Public Health Theses   School of Public Health

Spring 5-14-2021

The Impact of Seasonal Influenza & Influenza Vaccination in Children from Low Income Households: An Exploration of Vaccination Rates & Burden on Children in Low Income Households

Julia Splittorff
Georgia State University

Follow this and additional works at: https://scholarworks.gsu.edu/iph_theses

The Impact of Seasonal Influenza & Influenza Vaccination in Children

from Low Income Households: An Exploration of Vaccination Rates &

Burden on Children in Low Income Households

by

Julia Splittorff

Georgia State University

A Thesis Submitted to the Graduate Faculty of

Georgia State University in Partial Fulfillment

of the Requirements for the Degree

MASTER OF PUBLIC HEALTH

ATLANTA, GEORGIA 30303

The Impact of Seasonal Influenza & Influenza Vaccination in Children

from Low Income Households: An Exploration of Vaccination Rates &

Burden on Children in Low Income Households

by

Julia Splittorff

Approved by:

Richard Rothenberg, M.D. MPH

Committee Chair

Shannon Self-Brown, M.A. Ph.D.

Committee Member

May 14, 2021

Author's Statement Page

In presenting this thesis as a partial fulfillment of the requirements for an advanced degree from Georgia State University, I agree that the Library of the University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote from, to copy from, or to publish this thesis may be granted by the author or, in his/her absence, by the professor under whose direction it was written, or in his/her absence, by the Associate Dean, School of Public Health. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this dissertation which involves potential financial gain will not be allowed without written permission of the author.

Julia Splittorff

Table of Contents

List of Figures

The Impact of Seasonal Influenza & Influenza Vaccination in Children from Low Income Households: An Exploration of Vaccination Rates & Burden on Children in Low Income Households

by

Julia Splittorff

ABSTRACT

Background: Seasonal influenza results in a high burden in children, especially children under 5 years old. Vaccination, which is routinely recommended for every individual over the age of 6 months, is one of the most effective interventions in preventing severe illness and death from seasonal influenza. There is a disparity in vaccinations practices between high and low socioeconomic households, which may lead to a greater impact of influenza on children in these households. The purpose of this study is to explore potential relationships between socioeconomic and vaccination practice variables.

Methods: Using 2018 data from the National Immunization Survey, a biserial correlation between household Income-Poverty Ratio and vaccination status at 24 months of age was conducted as well as a linear regression of household Income-Poverty Ratio and age in days of first influenza vaccination. A logistic regression between household Income-Poverty Ratio and vaccination status at 24 months of age was additionally conducted. All analyses were done in RStudio.

Results: There was a small correlation between household Income-Poverty Ratio and vaccination status at 24 months of -0.231 (p-value <0.005). The linear regression model between Income-Poverty Ratio and age in days at first influenza vaccination indicated that households with the highest Income-Poverty Ratio vaccinated their children 57 days earlier on average than households of the lowest-Income-Poverty Ratio (p-value < 0.005). The logistic regression between household Income-Poverty Ratio and up to date status of vaccination at 24 months of age indicated that households at the highest ratio were more than twice as likely as those at the lowest ratio to have their children up to date on influenza vaccination (p-value <0.005).

Conclusion: There is a relationship between socioeconomic status and influenza vaccination practices which may impact and amplify the burden of influenza on children in lower income households.

Chapter I: Introduction

An annual influenza vaccination is one of the most effective protective factors against severe illness and increased mortality risk from an influenza infection [1]. Within the overall population, healthcare professionals and public health often prioritize elderly and chronically ill patients for protection from seasonal influenza, as they are typically the most at risk for severe complications and mortality following an influenza infection [2]. However, the impact of seasonal influenza on children specifically is often overlooked or minimized in healthcare and public health settings despite the potential for long-term health implications of severe complications from influenza in childhood.

Additionally, the burden of influenza disproportionately affects children who reside in low-income households who may not have regular access to the annual influenza vaccine or adequate medical care should they become infected and need treatment [3]. In conjunction with a lack of overall access to healthcare, children in low-income households are more likely to live in multi-generational households, which we know can increase the risk for many communicable diseases, including influenza [4]. The intersection of low socioeconomic status and the neglect of children in general regarding influenza vaccination campaigns creates an increase in marginalization and comprehensive risk to children in low socioeconomic households. The purpose of this thesis is to explore trends surrounding seasonal influenza and vaccination in children from low socioeconomic backgrounds.

Chapter II: Literature Review

Risk of Influenza Infection in Children

The World Health Organization (WHO) website on seasonal influenza indicates that young children under 59 months old are in a high-risk category for influenza infection. [5] Furthermore the WHO also list schools as one of the important areas of transmission during seasonal epidemics along with nursing homes and other crowded areas. One of the primary prevention tactics, outlined by the WHO, is proper sanitization and handwashing as well as good sneeze and cough etiquette. These are skills many younger children are still learning and perfecting, which makes it an imperfect mitigation strategy.

Poehling et al. analyzed data in 2006 surrounding the impact of influenza on children. Ultimately, researchers determined that the rate of clinic visits for influenza was 50 and 95 per 1,000 children in the 2002-2003 and 2003-2004 influenza seasons respectively, and the rate of emergency visits was 6 and 27 per 1,000 children in the 2002-2003 and 2003-2004 influenza seasons, respectively [Figure Six]. The overall annual rate of hospitalization was 0.9 per 1,000 children [6]. While the data collected were for children 5 years of age and younger, researchers indicated that this burden is even higher among younger children: "Modeling studies suggest that children younger than two years of age have high rates of hospitalization attributable to influenza; these rates are similar to rates of hospitalization attributable to influenza among older adults." [6] Generally, the burden of influenza on children has not been well described despite comparison to other more well-known high-risk groups such as elderly, chronically ill, and pregnant people.

In addition to the immediate effects of an influenza infection, there are serious long-term effects that are particularly problematic for young children. The Center for Disease Control (CDC)

indicate that some of the potential long-term effects could include the worsening of existing chronic conditions such as heart disease and asthma, brain dysfunction such as encephalopathy, chronic problems with ear and sinus infections, lung damage due to pneumonia, and death. The CDC posits that while death from influenza is rare, it is not impossible. The mortality rate is likely underreported, however, the typical range since 2004-2005 is between 37 to 188 deaths, with a notable spike in the 2009 H1N1 pandemic season with 358 influenza related deaths in children. [7] In addition to the possibility of death, the CDC estimates that between 5,000 and 26,000 children are hospitalized yearly for influenza. [7]

Fraaij and Heikkenin also focused on the impacts of childhood influenza in healthcare. They reported in agreement with the CDC that overall influenza mortality in children is low, but hospitalization and healthcare visits occur more frequently. Most hospitalizations are among the very young: for individuals <1 year of age, annual hospitalization rates range from 10 to over 100 hospitalizations per 10,000 children depending on influenza season and geographic region. In preschool age children, hospitalization rates approach or equal those observed in the elderly. With increasing age, the risk of hospitalization decreases rapidly from approximately 5 per 10,000 in children above 5 years to almost none in young adults. [8] The literature review also reports some metrics on outpatient care for influenza in children. [Outpatient visit] rates during influenza seasons are high in children, with the highest rates observed in children less than 1 year of age. In this age group, the consultation rates can exceed 10 per 100 children. [8] The burden placed on the healthcare system due to influenza infections in children is not insignificant and is largely preventable through vaccination.

