US Motor Vehicle Accident Deaths 1999-2016

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Executive Summary

This report examines United States motor vehicle accident (MVA) deaths during 1999-2016. The Society of Actuaries pursued the research as part of its ongoing longevity and mortality research initiatives. The objective of this research is to produce a long-term overview of these accident fatalities that may aid in a better understanding of them to support managing the selection and underwriting of insured risk. The report gives an overview of MVA deaths and analyzes them by person involved, age, gender, region, vehicle type, alcohol impairment, and by time series patterns.

The report is based on two main sources of publicly available data from the United States Department of Transportation. Accident data is from the National Highway Transportation Safety Administration (NHTSA) Fatal Accident Reporting System (FARS). That data includes multiple facet detail about the people, vehicles, and circumstances of every reported fatal motor vehicle accident (MVA) on a public roadway. Exposure, which is used to derive measures based on vehicle miles traveled and number of drivers, is drawn from the Federal Highway Administration.

Overview

Each year, there are thousands of MVA deaths in the United States. The Centers for Disease Control (CDC) reports, per data in the Wide-ranging Online Data for Epidemiologic Research (WONDER), that in 2016 MVA deaths were 25% of all accidental deaths, which placed them second to poisonings as the highest accidental cause of death. MVA deaths include vehicle occupants (drivers and passengers) and non-occupants (pedestrians and pedacyclists). Total annual deaths have declined from 41,717 in 1999 to 37,461 in 2016 (see Section 2.1 Figure 2). This is a 10.2% decrease that is equivalent to an annual 0.6% improvement (average geometric mean basis). During 1999 to 2016, MVA deaths increased slightly to a peak of 43,510 in 2005, declined to a low of 32,479 in 2011, and since resumed an increasing trend to current levels. Most recently, MVA deaths increased by 5.6% in 2016 versus 2015. When the number of licensed drivers, vehicle miles traveled (VMT), fatal crashes per VMT, and fatalities per fatal crash are considered as factors contributing to the number of deaths, fatal crashes per VMT stands out as the most variable of these elements and is the greatest contributor to the decrease of MVA deaths.

Person Involved

Experience varied notably by a person's involvement in a fatal accident. Table 1 shows that the total 1999 to 2016 decrease is comprised of increases and decreases by the type of person in an accident. Both drivers and passengers saw lower death rates, whereas those of pedestrians and pedacyclists increased. Because driver and passenger deaths comprise about 85% of all MVA deaths, their favorable experience prevailed over deteriorating pedestrian and pedacyclist experience. The decrease of passenger deaths was much higher than that of drivers. This occurred because drivers carrying passengers had much lower fatal accident involvement rates, about five to ten per 100,000 drivers depending on age, than those driving alone. The subset of drivers carrying passengers experienced about the same rate of improvement as their passengers.

Table 1

2016 VS. 1999 MVA DEATHS BY ACCIDENT INVOLVEMENT

	1999	2016	2016 vs. 1999		
	Deaths	Deaths	Deaths	Percentage	Annual Improvement
Driver	25,257	23,560	-1,697	-6.7%	0.4%
Passenger	10,521	6,740	-3,781	-35.9%	2.6%
Pedestrian	4,939	5,987	1,048	21.2%	-1.1%
Pedacyclist	754	840	86	11.4%	-0.6%
Miscellaneous*	246	334	88	35.8%	-1.8%
Total	41,717	37,461	-4,256	-10.2%	0.6%

* Miscellaneous includes occupants of non-moving vehicles, unknown occupant type, non-occupants and unknown type that together comprise less than one percent of MVA deaths from 1999-2016.

Age

Drivers

All driver age groups, combined by gender, had lower MVA death rates in 2016 versus 1999, but with varying degrees of improvement. The highest risk ages, 16-19, 20-24, 80-84 and 85+, decreased the most with average annual improvement ranging from 1.4% for ages 20-24 to 3.7% for ages 85+. This reduced the span of high to low age group death rates from 22.3 to 8.2 deaths per 100,000 drivers in 1999 and 2016, respectively. For all ages, improvement was strongest from 2005-2011. In more recent years, improvement slowed with recent near-term reversals. The MVA driver death rate increased in 2016 for all age groups except 16-19 and 50-54. The 2016 increase in driver death rates ranged from 0.4% for age group 55-59 to 10.2% for age group 30-34. The driver death rates for age groups 16-19 and 50-54 each decreased by 2.2% in 2016 (see Section 2.2.2 Figure 4).

Passengers

MVA deaths of passengers in transit decreased annually by 2.6% from 10,521 in 1999 to 6,740 in 2016. Deaths for every age group decreased over that period. The greatest reduction occurred for age groups under 16 through age group 25-29. Deaths for those ages, on a combined basis, decreased by 44% from 5,840 in 1999 to 3,269 in 2016. When passenger deaths are cross tabulated by age, two age regions comprise 80% of the decrease in passenger deaths (unknown ages excluded). Age region one with the greatest proportion, 63%, is passengers spanning one age group above and below the driver age. Within this region, the subset of drivers up to age 29 comprised 47% of the total decrease of passenger deaths from 1999-2016. Passengers under age 16 with drivers age 20 and higher comprised the second age region that was 17% of the total 1999-2016 decrease (see Section 2.2.3 Figure 7 and Figure 8).

Gender

Male MVA driver death rates increased relative to female rates during 1999 to 2016. The male to female ratio for all ages combined was 269% and 350% in 1999 and 2016, respectively. The greatest increase during 1999-2016 occurred for age group 55-59, which saw its ratio increase from 254% to 462%, while age group 85+ was the only age group that decreased and went from 295% to 249% (see Section 2.3 Figure 12). The variability of the increases by age group caused a reshaping of the male to female curve during the period. The reshaping of this curve was most evident for increases occurring at ages 35-44 and

55-69 (see Section 2.3 Figure 14). Those ages all had increases in the male to female ratio that exceeded the average increase. The most extreme was the 55-59 age group, which increased by over 3.5% annually, while the average for all ages was just over 1.5% from 1999 to 2016.

Region

The ten Department of Health and Human Services (HHS) regions are used for the study of geographic variation. The regions encompass groups of contiguous states in the continental United States plus Alaska and Hawaii (see Section 2.4.1 Figure 15).

Driver MVA death rates varied substantially across regions. Averaged over 1999-2016, the Southeast and NY-NJ had the highest and lowest rates, respectively. The Southeast rate of 10.2 deaths per billion VMT was 92% higher than the same rate, 5.3 deaths per billion VMT, for NY-NJ. Generally, rank-order of the regions was consistent over time, with only a small decrease of the span from the highest to lowest rates (see Section 2.4.2 Figure 16).

The number of driver deaths resulting from a fatal accident clustered closely near 0.70 except for three regions. The Plains were 10% higher at 0.77 driver deaths per fatal accident and NY-NJ and the Southwest were about 15% lower with 0.59 and 0.60 driver deaths, respectively (see Section 2.4.3 Figure 17). Although deaths were not mapped to their place of occurrence within the region, it appears these three outliers resulted from the corresponding incidence of non-occupant deaths. Given the occurrence of a fatal accident, in primarily urban regions, non-occupant deaths were higher than in rural regions. The higher incidence of non-occupant deaths reduced the average number of driver deaths per fatal accident in primarily urban regions (NY-NJ and the Southwest). Conversely, in primarily rural regions (Plains), the reverse was true.

Passenger deaths per fatal accident had a wider dispersion across regions. The national average of these deaths was 0.25 per fatal accident. The Rockies had the highest average of 0.30, while NJ-NY had the lowest average of 0.20 passenger deaths per fatal accident. Whereas the driver rate was almost constant for all years, the average passenger death rate decreased from 0.29 in 1999 to 0.20 in 2016. The regions generally followed the national pattern and retained similar rank-order through all years (see Section 2.4.3 Figure 18).

Vehicle

MVA driver deaths declined at an annual 0.4% rate from 1999 to 2016, but experience varied widely by vehicle type. Deaths of car drivers decreased by 2.1% annually, whereas those of motorcycle riders increased by a very high annual 4.6% rate over the same period. The annual improvement of cars and light truck driver deaths combined was 1.2% from 1999 to 2016. More recently, in 2016 versus 2015, driver deaths increased by 5.4% with all vehicle types, except buses that involved very small numbers, seeing increased deaths (see Section 2.5 Figure 20).

Alcohol Impairment

Driver deaths from accidents involving alcohol impairment (AI) decreased from 1999 to 2016 but remain a large proportion of all MVA driver deaths. Driver deaths from fatal accidents, where at least one driver was AI, comprised 35% and 32% of all driver deaths in 1999 and 2016, respectively. About 90% of these drivers were alcohol impaired. AI driver deaths declined from 7,928 in 1999 to 6,486 in 2016. Because most fatal AI accidents involve one vehicle, fatalities of non-AI drivers in an AI-related accident are much lower than AI drivers, but ranged from just under 800 drivers to over 1,100 annually (see Section 2.6.1 Figure 21). Age, gender, and regional experience varied widely.

Age

The AI percentage of driver deaths for all ages combined decreased from 31.5% in 1999 to 27.6% in 2016. The percentages for ages 16-19 through 45-49 and 70-74 decreased, while all other age groups had a higher percentage of AI driver deaths in 2016 vs. 1999. Age group 16-19 had the highest annual improvement of 2.0% (relative to the AI percentage measure, not the absolute driver death rate) with a decrease from 23.3% to 16.6% in 1999 and 2016, respectively. Age groups 20-24 through 40-44 had at least 40% of the AI driver deaths in 1999. These age groups had lower AI percentages in 2016, with annual improvement ranging from 0.7% to 1.3%. Age groups over age 49, except for 70-74, had higher AI percentages in 2016 than 1999, but started from much lower levels in 1999 than the younger ages. Generally, these age groups had decreasing AI percentages by increasing age in both 1999 and 2016. In 2016, the age group 50-54 AI percentage was 28.9%, and for 85+ it was 4.9%. During 1999 to 2016, age group 85+ had the largest negative annual improvement of -2.5%, but it started from a relatively low 3.2% of AI drivers in 1999. Recent experience for all age groups combined was better, with accelerating improvement of a 2.6% annual improvement rate over 2011-2016, and a 3.5% improvement rate in 2015-2016 (see Section 2.6.2 Figure 22).

Gender

Male drivers comprise about 85% of all MVA AI driver deaths (see Section 2.6.3 Figure 23). Although the proportion of AI female driver deaths is much lower than males, the percentage of female AI driver deaths to all female driver deaths increased from 1999 to 2016, while the corresponding measure for males decreased. This percentage increased from 1999 to 2016 annually by 0.8% for females and decreased 1.2% for males. The rank-order of the percentage of male and female AI drivers by age over 1999-2016 is similar where the highest concentration of AI driver deaths is at ages 20-24, and declines consistently to the highest ages. The male age proportions at ages 20-24 and 70-74 are 15.6% and 0.8%, respectively, and the corresponding female percentages for the same ages are 2.7% and 0.1%. Although starting from generally low percentages of 5.0% and 2.8%, the most adverse female experience in the same age range of 20 to 74 occurred for ages 60-64 and 65-69, respectively, that each saw their percentage increase by a very high annual 5.8% rate. Females had worse experience, based on this measure, than males for every age group, except ages 35-39 (see Section 2.6.3 Figure 24 and Figure 25). Females and males recorded 4.2% and 3.4% improvement, respectively, for all ages combined of the percentage of AI driver deaths in 2016 versus 2015.

Region

Alcohol impaired MVA driver deaths measured as a percentage of all MVA deaths declined nationally by a 0.8% average annual rate from 31.4% to 27.5% from 1999 to 2016, respectively. NY-NJ was the only region whose percentage increased during the same period. In most years, NY-NJ had the lowest percentage, but it increased from 24.2% in 1999 to 25.6% in 2016. The highest region in most years was South Central, but its decrease matched the 0.8% national average annual decrease. The South Central's percentage decreased from 35.9% in 1999 to 31.3% in 2016 (see Section 2.6.4 Figure 27).

Time Series

MVA deaths follow a seasonal pattern. Generally, from highest to lowest, the calendar quarter rank-order is third, second, fourth and first. The pattern is less consistent when results are adjusted for seasonal VMT variation. When a VMT adjustment is applied, the second and fourth quarters' mortality ratios switch place more often. VMT follows an intuitive expectation that it is highest in the third quarter (most months in the summer) and lowest in the first quarter (most months in the winter). MVA mortality follows the same general pattern with respect to those quarters on an unadjusted and VMT-adjusted basis. This suggests that, even when allowance is made for fewer miles driven in the winter, the generally more hazardous conditions do not result in higher driver mortality rates than other times of the year (see Section 2.7.1 Figure 28).

MVA driver mortality rates showed a strong association with VMT and the unemployment rate. The correlation of driver mortality to VMT was 0.72 and had a 2.62 slope coefficient. The latter statistic implies that a 1.00% increase (decrease) in VMT would increase (decrease) driver mortality by 2.62%. Because this is not a one-to-one relationship, it suggests that traffic density may affect driver mortality. The correlation of driver mortality to the unemployment rate was -0.49 and had a -2.38 slope coefficient. This implies a 1.00% increment to the unemployment rate would decrease driver mortality by 2.38%. When this analysis was broken out by vehicle type, large trucks showed the strongest association with a -0.57 correlation and had a slope coefficient of -7.10 (see Section 2.7.2 Table 10 and Table 11). Although driver mortality has a strong correlation to the unemployment rate, it is an imperfect one. Driver mortality decreased notably with rising unemployment during the 2008-2009 Great Recession, but there were also mortality variations counter to the correlation with both increases and decreases in the unemployment rate that serve to reduce the correlation (see Section 2.7.2 Figure 30).

Section 1: Introduction

1.1 Purpose

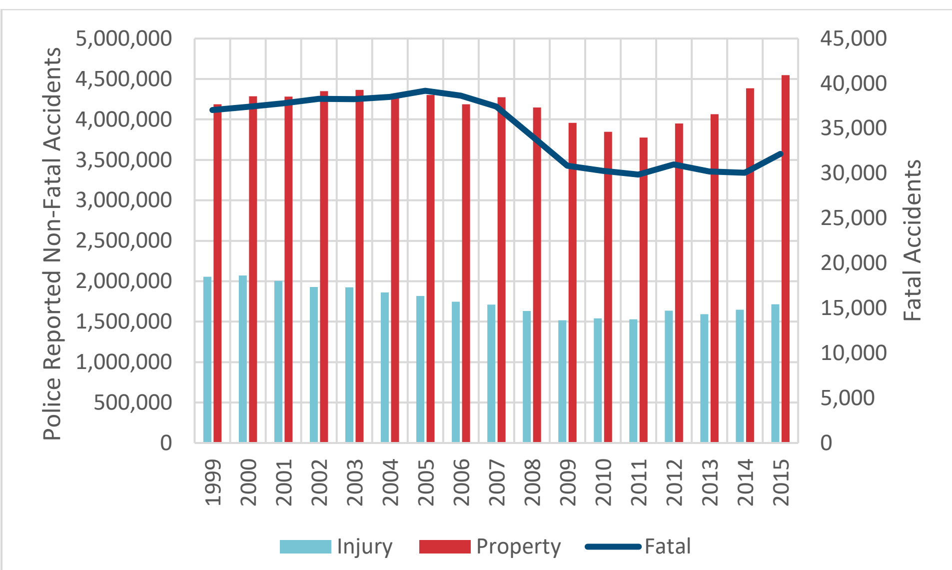
This report examines United States motor vehicle accident (MVA) deaths during 1999-2016. Each year, there are thousands of MVA deaths in the United States. The Centers for Disease Control (CDC) reports, per data in the Wide-ranging Online Data for Epidemiologic Research (WONDER), that in 2016 MVA deaths encompassed 25% of all accidental deaths, which placed them second to poisonings as the highest accidental cause of death. The objective of this research is to produce an overview of these accident fatalities that may aid in a better understanding of them to support managing the selection and underwriting of insured mortality risk.

1.2 Background

Each year, there are millions of motor vehicle accidents in the United States. Figure 1 shows annual MVA experience from 1999-2015 by type of accident. Property accidents (where there are no injuries) are more than double injury-related accidents (where there are no fatalities) in every year. Accidents with one or more fatalities are a very small proportion, 0.5%-0.6%, of reported accidents. Unreported accidents, which are assumed to be relatively minor, are estimated to be equal to the number of reported accidents[1].

Figure 1

MOTOR VEHICLE ACCIDENTS 1999-2015*



* The report covers the period 1999-2016, but non-fatal accident data is currently only available through 2015.

