The relationship between influenza vaccination coverage and Pneumonia and Influenza (P&I) mortality rates by state in US (2009-2019)

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Introduction

Dataset Background:

Pneumonia and Influenza (P&I) Deaths Data comes from National Center For Health Statistics Mortality Surveillance System (NCHS), a division of the Centers for Disease Control and Prevention (CDC).

Influenza Vaccinations Coverage Data comes from the National Immunization Survey-Flu (NIS-Flu) and the Behavioral Risk Factor Surveillance System (BRFSS).

Formulated Question:

Influenza (flu) is a contagious respiratory illness caused by influenza viruses. Seasonal flu vaccines are developed and distributed each year to help reduce the spread of the virus and mitigate its impact on public health. Vaccination is one of the primary strategies for preventing influenza.

The objective of this study is to examine the relationship between influenza vaccination coverage and P&I mortality rates during the specified time frame. Understanding this relationship can provide insights into the effectiveness of vaccination programs and the impact of vaccination on P&I-related mortality. It also allows for an assessment of geographic variations, highlighting areas with successful vaccination programs and areas where improvements may be needed.

Methods

Data Resources

Pneumonia and Influenza (P&I) Deaths Data contains information about deaths attributed to Pneumonia and Influenza (P&I) and all-cause mortality. The data is organized by state and region, allowing for a geographic analysis. It provides statistics on the number of deaths, death rates, and various demographic factors that might influence mortality rates, such as age group.

Influenza Vaccinations Coverage Data provides valuable insights into the prevalence of influenza vaccination across different demographic groups and geographic regions. NIS-Flu is a program conducted by the Centers for Disease Control and Prevention (CDC). It is part of the National Immunization Survey (NIS) and focuses on influenza vaccination coverage in the United States. BRFSS is a state-based system operated by state health departments in collaboration with the CDC. It collects information on health-related behaviors, including vaccination coverage, through telephone surveys.

Variables

- state: the different State names in the United States
- season: the specific time period during 2009 to 2019
- age_group: include <18 group, 18-65 group and 65+ group
- deaths_prop: the proportion of influenza deaths in total deaths

- vac_prop: the proportion of fully vaccinated individuals in the population

Clean the data

In deaths data, the variables we are interested in counts of P$I deaths by state and different season. Therefore, we:

- Delete the useless values
- Rename some variables for convenience
- Combine age groups: 0-18, 18-65 and 65+
- Impute missing values with mean(numeric) or mode(categorical)
- Reformat the numeric variables

Wrangle the data

Then we checked the major elements of this dataset, following with a closer look at the key variables to check for missing values and outliers. For each categorical variables, the name and order of categories were checked and corrected if necessary. Then we merge two datasets for further analysis.

Statistical methods

- Descriptive analysis is done by summarizing statistics of the variables that this study concern about.
- Plots are shown by bar charts and maps, in order to have a straight forward view of the concerned variables.
- The main question of this study is explored using correlation analysis and smooth graph, based on proportion data.

Results

1. Regional variations in P&I (Pneumonia and Influenza) death rates and flu vaccination rates

Table 1 Proportion of deaths and fully vaccined people in different states during 2009-2019

state	P&I Deaths proportion (%)	Fully Vaccined proportion (%)
Alabama	6.362	33.795
Alaska	5.903	32.067
Arizona	6.295	31.354
Arkansas	7.780	37.366
California	8.509	32.372
Colorado	6.284	37.130
Connecticut	7.444	39.506
Delaware	6.523	39.141
District of Columbia	6.318	38.986
Florida	5.664	27.568
Georgia	5.943	31.764
Guam	7.220	31.261
Hawaii	10.242	36.910
Idaho	6.276	31.203
IL-City of Chicago	7.220	37.685
IL-Rest of state	7.220	41.583
Illinois	7.180	33.380
Indiana	7.356	32.543
Iowa	7.611	39.522
Kansas	7.328	34.587
Kentucky	8.500	35.128
Louisiana	5.442	32.614