<u>Vaccination Practices</u>

Chung et al estimated the impact of the influenza vaccination during the 2018-2019 influenza season. Researchers created a model based on vaccination coverage, vaccine effectiveness, and estimated disease burden. Overall, approximately 49% of Americans received an influenza vaccination in the 2018-2019 season. Researchers estimated that influenza vaccination prevented an estimated 4.4 million illnesses, 2.3 million medical visits, 58,000 hospitalizations, and 3,500 deaths due to influenza viruses during the US 2018–2019 influenza season [Figure five]. Vaccination prevented 14% of projected hospitalizations associated with A(H1N1)pdm09 overall and 43% among children aged 6 months–4 years old. [9] Based on this study, influenza vaccination drastically reduces the burden of influenza on the whole population, including children. Furthermore, of the previously mentioned influenza-related pediatric deaths, the CDC estimated that 80% of the children who have died from influenza were not fully vaccinated. [7] In addition to this, the CDC routinely recommends that everyone over the age of 6 months receive an annual influenza vaccination. [7]

In 2014, Suryadevara et al described influenza vaccination coverage in a low-income community in New York among age, race, and gender demographics. Researchers surveyed attendees of a Salvation Army function about their vaccination status and their intent to get vaccinated. Eligible participants who had yet to receive their annual influenza vaccine were offered a free vaccination. Of the 312 participants who declined the offered influenza vaccination, 46% did so because of vaccine misperceptions. Of the 299 participants who intended to receive vaccine but had not yet done so, 284 (95%) stated the reason for delay was lack of access to the vaccine. [10] This research indicated not only a large presence of vaccine hesitancy due to misperceptions in this low-income community, but also a large obstacle in accessing the vaccination. Although

this study pertains to adults, it is not unreasonable to assume that there are implications for children of low-income parents as well.

Influenza Internationally

Influenza poses a problem globally as well as domestically. Although not all conclusions are wholly applicable to influenza in the US, due to the lack of literature, examining these issues from an international lens can help provide more insight into the issue. Shono and Kondo surveyed parents in Japan with children under the age of 13 in 2015 about their youngest child's vaccination status for the upcoming influenza season. Parents were asked to describe their vaccination habit as annual, sometimes, or never as well as describe their reasons for not vaccinating if applicable. Researchers found that 57% of parents indicated that their youngest child under 13 receives an annual influenza vaccine. [11] Among the portion of parents who indicated that they never had their child vaccinated for influenza, cost was listed as a major obstacle to accessibility. The main finding of the study is a significant association between household income and influenza vaccination of the youngest child in the household. [11] Generally, the research shows that low-income households are much less likely to vaccinate, often due to expense obstacles, increasing the risk of influenza infection and disease burden on the children in these households.

In 2017 Xu et al. studied the rate of influenza vaccination coverage in a low-income city in northwestern China. They examined children between the ages of 2-7 years old and found that the vaccination rate was 12.2% and 12.8% for the 2014-2015 and 2015-2016 seasons, respectively. [12] One of the primary reasons for vaccination non-compliance was a lack of knowledge in the student's parents. The most common concern that parents cited was the potential negative side effects of vaccination. Other reasons for not vaccinating their children included lack of information about the vaccine (30.2%), belief that their children were healthy and did not need to be vaccinated

11

(26.5%), and concern about vaccination expenses (6.3%). [12] It is worth noting that seasonal influenza vaccination is not covered under China's Expanded Program on Immunization that pays for vaccination for children under age 14 [12] so that figure may not be applicable to low-income households in other regions.

In 2002, Chiu et al detailed the hospitalization burden of children due to respiratory illness in Hong Kong during the 1998-1999 influenza season. The literature has established that definition of the exact burden of influenza can be difficult to assess due to the simultaneous circulation of other respiratory illnesses such as Respiratory Syncytial Virus, which can also cause serious illness in children. The aim of their study was to assess the true burden of influenza, and the researchers found that the adjusted rates of excess hospitalization for acute respiratory disease that were attributable to influenza were 278.5 and 288.2 per 10,000 children less than 1 year of age in 1998 and 1999, respectively; 218.4 and 209.3 per 10,000 children 1 to less than 2 years of age; 125.6 and 77.3 per 10,000 children 2 to less than 5 years of age; 57.3 and 20.9 per 10,000 children 5 to less than 10 years of age; and 16.4 and 8.1 per 10,000 children 10 to 15 years of age. [13]

In 2019, Marangu & Zar conducted a literature review to describe the burden of pneumonia on young children in low- and middle-income countries. Pneumonia is one of the most common severe complications of an influenza infection. They analyzed existing publications from 2013-2019 regarding pneumonia to review pneumonia epidemiology, etiology, and management practices. After this review, they concluded that morbidity and mortality from childhood pneumonia has decreased but a considerable preventable burden remains. Widespread implementation of available, effective interventions and development of novel strategies are needed. [14] In particular, they noted that pneumonia due to influenza infection had decreased with

the use of influenza vaccination. This demonstrates the important protective factors of influenza vaccination against severe complication like pneumonia.

Hospitalization Rates & Child Poverty Proportion

For additional background, during the 2017-2018 influenza season, the CDC states through the FluSurv-NET surveillance system that there were 188 total pediatric deaths [Figure Seven] [19]. FluSurv-NET data is a part of FluView, which is a weekly surveillance report published by the Epidemiology and Prevention branch of the CDC. The U.S. influenza surveillance system is a collaborative effort between CDC and its many partners in state, local, and territorial health departments, public health and clinical laboratories, vital statistics offices, healthcare providers, clinics, and emergency departments. Information in five categories is collected from eight data sources to find out when and where influenza activity is occurring, determine what influenza viruses are circulating, detect changes in influenza viruses, and measure the impact that influenza is having on outpatient illness, hospitalization, and death. [15] Data from FluSurv-NET is collected from 14 states. The data are obtained by surveillance of laboratory-confirmed influenza hospitalizations of children less than 18 years of age as well as adults. FluSurv-NET covers 70 counties, in 10 states: California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon, and Tennessee. For the purposes of evaluating the role of socioeconomic status in influenza hospitalization, this study will analyze data from the state with the highest poverty rates and the state with the lowest poverty rate. According to the US Census Bureau, New Mexico had a poverty rate of 26.3% for people under the age of 18 in 2018 and Maryland had a poverty rate of 11.6% for people under the age of 18 in 2018, making New Mexico and Maryland the states with the highest and lowest child poverty rates of the states included in the FluSurv-NET dataset. [16]

To explore the available data more, several analyses of childhood poverty and influenza hospitalization were done: first the correlation relationship, and second the logarithmic regression relationship. In the FluSurv-NET data, the independent variable is surveillance site, either Maryland or New Mexico, which serves as a proxy for socioeconomic status, and the dependent variable is rate of hospitalization per week in the 2017-2018 influenza season. FluSurv-NET documents all age groups, but this study uses data from the under 18 years of age group and excludes all other ages. In this study, the hospitalization rate by week is divided into two age groups: 0-4 years of age, and 5-17 years of age. Data from all other states aside from the proxy states, New Mexico and Maryland, were excluded.

Microsoft Excel was used to organize FluSurv-NET data for hospitalization rates. The study examines the following correlations: hospitalization rate and socioeconomic status in a high child poverty (New Mexico) rate state and a low child poverty rate state (Maryland). An alpha level of 0.05 was used for all statistical tests.

The hospitalization rate components were tested for logarithmic regression (glm function in RStudio). This regression was tested for both age groups, 0-4 years of age and 5-17 years of age. The surveillance site data were coded as 0 for New Mexico and 1 for Maryland. The level of significance was set as alpha 0.05 for both.

