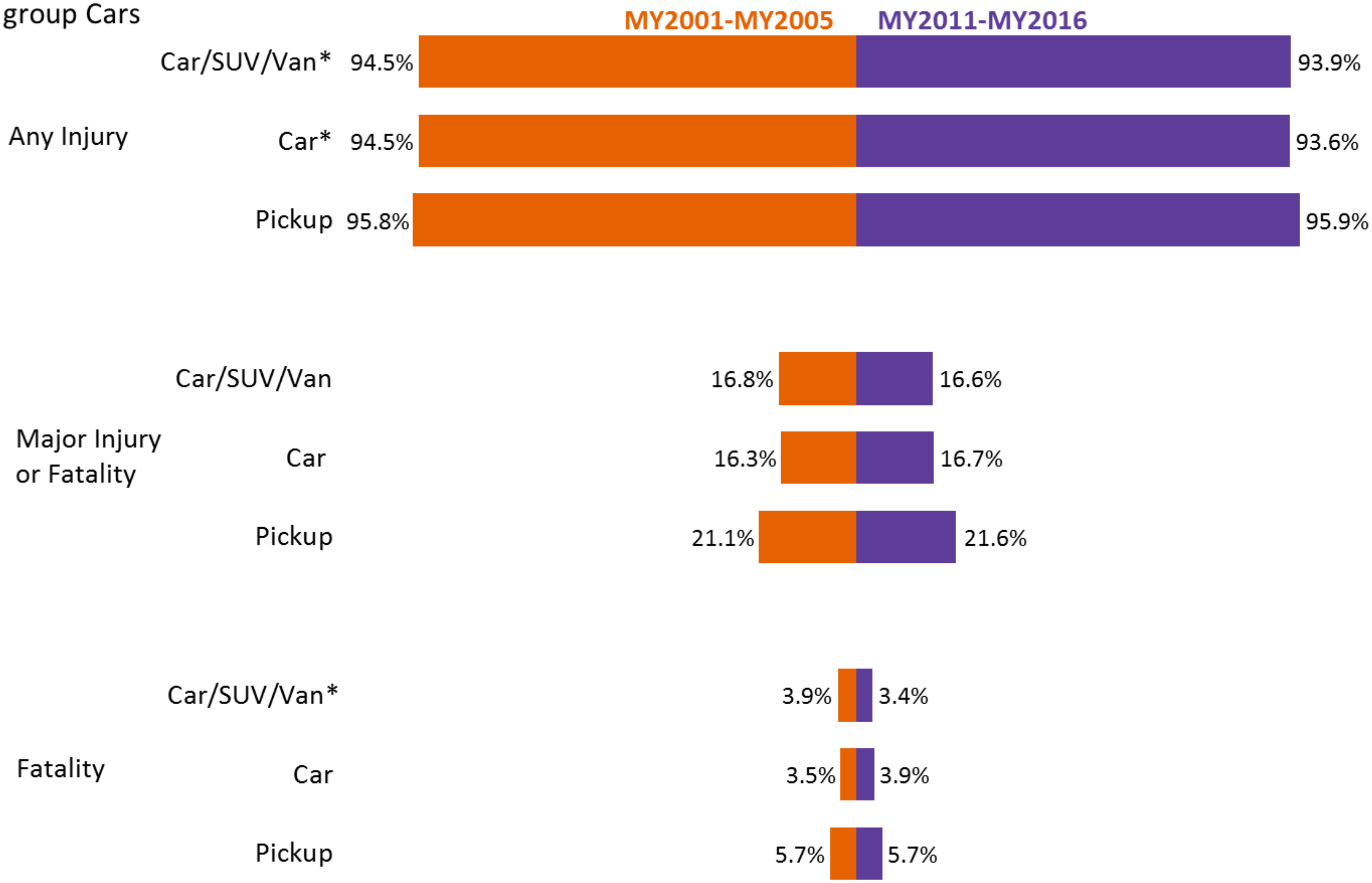


Figure 1d. The proportion of 18- to 65-year-old pedestrian fatalities was lower among later-model-year group Car/SUV/Vans, as were any injuries among this group and any injury for later-model-year group Cars



* These proportions are statistically different ($p < 0.05$)

DOT HS 812 819
March 2020

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14274-031120-v3