state	P&I Deaths proportion (%)	Fully Vaccined proportion (%)
Maine	7.259	37.871
Maryland	7.329	39.200
Massachusetts	8.392	41.571
Michigan	6.611	31.864
Minnesota	6.988	39.234
Mississippi	7.018	30.933
Missouri	6.899	35.712
Montana	6.415	32.830
Nebraska	7.852	38.373
Nevada	6.992	29.720
New Hampshire	7.083	38.974
New Jersey	6.185	36.084
New Mexico	7.347	37.060
New York	7.985	35.419
North Carolina	7.798	36.938
North Dakota	8.586	39.376
NY-City of New York	7.220	35.939
NY-Rest of state	7.220	46.747
Ohio	6.817	33.754
Oklahoma	8.267	35.935
Oregon	5.801	32.676
PA-Philadelphia	7.220	45.236
PA-Rest of state	7.220	48.786
Pennsylvania	6.389	36.960
Puerto Rico	7.220	15.015
Rhode Island	8.423	44.107
South Carolina	7.008	33.519
South Dakota	9.144	44.460
Tennessee	7.968	36.420
Texas	7.392	33.401
TX-Bexar County	7.220	40.237
TX-City of Houston	7.220	38.719
TX-Rest of state	7.220	41.211
Utah	6.986	34.566
Vermont	7.996	39.028
Virginia	6.345	38.853
Washington	7.299	35.596
West Virginia	8.338	37.414
Wisconsin	6.510	35.119
Wyoming	7.580	32.379

Table 1 shows that the states that have the highest and lowest P&I deaths rates are Hawaii and Louisiana, which are 10.242% and 5.442%, respectively. Also, the highest and lowest proportion of flu vaccination rates are PA-Rest of state and Puerto Rico, which have 48.786% and 15.015%, respectively.

Figure 1 P&I Deaths Proportion in different states in the United States

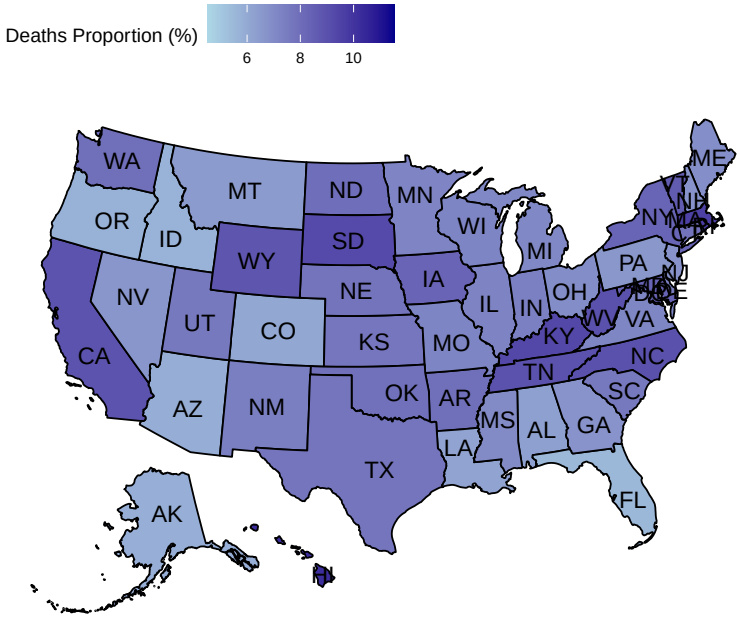

Figure 1 shows that Hawaii, North Dakota and California have the highest P&I deaths proportion. At the same time, Louisiana, Florida and Oregon have the lowest P&I deaths proportion.

