The International Young Researchers' Conference
DOI: 10.34614/iyrc2021f13

# Increase in Relative Highway Fatalities During the COVID-19 Pandemic with Respect to Driver Age Distribution

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## Abstract

The beginning of the COVID-19 pandemic in March, 2020 marked the start of a significant decrease in total vehicle miles traveled. This decrease was caused by lockdowns, increased unemployment and teleworking, and the shutdown of many different institutions. However, there has been a puzzling increase in relative highway fatalities per 100 million Vehicle Miles Traveled (VMT). In this paper I hypothesize that this increase in relative highway fatalities was due to a change in age profile of the drivers that was caused by rising unemployment rates and teleworking. I developed a model to represent the total highway fatalities as a weighted sum of each age group's contribution so that, by varying the age distributions, different total highway fatalities would be calculated. Age distributions were estimated for pre-COVID and during COVID times using various datasets. Despite using two different approaches with the model, the estimated age distributions for pre-COVID and during COVID ended up being too similar to demonstrate a significant increase in highway fatalities, and thus were unable to serve as evidence for the documented increase. However, different methods of estimation or including more factors could better showcase the change in driver age composition and, furthermore, better explain this increase in highway fatalities per 100 million VMT.

## Introduction

On March 13th, 2020 in the United States, in response to the prevalence of the infectious SARS-CoV-2 virus, the initial COVID-19 pandemic lockdown started. A national emergency proclamation from the president began the chain reaction of closures to prevent the spread of the virus (Trump, 2020). Schools, offices, stores, and other establishments shut down, putting "nearly 10 million Americans out of work" in just the first few weeks (Taylor, 2020). General unemployment rates soared with some parts of the population impacted more than others; women, at 14.3%, and young adults, at 25.3%, experienced some of the highest unemployment rates, exceeding their Great Recession rates by 4.9% and 5.3%, respectively (Kochhar, 2020). With this decrease in employment, along with enforced lockdowns, an increase in teleworking, and social distancing mandates, the logical effect would be more people staying home . Online grocery sales surged, sales increased by 79% (Leatherby & Gelles, 2020), suggesting that a significant sector of the population did not even drive to the grocery store to buy food. Based on this data, the assumption can be made that fewer people drove during these initial pandemic months.

The conjecture that the fewer people drove is, indeed, accurate, with a fall of around 50 trillion vehicle miles traveled (VMT) between March 1st and April 1st (Figure 1a). Overall, there was a

13.2% decrease in overall miles traveled in 2020 (NHTSA, 2021). Consequently, I assumed that the number of highway fatalities would decrease as well. However, the total number of highway fatalities continued in the same pattern as before after the pandemic began, and even increased (Figure 1b). To normalize the number of fatalities to the total driven miles, the Bureau of Transportation Statistics divided the two numbers and calculated the number of highway fatalities per 100 million VMT (Figure 1c). There was a sharp increase in relative highway fatalities from just before the pandemic started compared to during the pandemic -- the average until 1/1/2020 was 1.12 fatalities per 100 million VMT and increased to 1.47 after 4/1/2020. This reflected a significant increase of 0.35 highway fatalities per 100 million VMT (31.25% increase), from before to after the start of the pandemic (T-test returned a $p < 0.001$).

The question that these data pose is: what caused this relative increase in highway fatalities? The answer to this question is still unknown. However, some offered speculative reasonings, suggesting that this occurrence can be attributed to higher highway speeds, a heightened sense of general distress and craze from the pandemic, and a shift in the profile of the remaining active drivers (NHTSA, 2021; Liao & Lowry, 2021; Meyer, 2020). Still, uncertainty remains about the cause of this phenomenon. Here, I hypothesize that the majority of the increase in highway fatalities per 100 million VMT was not due to a direct mental effect of COVID-19 or increased speeding, but rather a change in the profile of drivers. Due to lockdowns, unemployment, and teleworking in the early phase of the pandemic, the profile of the drivers on the roads may have changed. In particular, since unemployment and teleworking likely has a differential effect on different age groups, I hypothesize that the age profile of the drivers may have changed and this change could potentially explain, at least in part, the increase in fatalities per 100 million VMT.

