Association between COVID-19 Deaths and Fully Vaccinated Status

Juehan Wang

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Introduction

As of November 30th, the coronavirus disease 2019 (COVID-19) pandemic had resulted in 49,716,825 cases and 806,398 deaths in the United States. As of November 24, 2021, around 28 percent of total COVID-19 deaths in the United States have been among adults 85 years and older, despite this age group only accounting for 2 percent of the US population. The widespread availability of vaccines in the United States helped to reduce cases in the spring and early summer. In this analysis, we obtain the COVID-19 Deaths and Fully Vaccinated Status Data, collected from January 1st, 2020 to December 7th, 2021. The main question that this analysis explores was the association between the number of deaths due to COVID-19 and the number of people who have been fully vaccinated in different age groups.

Methods

Three raw datasets were included in this analysis, which were COVID-19 deaths data by state and age group, COVID-19 fully vaccinated data by state and age group and state population data. COVID-19 Deaths Data involves corona virus disease 2019 (COVID-19) and pneumonia reported to NCHS by jurisdiction of occurrence, place of death, and age group, collected from 01/01/2020 to 12/07/2021. The link is https://data.cdc.gov/NCHS/Provisional-COVID-19-Deaths-by-Place-of-Death-and-/4va6-ph5s. COVID-19 Vaccinations Data includes the overall US COVID-19 Vaccine administration and vaccine equity data at county level, collected from 01/01/2020 to 12/07/2021. The link is https://data.cdc.gov/Vaccinations/COVID-19-Vaccinations-in-the-United-States-County/8xkx-amqh. Population of 2019 Data involves the estimates of the Total Resident Population and Resident Population Age 18 Years and Older for the United States. https://www.census.gov/data/tables/time-series/demo/popest/2010s-state-detail.html.

To analyze the data, R packages, dplyr, data.table, tidyr, tidyverse and usmap, were used.

In order to get the final analysis data, first, read in the data. Second, clean the raw datasets. For COVID-19 deaths data, the variables we were interested in counts of COVID-19 deaths by state and age group. Therefore, we clustered age groups into three groups, 0-18, 18-65 and 65+. Then the proportions of COVID-19 deaths among all deaths were calculated. Abbreviated state names were combined to the data. For COVID-19 fully vaccinated data, the variables of interest were the counts of fully vaccinated people by age group and state. Full state names were combined to the data. For state population data, the variables that we were concerned about were the population of different states and age groups. Therefore, we clustered age into three groups, 0-18, 18-65 and 65+. Third, merge the datasets and do some cleaning. Then we check the dimensions of the datasets. The COVID-19 deaths data and the fully vaccinated data have same number of columns. The population data have one more state data than the other two datasets. So, it should be mentioned here that the extra data will be deleted during data merging step. After checking the heads and tails and making sure that the datasets have good dimensions, we merge the datasets and do some cleaning, and then we get the final data for analysis.

As for statistical methods, descriptive analysis was done by summarizing statistics of the variables that this study concern about. Plots were shown by bar charts and maps, in order to have a straight forward view of the concerned variables. The main question of this study was explored using correlation analysis and smooth graph, based on proportion data.

Results

Preliminary Results

Table 1 Summarizes of Statistics by States (Appendix)

State	COVID-19 Deaths	COVID-19 Deaths proportion	COVID-19 Fully Vaccinated	COVID-19 Fully Vaccinated proportion
Alabama	47467	0.131	2283759	0.234
Alaska	2596	0.090	402529	0.283
Arizona	59706	0.137	4030601	0.278
Arkansas	26442	0.122	1504165	0.250
California	231870	0.128	25330031	0.322
Colorado	27945	0.105	3700789	0.323
Connecticut	26571	0.135	2598963	0.365
Delaware	6366	0.104	602666	0.311
Florida	177111	0.124	13321578	0.311
Georgia	79135	0.133	5266415	0.249

Summarizes of statistics were shown in tables. Table 1 illustrates the variables that this analysis concerns about in each state in the US, which were COVID-19 Deaths, COVID-19 Deaths proportion, COVID-19 Fully Vaccinated number and COVID-19 Fully Vaccinated proportion. Here only shows the numbers of first ten states. The whole table is in the Appendix (Table 1). From this table, we can get that the three states that have the highest deaths were California, Texas and Florida, which have 221,775, 218,261 and 169,626, respectively. Also, the three states that have the highest proportion of deaths in total deaths were New Jersey, Mississippi and Connecticut, which were 16.4%, 14.7% and 14%, respectively. As for the condition of fully vaccinated, the three states that have the highest number were California, Texas and New York, which were 23,996,305, 15,347,006 and 12,850,740, respectively. Additionally, the three states that have the highest proportion of fully vaccinated in the population were Vermont, Maine and Connecticut, which were 35.4%, 35.2% and 35.1%, respectively.