Table 2 shows the 1999-2015 change in the number of reported accidents and annual improvement (geometric basis) by accident type on an actual basis and normalized by vehicle miles traveled (VMT) and licensed drivers. The reduction in fatal and injury-related accidents has been greater than corresponding property accident experience. When it is viewed on a VMT or licensed-normalized basis, all accident types had reduced occurrences, but the unadjusted actual annual improvement of fatal and injury-related accidents exceeded property accidents by about 1.4% and 1.6%, respectively. Auto safety devices may have played a role in reducing MVA injuries and fatalities. An NHTSA report[2] on the effects of increased auto safety aligns with this reduction. The NHTSA estimated that, during 1999-2012, increased auto safety saved over 371,000 lives and reduced vehicular risk by 28%. Although safety devices could be contributing to the reduction (on a normalized basis) of both collisions and fatalties in the event of a collision, the analysis of MVA deaths in this report does not segregate those two effects in the analysis of MVA deaths.

TABLE 2
2015 VS. 1999 CHANGE IN MVA OCCURRENCE BY TYPE

	Actual		Normalized - VMT		Normalized - Drivers	
Accident Type	Total Change	Annual Improvement	Total Change	Annual Improvement	Total Change	Annual Improvement
Fatal	-13.2%	0.9%	-24.5%	1.7%	-25.5%	1.8%
Injury	-16.5%	1.1%	-27.4%	2.0%	-28.3%	2.1%
Property	8.6%	-0.5%	-5.6%	0.4%	-6.8%	0.4%
Total	0.3%	0.0%	-12.8%	0.9%	-13.9%	0.9%

1.3 Scope

This report analyzes MVA fatalities during 1999-2016, with an emphasis on understanding variations of mortality relative to factors including trends over time, driver, passenger, non-occupant, gender, geographic region, vehicle type, alcohol impairment, and external factors, e.g. economic conditions which are presented in Section 2 Findings.

MVA deaths include all fatalities resulting within thirty days of an accident that occurs on a public roadway. Drivers and passengers comprise the majority of MVA deaths, but accidents resulting in pedestrian, pedacyclist, and other non-occupant fatalities are also considered MVA deaths. Unless otherwise noted, the terms accidents and crashes imply the occurrence of at least one fatality resulting from the incident.

Section 2: Findings

2.1 MVA Deaths Overview

There are thousands of MVA deaths in the United States each year. Figure 2 shows annual MVA deaths since 1999. During the period 1999-2016, MVA deaths decreased by 10.2%. The overall decrease had three distinct trends. MVA deaths increased 4.3% from 1999-2005, decreased by 25.4% from 2005-2011, and increased 15.3% from 2011-2016. The last two years saw notable increases. Total MVA deaths increased by 8.4% and 5.6% in 2015 and 2016, respectively.

Figure 2

MOTOR VEHICLE ACCIDENT DEATHS 1999-2016

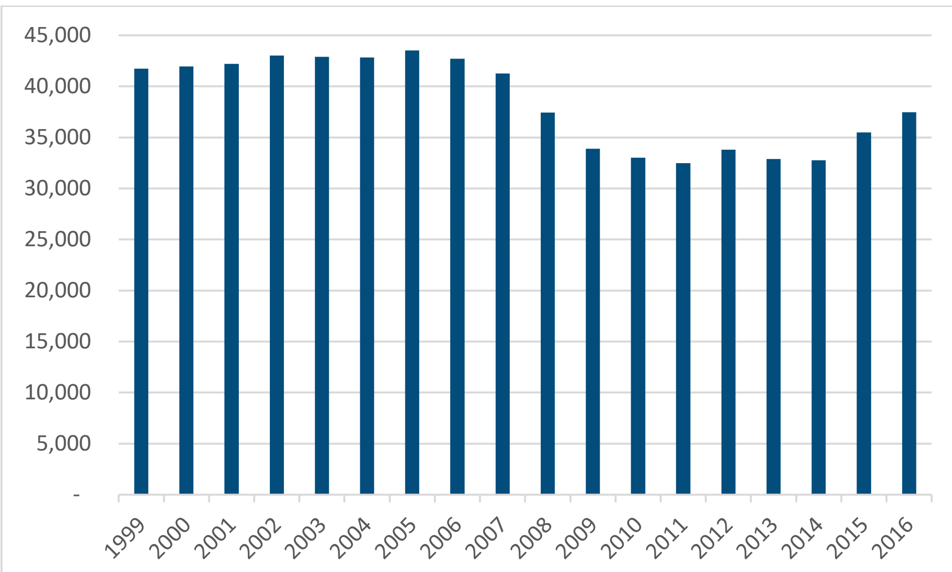


Table 3 shows an attribution of the change in annual MVA deaths due to the combination of the changes in licensed drivers, vehicle miles traveled (VMT), crashes per million VMT, and fatalities per crash. The attribution is shown for 1999-2016 and three periods within it, 1999-2005 (moderate trend up), 2005-2011 (trend down), and 2011-2016 (trend up).

Cumulatively, for 1999-2016, the 1.0% annual increase of licensed drivers was more than offset by 1.4% and 0.2% annual decreases of fatal crashes per million VMT and fatalities per crash, respectively. The combination of these factors produced an annual 0.6% decrease of MVA deaths from 1999-2016.

The annual change of the elements underlying the change in MVA deaths varied notably by element and across time. MVA deaths decreased by a very high 4.8% annual rate in 2005-2011, whereas in 1999-2005 and 2011-2016, they increased annually by 0.7% and 2.9%, respectively. While the number of licensed drivers increased in each of these periods, the change in the other three elements varied. The changes in VMT per driver followed the overall trend of each period, whereas fatal crashes per million VMT and fatalities per crash ran counter to trend in 1999-2005, but with trend in the following two periods. Fatal crashes per million VMT in 2005-2011 had the largest annual decrease, 4.2%, of any element, but there was a notable trend reversal in 2011-2016, where there was a 1.4% annual increase of fatal crashes per million VMT. This is notable because the reduction of fatal crashes per million VMT over 1999-2016 was the largest contributor to the drop in MVA deaths.

Table 3
ATTRIBUTION OF ANNUAL MVA DEATHS

Average Annual Change*	1999-2005	2005-2011	2011-2016	1999-2016
Licensed Drivers	1.2%	0.9%	0.9%	1.0%
VMT per Driver	0.6%	-1.1%	0.6%	0.0%
Crashes per Million VMT	-0.8%	-4.2%	1.4%	-1.4%
Fatalities per Crash	-0.2%	-0.3%	0.0%	-0.2%
MVA Deaths	0.7%	-4.8%	2.9%	-0.6%

All averages in the table are determined geometrically. The average annual change in MVA Deaths within each period is the product of one plus each element's growth rate minus one from the product of those factors, e.g. for 1999-2016 (1.010)(1.000)*(.986)*(.998) - 1.000 = -0.006. Rounding may affect the calculation in other instances. Values for annual MVA deaths of each element are listed in Appendix B.

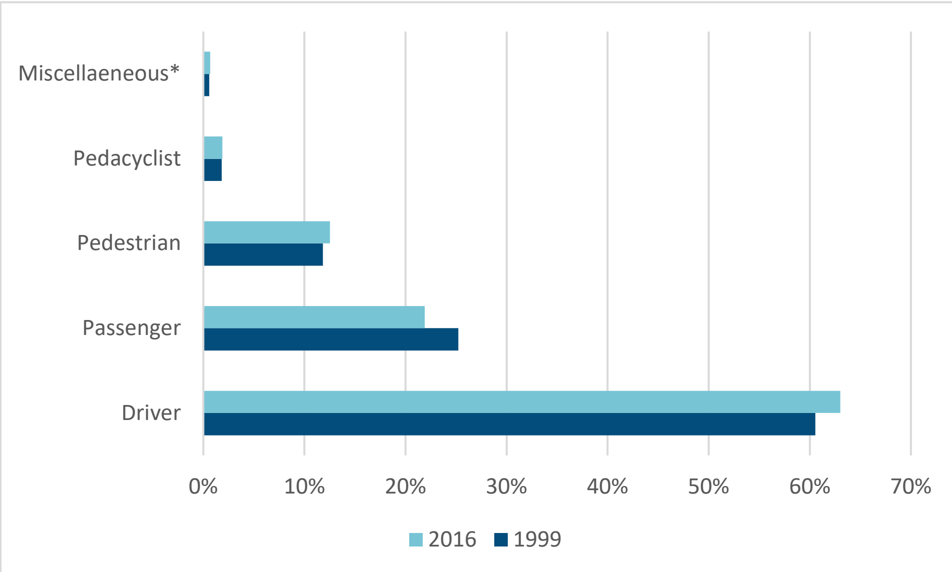
2.2 Person Type

2.2.1 Overview

Figure 3 shows the mix of MVA deaths by person type in 1999 and 2016. In both years, about 85% of MVA deaths are comprised of drivers and passengers. Driver deaths were the greatest percentage of deaths and increased from 60.5% in 1999 to 63.0% in 2016. Passenger deaths were the second largest and only person type that decreased in 2016 vs. 1999. Their percentage of deaths decreased from 25.2% in 1999 to 21.9% in 2016. Pedestrians, which are the next largest person type, saw their percentage of deaths increase from 11.8% to 12.5%. The combined percentage of pedacyclists and other miscellaneous types also increased but was a small part of the total, comprising about 2.5% of all deaths.

Figure 3

2016 VS. 1999 MVA DEATHS COMPOSITION BY PERSON TYPE



* Miscellaneous includes occupants of non-moving vehicles, unknown occupant type, non-occupants, and unknown type that together comprise less than one percent of MVA deaths from 1999-2016.

Table 4 shows the average annualized percentage change of MVA deaths by person type per the same periods within 1999-2016 shown in Table 3. Generally, directional change was consistent by person type within each period, except for passengers and pedestrians during 1999-2005, which both decreased while MVA deaths of drivers, pedacyclists, and non-occupants increased. During 2005-2011, driver and passenger deaths decreased by very large annual rates of 4.5% and 7.6%, respectively. The decreases during this period more than offset their combined experience of 1999-2005 and 2011-2016 to produce net 2016 vs. 1999 annual decreases of 0.4% and 2.6% for drivers and passengers, respectively. The passenger decrease was so large from 1999 to 2016 that, even though driver deaths decreased, their percentage of MVA deaths increased, as shown in Figure 3 above. While driver and passenger deaths decreased, all other person type deaths increased over 1999-2016. Most of their increases occurred during 2011-2016, with large average annual increases ranging from 4.3% for pedacyclists to 6.1% for pedestrians. Because drivers and passengers are a much larger proportion of total MVA deaths, their decreases more than offset other person type increases, which produced an average annual 0.6% decrease of all MVA deaths during 1999-2016.

Table 4

CHANGE IN MVA DEATHS BY PERSON TYPE

Average Annual Change*	1999-2005	2005-2011	2011-2016	1999-2016
Driver	1.4%	-4.5%	2.5%	-0.4%
Passenger	-0.7%	-7.6%	1.5%	-2.6%
Pedestrian	-0.2%	-1.5%	6.1%	1.1%
Pedacyclist	0.7%	-2.3%	4.3%	0.6%
Miscellaneous	1.7%	-0.2%	4.4%	1.8%
All Types	0.7%	-4.8%	2.9%	-0.6%

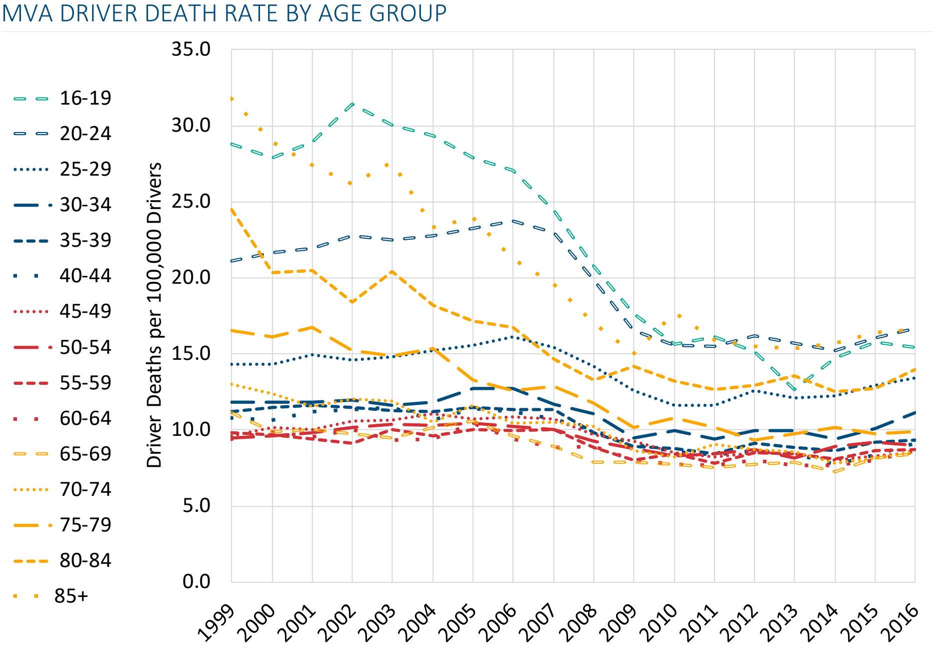
*All averages in the table are determined geometrically. The 1999-2016 annual change in passenger deaths is derived as $[(.993^{-6})*(.924^{6})*(1.015^{5})]^{(1/17)} - 1 = -.026$. Rounding may affect the calculation in other instances.

2.2.2 Driver

MVA driver mortality by age group, based on licensed drivers, varied substantially and resulted in a compression of mortality rates during 1999-2016. Figure 4 shows that strong decreases of mortality for the four highest risk age groups, each with over 20.0 driver deaths per 100,000 in 1999, work to reduce the difference between the highest and lowest age group mortality over 1999-2016. These four age groups 16-19, 20-24, 80-84, and 85+ had annual improvement over the period of 3.6%, 1.4%, 3.2%, and 3.7%, respectively. All other driver age groups' mortality also decreased from 1999-2016, but from lower starting levels in 1999. Age groups 75-79 and 50-54 had the highest and lowest annual improvement rates, 3.2% and 0.3%, respectively, within age groups that had less than 20.0 deaths per 100,000 drivers in 1999. Whereas experience since about 2010-2011 has been flat, most age groups saw an increase in 2016 versus 2015. Age groups 30-34 and 80-84 had the highest increases of 10.2% and 10.1%, respectively. Age groups 16-19 and 50-54 were the only two groups that had lower death rates in 2016 versus 2015 where each improved by 2.2%.

Figure 4

MVA DRIVER DEATH RATE BY AGE GROUP



	Driver Death Rate		Annual Improvement	
Age Group*	1999	2016	1999-2016	2015-2016
16-19	28.8	15.4	3.6%	2.2%
20-24	21.1	16.6	1.4%	-3.6%
25-29	14.3	13.4	0.4%	-3.7%
30-34	11.8	11.1	0.4%	-10.2%
35-39	11.2	9.3	1.1%	-1.5%
40-44	10.8	9.2	1.0%	-9.4%
45-49	9.6	8.5	0.7%	-3.1%
50-54	9.4	9.0	0.3%	2.2%
55-59	9.8	8.7	0.7%	-0.4%
60-64	9.4	8.6	0.5%	-7.7%
65-69	11.1	8.4	1.6%	-3.0%
70-74	13.0	8.6	2.4%	-5.0%
75-79	16.5	9.9	3.0%	-1.5%
80-84	24.5	14.0	3.2%	-10.1%
85+	31.7	16.6	3.7%	-1.4%

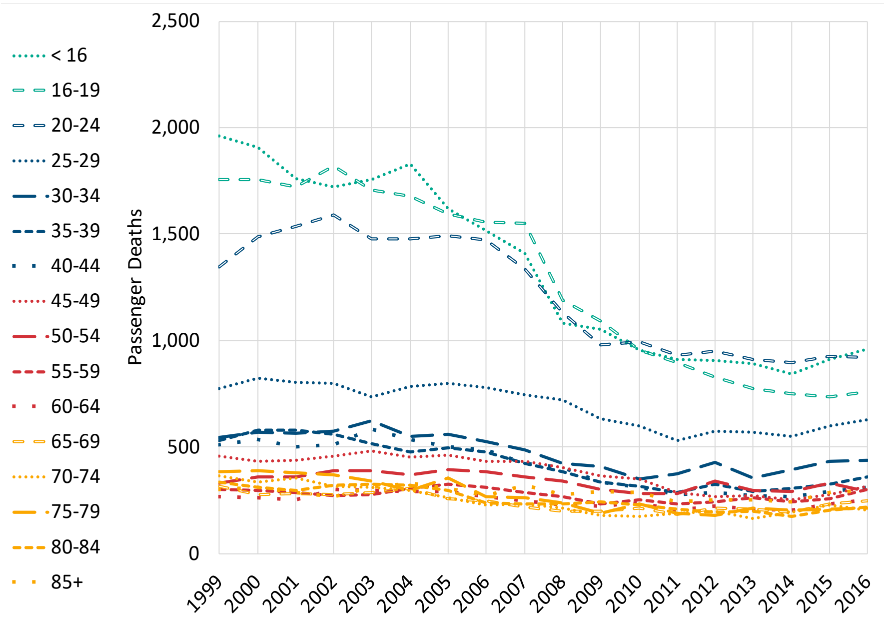
* Includes both genders

2.2.3 Passenger

MVA passenger mortality varied substantially during 1999-2016. Because we do not know the total number of passengers in transit or the number of miles they traveled, this section analyzes passenger experience by numbers of deaths rather than by incidence rates. MVA passenger deaths decreased for every age group, but the largest reductions were concentrated in the lowest age groups. Figure 5 shows vehicle in transit MVA passenger deaths by age group (unknown ages excluded) for each year. Age groups 15 and under, 16-19, and 20-24 comprised 64% of the total reduction, 3,776 deaths, in 2016 versus 1999. Age group 16-19 had the highest annual improvement of 4.8%, while age groups 55-59 and 85+ had the least improvement with virtually no change over the period. Experience was varied in the most recent year. Age groups 50-54 and 55-59 had the highest and lowest improvement, 11.2% and -17.2%, respectively, from 2015-2016.