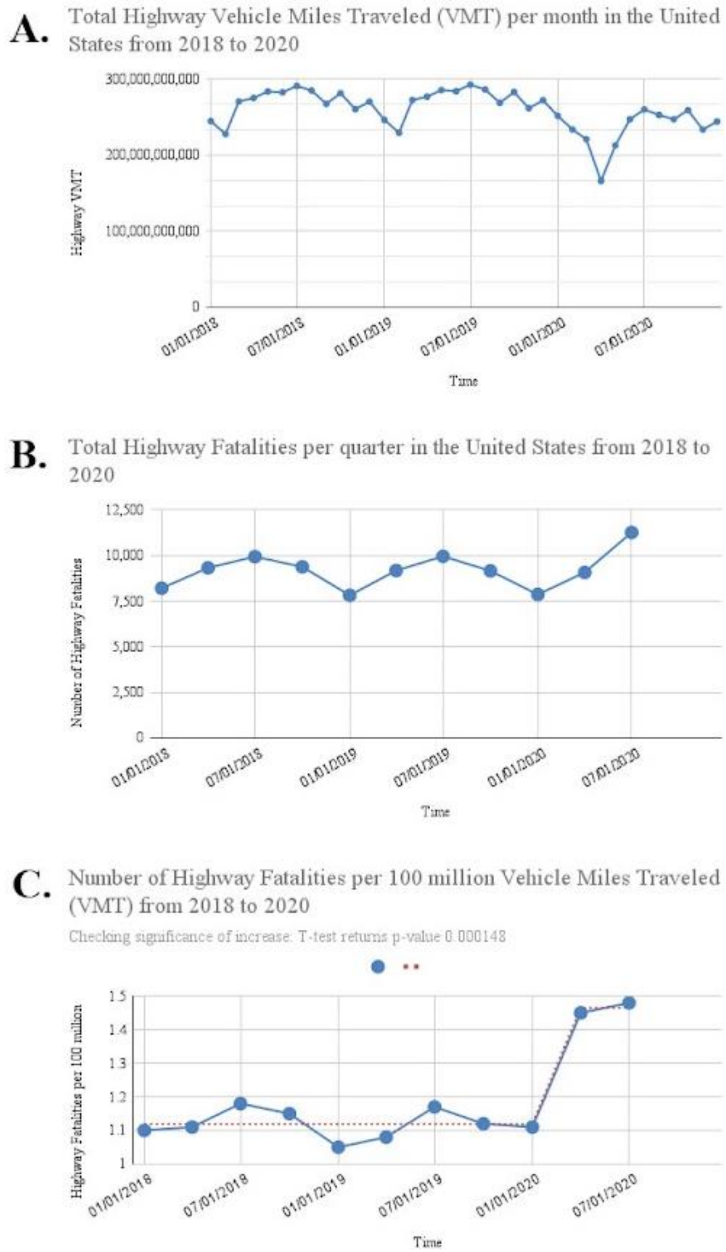


FIGURE 1. (a) Total Highway VMT in the United States from 2018 to 2020 recorded monthly. (b) Total Highway Fatalities in the United States from 2018 to 2020 recorded quarterly. (c) Number of Highway Fatalities per 100 Million VMT recorded quarterly. Data retrieved from the Monthly Transportation Statistics from the Bureau of Transportation Statistics of the U.S. Department of Transportation.

## Methods

Based on an initial inquiry about how the pandemic affected transportation, preliminary research was conducted through the Google Scholar search engine, with keywords such as 'highway fatalities', 'covid-19', '2020' and other versions and permutations of these. Using general Google searches, raw data was found and used from various government bureaus or private associations and organizations like the Bureau of Transportation Statistics, the Bureau of Labor Statistics, the AAA (American Automobile Association), and the Gun Violence Archives. Road rage data from the Gun Violence Archives, accessed on August 15th, listed the latest 2000 instances of gun-related road rage, most of which resulted in either injuries or fatalities, the earliest being on November 9, 2018.

*Generating Figure 1*

Data from the Bureau of Transportation Statistics was plotted using Google Sheets (Figure 1a and Figure 1b). Figure 1c was created through the same data set, with values of the number of Highway Fatalities per 100 million VMT. Additionally, the average values of before and during the pandemic were plotted in a red dashed line, where the before includes all values from 1/1/2018 until 1/1/2020. A Google Sheets T-test of unequal sized groups was then run to compare the different values from before and during the pandemic, resulting in a p. $< 0.001$.