Table 2 Summarizes of Statistics by Age Groups

Age.group	Average of deaths	Average of proportation of deaths	Average of fully vaccinated	Average of proportation of fully vaccinated
Age 0-18	19	0.002	287693	0.093
Age 18-65	10925	0.096	2667463	0.313
Age >65	33372	0.116	927089	0.459
All	44495	0.112	3882245	0.287

The age group description table (Table 2) shows that people older than 65 years old have both the highest number of average deaths in all states and the highest proportion of deaths in total deaths, which were

31,530 and 0.115. More number of people age between 18 and 65 have fully vaccinated compared to the other two groups, which was 2,554,933. But larger proportion of older people have fully vaccinated compared to younger people.

Bar charts and maps were shown to have a better view of the condition of COVID-19 Deaths and status of fully vaccinated in different states among age groups.

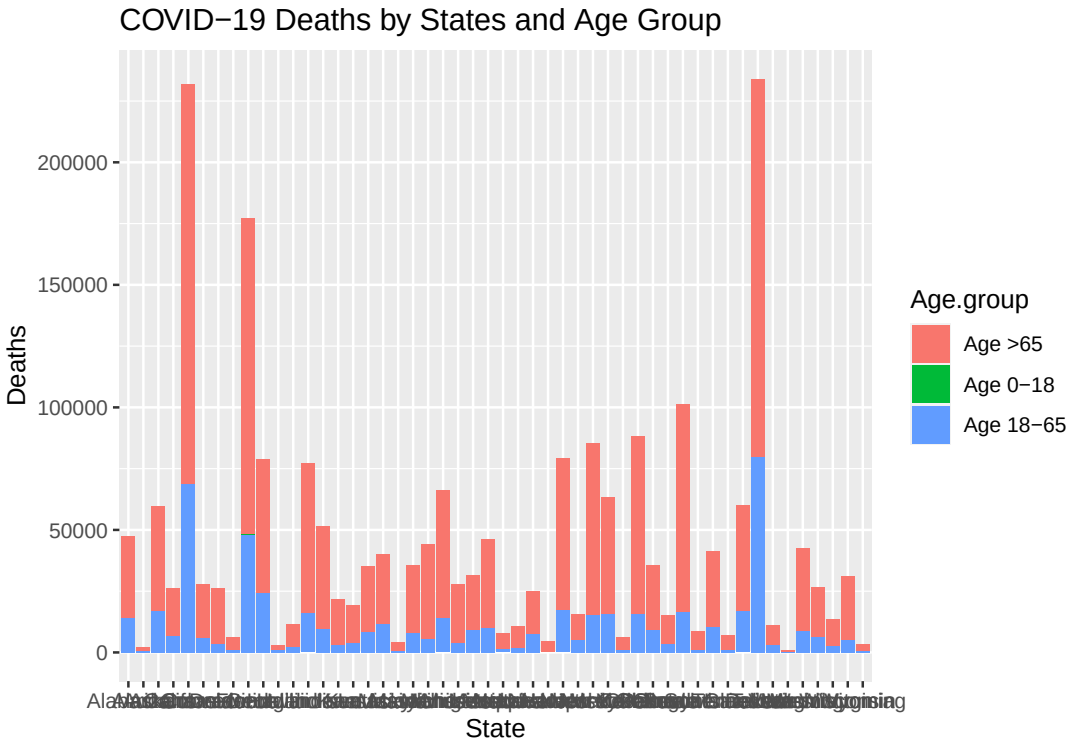