Figure 2 Flu Vccination Proportion in different states in the United States

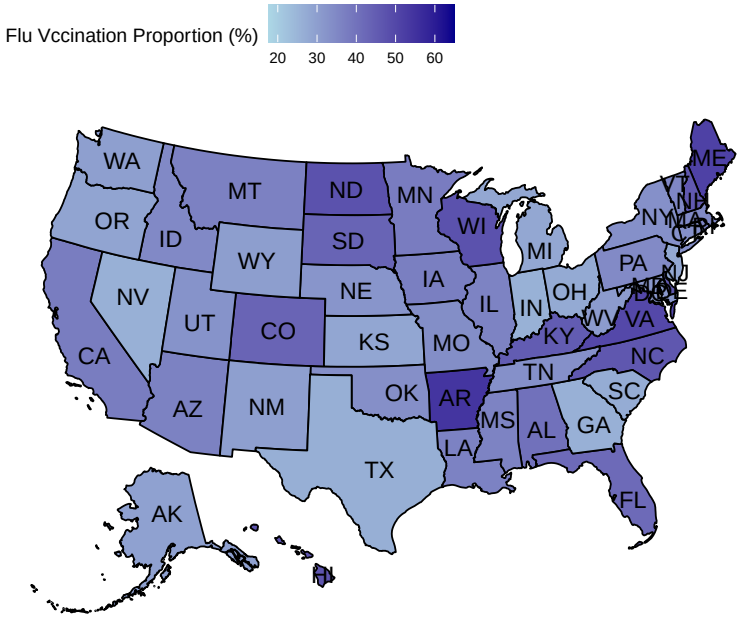

Figure 2 shows that PA-Rest of state, NY-Rest of state and PA-Philadelphia have the highest flu vaccination proportion. At the same time, Puerto Rico, Florida and Mississippi have the lowest flu vaccination proportion.

2.Yearly Fluctuations of P&I (Pneumonia and Influenza) death rates and flu vaccination rates

Table 2 Proportion of deaths and fully vaccined people in different years during 2009-2019 in the United States

season	P&I Deaths proportion (%)	Fully Vaccined proportion (%)
2009-10	7.848	33.938
2010-11	7.875	37.692
2011-12	7.418	36.385
2012-13	7.590	37.213
2013-14	7.235	35.996
2014-15	7.318	37.359
2015-16	6.708	35.564
2016-17	6.730	35.461
2017-18	6.918	32.710
2018-19	6.727	37.087

Table 2 shows that the highest and lowest P&I deaths rates are in year 2010-11 and 2015-16, which are 7.875% and 6.708%, respectively. Also, the highest and lowest proportion of vaccination rates are in year 2010-11 and 2017-18, which have 37.692% and 32.710%, respectively.