Figure 5

MVA PASSENGER DEATHS BY AGE GROUP



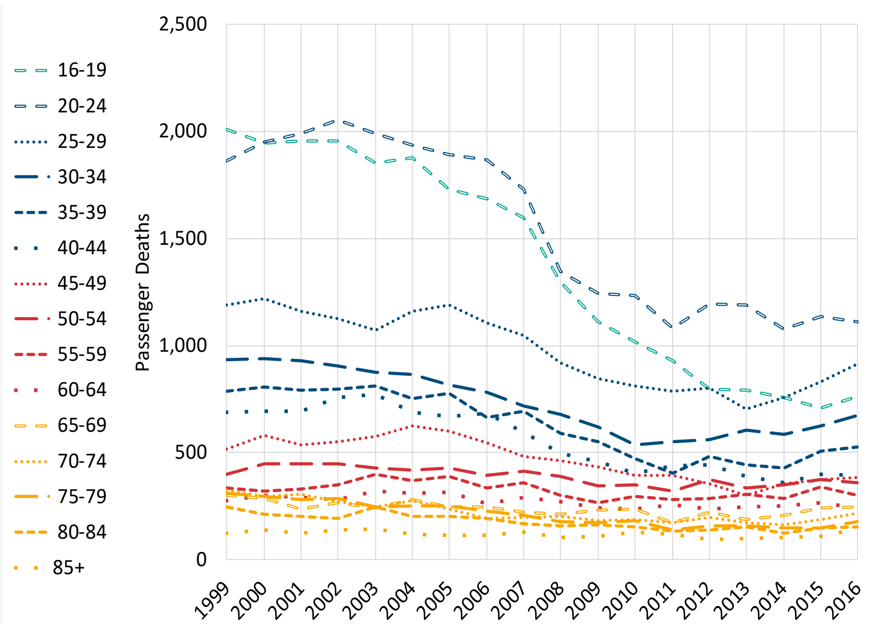
Age Group*	Passenger Deaths 1999	Passenger Deaths 2016	Annual Improvement 1999-2016	Annual Improvement 2015-2016
< 16	1,963	961	4.1%	-5.1%
16-19	1,754	761	4.8%	-3.1%
20-24	1,347	920	2.2%	0.6%
25-29	776	627	1.2%	-4.8%
30-34	548	437	1.3%	-0.7%
35-39	533	362	2.3%	-11.0%
40-44	514	310	2.9%	-5.8%
45-49	456	317	2.1%	-14.0%
50-54	330	292	0.7%	11.2%
55-59	302	300	0.0%	-17.2%
60-64	268	251	0.4%	-6.4%
65-69	319	247	1.5%	-6.0%
70-74	366	206	3.3%	9.3%
75-79	387	212	3.5%	-1.9%
80-84	334	220	2.4%	-6.8%
85+	300	298	0.0%	-4.6%

* Includes both genders

Figure 6 shows vehicle in transit MVA passenger deaths by driver age group (drivers under age 16 and unknown ages excluded) for each year. Every driver age group, except age 85+, had fewer passenger deaths in 2016 than 1999. Age group 16-19 had the highest annual improvement of 5.5%, while age group 85+ had the least favorable experience with an annual deterioration of 1.0%. Like passenger age-group deaths, experience also varied for passengers classified by their driver's age in the most recent year. Age group 55-59 had the highest improvement of 10.9%, while age group 85+ had the worst deterioration, 33.9%, from 2015-2016.

Figure 6

MVA PASSENGER DEATHS BY DRIVER AGE GROUP



	Passenger Deaths		Annual Improvement	
Age Group*	1999	2016	1999-2016	2015-2016
16-19	2,008	763	5.5%	-7.6%
20-24	1,864	1,110	3.0%	2.3%
25-29	1,188	916	1.5%	-10.0%
30-34	935	676	1.9%	-8.5%
35-39	788	526	2.3%	-4.0%
40-44	687	394	3.2%	1.3%
45-49	518	384	1.7%	-1.9%
50-54	397	360	0.6%	4.3%
55-59	333	302	0.6%	10.9%
60-64	276	241	0.8%	9.7%
65-69	301	249	1.1%	-2.9%
70-74	324	217	2.3%	-14.8%
75-79	310	176	3.3%	-17.3%
80-84	249	153	2.8%	-2.7%
85+	123	146	-1.0%	-33.9%

* Includes both genders

Figures 7 and 8 below show passenger deaths by a cross tabulation of driver and passenger age (unknown ages excluded) for 1999 and 2016. There was a substantial decrease of 3,684 passenger deaths in 2016 versus 1999. Two age regions comprise a decrease of 2,955 deaths, which is 80% of the total decrease of 3,684 deaths.

1) Passengers spanning one age group above and below the driver age were 63% of the total decrease. They had 2,318 fewer deaths in 2016 vs. 1999. Within this age region, there were 1,722 fewer deaths of passengers riding with drivers up to age 29, which was 47% of the total decrease of passenger deaths.

2) The reduction of passenger deaths under age 16 riding with drivers age 20 and higher was 17% of the total decrease of passenger deaths. There were 637 fewer deaths of these passengers in 2016 versus 1999.

The concentration of reduced passenger deaths in these age regions explains the source by driver and passenger age of the greatest annual decrease by person type of MVA fatalities listed in Table 4. Whether passenger deaths can continue to decrease at a greater rate than driver deaths is discussed next.

Figure 7

1999 MVA PASSENGER DEATHS BY DRIVER VS. PASSENGER AGE GROUP

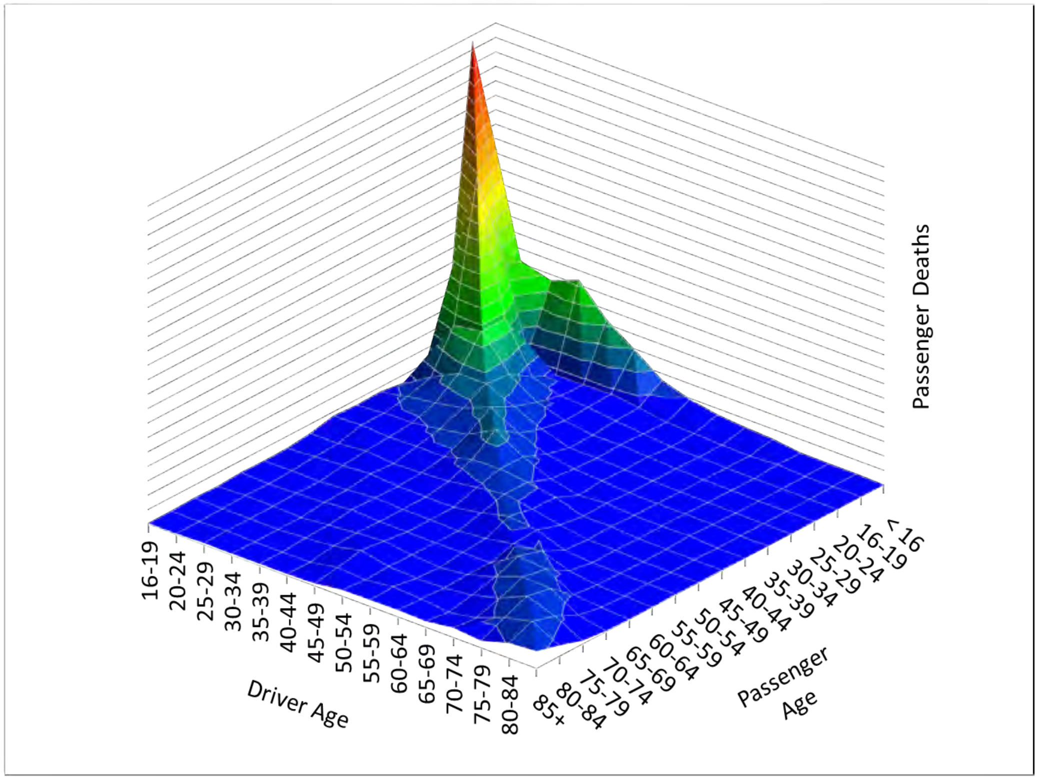


Figure 8

2016 MVA PASSENGER DEATHS BY DRIVER VS. PASSENGER AGE GROUP

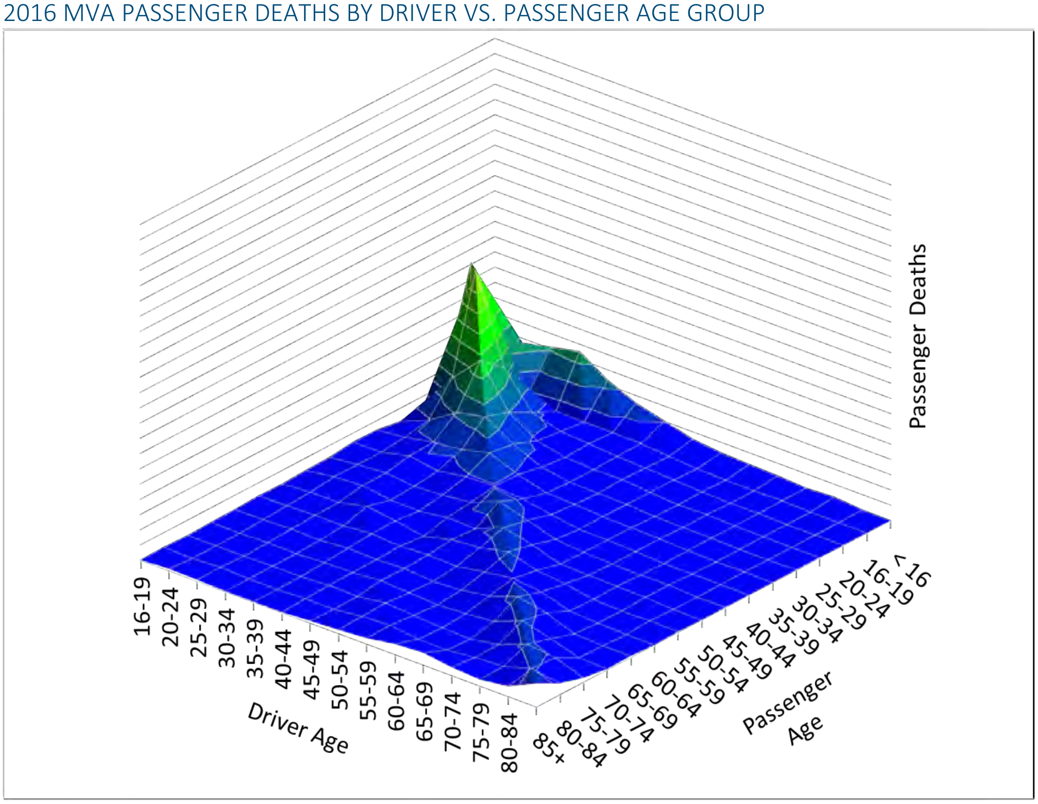


Table 5 below summarizes driver deaths by whether a driver is carrying any passengers. There is a striking difference in percentage change in driver deaths depending on whether passengers ride with them. There is a 2.3% annual reduction of driver deaths carrying passengers versus a 0.2% increase when there are no passengers. This explains an otherwise inconsistent relationship of substantially higher annual mortality improvement for passengers in Table 4, 2.6%, versus 0.4% for drivers. The similarity of the 2.6% annual improvement for passengers to the 2.3% for drivers with passengers implies that whether future passenger mortality improvement can exceed that of all drivers will depend on the mix of drivers with and without passengers and their respective future experience.

Table 5
1999-2016 DRIVER MVA DEATHS BY PASSENGER PRESENCE

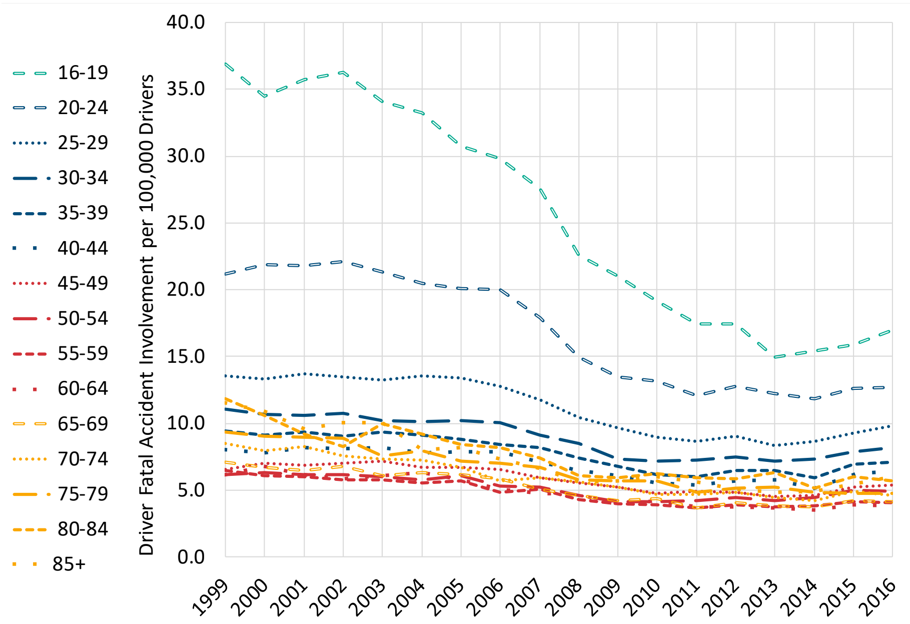
	1999	2016	2016 vs. 1999		
Driver Status	Deaths	Deaths	Change	Change %	Annual Improvement
Without Passenger(s)	18,310	18,905	595	3.2%	-0.2%
With Passenger(s)	6,947	4,655	-2,292	-33.0%	2.3%
Total	25,257	23,560	-1,697	-6.7%	0.4%

Figures 9 and 10 and Table 6 show three factors that imply the difference between total driver and passenger mortality improvement is likely to narrow in the future. These three factors are as follows:

The rate of fatal accident involvement of drivers carrying passengers has already declined substantially. Figure 9 shows that the rates of fatal accident involvement of drivers up to age 29 have converged toward the lower rates of higher ages. There is less room for improvement in drivers up to age 29, which produced 61% of the passenger improvement. Notably, age group 16-19 had an outsized 4.5% annual improvement, but it has seen a moderate reversal since 2013. Because rates of involvement are lower, closer together, and stabilizing in recent years for the lowest risk age groups (ages 30 and higher), future gains are more limited than at the start of the experience period in 1999.