Figure 1 COVID-19 Deaths by States and Age Group

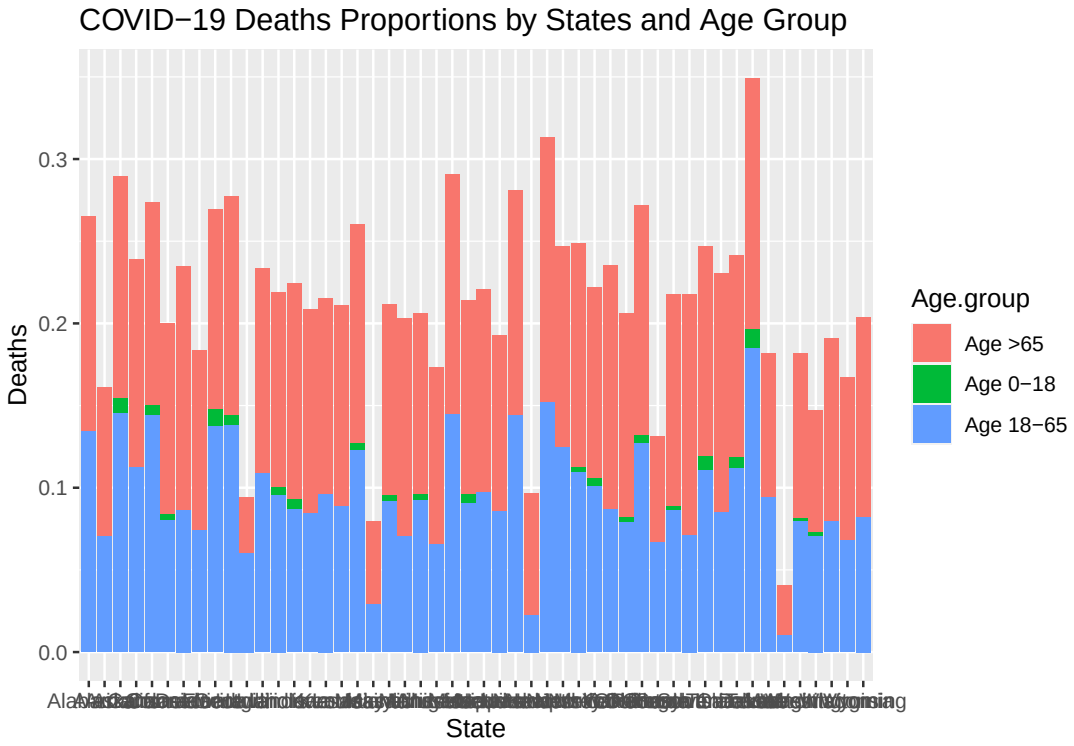

Figure 2 COVID-19 Deaths Proportions by States and Age Group

From the bar chart of deaths due to Covid-19 (Figure 1), we can straightly get that the largest numbers of deaths due to Covid-19 were in Texas and California. It was also obvious that the numbers of deaths in people older than 65 were much larger than those in other age groups. When looking at the bar chart of death proportions due to Covid-19 among all deaths (Figure 2), we get that the largest proportion was in Texas, while that of other states were quite even.

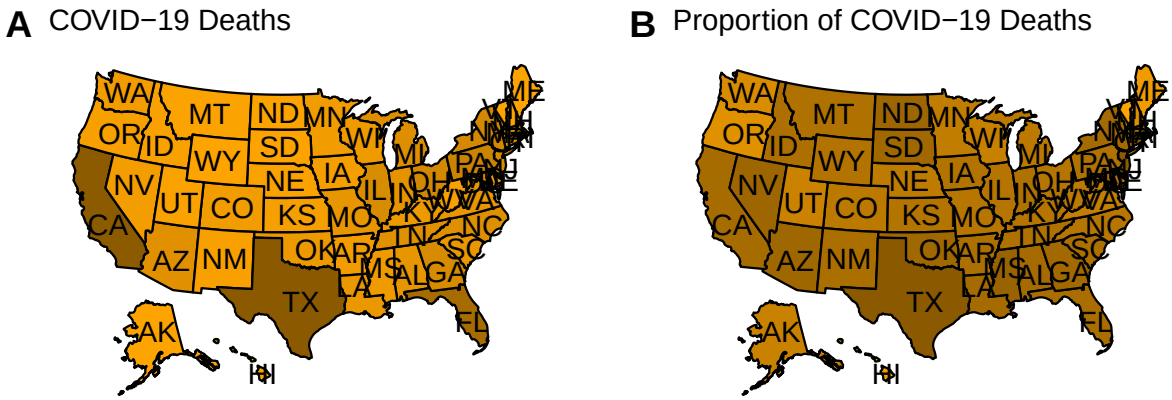

Figure 3 Maps of COVID-19 Deaths and Proportions in the US

Maps of deaths due to Covid-19 (Figure 3A) and death proportions due to Covid-19 (Figure 3B) show a more straight forward view of the condition of deaths in the US. Darker states had more deaths or larger death proportions.