All hospitalization rate analyses contained data for the 2017-2018 influenza season. Hospitalization data was collected over 30 weeks, which were Morbidity & Mortality Weekly Report (MMWR) week 40 in 2017 through week 17 in 2018. The average weekly rate of influenza related hospitalization per 100,000 residents for the 5-17 age group in New Mexico and Maryland was 0.817 and 0.833 respectively. The same rate in the 0-4 age group was 3.943 and 2.63 for New Mexico and Maryland, respectively. These rates peaked in the 0-4 age group at MMWR week 5

14

in 2018 at 15.6 for New Mexico and MMWR weeks 4 and 6 in 2018 at 10.9 in Maryland. The peaks in the 5-17 age group were at MMWR week 5 of 2018 at 3.7 in New Mexico and MMWR week 8 of 2018 at 4.1 in Maryland. The overall cumulative hospitalization rate for the 2017-2018 influenza season in the 0-4 age group was 118.5 for New Mexico and 79.1 for Maryland. The overall cumulative hospitalization for the 2017-2018 influenza season in the 5-17 age group was 24.4 in New Mexico and 25 in Maryland.

The logistic regression between state and hospitalization rate in the 0-4 age group was very small and negative (-0.09933) as was the logistic regression between state and hospitalization rate in the 5-17 age group (-0.01115). However, neither returned a statistically significant result (p-value 0.163 and 0.965, respectively).

There may be a few reasons for the lack of significant relationships. First, it is possible that other confounding factors such as variability of circulating strains of influenza in each surveillance state created an inconsistency in severity or transmissibility of influenza. It is likely that there are also cultural and racial differences between the two states that may lead to increased disparities outside of the scope of socioeconomic status alone. Additionally, the difference could also be explained by the limitations of this analysis, such as the indirect proxy used for socioeconomic status or the one-year time frame in which the data was collected.

Chapter III: Methods & Procedures

<u>Study Design</u>

This study consists of a cross-sectional analysis using biserial correlation, linear regression, and logistic regression of CDC National Immunization Survey (NIS) data from 2018 provided by the CDC to assess the role of socioeconomic status in influenza vaccination practices in children.

<u>Data Source</u>

Data for vaccination status is a part of the National Immunization Survey, which is an annual report sponsored by the National Center for Immunization and Respiratory Diseases (NCIRD) and Center for Disease Control (CDC) and authorized by the Public Health Service Act. "The NIS provides current, population-based, state and local area estimates of vaccination coverage among children and teens using a standard survey methodology. The surveys collect data through telephone interviews with parents or guardians in all 50 states, the District of Columbia, and some U.S. territories." [17] The dataset provided by the CDC is entitled NISPUF, which stands for National Immunization Survey – Public Use File.

<u>Setting and Participants</u>

The NIS collects data by telephone survey. The study is conducted using a single frame survey design to monitor vaccination practices for 15–35-month-old children, teens ages 13-17, and annual influenza vaccination for children 6 months of age through 17 years of age. Households are sampled from all 50 states and D.C. using a random sampling method to select cell phone numbers for voluntary enrollment in the survey. Once enrolled, a questionnaire is sent to the vaccination administrator (usually the child or family doctor) to collect information about types of

vaccination administered, dates of administration, as well as other relevant data. For the 2018 NIS dataset, there were a total of 28,971 children included in the study. [17]

<u>Variables</u>

For the first part of this study, the independent variable from the NIS data is a numeric income to poverty ratio of the family, and the outcome variable is the up to date status of influenza vaccination at 24 months of age. The independent variable is a ratio of family income to the poverty line based on the 2017 Census poverty threshold, with a minimum value of 0.5 times that of the poverty line, and a maximum value of 3 times that of the poverty line. All 28,971 children in the study were included in this variable, which had a mean of 2.1 and a median of 2.5 times that of the 2017 poverty line. The first outcome variable is specifically described in the data user manual as 2+ influenza vaccinations at least four weeks plus four days apart by 24 months of age. The outcome of the variable is binary, either up to date or not, and there were 15,657 children with completed records for this variable.

The vaccination status variable was also derived from the same number of households, however, 13,314 households did not have completed data for this variable, so they were excluded. Of the 15,657 remaining households, 6,347 (40.5%) were not up to date, and 9,310 (59.5%) were up to date. This variable was a binary outcome whether the immunization provider had completed 2+ influenza vaccinations at least 4 weeks and 4 days apart by 24 months of age.

The liner regression portion of the analysis will use the same income-poverty ratio variable from the 2018 NIS data as well as the variable which accounts for the age in days of the child upon their first influenza vaccination as recorded by the healthcare provider including vaccinations administered both before and after the household interview and enrollment in the study. A total of

11,746 (40.5%) of the sample gave valid responses to this survey question, and the remaining 17,225 (59.5%) of the sample were excluded. The mean age in days of the sampled children's first influenza vaccination was 317.8 days, and the median was 276.0 days. The CDC recommends that children receive their first dose at 6 months of age, so we would expect to see that most first influenza vaccines would first be given around 180 days of age. [1] This variable included 11,746 children, for whom their age when first vaccinated was known with a mean of 317.8 days and a median of 276.0 days.

Statistical Methods

For the up to date at 24 months vaccination status component, the variables (independent variable: income to poverty ratio of the family; dependent variable: up to date vaccination) were tested for their correlation (biserial.cor function in RStudio) to assess the relationship between influenza vaccination and socioeconomic status. The second component uses the same independent variable as the first analysis, and the dependent variable is the age in days of the first administered influenza vaccination. This analysis uses a linear regression model (lm function in RStudio) to analyze the relationship between the variables of poverty to income ratio of the family and vaccination status. The last analysis is a logistic regression model (glm function in RStudio) to analyze the relationship between the variables of Income-Poverty Ratio and up to date vaccination at 24 months. All analyses were done using R-Studio 1.4.1103.

Chapter IV: Results

The biserial correlation between income-poverty ratio and vaccination status was weak and negative (-0.2310118). This correlation was tested for significance using Chi-Square and was determined to have statistical significance with a p-value of <0.005.

The linear regression model between income-poverty ratio and age in days at first influenza vaccination was negative (-22.973). This regression model was determined to be significant based on its p-value of <0.005.

The logistic regression model between income-poverty ratio and up-to-date vaccination status at 24 months was positive (0.457856). This regression model was determined to be significant based on its p-value of <0.005.

To provide more context for these results, the data have been broken down by income category in the below table. Data from the unknown income category was excluded. The proportion of children who were up to date on their vaccinate at 24 months was greatest in the highest income category, and smallest in the lowest income category.

	Not Up to Date	Up to Date	% Up to Date
>$75,000	1859	4829	72.2%
<75,000	2405	2642	52.3%
Below Poverty	1806	1493	45.3%

This table breaks down the data by income category and whether or not a child received their first vaccination by their first birthday (the CDC recommends that children receive their first vaccination at 6 months). These proportions are similar to the first table. The highest proportion

of children who have received their first vaccination by the first birthday is in the highest income category, while the lowest proportion of children who have received their first vaccination by the first birthday in the lowest income category.

	After Birthday	Before Birthday	% Before Birthday
>$75,000	1517	4071	72.9%
<$75,000	1220	2240	64.7%
Below Poverty	893	1341	60.0%

Chapter V: Discussion

The purpose of this thesis was to explore available data to gain a better understanding of the relationship between socioeconomic status and vaccination practices in children from low-income households. The data analysis shows that there is a delay in influenza vaccination for children from lower socioeconomic households compared to their higher socioeconomic household counterparts. This supports evidence found in the existing literature that low socioeconomic status imposes barriers to accessing regular influenza vaccination. [3, 10, 11, 12]

Up to Date Immunization & Income-Poverty Ratio Biserial Correlation

Since the variable for immunization status was dichotomous (up to date or not up to date), a point biserial correlation was used. This correlation was weak and negative. The correlation indicates that as family income-poverty ratio went up, the child in question was more likely to have completed the 2+ vaccination spaced at least 4 weeks and 4 days apart by 24 months of age course for immunization against influenza. This correlation was under the establish 0.05 alpha level test for statistical significance, so it is unlikely that this relationship is due to chance or error.