Figure 9

MVA FATAL ACCIDENT DRIVER INVOLVEMENT CARRYING PASSENGERS BY AGE GROUP



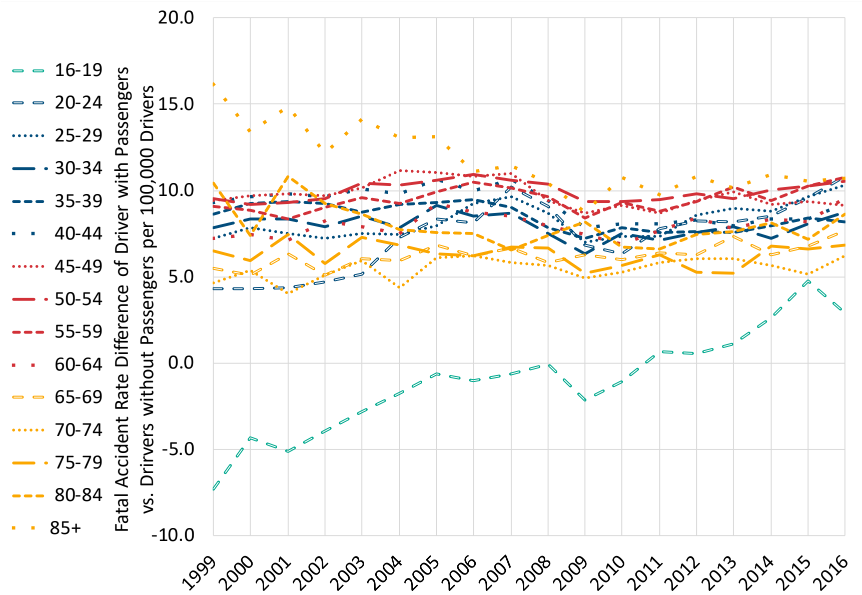
	Driver Accident Rate*		Annual Improvement	
Age Group**	1999	2016	1999-2016	2015-2016
16-19	36.9	16.9	4.5%	-6.4%
20-24	21.2	12.7	3.0%	-0.6%
25-29	13.6	9.8	1.9%	-5.9%
30-34	11.1	8.2	1.7%	-4.0%
35-39	9.4	7.1	1.7%	-2.0%
40-44	8.1	6.5	1.3%	-4.7%
45-49	6.5	5.4	1.1%	-2.9%
50-54	6.2	4.9	1.3%	1.4%
55-59	6.4	4.1	2.7%	1.3%
60-64	6.2	3.8	2.8%	1.1%
65-69	7.1	4.2	3.1%	1.8%
70-74	8.5	4.7	3.5%	6.0%
75-79	9.4	4.7	3.9%	0.3%
80-84	11.9	5.7	4.2%	5.1%
85+	11.6	6.0	3.8%	-10.6%

* Fatal Accident Involvement Rate
** Includes both genders

Figure 10 shows the increment of the fatal accident involvement rate for drivers without passengers versus those with passengers. Drivers aged 16-19 with passengers improved sharply relative to drivers without passengers during 1999-2016. Whereas in 1999 drivers aged 16-19 with passengers had higher rates than those driving alone, by 2016 the situation reversed and drivers with passengers had lower rates. That trend aligns with research on the effectiveness of graduated driver license programs where restrictions on the number of passengers were deemed an important component in their overall effectiveness[3]. The reversal of the passenger versus no passenger rate for that age group is a one-time gain that produced an estimated 17% of the total decrease of annual passenger deaths in 1999 versus 2016. Though current trends do not indicate it will occur, drivers not carrying passengers have greater opportunity for better mortality improvement than drivers with passengers. That is because every driver age group without passengers has higher fatal accident involvement rates than drivers with passengers.

Figure 10

EXCESS NO PASSENGERS TO WITH PASSENGERS MVA FATAL ACCIDENT DRIVER INVOLVEMENT BY AGE GROUP



	Driver Involvement*		Change	
Age Group**	1999	2016	1999-2016	2015-2016
16-19	(7.3)	2.9	10.2	(1.8)
20-24	4.3	10.8	6.5	(0.1)
25-29	7.2	10.3	3.1	(0.1)
30-34	7.8	8.8	0.9	(0.1)
35-39	8.6	8.2	(0.4)	0.0
40-44	9.3	9.3	(0.0)	(0.1)
45-49	9.4	9.2	(0.2)	0.0
50-54	9.5	10.5	1.0	(0.0)
55-59	9.1	10.8	1.7	(0.1)
60-64	7.2	9.6	2.4	(0.2)
65-69	5.5	7.7	2.2	(0.1)
70-74	4.6	6.2	1.6	(0.2)
75-79	6.5	6.8	0.3	(0.0)
80-84	10.4	8.6	(1.8)	(0.2)
85+	16.2	10.7	(5.4)	(0.0)

* Fatal Accident Driver Involvement Without minus With Passengers Rate
** Includes both genders

Table 6 shows that, of three factors that determine the change in the number of passenger deaths, the fatal accident involvement rate is the greatest contributor. Two other factors are the average number of passengers in a vehicle and the passenger fatality rate in a fatal accident. These factors both declined, but not with enough strength or consistency to produce a different result of passenger mortality than that of their drivers. This means that whether passenger mortality improvement can outpace drivers is dependent on how the experience of the fatal accident involvement rate unfolds, respectively, for drivers with and without passengers in the future.

Table 6

1999-2016 PASSENGER EXPERIENCE CONDITIONAL ON FATAL ACCIDENT INVOLVEMENT

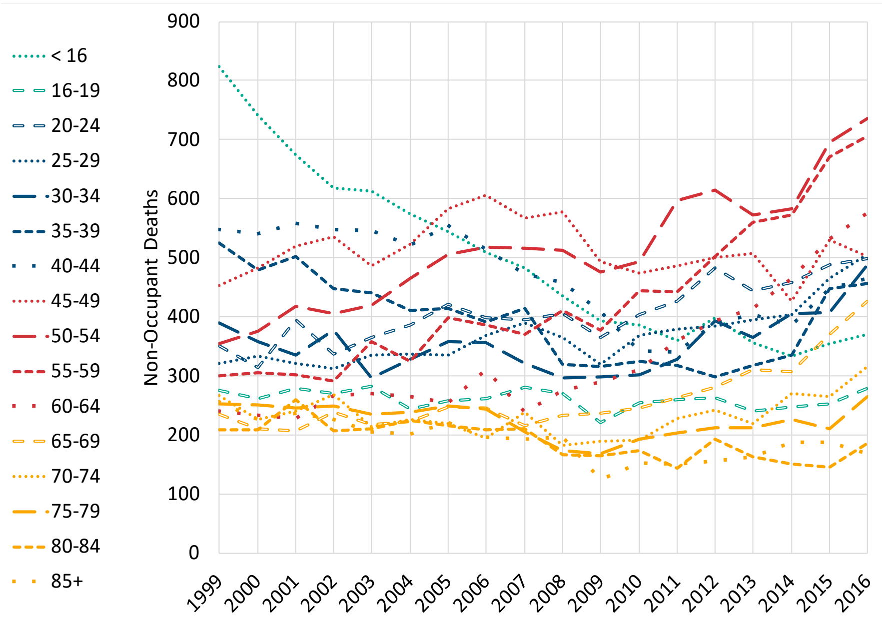
Driver Age	1999	2016	2016 vs. 1999	Trend
Age Group 16-19				
Driver Involvement Rate	36.9	16.9	-54%	
Passengers per Vehicle	1.82	1.79	-2%	
Passenger Death Rate	31%	29%	-7%	
Age Group 20-24				
Driver Involvement Rate	21.2	12.7	-40%	
Passengers per Vehicle	1.81	1.62	-11%	
Passenger Death Rate	31%	30%	-3%	
Age Group 25-29				
Driver Involvement Rate	13.6	9.8	-28%	
Passengers per Vehicle	1.76	1.74	-1%	
Passenger Death Rate	28%	27%	-4%	
Age Group 30+				
Driver Involvement Rate	8.1	5.5	-33%	
Passengers per Vehicle	1.70	1.62	-5%	
Passenger Death Rate	26%	25%	-6%	

2.2.4 Non-Occupant

Figure 11 shows non-occupant MVA deaths, comprised mostly of pedestrians and pedacyclists, from 1999-2016. Unlike drivers or passengers, the age groups do not show general rank-order consistency nor trend across the period. The number of deaths increased for most age groups, with the two highest increases for age groups 55-59 and 60-64, with very high annual increases of 5.1% and 5.3%, respectively. Conversely, some ages decreased with under age 16 recording a very high 4.6% annual decrease. In 2016 versus 2015, experience varied more widely. The only ages that decreased were ages 45-49 and 85+, which had 5.5% and 10.6% decreases, respectively. Three age groups, 30-34,75-79, and 80-84, had greater than 20% one-year increases. The greatest increase was 27.4% for ages 80-84.

Figure 11

NON-OCCUPANT MVA DEATHS



	Non-Occupant Deaths		Annual Improvement	
Age Group*	1999	2016	1999-2016	2015-2016
< 16	823	371	4.6%	-4.5%
16-19	276	279	-0.1%	-10.3%
20-24	351	498	-2.1%	-2.0%
25-29	321	505	-2.7%	-8.6%
30-34	389	489	-1.4%	-20.1%
35-39	525	456	0.8%	-1.8%
40-44	547	466	0.9%	-4.0%
45-49	453	502	-0.6%	5.5%
50-54	354	736	-4.4%	-5.9%
55-59	301	706	-5.1%	-5.4%
60-64	240	576	-5.3%	-8.3%
65-69	236	426	-3.5%	-14.8%
70-74	267	316	-1.0%	-19.2%
75-79	253	265	-0.3%	-25.6%
80-84	209	186	0.7%	-27.4%
85+	256	168	2.4%	10.6%

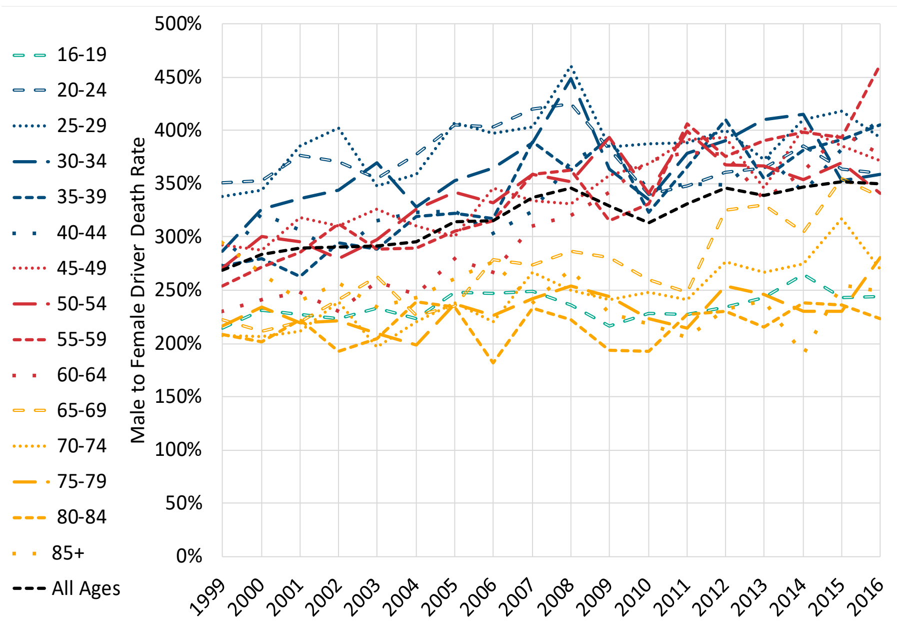
* Includes both genders

2.3 Gender

Figure 12 shows the ratio of male to female driver mortality rates, based on the number of licensed drivers, increased for all ages combined from 269% in 1999 to 350% in 2016, which is equivalent to an annual 1.6% increase. Generally, the annual increase was smallest for age groups at the lowest and highest age groups. Age groups under age 30 and 80-84 had annual increases of less than 1.0%, and age 85+ was the only age group with an annual decrease. Its ratio decreased from 295% to 249% in 1999 and 2016, respectively, which was equivalent to an annual 1.0% decrease. Age group 55-59 had the greatest annual increase during 1999-2016, 3.6%, and highest ending ratio of 462%. The most recent one-year experience had an all ages combined 0.5% decrease, but with less consistent results across the age groups. During 2015-2016, the male to female ratio increased the most, 21.9%, for age group 75-79, and decreased the most, 15.1%, for age group 70-74.

Figure 12

MALE TO FEMALE DRIVER MORTALITY RATIO BASED ON LICENSED DRIVERS



	M/F Driver Death Rate		Annual Improvement	
Age Group	1999	2016	1999-2016	2015-2016
16-19	214%	245%	-0.8%	-0.7%
20-24	351%	360%	-0.2%	0.9%
25-29	339%	394%	-0.9%	5.8%
30-34	287%	359%	-1.3%	-1.8%
35-39	273%	406%	-2.4%	-3.6%
40-44	273%	411%	-2.4%	-7.3%
45-49	292%	371%	-1.4%	3.6%
50-54	271%	341%	-1.4%	7.9%
55-59	254%	462%	-3.6%	-17.5%
60-64	230%	377%	-2.9%	5.4%
65-69	222%	338%	-2.5%	4.9%
70-74	207%	270%	-1.6%	15.1%
75-79	216%	281%	-1.6%	-21.9%
80-84	209%	224%	-0.4%	5.2%
85+	295%	249%	1.0%	2.6%
All Ages	269%	350%	-1.6%	0.5%

Figures 13 and 14 are depictions of the 1999-2016 table information in Figure 12. The large variation of annual increase by age group relative to the 1.6% increase for all ages combined, shown in Figure 13, resulted in a reshaping of the male to female ratio curve across ages shown in Figure 14. Generally, for that curve, the downward trend in 1999 from a peak at age group 20-24, 351%, to age group 70-74, 207%, changed in 2016 to a choppy increasing pattern from age group 20-24, 360%, that was at or above the average for all ages, to a peak at age group 55-59 of 462%. The decrease from that point was steeper than 1999 but ended at a similar level for age group 80-84 of 224%.

Figure 13

1999-2016 AVERAGE ANNUAL MALE TO FEMALE DRIVER MORTALITY RATIO INCREASE

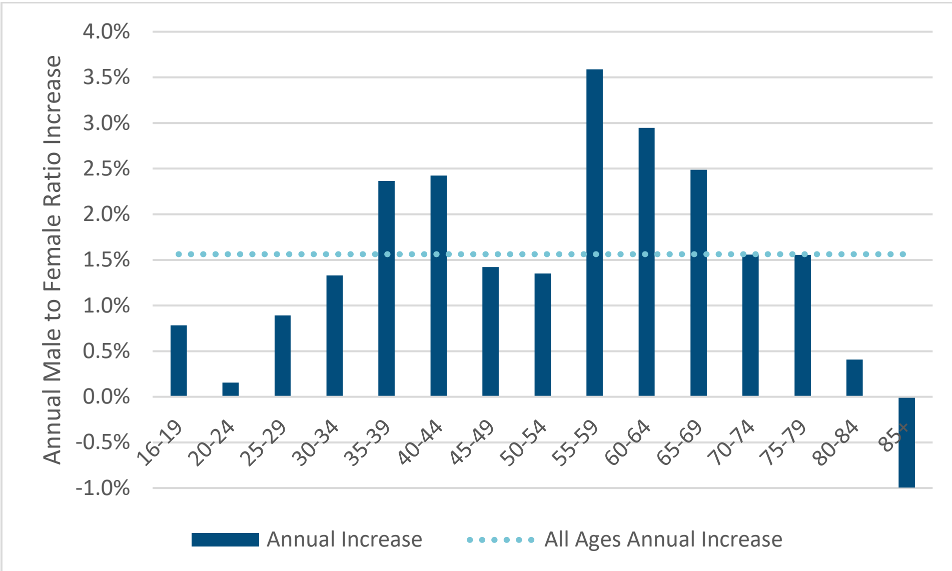
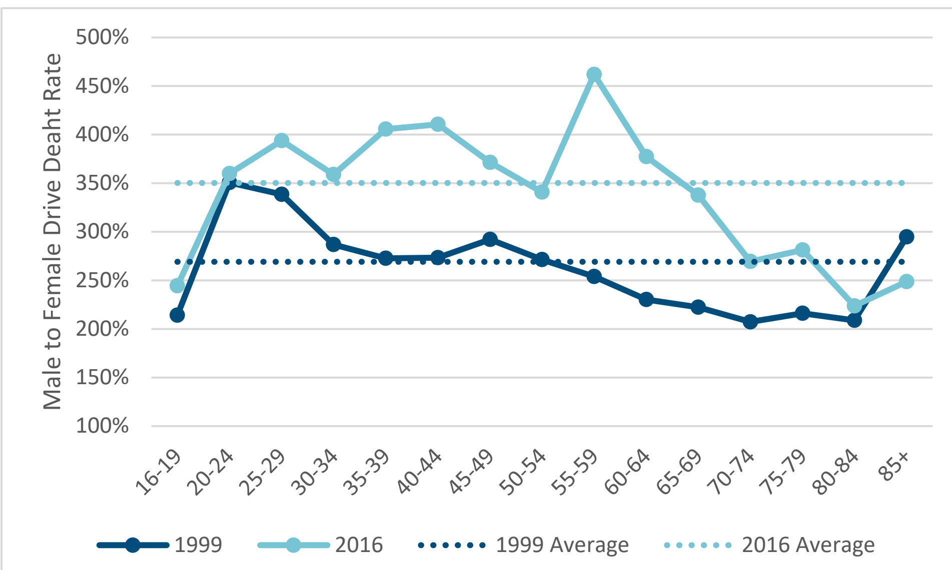


Figure 14

1999 VS. 2016 MALE TO FEMALE DRIVER MORTALITY RATIO



2.4 Region

2.4.1 Overview

Regional MVA deaths of drivers and passengers are analyzed in this section. The ten Department of Health and Human Services (HHS) regions are used for that purpose. The states comprising the HHS regions are shown in Figure 15. The names assigned to the regions are used to refer to regional experience in subsequent tables. The colors associated with the regions in the map below are used for all subsequent regional graphs.