*Model of number of highway fatalities per 100 million VMT based on age groups*

I modeled the number of highway fatalities per 100 million VMT as a weighted sum of each age group's contribution to the fatalities (Equation 1). I denoted the number of highway fatalities per 100 million VMT pre-COVID as yPand during COVID as yC. A represents the total number of age groups. The variable wi in both the pre-COVID and during COVID equations denotes the fraction of drivers within the ith age group. The variable yireflects the total number of highway fatalities per 100 million VMT if all drivers were from age group i. Here we assume that yi do not change due to the pandemic, and the only difference between pre-COVID and COVID times is the fraction of drivers in each age group.

$$y^P = \sum_{i=1}^{A} w_i^P y_i \qquad y^C = \sum_{i=1}^{A} w_i^C y_i$$

Equation 1: The models for the number of highway fatalities per 100 million VMT pre-COVID(yP) and during COVID (yC)using a weighted sum of each age group's contribution to the total number of highway fatalities.

*Estimating the age-specific Highway fatalities per 100 million VMT*

The values of yi values were estimated in two different approaches:

**Approach 1.** In the first approach, yi was calculated in 3 parts: a relative road rage index, a fatality crash index, and an unknown factor x (which was extracted from the data). The relative road rage index indicates a relative value that identifies for each age group the level of recklessness based on data from the AAA, where each age group had a value per aggressive action that represented the percentage of that age group that have participated in that action. The process to obtain the relative road rage index began by identifying which of the road rage actions listed in the table the AAA provided (Tailgate, Yell, Honk, Gesture, Block from changing lanes, Cut off, Confront, and Bump/Ram) would qualify as or could potentially lead to a fatality. After choosing 4 such categories (Block from changing lanes, Cut off, Confront, and Bump/ram) as those that would qualify, I calculated the relative increase in participating in this action in the specific age group. I first calculated the average percent of all age groups. Then, each action's percent value was divided by the average of that action. By averaging the resulting values per age group, the relative road rage indices were obtained.

The fatality crash index was taken from the AAA 2015 study that showed that individuals in the youngest age groups and the oldest age group were more likely to be involved in a fatal crash with rates per age group. Because the age groupings used in the study did not align with those in this study, it was assumed that the rate was constant across all ages within each age group range. The mean was then found for each of my study's age groups and served as the fatality crash index. The two indices were multiplied together to reflect the overall recklessness of drivers in each age group. I assume that the number of Highway fatalities per 100 million VMT is proportional to the combined index and therefore multiplied the indices by an unknown proportionx, which is later found by fitting to the pre-COVID data.

The wiP, or what percent of the total number of drivers each age group is, was found with data about distribution of licensed drivers. Once again, the age groupings in the data found were not consistent with those in my study, so the same methods had to be employed as previously stated with the fatality crash index. The given pre-COVID average number of highway fatalities per 100 million VMT, 1.12, was plugged in as yPand x was solved for using the values of wiPand yi, returning x = 0.68.

The fraction of drivers in each age group during COVID, wiC, was found by taking two factors into account: (i) the increase in unemployment rate from February to May, multiplying the pre-COVID fractions by (1 - addition unemployment rate); and (ii) the fraction of people that are teleworking, multiplying by (1 - the percent of employed people teleworking in May). Once the new wiC values were found, I normalized them again to reflect the fraction of each age group (Figure 3). The x value and yi values were multiplied by the wiCvalues (the distributions during COVID) to find the yC, which resulted with 1.125 highway fatalities per 100 million VMT, reflecting only a small increase from 1.12 (0.45% increase).

Approach 2. In the second approach, only the fatality crash index was used as yi and an x value was not necessary. Because this index was already in the correct units, it assumes the yi role perfectly; it represents the number of crash fatalities each age group would cause on its own. However, when plugged in with the wiPdistribution values, the yPdid not equal 1.12, but rather 1.56. When the calculated wiCdistribution values were multiplied by the yivalues, the yCequaled 1.59, reflecting an increase of 1.92%.

*Generating Figure 3*

I analyzed the list of gun violence road rage events and subsetted the data to highways by searching for road names that had '-' [dash] in their name and included one or more people killed (using Google Sheet functions). The remaining data was then grouped quarterly (summed values for every 3 months) in order to match the relative highway fatalities that were recorded quarterly. After lining up the data and finding the timepoints that had values for both the highway fatalities per 100 million VMT and the gun violence road rage, a scatter plot was made, with the x-axis being the number of highway fatalities per 100 million VMT and the y-axis being the number of highway fatalities due to gun violence road rage. The line of best fit that data was also plotted. The R2 value was found and from there, the p-value was calculated to check if this correlation is statistically significant (using an online calculator that used the R2 and number of data points).