This relationship could indicate that families with a lower income-poverty ratio are less likely to get their children vaccinated against influenza. As seen in the literature, there seem to be several potential barriers to access to this kind of healthcare [3]. First, there is a general barrier to access to healthcare due to fiscal cost. Second, families of lower socioeconomic status may be unaware, and/or not have had the opportunity to receive important health information on the importance of influenza related vaccinations for young children. It is imperative for pediatricians to incorporate this information into well visits, especially at times when flu season is approaching.

As with the hospitalization rate analysis, it is also possible that this relationship is not representative of other influenza seasons as outlined in the limitations section.

Age in Days at First Immunization & Income-Poverty Ratio Linear Regression

Findings from this study revealed a negative relationship between income-poverty ratio and age in days at first vaccination, -22.973 days. This value indicated that families with higher income-poverty ratios would get their children the first influenza vaccine sooner than families who income-poverty ratio was lower. A family with an income-poverty ratio of 3 would have their child first vaccinated on day 299.107 on average, compared to a family with an income-poverty ratio of 0.5, who would have their child first vaccinated at day 356.540, a difference of almost two months.

Considering the high risk of contracting influenza in young children, a difference of about 57 days before starting the influenza immunization regimen leaves the children at the lower end of the socioeconomic spectrum more vulnerable to the negative outcomes associated with influenza. This measurement demonstrably agrees with the literature on the subject that indicates that families in lower socioeconomic classes face more barriers to vaccinating their children than families in higher socioeconomic classes [10, 11,12] since there is a delay in the initiation of the influenza vaccination regimen for lower socioeconomic households.

Up to Date Immunization & Income-Poverty Ratio Logistic Regression

Additional finding from this study indicate that the likelihood of that a child is up to date on influenza vaccination at 24 months of age increases by 61% with each unit increase of Income-Poverty Ratio. This means that families on the highest end of the Income-Poverty Ratio (3.0) are more than two times as likely to have their children up to date on influenza vaccination at 24 months than households on the lowest end of the income-poverty ratio (0.5).

Again, considering the high risk of potential influenza related outcomes in young children, staying up to date on vaccination is a crucial part in reducing children's overall risk. The implication that households with higher socioeconomic statuses are more likely to keep their children up to date on vaccinations than households with lower socioeconomic statuses suggests that children living in poverty are more vulnerable to negative influenza outcomes. This measurement is also in agreement with existing literature that there are barriers to influenza vaccination for children and families in low socioeconomic situations (citation).

Limitations

There were several limitations to this study. Firstly, the data analysis only tracked the status of two milestones of vaccination history, which was the completion of 2+ influenza vaccinations spaced at least 4 weeks and 4 days apart by 24 months of age and the age in days at which a child was first vaccinated against influenza. There was no direct variable for seasonal vaccination status in the 2017-2018 influenza season provided by this data source. Second, data for both portions of analysis used only numbers from the 2018 NIS, which may not have been representative of all influenza seasons. In future studies, researchers should either collect or utilize existing data that more directly represents the variables of interest, including seasonal vaccination against influenza. Another limitation specific to the age in days portion of the analysis is the potential for delay in vaccination to wait for influenza season: families may not want to vaccinate their children as soon as they reach the six month threshold if it is during the influenza off season. Additionally, researchers may find the results of this study and other similar studies to have a changed relevancy due to the lasting impacts of the COVID-19 pandemic and societal attitudes around respiratory illnesses and vaccine compliance.

Conclusion

Socioeconomic status has a role to play as a social determinant of health, and this seems to be the case in the category of childhood influenza based on the exploration of available data. Despite the potential important part socioeconomic status may have for children and seasonal influenza, there is a lack of literature describing the specific impacts on the burden of childhood influenza, which are influenced by socioeconomic status. Without express analysis of how much of a role socioeconomic status plays in these outcomes, it is all the more difficult to create an approach to bridge the disparity. Additionally, in light of the COVID-19 pandemic, there may be changes in societal attitudes regarding vaccination, and there may be lasting socioeconomic impacts from the pandemic recession as well. Though this exploratory analysis has shed some light on the relationship of socioeconomic factors and influenza and vaccination practices in children, further research is needed. Health promotion researchers should consider these findings, and determine best practices for intervening with families living in poverty to offer educational programming about the benefits of influenza vaccination, and ways to reduce other barriers that decrease accessibility of this vaccination for young children.

References

[1] Everyone 6 months of age and older should get a flu vaccine. (2021, January 25). Retrieved from https://www.cdc.gov/flu/prevent/vaccinations.htm

[2] People at High Risk of Flu. (2021, February 11). Retrieved from https://www.cdc.gov/flu/highrisk/index.htm

[3] Mamelund, S. E., Shelley-Egan, C., & Rogeberg, O. (2019). The association between socioeconomic status and pandemic influenza: protocol for a systematic review and meta-analysis. *Systematic reviews*, *8*(1), 5. https://doi.org/10.1186/s13643-018-0931-2

[4] Hood E. (2005). Dwelling disparities: how poor housing leads to poor health. *Environmental health perspectives*, *113*(5), A310–A317. https://doi.org/10.1289/ehp.113-a310

[5] Influenza (Seasonal). (2018, November 6). Retrieved from https://www.who.int/news-room/fact-sheets/detail/influenza-(seasonal)

[6] Poehling, K. A., Edwards, K. M., Weinberg, G. A., Szilagyi, P., Staat, M. A., Iwane, M. K., . . . Griffin, M. R. (2006). The Underrecognized Burden of Influenza in Young Children. New England Journal of Medicine, 355(1), 31-40. doi:10.1056/nejmoa054869

[7] Children & Influenza (Flu). (2021, February 10). Retrieved from https://www.cdc.gov/flu/highrisk/children.htm

[8] Fraaij, P. L. A., & Heikkinen, T. (2011). Seasonal influenza: The burden of disease in children. *Vaccine*, *29*(43), 7524–7528. https://doi.org/10.1016/j.vaccine.2011.08.010

[9] Jessie R Chung, Melissa A Rolfes, Brendan Flannery, Pragati Prasad, Alissa O'Halloran, Shikha Garg, Alicia M Fry, James A Singleton, Manish Patel, Carrie Reed, US Influenza Vaccine Effectiveness Network, the Influenza Hospitalization Surveillance Network, and the Assessment Branch, Immunization Services Division, Centers for Disease Control and Prevention, Effects of Influenza Vaccination in the United States During the 2018–2019 Influenza Season, Clinical Infectious Diseases, Volume 71, Issue 8, 15 October 2020, Pages e368–e376, https://doi.org/10.1093/cid/ciz1244

[10] Suryadevara, M., Bonville, C. A., Rosenbaum, P. F., & Domachowske, J. B. (2014). Influenza vaccine hesitancy in a low-income community in central New York State. Human vaccines & immunotherapeutics, 10(7), 2098–2103. https://doi.org/10.4161/hv.28803

[11] Shono, A., & Kondo, M. (2015). Factors associated with seasonal influenza vaccine uptake among children in Japan. BMC infectious diseases, 15, 72. https://doi.org/10.1186/s12879-015-0821-3