Figure 15

DEPARTMENT OF HEALTH AND HUMAN SERVICES REGIONS

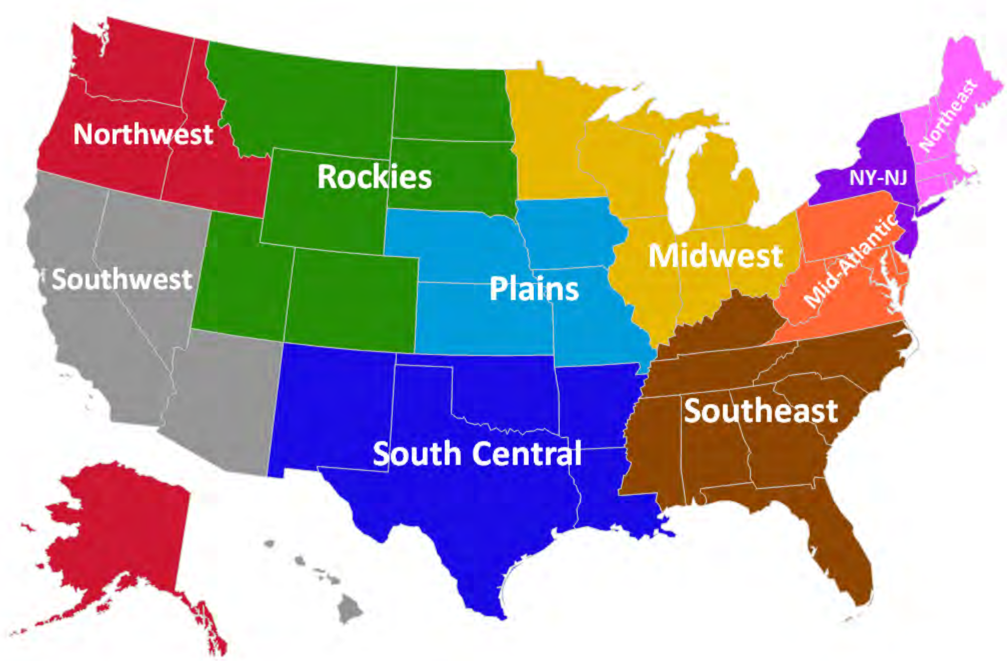


Table 7 lists demographic features of the regions as of 2016.

Table 7
2016 REGIONAL CHARACTERISTICS

Region	Population % of Nation	Drivers % of Nation	VMT per Driver*	Urban % of Region	Fatal Accident % of Nation	Occupant Deaths % of Nation	Non-Occupant Deaths % of Nation
Mid-Atlantic	9.5%	9.7%	12,897	68.8%	7.8%	7.7%	7.3%
Midwest	16.2%	16.1%	14,890	66.3%	13.7%	14.2%	11.0%
Northeast	4.6%	5.0%	12,380	79.4%	3.0%	2.9%	3.1%
Northwest	4.3%	4.6%	11,799	63.6%	3.7%	3.8%	3.2%
NY-NJ	8.9%	8.2%	10,999	85.0%	4.5%	3.6%	7.6%
Plains	4.3%	4.5%	16,129	52.2%	5.2%	5.9%	2.8%
Rockies	3.7%	3.8%	14,811	58.1%	3.8%	4.1%	2.6%
South Central	12.9%	11.6%	16,860	66.5%	16.2%	16.5%	16.0%
Southeast	20.1%	21.1%	15,918	68.9%	28.8%	29.4%	26.4%
Southwest	15.6%	15.4%	13,006	82.9%	13.5%	11.9%	19.9%

* VMT per Driver is an approximate measure. VMT is specific to a region, including drivers in transit from other regions, and drivers are based on licensed regional drivers.

Table 8 shows the urban percentage of a region relative to a region's mortality indices for fatal accidents, occupants and non-occupants. There is a notable relationship of the urban percentage to the indices. Fatal accidents and occupant deaths (drivers and passengers) have strong negative correlations to the urban percentages of -0.55 and -0.69, respectively. Non-occupant deaths (mostly pedestrians and pedacyclists) correlate positively to the urban percentage but with less strength at 0.35. The relationship of the urban percentage in a region of MVA deaths and the incidence of fatal accidents is a theme that is evident in subsequent analysis within this section.

Table 8
2016 REGIONAL URBAN PERCENTAGE VS. FATAL ACCIDENT AND PERSON TYPE INDICES*

Region	Urban % of Region	Fatal Accident Index	Occupant Index	Non-Occupant Index
Mid-Atlantic	68.8%	0.80	0.79	0.77
Midwest	66.3%	0.85	0.88	0.68
Northeast	79.4%	0.60	0.58	0.67
Northwest	63.6%	0.80	0.83	0.74
NY-NJ	85.0%	0.55	0.44	0.85
Plains	52.2%	1.16	1.31	0.65
Rockies	58.1%	1.00	1.08	0.70
South Central	66.5%	1.40	1.42	1.24
Southeast	68.9%	1.36	1.39	1.31
Southwest	82.9%	0.88	0.77	1.28

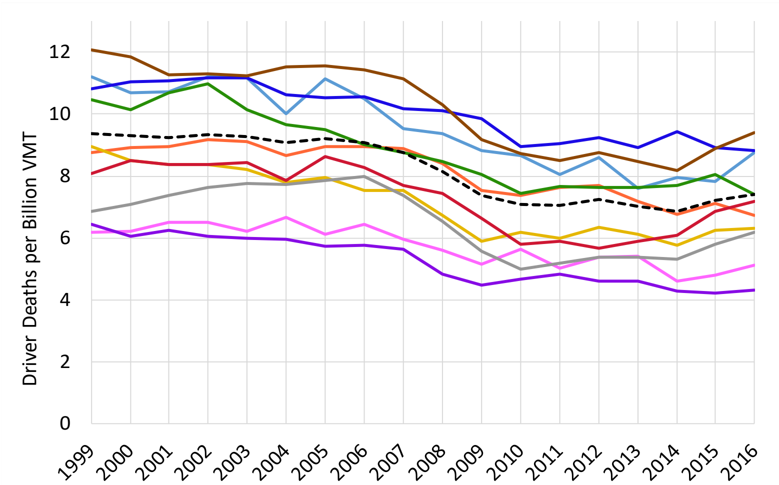
* The indices are derived from Table 7. They show the regional share of fatal accidents and deaths in relation to the regional share of exposure. The exposure for fatal accidents and occupants is drivers, and for non-occupants, it is population. For example, the Fatal Accident Index is derived as the Fatal Accident % of Nation divided by the Drivers % of Nation. A value greater than one means that a region has more fatal accidents given its number of drivers than the national average.

2.4.2 Driver Death Rates

Figure 16 shows a substantial variation of fatal MVA driver rates by geographic region. Generally, each region follows the All Regions pattern, which has a moderate decline from 1999 to 2005, and then accelerates until a relative flattening of the rate at about 2010-2011 which, with a modest uptick in 2012, continues to a low in 2014, followed by an increase in each of 2015 and 2016. While all regional accident driver death rates decrease during 1999-2016, the range between the highest and lowest rates and their rank relative to one another is consistent. Averaged over 1999-2016, the Southeast and NY-NJ had the highest and lowest rates, respectively. The Southeast rate of 10.2 deaths per billion VMT was 92% higher than the same rate, 5.3 deaths per billion VMT, for NY-NJ.

Figure 16

MOTOR VEHICLE ACCIDENT DRIVER DEATHS BY REGION



Region	1999 - 2016 Driver Death Rate 1999 - 2016	Driver Death Rate Region minus National	Annual Improvement 1999 - 2016	Annual Improvement Region minus National
Mid-Atlantic	8.2	0.0	1.5%	0.2%
Midwest	7.1	-1.1	2.0%	0.7%
Northeast	5.8	-2.5	1.1%	-0.3%
Northwest	7.3	-0.9	0.7%	-0.7%
NY-NJ	5.3	-2.9	2.3%	0.9%
Plains	9.5	1.3	1.4%	0.1%
Rockies	8.8	0.6	2.0%	0.6%
South Central	10.0	1.8	1.2%	-0.2%
Southeast	10.2	2.0	1.5%	0.1%
Southwest	6.5	-1.7	0.6%	-0.8%
All Regions	8.2		1.4%	

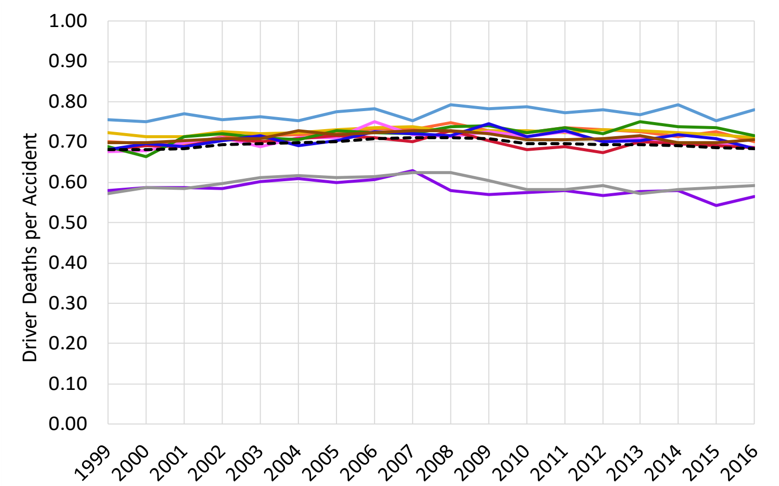
2.4.3 Deaths per Accident by Person Type

Figures 17, 18, and 19 show the number of driver, passenger, and non-occupant deaths, conditional on the occurrence of a fatal accident, by geographic region. Because a fatal accident can be due to one death of any person type, the average number per accident for each is less than one. The combined experience of all person types averaged over 1999-2016 was 1.10 deaths per fatal accident.

Nationally for all regions, the rate per fatal accident for drivers in Figure 17 is consistent during 1999-2016. Most regional rates are clustered in a band near the national average except for the Plains, Southwest, and NY-NJ. The Plains are above the average and the other two regions are below it.

Figure 17

MOTOR VEHICLE ACCIDENT DRIVER DEATHS PER ACCIDENT BY REGION

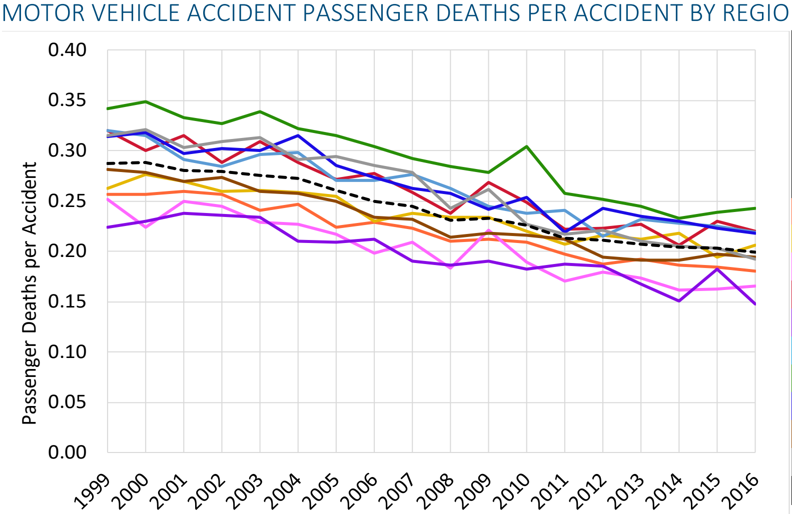


	1999 - 2016			
	Driver Death Rate		Annual Improvement	
Region	1999 - 2016	Region minus National	1999 - 2016	Region minus National
Mid-Atlantic	0.72	0.02	0.0%	0.0%
Midwest	0.72	0.03	0.1%	0.1%
Northeast	0.71	0.01	-0.1%	0.0%
Northwest	0.70	0.00	0.0%	0.0%
NY-NJ	0.59	-0.11	0.2%	0.2%
Plains	0.77	0.07	-0.2%	-0.2%
Rockies	0.72	0.02	-0.2%	-0.2%
South Central	0.71	0.01	0.0%	0.0%
Southeast	0.71	0.02	-0.1%	0.0%
Southwest	0.60	-0.10	-0.2%	-0.2%
All Regions	0.69		0.0%	

Figure 18 shows the regions have relatively consistent annual rank of the number of passenger deaths per fatal accident, which has a moderate decreasing trend through all years that is in a tighter range from high to low than the corresponding driver or non-occupant mortality measure. Nationally, the rate declines from 0.29 in 1999 to 0.20 in 2016. This 31% decrease contrasts to the corresponding fatal driver rate (see Figure 17), which was the same in 1999 and 2016. NY-NJ was the lowest region in 1999 and 2016, but frequently traded places during the period for lowest annual rate with the Northeast, while the Rockies had the highest rate in all years. The Rockies rate was 52% and 47% higher than NY-NJ in 1999 and 2016, respectively.

Figure 18

MOTOR VEHICLE ACCIDENT PASSENGER DEATHS PER ACCIDENT BY REGION

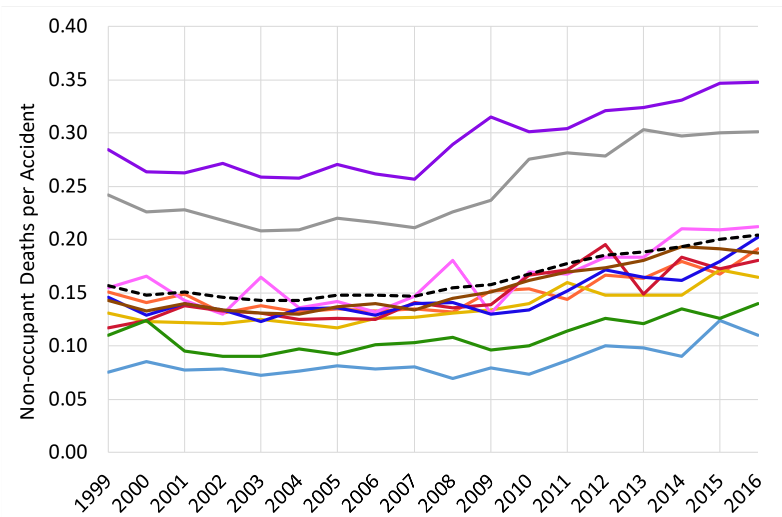


	1999 - 2016			
	Passenger Death Rate		Annual Improvement	
Region	1999 - 2016	Region minus National	1999 - 2016	Region minus National
Mid-Atlantic	0.22	-0.02	2.0%	-0.1%
Midwest	0.24	-0.01	1.4%	-0.7%
Northeast	0.21	-0.04	2.4%	0.3%
Northwest	0.27	0.02	2.2%	0.1%
NY-NJ	0.20	-0.04	2.4%	0.3%
Plains	0.27	0.02	2.2%	0.1%
Rockies	0.30	0.05	2.0%	-0.1%
South Central	0.27	0.02	2.1%	0.0%
Southeast	0.23	-0.01	2.2%	0.1%
Southwest	0.26	0.02	2.9%	0.8%
All Regions	0.25		2.1%	

Figure 19 shows that the All Regions number of non-occupant deaths per fatal accident after being mostly flat from 1999 to 2007 steadily increased since then from 0.15 to 0.20 in 2016. It was the only person type where all regions' mortality increased from 1999 to 2016 on this measure. NY-NJ had the highest rate in all years followed by the Southwest. The Plains had the lowest rate in all years, with the Rockies as the next lowest in all years. Notably, number of deaths per accident for non-occupants, which are mostly pedestrians and pedacyclists, in NY-NJ and the Southwest was higher than the corresponding highest regional passenger measure in 2016. Non-occupant rank order for the Plains, NY-NJ, and the Southwest was reverse of that for drivers (see Figure 17). Although specific deaths were not mapped to urban or rural locations, the data suggests the driver death rate per accident is lower in urban locations, in part, because non-occupant deaths, mostly pedestrians and pedacyclists, occur more often in urban areas where NY-NJ and the Southwest have the highest urban percentages. Conversely, the opposite applies to the Plains, which has the highest rural percentage.