## Results

To test if indeed there was a statistically significant difference between the before and during the pandemic subsets of relative highway fatalities, a T-test was run that returned a p. < 0.001. With this p-value, it proved itself to be significant. To try to explain this significant increase in highway fatalities, the change in age profile needed to be assessed. Firstly, the baseline age profiles of the drivers were evaluated to check how each group contributed to the total fatalities before COVID-19.

Due to a lack of access to the most accurate, fitting data, the distribution of age groups within the total number of drivers was taken from data about licensed drivers. I used these percentages to represent the distribution of active drivers pre-COVID by age (blue). The fact that I used licensed drivers rather than active drivers may pose inaccuracies in the distribution.

Next, to calculate the distribution of age groups driving during COVID (red), data on unemployment and teleworking were used to alter the percentages and then re-normalize them so they add up to 100% (Figure 2). According to my estimates, there did not seem to be much variation in the age profile of drivers from pre-COVID to COVID. The two factors had opposite effects, where the product of rise in unemployment and the percent teleworking counteracted each other and ended up keeping the overall fractions similar. However, social distancing measures and driving experience were not taken into account, thus my estimated fractions may be inaccurate. According to a Michigan Medicine study, over double the number of older adults felt lonely or isolated during the early months of the pandemic due to social distancing and COVID-19 restrictions (Gavin, 2020). Additionally, the oldest age group in data from the CDC, people above 60 years of age, consistently had the greatest percentage of participation in mitigating and safe behaviors during the pandemic, like maintaining 6 feet of social distance or avoiding restaurants and other public places (CDC, 2020). Another source mentioned their findings that older individuals were more consistent over time and were more quick to adopt behavioral changes, like the previously mentioned ones (Kabiri et al., 2020). The CDC explains how teens are at a greater risk of car accidents and fatalities due to inexperience, lack of seatbelt use, distracted driving, speeding, and alcohol use (CDC, 2021).

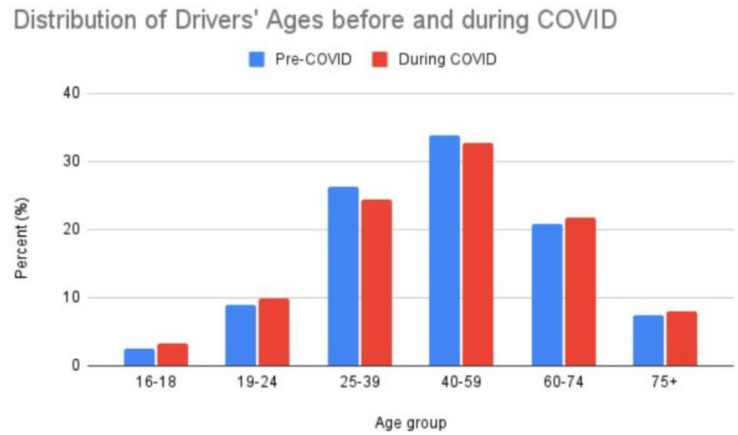


FIGURE 2: Distribution of licensed drivers by age pre-COVID and estimated distribution of drivers per age group during COVID based on unemployment and teleworking data. Data retrieved from the Office of Highway Policy Information from the Federal Highway Administration, AAA Foundation for Traffic Safety, U.S. Bureau of Labor Statistics, and Pew Research Center.

Once the changes in percentages of each age group were noted, I used data on road rage and reckless driving by age group as a proxy for each group’s contribution to the overall sum of highway fatalities. Aggressive driving, the term for less extreme road rage, is defined by the AAA as “any unsafe driving behavior, performed deliberately and with ill intention or disregard for safety” (“Aggressive Driving”, n.d.). Studies have shown that certain sectors of the demographic exhibit higher levels of road rage and reckless driving while others exhibit lower levels. For example, in a study by the AAA on self-reported aggressive driving behaviors, “drivers ages 25-39 were the most likely to report the majority of the behaviors, including tailgating, yelling, honking, gesturing, cutting off, or exiting their vehicle to confront” (AAA, 2016). Additionally, there has been a gradual increase in road rage and gun violence in the past few years with more substantial jumps in 2020 and 2021, which could provide some evidence for the paralleled increase in relative highway fatalities (Deliso, 2021).