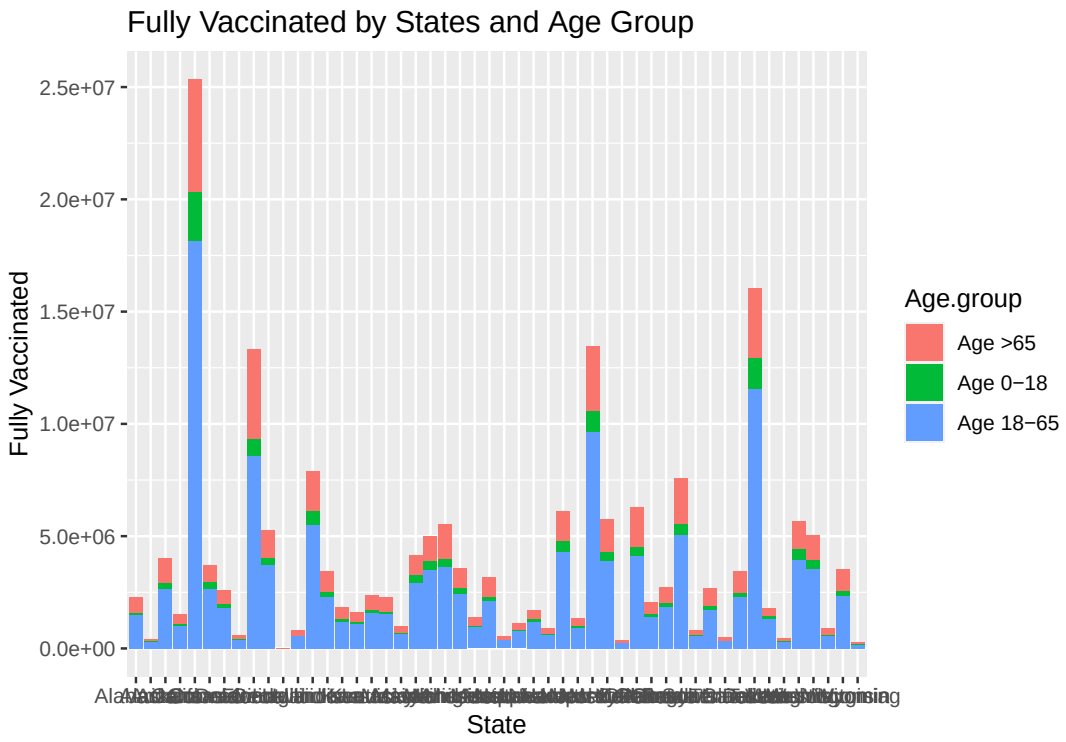

Figure 4 Fully Vaccinated by States and Age Group

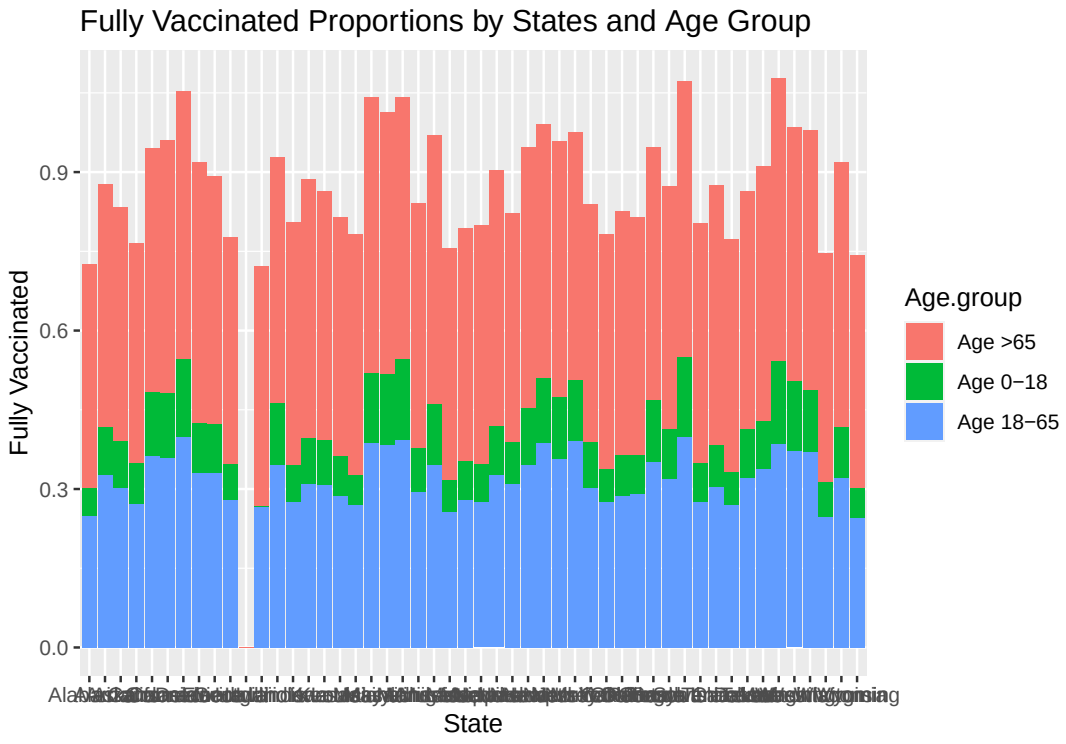

Figure 5 Fully Vaccinated Proportions by States and Age Group

From the bar chart of numbers of people who were fully vaccinated (Figure 4) we can straightly get that the largest number of people who have got fully vaccinated was in California. It was also obvious that the

numbers in people who were between 18 to 65 years old were much larger than those in other age groups. When looking at the bar chart of fully vaccinated proportions among the population (Figure 5), we get that the largest proportions were in Vermont, Rhode Island and Connecticut. The reason that California had the most deaths but didn't have the highest proportion of deaths was probably because California had larger population compared to most of other states. Also, the proportions of fully vaccinated in people who were older than 65 years old were larger than those in other age groups.