Figure 19

MOTOR VEHICLE ACCIDENT NON-OCCUPANT DEATHS PER ACCIDENT BY REGION



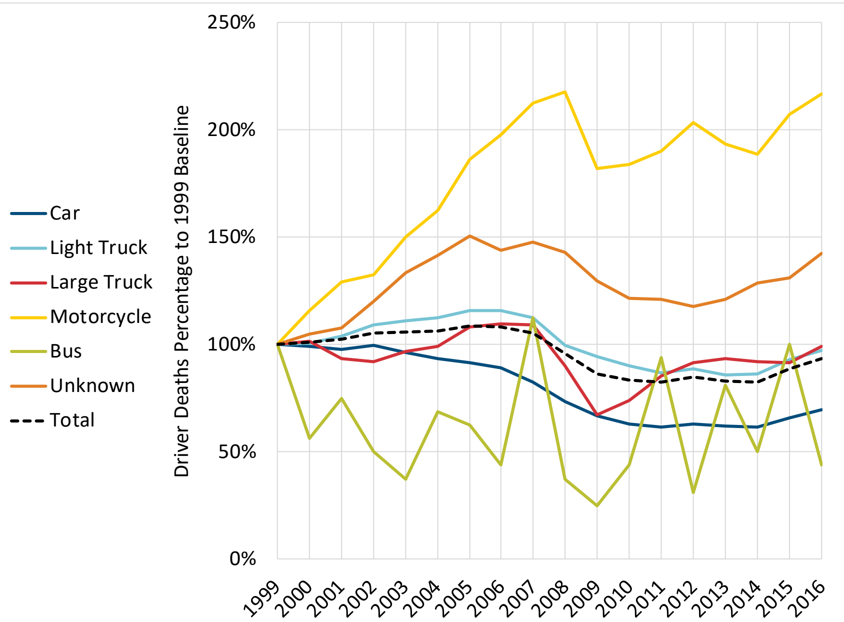
Region	1999 - 2016 Non-Occ Death Rate 1999 - 2016	Non-Occ Death Rate Region minus National	Annual Improvement 1999 - 2016	Annual Improvement Region minus National
Mid-Atlantic	0.15	-0.01	-1.4%	0.2%
Midwest	0.13	-0.03	-1.4%	0.2%
Northeast	0.16	0.00	-1.9%	-0.3%
Northwest	0.15	-0.02	-2.5%	-1.0%
NY-NJ	0.29	0.13	-1.2%	0.4%
Plains	0.08	-0.08	-2.3%	-0.7%
Rockies	0.11	-0.05	-1.4%	0.2%
South Central	0.15	-0.02	-1.9%	-0.4%
Southeast	0.15	-0.01	-1.6%	0.0%
Southwest	0.25	0.08	-1.3%	0.3%
All Regions	0.16		-1.6%	

2.5 Vehicle Type

Figure 20 shows the change in MVA driver deaths by vehicle type as an index relative to deaths in 1999. Because the results are shown by number of driver deaths, the change in the number of drivers and vehicle miles traveled by vehicle type, which is unknown, affects the trends. Except for bus driver deaths, which are small and erratic, drivers of cars had the greatest annual improvement of 2.1% from 1999-2016. Light trucks, which include sport utility vehicles, had lower corresponding annual improvement of 0.2%. The annual improvement rate of cars and light trucks combined is 1.2%. Motorcycle driver deaths had the worst experience with a very high 4.6% annual increase from 1999-2016. Motorcycle driver deaths more than doubled from 1999-2008 and, after a decrease in 2009, have returned to their previous high in 2016. Except for buses, all vehicle types had higher driver deaths in 2016 than 2015. Experience ranged from increases of 4.5% to 8.7% (buses excluded) for motorcycle and unknown type of vehicle drivers, respectively. Large trucks also recorded a notable 8.0% one-year increase in 2016.

Figure 20

CHANGE IN MVA DEATHS BY VEHICLE TYPE



	Driver Deaths*		Annual Improvement	
Vehicle Type**	1999	2016	1999-2016	2015-2016
Car	14,186	9,913	2.1%	-6.1%
Light Truck	7,785	7,567	0.2%	-4.8%
Large Truck	644	638	0.1%	-8.0%
Motorcycle	2,286	4,950	-4.6%	-4.5%
Bus	16	7	4.7%	56.3%
Unknown	340	485	-2.1%	-8.7%
Total	25,257	23,560	0.4%	-5.4%

* Includes both genders

** Light truck combines light pickup, light utility, light van and light other

2.6 Driver Alcohol Impaired

This section analyzes the influence of alcohol on the occurrence of MVA driver deaths. For this purpose, alcohol impaired (AI) is defined as a blood alcohol concentration (BAC) at or over 0.08 grams (0.04 grams for large truck and bus drivers) per deciliter (g/dL). FARS BAC data is used for this purpose. Details about the data are discussed in Data and Methods.

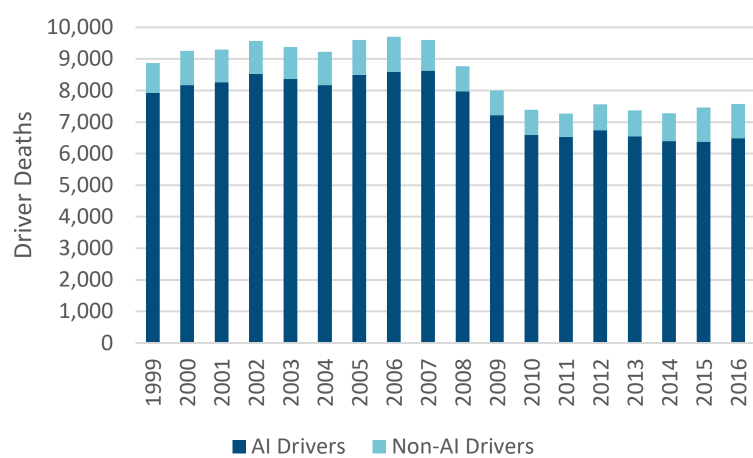
2.6.1 AI Driver Deaths

Figure 21 shows fatal AI-related accident driver deaths and divides them between AI and non-AI drivers from 1999-2016. For this purpose, an accident is AI related if any driver in the accident is AI. Total driver deaths from AI accidents rose from 8,874 in 1999 to a peak of 9,704 in 2006, then trended down to a low of 7,266 in 2011 and ended 2016 at 7,575. This produced a 0.9% annual improvement during 1999-2016, but total AI accident deaths from more recent periods show reversals of prior improvement. During 2011-2016, AI accident deaths increased by 0.8% on an annual basis, and by 1.6% from 2015 to 2016. Total AI accident related driver deaths were 35.1% and 32.2% of all driver deaths in 1999 and 2016, respectively.

Annual AI driver deaths decreased while non-alcohol driver deaths increased from 1999 to 2016. AI driver experience improved by 1.2% on an annual basis from 1999-2016, but in more recent years, this experience has leveled off. AI deaths decreased by only 0.1% annually from 2011-2016 and increased by 1.7% in 2016. Non-AI MVA driver deaths varied more but were based on much smaller numbers. During 1999-2016, non-AI driver deaths in AI accidents increased annually by 0.8%. Non-AI driver deaths peaked in 2006 at 1,118 and, after a period of improvement, reached a low of 734 in 2011, then reversed most of the prior gains with 1,089 deaths in 2016. This produced a very high average annual 8.2% increase from 2011-2016 and a 0.7% increase from 2015-2016.

Figure 21

ALCOHOL IMPAIRED RELATED ACCIDENT DRIVER DEATHS



AI Status	Annual Improvement 1999-2016	2011-2016	2015-2016
Both	0.9%	-0.8%	-1.5%
AI	1.2%	0.1%	-1.7%
Non-AI	-0.8%	-8.2%	-0.7%

Based on MVA AI and Non-AI driver deaths in an AI-related accident where there were one or more AI drivers.

AI drivers comprised 89% of all driver deaths in AI-related accidents from 1999-2016. Table 9 shows the mix of the number of drivers and vehicles in these accidents. Most fatal AI-related accident deaths involved only one AI driver. AI driver deaths from a one car accident were 65% of all AI-related driver deaths. When two vehicles were involved in an AI related accident, AI driver and non-AI driver deaths were 20% and 9% of all AI related driver deaths, respectively.

Table 9

AI ACCIDENT DRIVER DEATHS BY NUMBER OF VEHICLES INVOLVED AND AI STATUS

	AI Drivers		Non-AI Drivers		AI and Non-AI Drivers	
Vehicles	Deaths	%	Deaths	%	Deaths	%
1	100,314	65%	0	0%	100,314	65%
2	30,923	20%	13,167	9%	44,089	29%
3 or More	4,729	3%	4,056	3%	8,785	6%
Total	135,965	89%	17,223	11%	153,188	100%

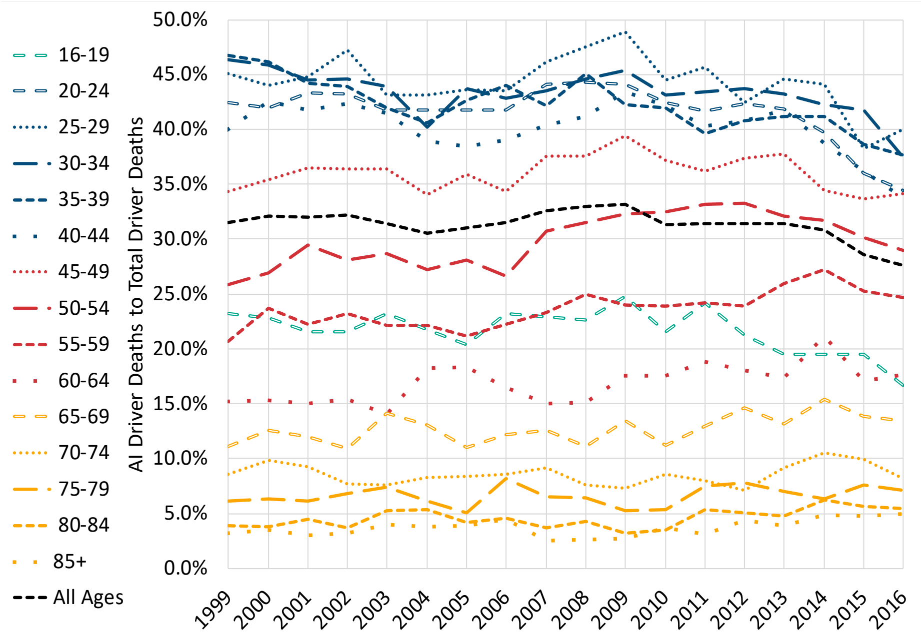
The following sections discuss the variation of experience due to AI drivers relative to age, gender, and region. AI driver mortality rates are analyzed relative to the experience of all drivers (AI plus non-AI) for a given classification, e.g. gender. While the actual AI driver mortality rates could be shown, they are not because their patterns are affected by the characteristics of AI and non-AI drivers. Measurements of AI driver experience alone could include other effects not related to AI. By comparing AI to total experience of the same group, the relative level and improvement or deterioration due to AI can be judged.

2.6.2 Age

Figure 22 shows the percentage of AI driver deaths to total driver deaths by age group from 1999-2016. All ages combined had an annual 0.8% decrease from 1999-2016. The degree of improvement accelerated, with annual 2.6% and 3.5% decreases in 2011-2016 and 2015-2016, respectively. Generally, except for age group 16-19, lower age groups had a higher proportion of AI deaths. Age groups ranging from 20-49 had higher AI than the average of all ages combined for every year in 1999-2016. The highest percentage occurred for ages 25-29, 48.9%, in 2009. Age groups 16-19 and 55 and over, had AI driver death percentages less than all ages combined in every year, but these ages, except ages 16-19 and 70-74, had deteriorating relative AI driver deaths from 1999-2016. The greatest deterioration occurred for age group 85+, which had an average annual AI percentage increase of 2.5%, but that increase occurred from the lowest age group percentage in 1999 of 3.2% and remained the lowest age group in 2016 at 4.9%. The highest age group percentage in 2016 occurred for ages 25-29, which had 40% of driver deaths classified as AI. All age groups, except ages 25-29, 60-64, and 85+, which increased 4.7%, 3.3% and 4.4%, respectively, had decreasing percentages of AI deaths from 2015-2016. The highest decrease, 17.7%, occurred for age group 70-74.

Figure 22

ALCOHOL IMPAIRED PERCENTAGE OF DRIVER DEATHS BY AGE GROUP



	Avg AI %	Annual Improvement		
Age Group*	1999-2016	1999-2016	2011-2016	2015-2016
16-19	21.9%	2.0%	7.2%	14.8%
20-24	41.8%	1.2%	3.7%	4.2%
25-29	44.3%	0.7%	2.6%	-4.7%
30-34	43.4%	1.3%	2.9%	10.4%
35-39	42.4%	1.2%	1.0%	2.4%
40-44	40.2%	1.0%	3.5%	6.8%
45-49	36.0%	0.0%	1.2%	-1.3%
50-54	29.7%	-0.7%	2.7%	4.0%
55-59	23.5%	-1.0%	-0.4%	2.3%
60-64	16.8%	-0.9%	1.3%	-3.3%
65-69	12.6%	-1.1%	-0.6%	2.9%
70-74	8.5%	0.3%	-0.5%	17.7%
75-79	6.6%	-0.9%	1.1%	6.7%
80-84	4.5%	-2.0%	-0.2%	3.7%
85+	3.7%	-2.5%	-10.0%	-4.4%
All Ages	31.4%	0.8%	2.6%	3.5%

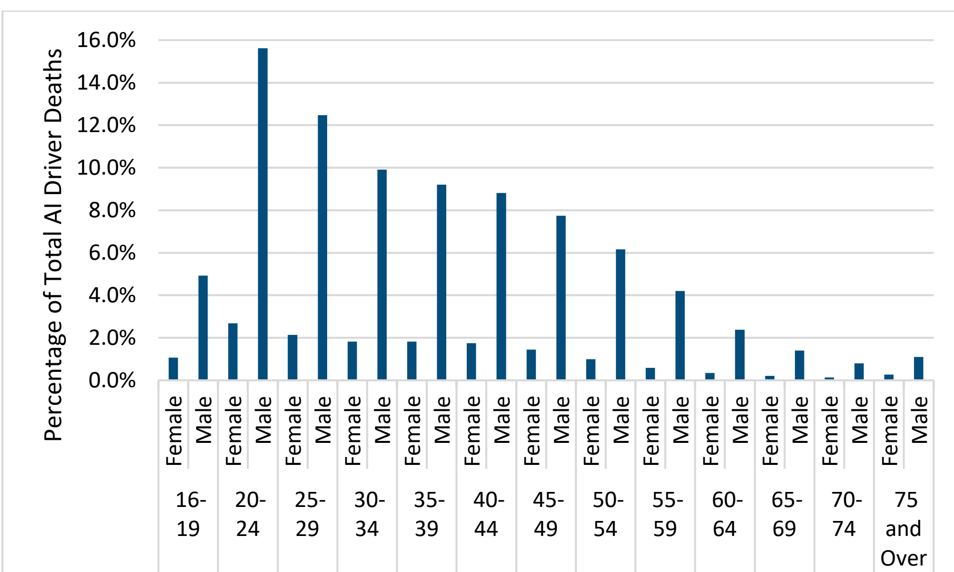
* Includes both genders

2.6.3 Gender

Figure 23 shows the gender composition of AI deaths by age group for all years (1999-2016) combined. The pattern by age group for males is like the hierarchy of AI percentages by age group in Figure 22 because males are the predominant proportion of AI drivers. For all ages combined from 1999-2016, males were 84.7% of all AI driver deaths.