In order to use data on how age groups differ in terms of road rage, I checked for a correlation between the increase in relative highway fatalities per 100 million VMT and highway fatalities due to road rage, during the pandemic (Figure 3). With a p. = 0.019, there is a statistically significant correlation between these two datasets. Therefore, a model can be constructed that uses ratios taken from studies on road rage levels of different age groups.

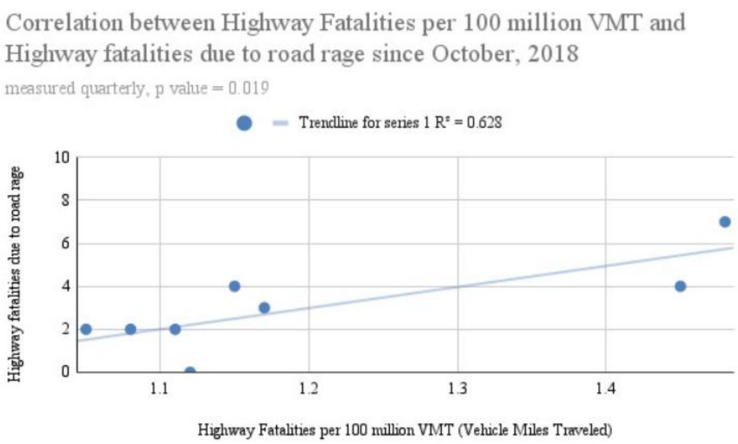


FIGURE 3. A scatterplot of the correlation between the relative number of highway fatalities per 100 million VMT to the filtered highway fatalities due to gun violence road rage. Data retrieved from the Bureau of Transportation Statistics and the Gun Violence Archives.

In this model, each age group has contributed its factor to the overall number of relative highway fatalities. This is done through a weighting process (Methods). Through two different tactics, one using highway road rage deaths data and age group distribution of fatalities in crashes data and the other only using the second dataset, results were obtained. The first method resulted in a 0.45% increase from the pre-COVID average of 1.12 highway fatalities per 100 million VMT to an estimated 1.125 highway fatalities per 100 million VMT during COVID. This does not fully explain the 26.78% recorded increase. The second method resulted in a 1.92% increase from the distribution values before and during COVID, which also does not fully explain the aforementioned recorded increase, but the average pre-COVID highway fatalities value of 1.12 was not used.

## Discussions

It was surprising that, in my model, the distribution of ages did not change substantially despite calculations done to factor in increasing unemployment rates and teleworking rates. An improved model could more accurately show the change in driver age distribution if there exist additional factors that would do such.

Other changes in the distribution of the driving demographic besides age could have made an impact on the increase in relative highway fatalities, such as a change in the gender distribution, a change in the socioeconomic distribution, and a change in the education level distribution. Another direction that one could take this preliminary research is to develop a similar model with the socioeconomic status distribution or education level distribution as opposed to the age distribution. Studies have shown that, on average, wealthier people had the privilege of staying at home during the pandemic while poorer populations did not always have this option (Valentino-DeVries et al., 2020). This implies that research into the changes in distribution of socioeconomic status of drivers could show more drastic shifts in active drivers from before to after the pandemic began in comparison to the age distribution. Thus, it might account for more of the increase in relative highway fatalities. Such findings could be taken in their own context or merged with the findings in this paper to compare which change in distribution has the greatest correlation with the increase in relative highway fatalities during the COVID-19 era.

As stated earlier, there are several other factors that were not accounted for in my calculations, like driving inexperience, increased speeding, likelihood to stay at home during the COVID-19 pandemic, and more. Beyond this, my model could have possibly shown more of an increase in highway fatalities if there was more precise and accurate data available on the age distribution of active drivers rather than licensed drivers. For example, further investigation into the population's tendency to leave the house during the pandemic by age could better address the greater health risk factor for the elderly and the implications of that on the active driver distribution. Another option for a future direction is to actively collect data on the age and miles driven on the highway during the pandemic using surveys, but there are limitations to data that can be collected and it may not be relevant, as the situation has changed since the onset of the pandemic in March and April of 2020.

Overall, despite not being shown as significantly responsible for the puzzling increase in highway fatalities per 100 million VMT in the U.S. with my model, the age distribution and road rage tendencies of drivers are very important factors that impact the safety of our country's people during this pandemic. This analysis provokes further questions and investigations into the change of driver distribution due to COVID-19.

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