[12] Xu, L., Qin, Y., Yang, J., Han, W., Lei, Y., Feng, H., … Shi, Y. (2017). Coverage and factors associated with influenza vaccination among kindergarten children 2-7 years old in a low-income city of north-western China (2014-2016). *PLOS ONE*, *12*(7), e0181539. https://doi.org/10.1371/journal.pone.0181539

[13] Chiu, S. S., Lau, Y. L., Chan, K. H., Wong, W. H. S., & Peiris, J. S. M. (2002). Influenza-Related Hospitalizations among Children in Hong Kong. *New England Journal of Medicine*, *347*(26), 2097–2103. https://doi.org/10.1056/nejmoa020546

[14] Marangu, D., & Zar, H. J. (2019). Childhood pneumonia in low-and-middle-income countries: An update. Paediatric respiratory reviews, 32, 3–9. https://doi.org/10.1016/j.prrv.2019.06.001

[15] U.S. Influenza Surveillance System: Purpose and Methods | CDC. (2020). Retrieved from https://www.cdc.gov/flu/weekly/overview.htm?web=1&wdLOR=c2FD37460-74A4-42E1-9FAB-D740B8F31DDA

[16] US Census Bureau. (2019, September 26). 2018 Poverty Rate in the United States. Retrieved from https://www.census.gov/library/visualizations/interactive/2018-poverty-rate.html

[17] NIS | About the National Immunization Surveys | Vaccines | CDC. (2018). Retrieved from https://www.cdc.gov/vaccines/imz-managers/nis/about.html

[18] Laboratory-Confirmed Influenza Hospitalizations. (2020). Retrieved from https://gis.cdc.gov/GRASP/Fluview/FluHospRates.html

[19] Influenza-associated Pediatric Mortality. (2020). Retrieved from https://gis.cdc.gov/GRASP/Fluview/PedFluDeath.html
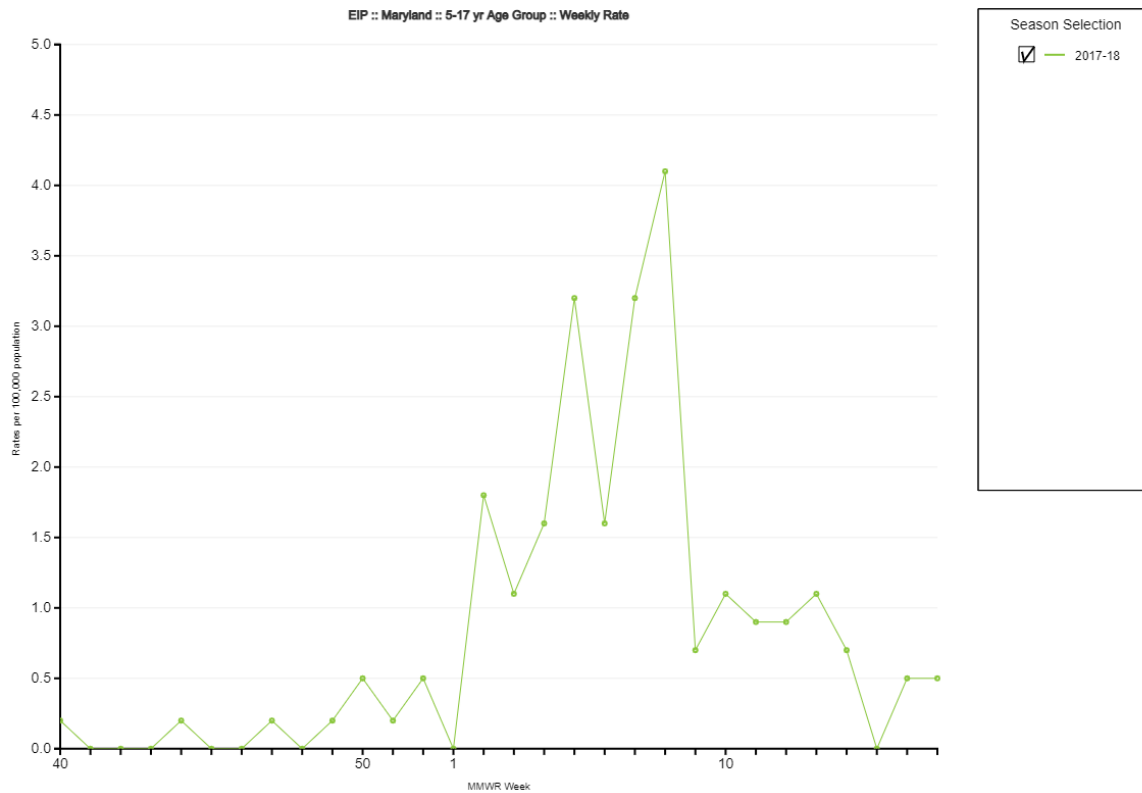
Figures

Figure One. Weekly Hospitalization Rates of 5-17 year Age Group in Maryland during 2017-2018

Influenza Season from FluSurv-NET [18]

Laboratory-Confirmed Influenza Hospitalizations

Preliminary weekly rates as of Oct 31, 2020
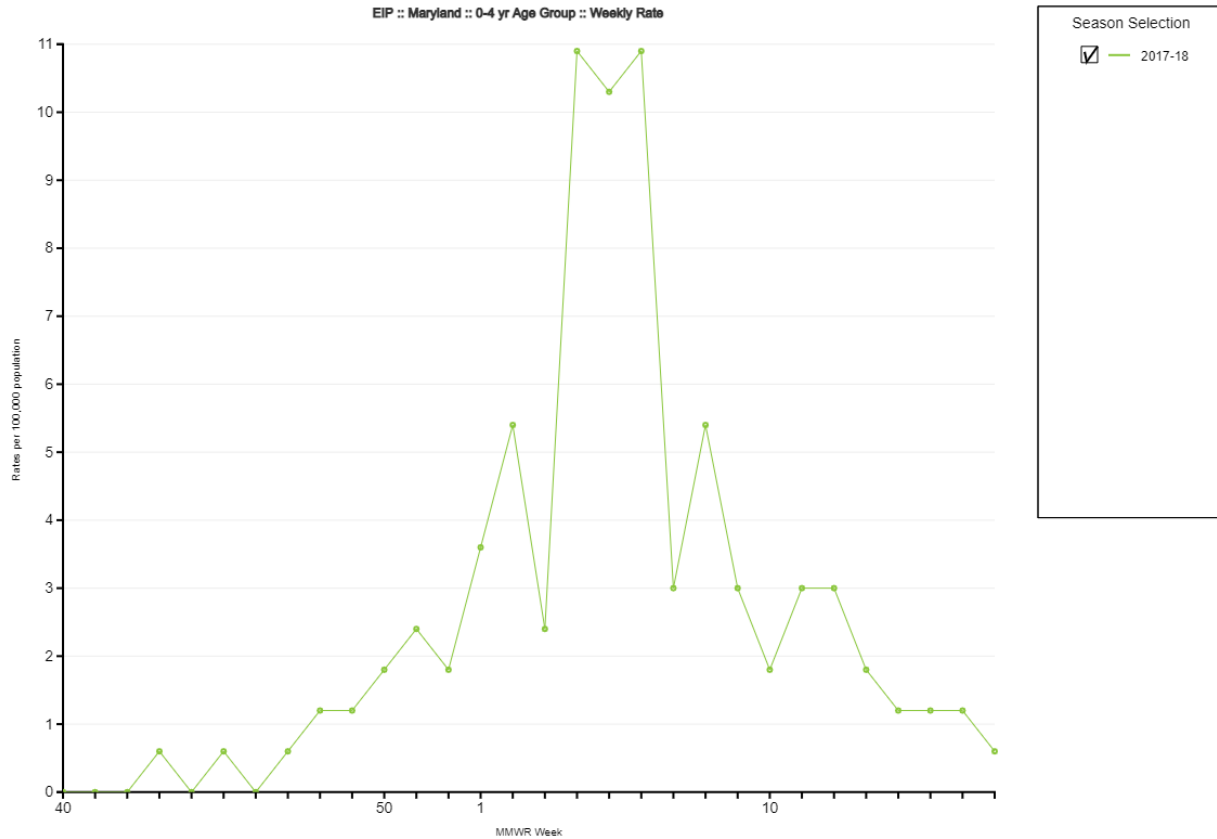
EIP :: Maryland :: 5-17 yr Age Group :: Weekly Rate