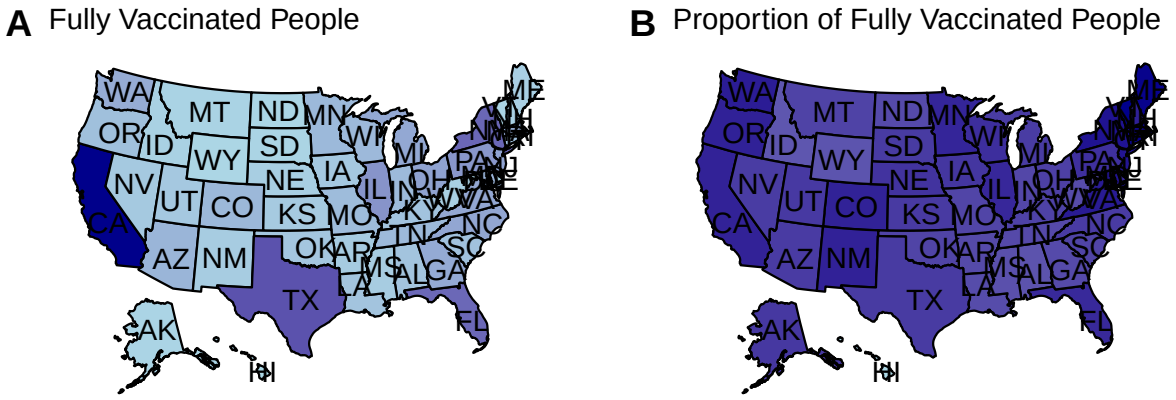

Figure 6 Maps of Fully Vaccinated and Proportions in the US

In the maps of deaths (Figure 6A), states that were darker in the maps have more deaths or larger proportion of deaths. In the maps of status of fully vaccinated (Figure 6B), states that were darker in the maps have larger number or proportion of people who were fully vaccinated.

Final Results

The association between COVID-19 Deaths and fully vaccinated status was explored by correlation analysis of the proportion of COVID-19 deaths in all deaths and the proportion of fully vaccinated people in the population. The correlation between these two variables was 0.02, which was close to 0. Therefore, these two variables were not related.