Figure 23

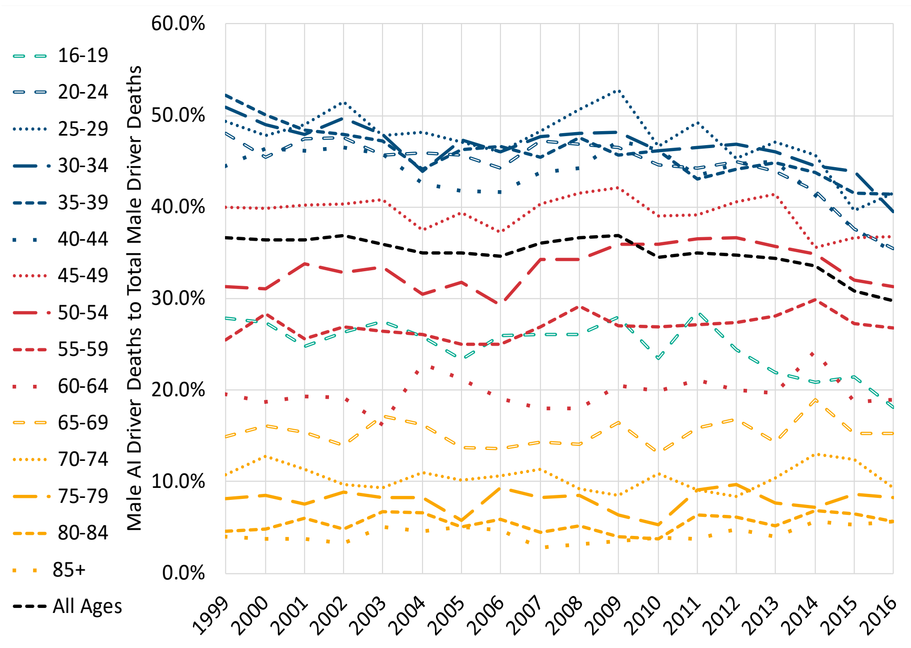
ALCOHOL IMPAIRED BY AGE GROUP AND GENDER 1999-2016



Figures 24 and 25 show the percentage of AI male and female driver deaths, respectively, relative to total male and female driver deaths by age group. Generally, the hierarchy of ages is consistent across gender, but male AI percentages are higher than the same age group female AI percentages. For all ages combined in 1999, the male and female AI percentages were 36.6% and 17.5%, respectively, and in 2016 were 29.8% and 20.1%, respectively. Whereas male AI percentages trended down from 1999-2016, female AI percentages trended slightly up. During 1999-2016, the male AI percentage for all ages combined decreased by an annual 1.2% rate, while the female AI percentage increased annually by 0.8%. Both genders recorded similar AI percentage decreases for all ages combined from 2015-2016, with male and female decreases of 3.4% and 4.2%, respectively.

Figure 24

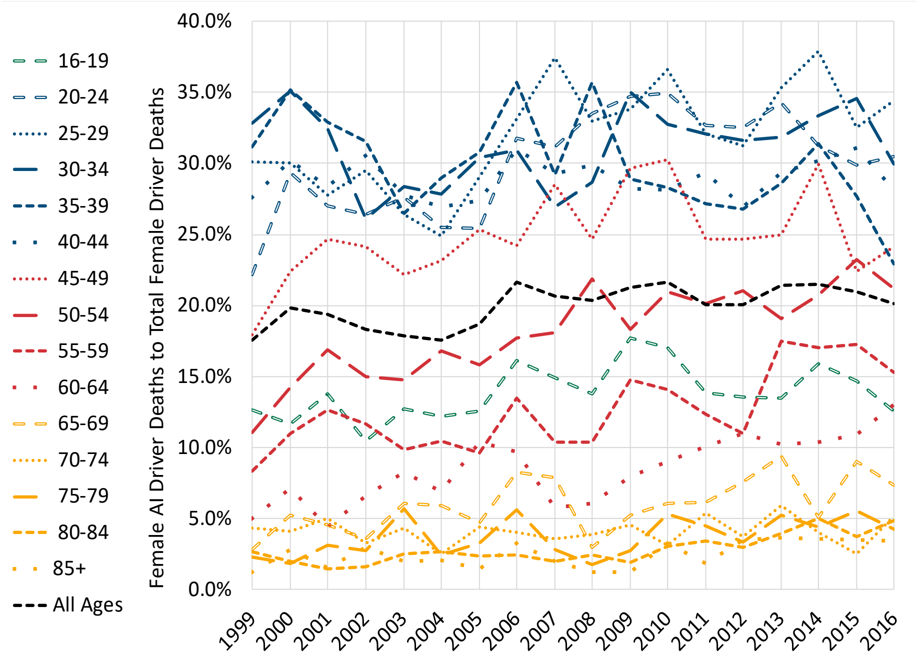
MALE - AI PERCENTAGE OF DRIVER DEATHS



Age Group	Avg AI % 1999-2016	Annual Improvement 1999-2016	Annual Improvement 2011-2016	Annual Improvement 2015-2016
16-19	25.4%	2.5%	8.7%	15.4%
20-24	44.9%	1.8%	4.3%	5.6%
25-29	47.4%	1.0%	3.4%	-4.8%
30-34	46.7%	1.5%	3.2%	9.9%
35-39	46.2%	1.4%	0.8%	0.2%
40-44	43.7%	1.4%	4.2%	6.5%
45-49	39.4%	0.5%	1.2%	-0.5%
50-54	33.4%	0.0%	3.0%	2.5%
55-59	27.0%	-0.3%	0.3%	2.1%
60-64	19.8%	0.2%	2.2%	-1.0%
65-69	15.3%	-0.2%	0.7%	-0.5%
70-74	10.5%	0.8%	-0.6%	24.5%
75-79	8.0%	-0.1%	1.9%	4.8%
80-84	5.5%	-1.3%	2.1%	12.4%
85+	4.3%	-2.0%	-8.4%	-6.3%
All Ages	35.0%	1.2%	3.2%	3.4%

Figure 25

FEMALE - AI PERCENTAGE OF DRIVER DEATHS

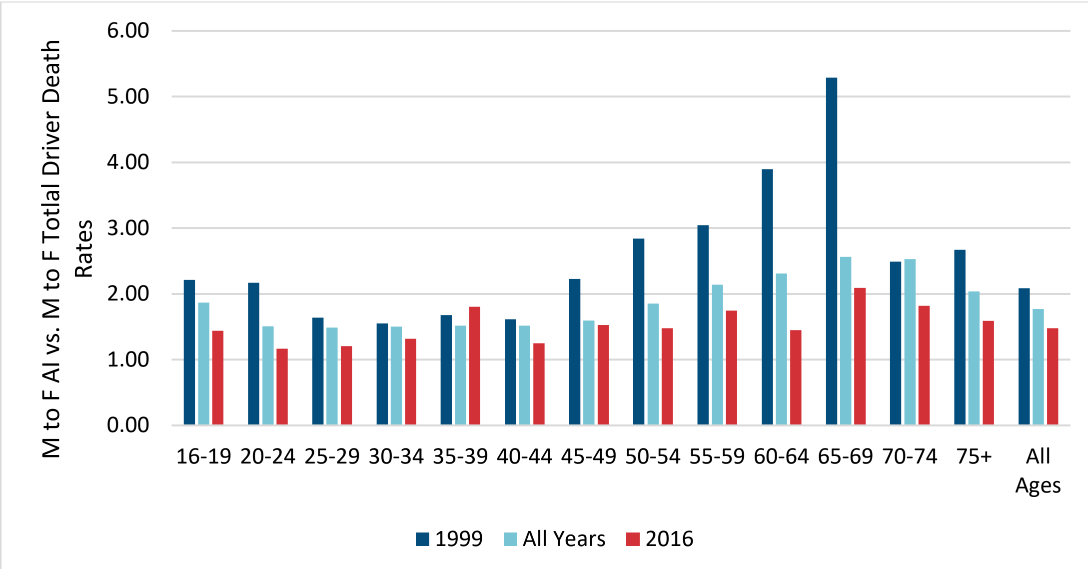


	Avg AI %	Annual Improvement		
Age Group	1999-2016	1999-2016	2011-2016	2015-2016
16-19	13.6%	0.0%	1.9%	14.3%
20-24	29.7%	-1.9%	1.4%	-1.9%
25-29	31.8%	-0.8%	-1.4%	-5.8%
30-34	31.1%	0.5%	1.4%	13.3%
35-39	30.4%	1.8%	3.3%	17.2%
40-44	28.9%	-0.1%	0.8%	9.5%
45-49	24.8%	-1.8%	0.4%	-7.7%
50-54	18.0%	-3.9%	-1.0%	8.9%
55-59	12.6%	-3.6%	-4.4%	11.5%
60-64	8.5%	-5.8%	-5.2%	-19.9%
65-69	6.0%	-5.8%	-3.6%	18.4%
70-74	4.1%	-1.0%	1.0%	-102.5%
75-79	3.6%	-3.7%	1.0%	23.2%
80-84	2.7%	-3.6%	-7.0%	-30.0%
85+	2.5%	-6.3%	-13.4%	1.6%
All Ages	19.8%	-0.8%	-0.1%	4.2%

Figure 26 shows a comparison of the male to female ratio of AI driver death rates to the corresponding ratio of total male to female driver death rates. Comparing the respective male to female ratios of AI drivers and all drivers (AI plus non-AI) isolates the AI effect. When viewed at a point in time, the measure indicates whether the ratio of male to female AI mortality is higher (greater than 1.0) or lower (less than 1.0) than corresponding male to female mortality of all drivers. The pattern generally shows a decreasing value from 1999-2016. This is caused by decreases in male AI to total driver death rates shown in Figure 24 and increases shown in Figure 25 of corresponding female AI to total driver death rates. During 1999-2016, the measure decreased for every age group except ages 35-39. For all ages combined, the measure decreased from 2.09 in 1999 to 1.48 in 2016 and averaged 1.77 over the full period. This implies that male AI mortality experience improved relative to females because the male to female AI ratio decreased relative to the same ratio for all drivers. However, even with this improvement, male AI experience was relatively worse than females for all ages combined in both 1999 and 2016.

Figure 26

1999-2016 MALE TO FEMALE AI DRIVER DEATH RATES VS. MALE TO FEMALE TOTAL DRIVER DEATH RATES

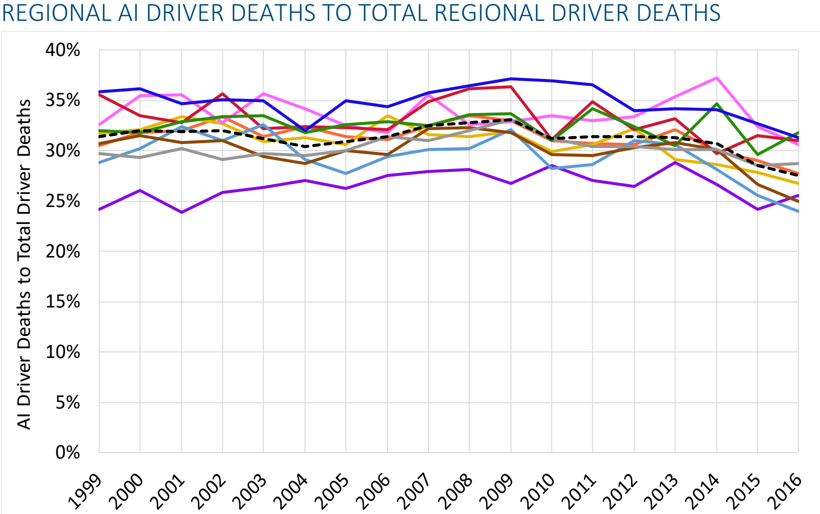


2.6.4 Region

Figure 27 shows relative regional AI experience. During 1999-2016, the national percentage of AI drivers to all drivers MVA deaths decreased by an annual average of 0.8%. All regions except NY-NJ and the Rockies had decreasing percentages of AI driver deaths. The greatest reduction occurred in the Southeast, which saw its AI percentage decrease by 1.2% on an annual basis, while the NY-NJ region saw the most increase with the AI percentage going up by an annual 0.3% rate. But even with an increasing AI percentage, the NY-NJ region had the lowest percentage in most years from 1999-2016. In most years, South Central was the highest region. During 2015-2016, all regions except NY-NJ, the Rockies, and the Southwest had decreasing percentages. The Plains had the largest one-year decrease, 6.9%, while the Rockies had the largest one-year increase of 7.0%.

Figure 27

REGIONAL AI DRIVER DEATHS TO TOTAL REGIONAL DRIVER DEATHS



	1999 - 2016			
	Avg AI %		Annual Improvement	
Region	1999 - 2016	Region minus National	1999 - 2016	Region minus National
Mid-Atlantic	31.4%	0.2%	0.6%	-0.2%
Midwest	31.0%	-0.2%	1.0%	0.2%
Northeast	33.7%	2.5%	0.4%	-0.4%
Northwest	33.2%	2.0%	0.8%	0.0%
NY-NJ	26.5%	-4.7%	-0.3%	-1.1%
Plains	29.5%	-1.7%	1.1%	0.3%
Rockies	32.5%	1.3%	0.0%	-0.7%
South Central	34.8%	3.6%	0.8%	0.0%
Southeast	30.0%	-1.2%	1.2%	0.4%
Southwest	30.2%	-1.0%	0.2%	-0.6%
All Regions	31.2%		0.8%	

2.7 Time Series Analysis

2.7.1 Seasonal Variation

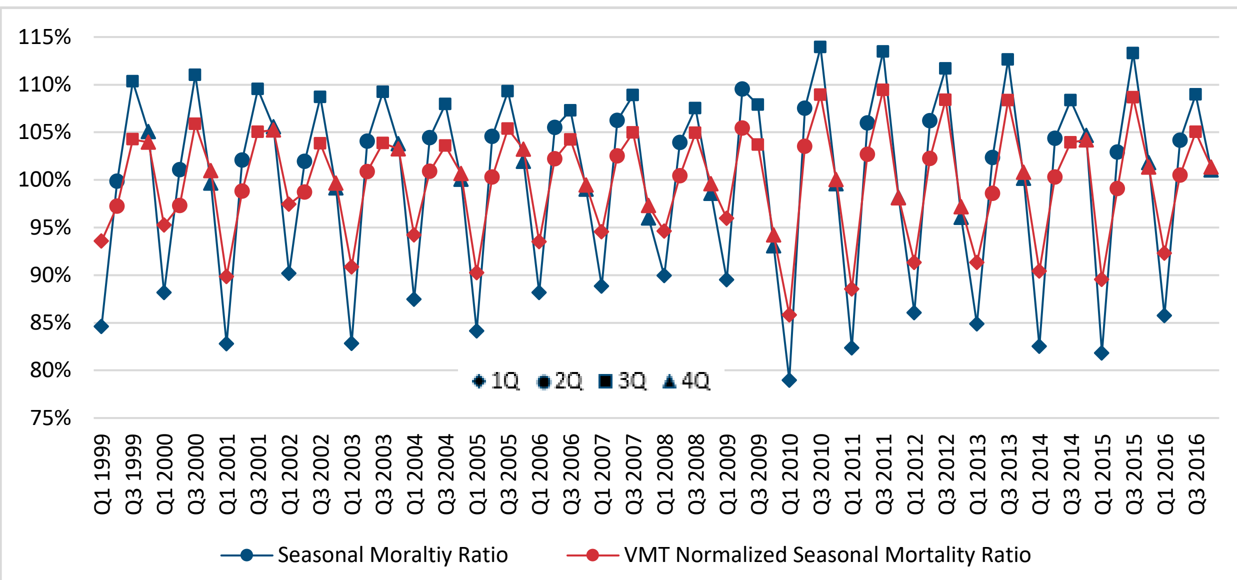
Motor vehicle accident deaths show significant seasonal and annual variation. Figure 28 shows seasonal variation of driver MVA death rates, by licensed drivers, on two bases for calendar quarters from 1999-2016. The seasonal ratio is derived as the ratio of the quarterly annualized mortality rate to the annual mortality rate. This is done with quarterly and annual rates that are unadjusted or adjusted by VMT. This produces two measures, the Seasonal Mortality Ratio (unadjusted) and VMT Normalized Seasonal Mortality Ratio.