The Influenza Hospitalization Surveillance Network (FluSurv-NET) conducts population-based surveillance for laboratory-confirmed influenza-associated hospitalizations in children (persons younger than 18 years) and adults. The current network covers over 70 counties in the 10 Emerging Infections Program (EIP) states (CA, CO, CT, GA, MD, MN, NM, NY, OR, and TN) and three additional states (MI, OH, and UT). The network represents approximately 9% of US population (~27 million people). Cases are identified by reviewing hospital, laboratory, and admission databases and infection control logs for patients hospitalized during the influenza season with a documented positive influenza test (i.e., viral culture, direct/indirect fluorescent antibody assay (DFA/IFA), rapid influenza diagnostic test (RIDT), or molecular assays including reverse transcription-polymerase chain reaction (RT-PCR)). Data gathered are used to estimate age-specific hospitalization rates on a weekly basis, and describe characteristics of persons hospitalized with associated influenza illness. Laboratory-confirmation is dependent on clinician-ordered influenza testing. Therefore, the unadjusted rates provided are likely to be underestimated as influenza-associated hospitalizations can be missed if influenza is not suspected and tested for. FluSurv-NET hospitalization data are preliminary and subject to change as more data become available. All incidence rates are unadjusted. Please use the following citation when referencing these data: "FluView: Influenza Hospitalization Surveillance Network, Centers for Disease Control and Prevention. WEBSITE. Accessed on DATE".

Figure two. Weekly Hospitalization Rates of 0-4 year Age Group in Maryland during 2017-2018
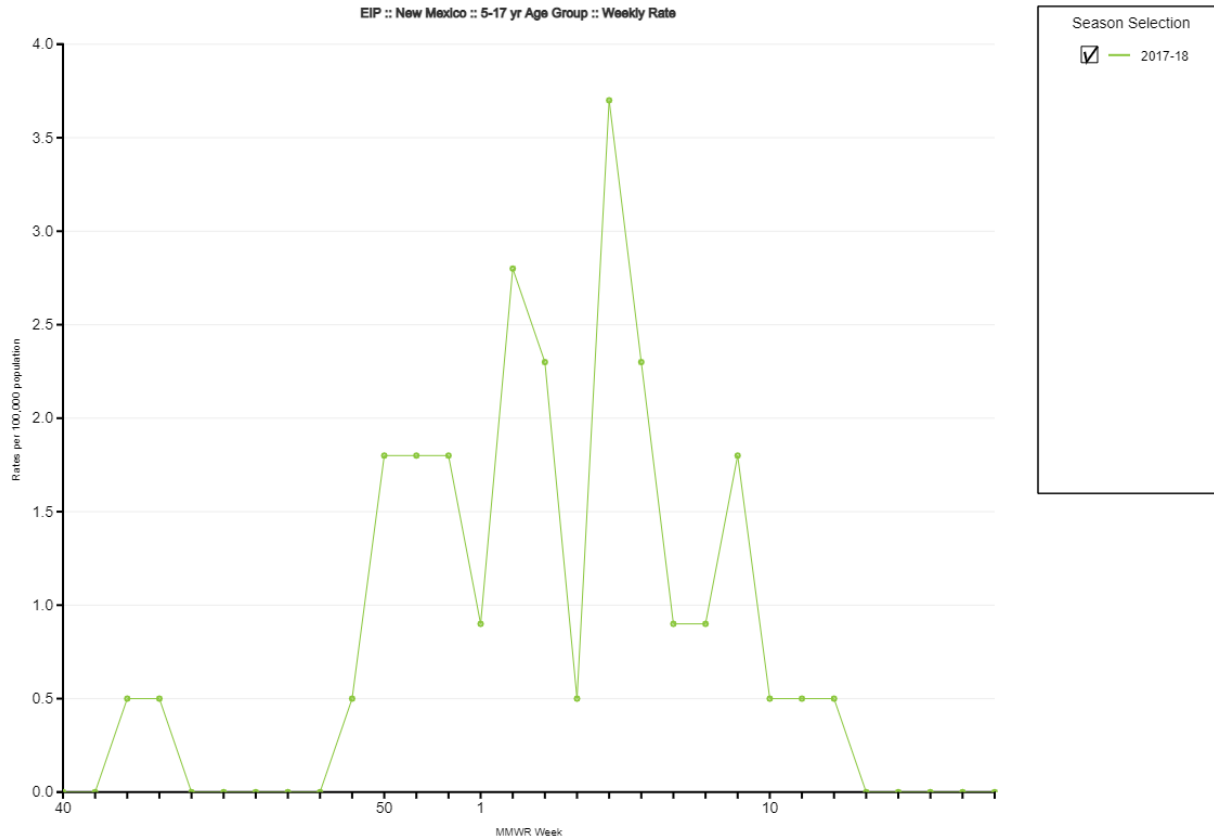
Influenza Season from FluSurv-NET [18]

The Influenza Hospitalization Surveillance Network (FluSurv-NET) conducts population-based surveillance for laboratory-confirmed influenza-associated hospitalizations in children (persons younger than 18 years) and adults. The current network covers over 70 counties in the 10 Emerging Infections Program (EIP) states (CA, CO, CT, GA, MD, MN, NM, NY, OR, and TN) and three additional states (MI, OH, and UT). The network represents approximately 9% of US population (~27 million people). Cases are identified by reviewing hospital, laboratory, and admission databases and infection control logs for patients hospitalized during the influenza season with a documented positive influenza test (i.e., viral culture, direct/indirect fluorescent antibody assay (DFA/IFA), rapid influenza diagnostic test (RIDT), or molecular assays including reverse transcription-polymerase chain reaction (RT-PCR)). Data gathered are used to estimate age-specific hospitalization rates on a weekly basis, and describe characteristics of persons hospitalized with associated influenza illness. Laboratory-confirmation is dependent on clinician-ordered influenza testing. Therefore, the unadjusted rates provided are likely to be underestimated as influenza-associated hospitalizations can be missed if influenza is not suspected and tested for. FluSurv-NET hospitalization data are preliminary and subject to change as more data become available. All incidence rates are unadjusted. Please use the following citation when referencing these data: "FluView: Influenza Hospitalization Surveillance Network, Centers for Disease Control and Prevention. WEBSITE. Accessed on DATE".