Figure 3 Fully Flu Vaccination and P&I Deaths Proportion by Year(2009−201

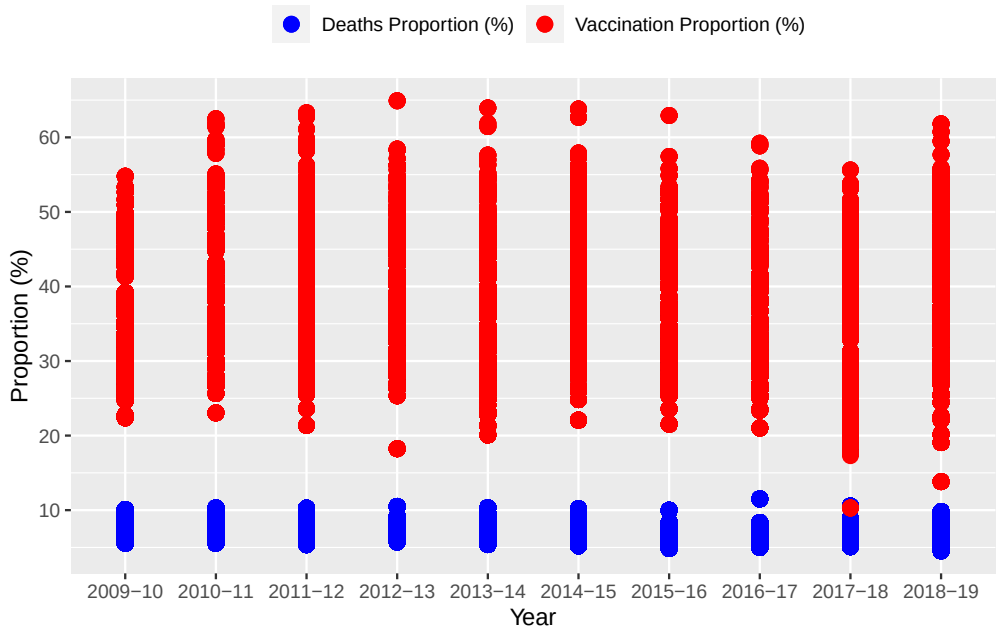

Figure 3 shows that the mortality rate show some variability across the years from 2009 to 2019, and the vaccination rate changed slightly, especially from 2017 to 2019 when it increased significantly.

3.Age Group Vaccination Pattern

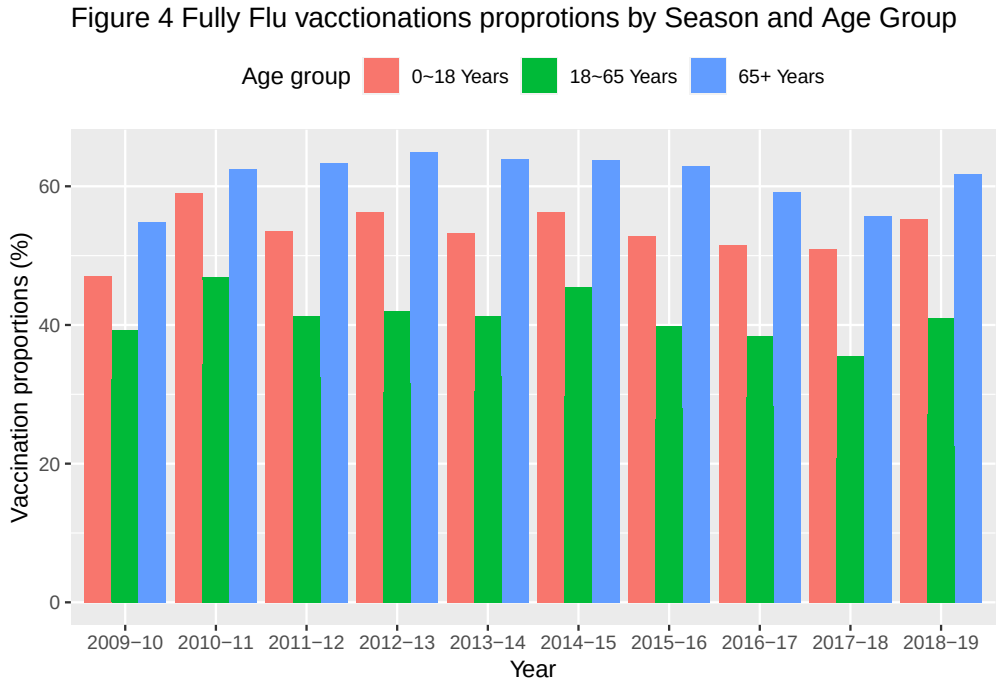

Figure 4 shows that from 2009-2019 vaccine uptake rates pattern in different age groups are almost the same: people older than 65 years old have the largest proportion of vaccinations, people with age between 18-65 have the smallest rates.