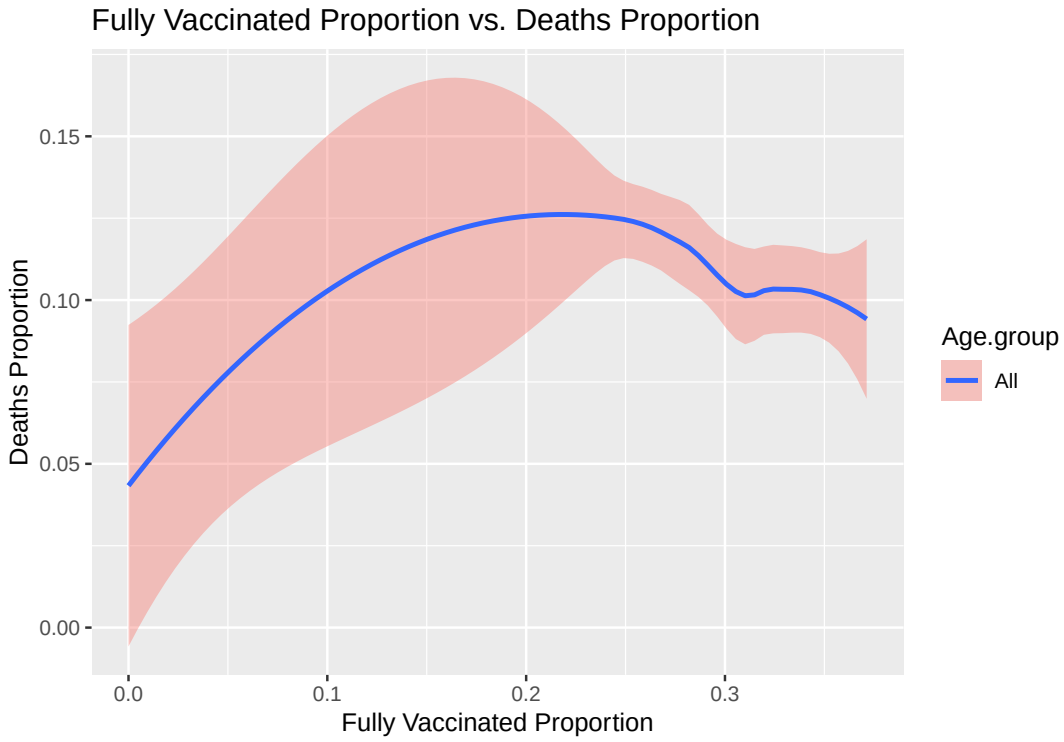

Figure 7 Fully Vaccinated Proportion vs. Deaths Proportion

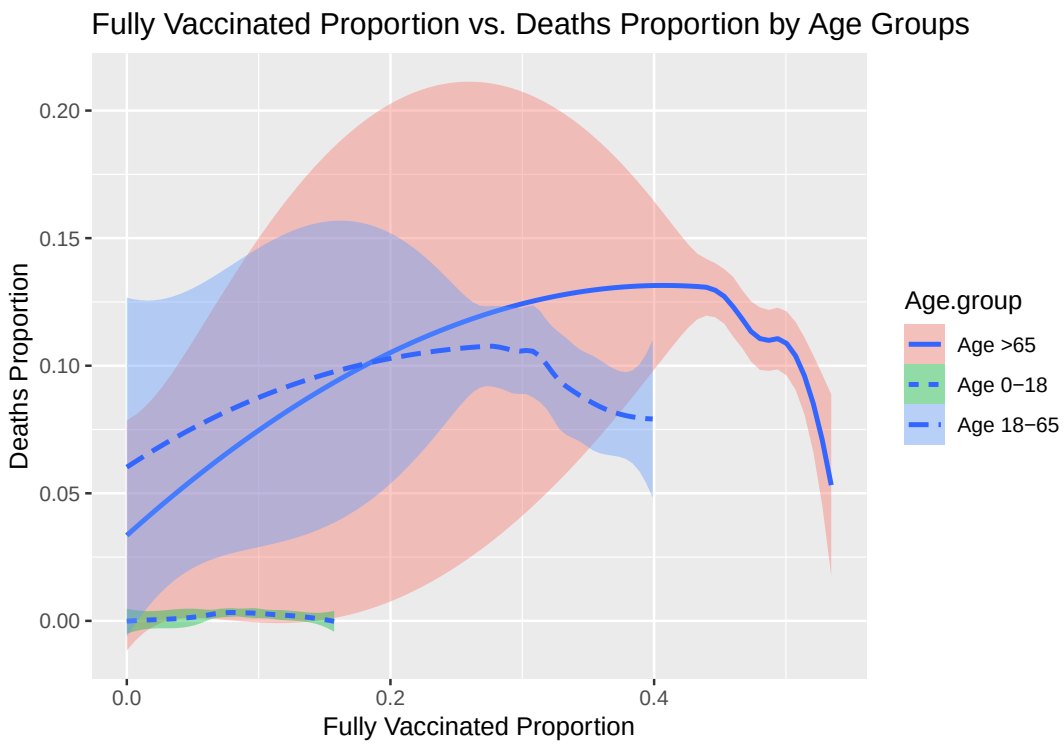

Figure 8 Fully Vaccinated Proportion vs. Deaths Proportion by Age Groups

The association between COVID-19 Deaths and fully vaccinated status in different age groups was also showed in the smooth graphs (Figure 8). The plot shows that there was no definite or fixed trend in the

relationship between the two variables. There seems to have an increasing trend when the fully vaccinated proportion was small, but a turning point appears when the proportion increases. Still, the confidence intervals were quite wide as shown in the plot, so the trends were not reliable.

Conclusion

There was no association between COVID-19 Deaths and fully vaccinated status in different age groups based on the current data. It was also found that people over the age of 65 have the highest deaths, which means that younger people were more likely to survive from COVID-19. Meanwhile, people older than 65 years old have the largest proportion of having been fully vaccinated among the whole population. In future analysis, longer term association between deaths due to COVID-19 and the status of fully vaccinated among different age groups should be looked at.

References

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Statista https://www.statista.com/statistics/1254488/us-share-of-total-covid-deaths-by-age-group/

Graphics Reuters https://graphics.reuters.com/HEALTH-CORONAVIRUS/USA-TRENDS/dgkvlgkrkpb/

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Florida	177111	0.124	13321578	0.311