Figure three. Weekly Hospitalization Rates of 5-17 year Age Group in New Mexico during

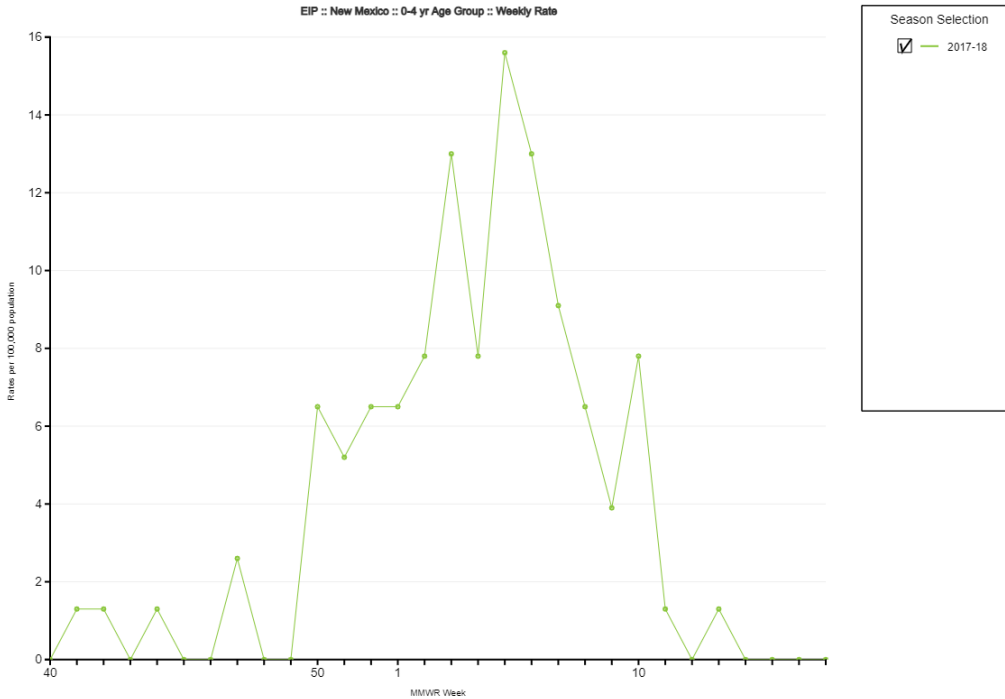2017-2018 Influenza Season from FluSurv-NET [18]

The Influenza Hospitalization Surveillance Network (FluSurv-NET) conducts population-based surveillance for laboratory-confirmed influenza-associated hospitalizations in children (persons younger than 18 years) and adults. The current network covers over 70 counties in the 10 Emerging Infections Program (EIP) states (CA, CO, CT, GA, MD, MN, NM, NY, OR, and TN) and three additional states (MI, OH, and UT). The network represents approximately 9% of US population (~27 million people). Cases are identified by reviewing hospital, laboratory, and admission databases and infection control logs for patients hospitalized during the influenza season with a documented positive influenza test (i.e., viral culture, direct/indirect fluorescent antibody assay (DFA/IFA), rapid influenza diagnostic test (RIDT), or molecular assays including reverse transcription-polymerase chain reaction (RT-PCR)). Data gathered are used to estimate age-specific hospitalization rates on a weekly basis, and describe characteristics of persons hospitalized with associated influenza illness. Laboratory-confirmation is dependent on clinician-ordered influenza testing. Therefore, the unadjusted rates provided are likely to be underestimated as influenza-associated hospitalizations can be missed if influenza is not suspected and tested for. FluSurv-NET hospitalization data are preliminary and subject to change as more data become available. All incidence rates are unadjusted. Please use the following citation when referencing these data: "FluView: Influenza Hospitalization Surveillance Network, Centers for Disease Control and Prevention. WEBSITE. Accessed on DATE".

Figure four. Weekly Hospitalization Rates of 0-4 year Age Group in New Mexico during 2017-2018 Influenza Season from FluSurv-NET [18]

The Influenza Hospitalization Surveillance Network (FluSurv-NET) conducts population-based surveillance for laboratory-confirmed influenza-associated hospitalizations in children (persons younger than 18 years) and adults. The current network covers over 70 counties in the 10 Emerging Infections Program (EIP) states (CA, CO, CT, GA, MD, MN, NM, NY, OR, and TN) and three additional states (MI, OH, and UT). The network represents approximately 9% of US population (~27 million people). Cases are identified by reviewing hospital, laboratory, and admission databases and infection control logs for patients hospitalized during the influenza season with a documented positive influenza test (i.e., viral culture, direct/indirect fluorescent antibody assay (DFA/IFA), rapid influenza diagnostic test (RIDT), or molecular assays including reverse transcription-polymerase chain reaction (RT-PCR)). Data gathered are used to estimate age-specific hospitalization rates on a weekly basis, and describe characteristics of persons hospitalized with associated influenza illness. Laboratory-confirmation is dependent on clinician-ordered influenza testing. Therefore, the unadjusted rates provided are likely to be underestimated as influenza-associated hospitalizations can be missed if influenza is not suspected and tested for. FluSurv-NET hospitalization data are preliminary and subject to change as more data become available. All incidence rates are unadjusted. Please use the following citation when referencing these data: "FluView: Influenza Hospitalization Surveillance Network, Centers for Disease Control and Prevention. WEBSITE. Accessed on DATE".

Figure five. Estimations for prevention of influenza disease burden from Chung et al [9]

Table 2.

Estimates of All Influenza-Associated Illnesses, Medical Visits, Hospitalizations, and Deaths Prevented by Influenza Vaccination—United States, 2018–2019 Influenza Season

Age Group	Illnesses		Medical Visits		Hospitalizations		Deaths	
	Number Prevented	95% UI[a]	Number Prevented	95% UI	Number Prevented	95% UI	Number Prevented	95% UI
6 months–4 years	1 335 840	(736 978–2 851 485)	895 012	(492 938–1 926 307)	10 569	(5933–22 379)	111	(25–381)
5–17 years	1 021 821	(446 661–1 870 063)	531 347	(230 928–980 184)	3269	(1478–5709)	33	(4–108)
18–49 years	984 698	(612 071–1 610 237)	364 338	(225 540–600 040)	6239	(3919–9884)	229	(114–588)
50–64 years	785 710	(241 045–2 158 024)	337 855	(102 597–926 454)	9250	(2970–23 951)	536	(143–2000)
≥65 years	300 879	(3249–1 316 421)	168 492	(1844–737 768)	28 695	(1533–121 752)	2625	(122–12 163)
All ages	4 428 947	(3 429 414–7 070 624)	2 297 045	(1 755 797–3 768 642)	58 022	(29 598–156 185)	3533	(1016–13 393)

Abbreviation: UI, uncertainty interval.

[a] 95% UI from 5000 Monte Carlo simulations.