4.The correlation between P&I (Pneumonia and Influenza) death rates and flu vaccination rates

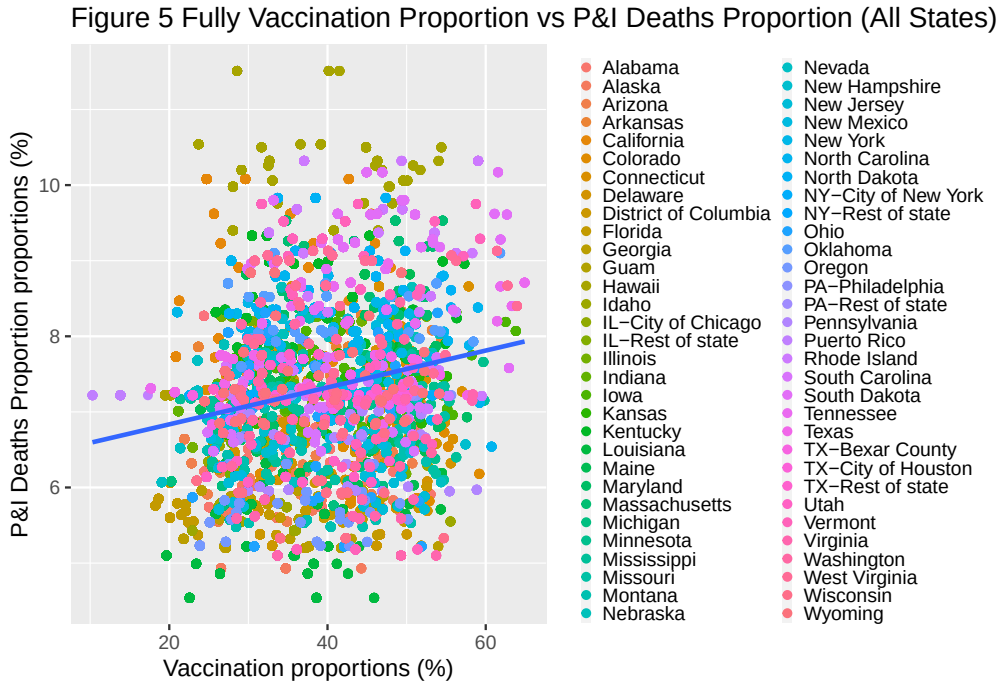

Figure 5 shows that there is a significant positive relationship between fully Vaccination proportion and P&I deaths proportion, indicating that higher vaccination coverage tends to be associated with higher mortality rates due to pneumonia and influenza.

Table 3 Correlation of deaths and fully vaccined people during 2009-2019 in different states

State	Correlation
Utah	0.230
Tennessee	0.218
Louisiana	0.176
Indiana	0.159
West Virginia	0.146
Minnesota	0.136
Vermont	0.124
Virginia	0.102
Wyoming	0.101
New Mexico	0.084
Iowa	0.082
South Carolina	0.076
Arkansas	0.061
Alaska	0.060
Arizona	0.057
Massachusetts	0.054
Rhode Island	0.046
Illinois	0.034
Michigan	0.033
Georgia	0.032
Maine	0.032
Ohio	0.032
Oklahoma	0.027
Kentucky	0.017
Colorado	0.013
Nebraska	0.010
South Dakota	0.004
Texas	-0.006
Kansas	-0.007
Nevada	-0.010
New Hampshire	-0.013
Oregon	-0.017
Mississippi	-0.021
Idaho	-0.028
Missouri	-0.040
Wisconsin	-0.051
North Dakota	-0.057
Alabama	-0.059
Connecticut	-0.069
Maryland	-0.070
Pennsylvania	-0.075
Florida	-0.078
Montana	-0.086
New York	-0.107
New Jersey	-0.111
Delaware	-0.113
Hawaii	-0.113
North Carolina	-0.121
Washington	-0.139
California	-0.143
District of Columbia	-0.174

Table 3 shows that Utah has the strongest positively correlation bewteen flu vaccination rates and P&I deaths rates

and District of Columbia has the strongest negatively correlation.