Georgia	79135	0.133	5266415	0.249
Hawaii	3002	0.043	0	0.000
Idaho	11667	0.121	813745	0.228
Illinois	77463	0.112	7916319	0.313
Indiana	51537	0.119	3433754	0.255
Iowa	22137	0.116	1813404	0.288
Kansas	19511	0.113	1611788	0.279
Kentucky	35229	0.112	2361175	0.265
Louisiana	40381	0.129	2288925	0.247
Maine	4322	0.048	985201	0.367
Maryland	35658	0.109	4144638	0.345
Massachusetts	44072	0.119	4983806	0.362
Michigan	66328	0.105	5519936	0.276
Minnesota	27882	0.098	3578931	0.317
Mississippi	31824	0.145	1411175	0.238
Missouri	46212	0.110	3170312	0.259
Montana	8086	0.119	560890	0.263
Nebraska	10896	0.103	1126807	0.292
Nevada	25023	0.139	1696624	0.276
New Hampshire	4956	0.065	886860	0.326
New Jersey	79593	0.158	6097687	0.344
New Mexico	15734	0.123	1349097	0.323
New York	85422	0.130	13466844	0.347
North Carolina	63596	0.111	5769190	0.278
North Dakota	6398	0.139	376592	0.249
Ohio	88260	0.112	6282308	0.269
Oklahoma	35540	0.135	2062867	0.262
Oregon	15189	0.065	2734587	0.324
Pennsylvania	101430	0.118	7605646	0.297
Rhode Island	8615	0.133	782906	0.371
South Carolina	41586	0.122	2675321	0.262

State	COVID-19 Deaths	COVID-19 Deaths proportion	COVID-19 Fully Vaccinated	COVID-19 Fully Vaccinated proportion
South Dakota	7186	0.135	490572	0.278
Tennessee	60279	0.118	3417065	0.251
Texas	234218	0.160	16064673	0.278
Utah	11258	0.089	1800713	0.281
Vermont	1085	0.032	462912	0.371
Virginia	42762	0.094	5638663	0.335
Washington	26560	0.073	5030544	0.333
West Virginia	13807	0.103	880942	0.246
Wisconsin	31166	0.092	3509884	0.302
Wyoming	3653	0.116	267460	0.232