Figure six. Hospitalizations for Influenza and Proportion of Hospitalization for Acute Respiratory Tract Infection of Fever Attributable to Influenza from Poehling et al [6]
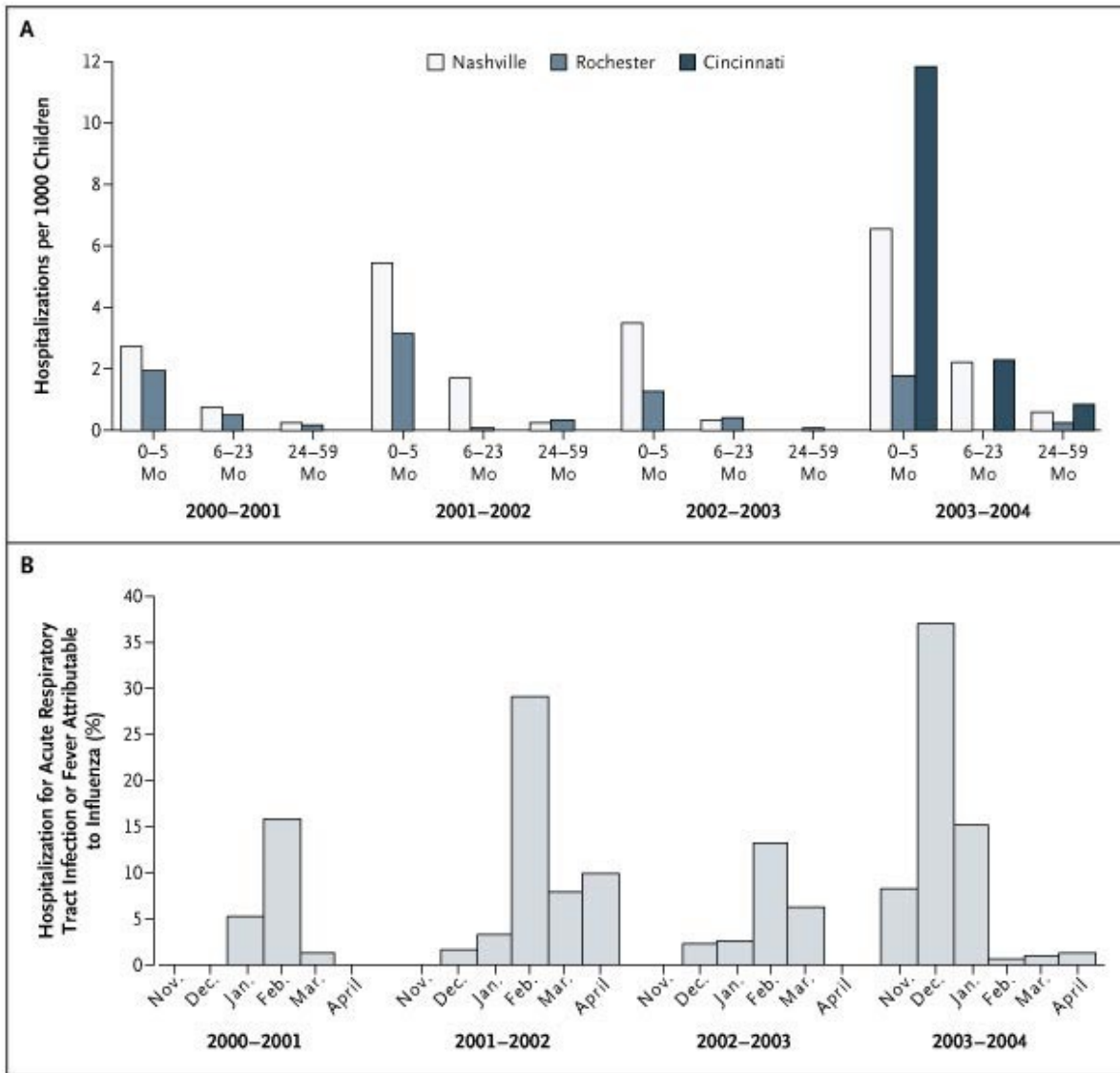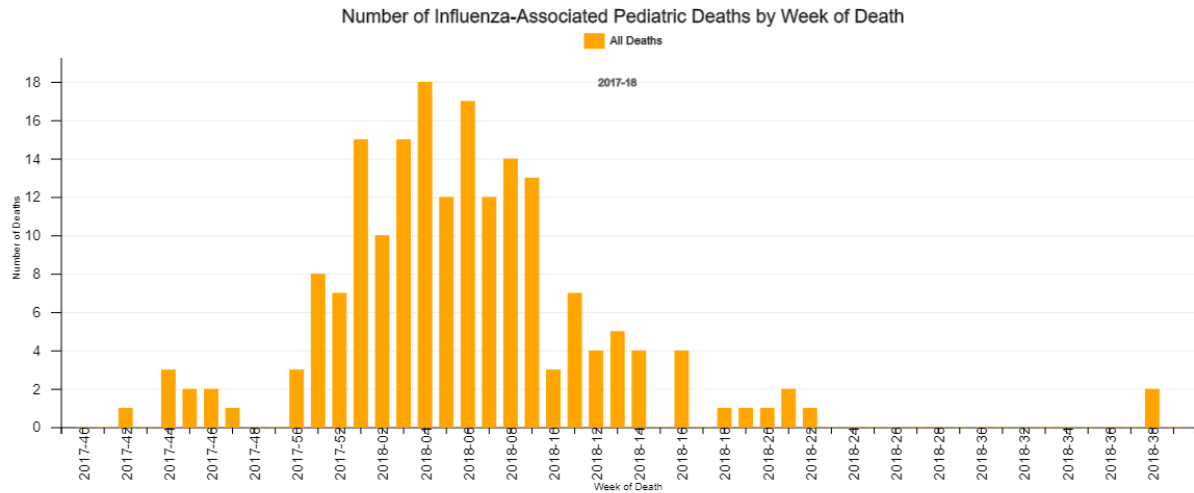
Figure seven. Number of Influenza-Association Pediatric Deaths by Week During 2017-2018

Influenza Season [19]

Figure eight. Scatter plot of Income-Poverty Ratio and Age in Days at First Vaccination with
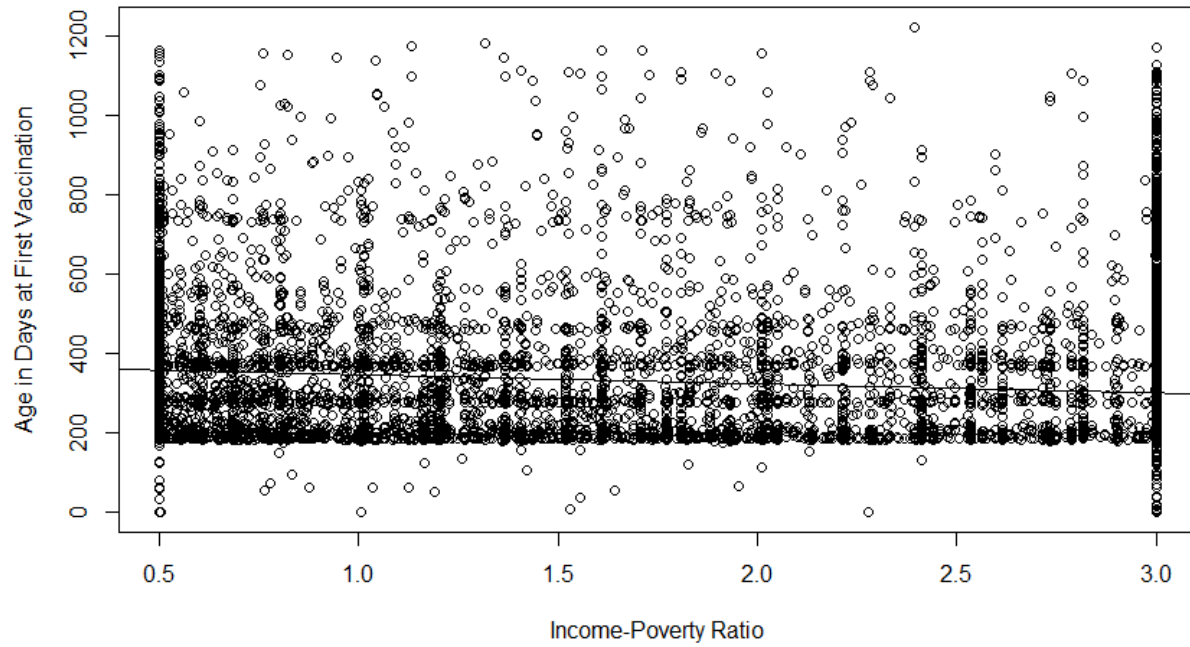
regression line from NIS data analysis

Figure nine. Box plot of Income-Poverty Ratio by Vaccination Up-to-Date Status from NIS data

analysis