Figure 6 Vaccination Coverage vs P&I Deaths Proportion Over Year

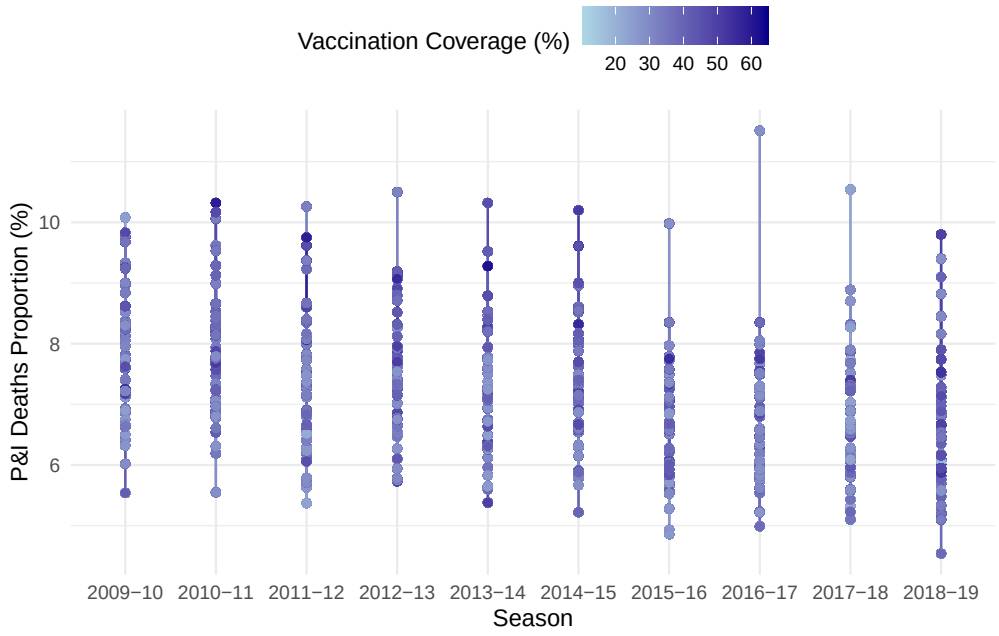

Figure 6 shows that the P&I deaths proportion fluctuates across seasons but generally remains between certain levels (roughly 6% to 10%). The highest vaccination coverage do not seem to align with the lowest P&I deaths proportion, suggesting that higher vaccination coverage does not necessarily correspond to lower death proportions in a straightforward or simple manner.

Conclusion

1.State Variations: There are significant regional variations in P&I (Pneumonia and Influenza) death rates and flu vaccination rates in the United States. States like Hawaii have higher P&I death rates, while states like Louisiana have lower P&I death rates. Conversely, states like South Dakota have higher flu vaccination rates, while states like Florida have lower rates.

2.Yearly Fluctuations: The vaccination rates are high and changed slightly, while the death rates are low and show some variability. This could imply that the vaccination efforts are effective, but a more in-depth statistical analysis would be necessary to draw any concrete conclusions.

3.Age Group Vaccination Pattern: Over the years, the vaccination rates in different age groups remained fairly consistent. The highest vaccination proportions are consistently among the oldest age group (65 years), which is expected since older adults are often prioritized for flu vaccinations due to higher risk of complications. The next highest group appears to be children (0-18 years), which may reflect public health efforts to immunize children against the flu. Adults aged 18-65 years have the lowest proportions, which might indicate less uptake or lower prioritization within public health campaigns compared to the other groups.

4.Correlation: There is a significant positive relationship between fully Vaccination proportion and P&I deaths proportion, indicating that higher vaccination coverage tends to be associated with higher mortality rates due to pneumonia and influenza. While the correlation exists, the strength varies across seasons, emphasizing the importance of considering seasonal factors. However, further investigation and consideration of confounding variables are necessary for a comprehensive understanding of the observed patterns.

Summary

In summary, the data suggests that there are significant state variations in P&I deaths and flu vaccination rates in the U.S. with year-to-year fluctuations. While vaccination rates have generally improved in recent years, there are

some exceptions. The correlation analysis highlights that vaccination efforts can have a positive impact on reducing P&I deaths in some states. However, specific factors contributing to these trends would require further investigation.