Generally, the calendar quarterly ranking of the Seasonal Mortality Ratio from highest to lowest is third, second, fourth and first quarters. This aligns with the general pattern of VMT, which follows the same quarterly ranking, except for four years where the second and third quarters changed places. The calendar quarterly ranking of the VMT Normalized Seasonal Mortality Ratio does not have as much consistency but shows similar and compressed variation relative to the unadjusted ratio.

The quarterly variation of VMT follows an intuitive expectation that miles driven would be highest in the third quarter (most months in the summer) and lowest in the first quarter (most months in the winter). This pattern also applies in most years to the unadjusted and VMT-adjusted seasonal mortality ratios. This suggests that, even when allowance is made for fewer miles driven in the winter, the generally more hazardous conditions do not result in higher driver mortality rates than other times of the year.

Figure 28

SEASONAL VARIATION OF MVA DRIVER MORTALITY RATES 1999-2016



2.7.2 Driver Mortality Rate vs. External Factors

Figure 29 shows the change in driver mortality rates (unadjusted for seasonal VMT variation) in Figure 28 on a twelve-month lagged basis. Because there is seasonal quarterly variation, this basis is used to have consistent time series comparisons. Excluding the potential effect from higher driver densities, mortality variation from the number of drivers is implicitly neutralized in the mortality measure. Alternatively, VMT variation is not neutralized and it affects the measured rates across years.

Figure 29

CHANGE IN MVA DRIVER MORTALITY RATE - 12 MONTH LAG

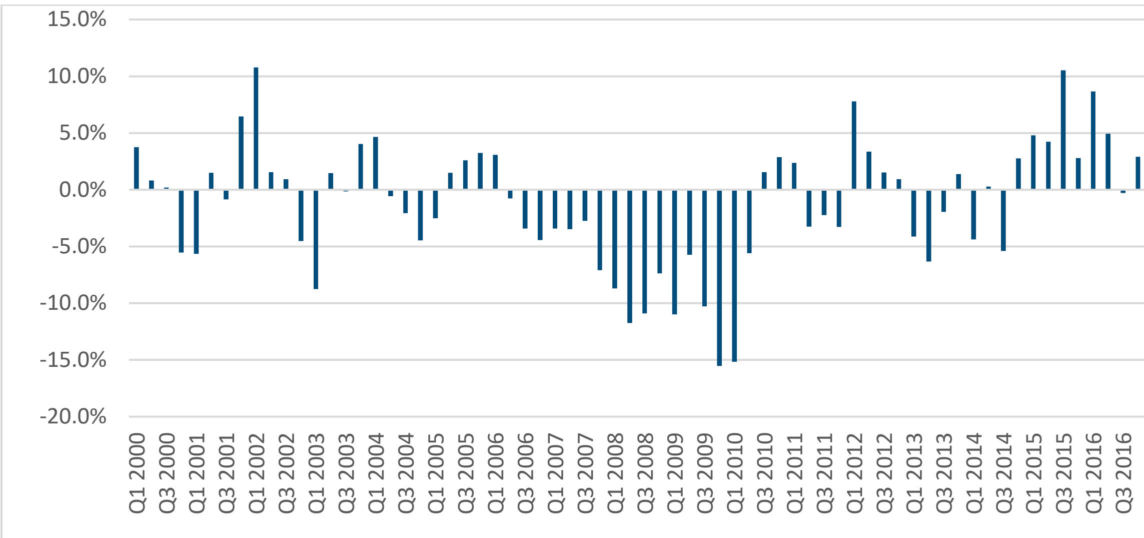


Table 10 shows linear regression results from various indicators as the predictor variables to MVA driver mortality rates shown in Figure 29 as the response variable. The change in MVA driver mortality rate with a twelve-month lag correlates in increasing degree, respectively, to the twelve-month changes of the unemployment rate, VMT, and fatal crash rate. The unemployment rate shows a borderline strong association with correlation of -0.49 (absolute value of 0.50 is considered strong). VMT shows a stronger association to driver mortality with a 0.72 correlation. The fatal crash rate shows the strongest association with a correlation of 0.95. The very high correlation of fatal crash rate to driver mortality should be expected because a fatal crash includes at least one fatality and drivers comprise the highest proportion, 63%, of MVA deaths.

The relationship of total MVA deaths to unemployment and VMT were reported for 2011-2015 by the NHTSA[4]. They reported correlations of -0.26 and 0.80 for unemployment and VMT, respectively. Because the time periods and basis of comparison are different (total MVA deaths versus driver mortality), different results should be expected than shown here with respect to those variables, but the result of a stronger relationship for VMT versus unemployment is consistent, which lends support for the correlations of unemployment and VMT shown below.

Unemployment shows an inverse relationship to driver mortality. The coefficient implies that a 1.00% increment to the unemployment rate will reduce driver mortality by 2.38%. The relationship is the opposite for VMT. Each 1.00% increase of VMT increases driver mortality by 2.62%. This suggests that, because it is not a one-to-one relationship, the density of traffic may have a material effect on the driver mortality rate. The fatal crash rate has a much more direct relationship to the driver mortality rate as intuitively would be expected. It serves as a check on the analysis and point of comparison to the first two indicators. The very low p values imply, with very high probability, that the stated coefficients are all non-zero.

Table 10

REGRESSION OF MVA DRIVER MORTALITY TO UNEMPLOYMENT AND OTHER INDICATORS

Indicator(s)*	Correlation	Coefficient	Coefficient 95% Confidence Level Range	p Value
Unemployment Rate	-0.49	-2.38	-3.43 – -1.33	<10E-4
VMT	0.72	2.62	2.00 – 3.23	<10E-11
Fatal Crash Rate per VMT	0.95	1.18	1.09 – 1.28	<10E-33

* Regressions use the twelve-month change on a quarterly basis for all predictor and response variables.

Table 11 shows the relationship of MVA driver deaths to the unemployment rate by vehicle type excluding bus (due to small numbers) and unknown type. Large truck had the highest response to the unemployment rate. The coefficient implies that a 1.00% increase in the unemployment rate will produce a 7.10% decrease in large truck driver deaths. This is intuitively appealing because it is reasonable to expect that large truck usage, which is associated with commercial enterprise, would show the greatest sensitivity to economic variation. The other three vehicles have lower correlation and coefficients. Passenger car shows results very similar to all vehicles combined in Table 10 for unemployment. Motorcycle and light truck have relatively low correlations. Because of that, regression conclusions are less reliable. Although their p values are less than 0.05 (considered a reliability breakpoint), some practitioners do not consider results reliable if the correlation is less than, exclusive of sign, 0.50.

Table 11

REGRESSION OF MVA DRIVER DEATHS TO UNEMPLOYMENT BY VEHICLE TYPE

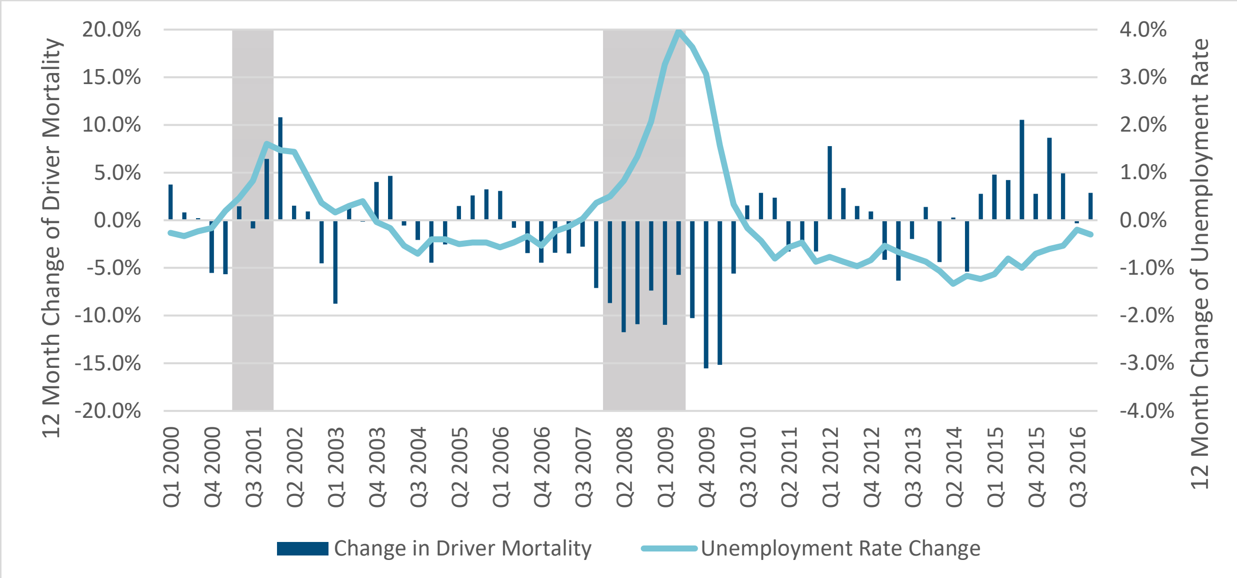
Vehicle*	Correlation	Coefficient	Coefficient 95% Confidence Level Range	p Value
Passenger Car	-0.43	-2.25	-3.43 – -1.08	<10E-3
Motorcycle	-0.28	-3.30	-6.09 – -0.51	0.021
Light Truck	-0.27	-1.54	-2.91 – -0.17	0.028
Large Truck	-0.57	-7.10	-9.63 – -4.55	<10E-6

* Regressions use the twelve-month change on a quarterly basis for all predictor and response variables.

The data in Table 10 and Table 11 show a strong association, but an imperfect one, of driver mortality to the unemployment rate over 1999-2016. Figure 30 modifies Figure 29 by adding the twelve-month change in the unemployment rate and shading to indicate recessions. Notably, the change in mortality over the prior twelve months correlated strongly during and after the 2008-2009 Great Recession with the unemployment rate change. Mortality also showed results in contradiction to that correlation, falling with unemployment decreases and increasing during rising unemployment. These occurrences serve to reduce the correlation. While they are not analyzed here, there are likely other causes of variation, including random variation, that are substantial and not strongly related to the economy. Other studies discuss reduced MVA deaths due to safety standards, behavioral trends (e.g. reduced fatal MVA driver alcohol impairment), and graduated driver license programs[3 5 6], which contribute to the downward drift of MVA deaths. These are potential disrupters of higher correlation but are not quantified here. A steady decline would not impact correlation. The declines would have to be abrupt and infrequent.

Figure 30

CHANGE IN MVA DRIVER MORTALITY VERSUS CHANGE IN UNEMPLOYMENT RATE



Section 3: Reliance and Limitations

MVA deaths and mortality rates are derived from publicly available data available through two parts of the US Department of Transportation, the National Highway Transportation Safety Administration (NHTSA), and the Federal Highway Administration (FHWA). Fatal Analysis Reporting System (FARS) MVA death data is final through 2015 and is based on the preliminary 2016 file that was released in 2017. The report has not been updated for the final 2016 data released on September 27, 2018. The number of 2016 MVA deaths was revised up 0.9% from 37,461 to 37,806 in the final file. The NHTSA data is provided through FARS, which conforms to the Privacy Act. There are no restrictions on the use of this data, but no assessment has been made concerning the applicability of this experience to other purposes.

Appendix A: Data Sources and Methods

A.1 Data Sources

Data to calculate mortality and fatal accident rates are drawn from two sources within the US Department of Transportation. Motor vehicle accident (MVA) data is from the National Highway Transportation Safety Administration (NHTSA) Fatal Analysis Reporting System (FARS). The FARS data has accident-level detail on all motor vehicle accidents on public roadways involving at least one fatality within 30 days of a vehicle occupant or non-occupant. Although death can lag the date of the accident, this analysis assumes the accident date is the date of death. Exposure data to determine rates, licensed drivers, and vehicle miles traveled (VMT) is from the Federal Highway Administration (FHWA). Data on GDP and unemployment is from the Bureau of Economic Analysis and Bureau of Labor Statistics, respectively. Limited use of population data is drawn from CDC WONDER.

A.2 Methods

Mortality and fatal accident involvement rates are derived on two bases for drivers. Rates are based on the number of licensed drivers and vehicle miles traveled (VMT). When rates of improvement or change are cited that span more than one year, the quoted basis is always an average annual rate determined on a geometric basis. Licensed driver data is used for analysis by age and gender. Analysis by age group of drivers under age 16 is excluded because of unreliable results from very low exposure, but those drivers are included for analyses not covering age group distinctions to be consistent with other reported sources for results such as total MVA deaths. VMT is used for geographic regional analysis. Because VMT data is not age or gender specific, regional analysis is for all ages and both genders combined. Also, because VMT data is limited to region, gender, and age group, analysis does not include VMT differences that could affect those results. Analysis of passenger outcomes (fatal and non-fatal) from involvement in a fatal MVA is done with respect to the number of passengers in an accident. Incidence rates for passengers are not derived because the total number of passengers and their VMT involved and not involved in accidents are not known. Annual VMT and numbers of drivers are converted to a quarterly basis for the time series analysis. Deaths for that purpose are not estimated because the FARS data provides the date of the accident.

A.3 Alcohol Impairment

Alcohol impairment is defined as a blood alcohol concentration (BAC) at or over 0.08 grams (0.04 grams for large truck and bus drivers) per deciliter (g/dL). FARS provides BAC data composed of actual or imputed values for every driver[7]. When the BAC level of a driver is not known, FARS substitutes imputed values. This occurs for a variety of reasons where tests are not done, are not reported, or are not available. Frequently, there is no test done on drivers that die in an accident. The imputed values are determined through a regression procedure that produces ten BAC estimates. When a value is imputed, all ten BAC estimates must be considered to derive statistically reliable results. The number of alcohol impaired drivers is the average of the ten imputed estimates. For this purpose, each of the ten estimates is used to determine alcohol impairment. The resulting number of estimated instances of alcohol impairment for a person is divided by ten to determine the number impaired, which can range from zero to one. It is not sufficient or acceptable to average the BAC values to derive a single yes or no alcohol impairment determination for an individual.

Appendix B: Data Tables

An Excel file is available that contains data underlying figures and tables in the report. It is located on the SOA website: https://www.soa.org/research-reports/2018/us-motor-vehicle-deaths/. The Excel file is arranged with tables in tabs that follow the order of the figures and tables listed in the report. The data tables listed correspond directly to figures or tables in the report or, in some instances, enable the derivation of listed tables and figures. For example, Appendix B.3 can be used to construct Table 1, Figure 2, Figure 3 and Table 4. Appendices B.22 through B.27 are data that underlie other prior data tables. For example, Appendices B.25 and B.27 are used to construct Appendix B.12. The data tables are listed below.

Appendix	Data Table Content
B.1	Motor Vehicle Accidents By Type 1999-2015
B.2	Attribution Elements of MVA Fatalities
B.3	MVA Deaths by Person Type
B.4	MVA Driver Death Rates by Age Group
B.5	MVA Passenger In Transit Deaths By Age Group
B.6	MVA Passenger In Transit Deaths By Driver Age Group
B.7	1999 and 2016 MVA Passenger Deaths By Driver vs. Passenger Age Group
B.8	MVA Passenger Experience Conditional On Fatal Accident Involvement
B.9	MVA Excess No Passengers To With Passengers Fatal Accident Driver Involvement Rates By Age Group
B.10	MVA Non-Occupant Deaths By Age Group
B.11	MVA Female and Male Driver Mortality Rates By Age Group
B.12	MVA Driver Death Rates By Region
B.13	MVA Passenger Deaths Per Accident By Region
B.14	MVA Non-Occupant Deaths Per Accident By Region
B.15	MVA Driver Deaths By Vehicle Type
B.16	MVA Alcohol Impaired Accident Driver Deaths
B.17	MVA Alcohol Impaired Percentage Of Driver Deaths By Age Group
B.18	MVA Female and Male - Alcohol Impaired Percentage Of Driver Deaths By Age Group
B.19	MVA Regional Alcohol Impaired Driver Deaths To Total Regional Driver Deaths
B.20	Seasonal Variation Of MVA Driver Mortality Rates 1999-2016
B.21	Change In MVA Driver Mortality Versus Change In Unemployment Rate
B.22	MVA Female and Male Driver Deaths By Age Group
B.23	MVA Female and Male Alcohol Impaired Driver Deaths By Age Group
B.24	Female and Male Licensed Drivers by Age Group
B.25	MVA Driver Deaths by Region
B.26	MVA Fatal Accidents by Region
B.27	Vehicle Miles Traveled By Region

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