THE IMPACT OF MANDATORY INFLUENZA VACCINATION IN CHILD CARE CENTERS IN NEW JERSEY

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ABSTRACT OF THE DISSERTATION

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Introduction: Preschool-aged children are at increased risk for severe influenza-related illness and complications. Congregate child care settings facilitate influenza transmission among susceptible children. To protect against influenza transmission in these settings, New Jersey (NJ) became, in 2008, the first state to implement regulations requiring that all children aged 6–59 months receive at least 1 dose of influenza vaccine each year to attend a licensed child care program. To date, no studies have been performed to evaluate the impact of the New Jersey mandate on influenza vaccination coverage. The purpose of this study was to assess influenza vaccination coverage before and after the mandates' implementation using New Jersey Immunization Information System (NJIIS) and the National Immunization Survey (NIS); to assess demographic and socioeconomic factors which alter vaccination coverage; and to assess changes in hospitalization and mortality rates after the mandates' implementation.

Methods: Coverage rates for influenza, measles mumps and rubella (MMR) and pneumococcal conjugate (PCV) vaccine were calculated from the NJIIS and NIS systems. Coverage was evaluated over time, at different geographic regions (i.e., New Jersey vs. United States) and by select demographic factors. Changes in population-based morbidity and mortality rates were also evaluated for New Jersey (NJ), the Northeast and the United States (US).

Results: The findings demonstrated that after the mandates' implementation an increase in influenza vaccine coverage in NJ was observed in both data systems analyzed. Substantial gains in vaccination coverage were not observed in the US for other childhood vaccinations evaluated. Similarly, NJ did not see gains in MMR vaccine but some gains in coverage for PCV vaccine were observed. Overwhelming difference in rates of influenza- associated hospitalizations and influenza-associated deaths were not observed after the mandates' implementation.

Conclusion: The findings of this dissertation provide evidence that the mandate likely contributed to the increases in influenza vaccine coverage in New Jersey. While increases in vaccine coverage were noted, changes in rates of morbidity and mortality were not observed.

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OVERALL INTRODUCTION

Annual epidemics of influenza with varying impact occur each year in the United States (US). Since 2010, it has been estimated that influenza results in between 9.2 million and 35.6 million illnesses and between 140,000 and 710,000 hospitalizations.[1-3] Hospitalization rates are highest for those greater than 65 and less than 4 years of age.[3] Evaluating seasonal influenza data from 1976 to 2006, influenza-associated deaths range widely with a low of approximately 3,000 to a high of about 49,000 deaths.[2] Influenza attack rates are generally higher in younger individuals while mortality is highest among older adults. Excess morbidity and mortality are commonly seen in a subgroup of individuals with certain high-risk medical conditions (e.g. cardiovascular, pulmonary, chronic metabolic conditions, renal dysfunctions, and immunodeficiency).[4]

In the United States, nearly 11 million children under the age of 5 have a child care arrangement each week with children of working parents spending an average of 35 hours per week in child care[5,6]. Preschool-aged children are at increased risk for influenza-related illness and complications. Transmission of influenza in this age group is often facilitated by child care centers where there is interaction among many susceptible children. Annual influenza vaccination for children aged 6-23 months was first recommended by the Advisory Committee on Immunization Practice (ACIP) in 2004[7] and for children aged 24-59 months in 2006[8]. Even with these recommendations, national influenza vaccine levels among children aged 6–59 months in the 2011–12 season was 67.6%, the lowest among vaccines routinely recommended for this age group except for rotavirus and hepatitis A vaccines[9,10].

In an effort to promote vaccinations and reduce disease transmission and outbreaks, all 50 states have legal requirements for specific immunizations for children attending schools and child care centers[11] with only a few states having legal requirements for influenza vaccine. On September 1, 2008, New Jersey (NJ) was the first state to implement a regulation requiring children six months through 59 months of age attending any licensed child care center or preschool facility to receive at least one dose of influenza vaccine between September 1 and December 31 each year. This mandate was to be fully implemented for the 2009-2010 school year; however, the mandate was suspended by the Commissioner of the New Jersey Department of Health due to limited vaccine availability. The regulation was fully implemented in the 2010-2011 school year. Since that time, Connecticut, Ohio and Rhode Island have enacted similar vaccine mandates[11] in January 2011, March 2015, and August 2015, respectively.

While studies have proven that state enacted vaccine mandates work to increase routine childhood vaccination rates[12,13], limited studies have been conducted to specifically determine if influenza vaccine mandates targeting children in child care centers are effective at increasing influenza vaccination coverage. Increases in vaccination coverage in Connecticut were noted after the implementation of this states' mandate[14], however, there are no studies to our knowledge that have been performed to evaluate the impact of the New Jersey mandate on influenza vaccination coverage.

The present study utilized vaccination records from the New Jersey immunization registry and the National Immunization Survey to assess if the implementation of an influenza vaccine mandate in NJ child care centers impacted overall influenza vaccine coverage. An assessment of factors (e.g., maternal education, insurance) impacting vaccination coverage was conducted. In addition, this study evaluated hospitalization discharge records and death certificate data to assess if the NJ vaccine mandate impacted overall hospitalization or mortality rates.

OVERALL METHODS

Data Sources

Vaccination Coverage

Vaccination coverage was assessed using two systems. First, the New Jersey Immunization Information System (NJIIS) was used to assess records specific to New Jersey. NJIIS is a confidential, population-based online system that collects and consolidates vaccination data for New Jersey's residents and is the official Immunization Registry per the Statewide Immunization Registry Act (NJAC 8:57-3). A random sample of 105 providers was selected and individual immunization records along with information about the client (i.e., residence, insurance) were obtained for these providers' patients.

The second system used to assess vaccination coverage was the National Immunization Survey (NIS). This is federally funded, nationally representative survey which uses random digit dialing (RDD) telephone survey methodology to identify households containing children in the target age range and interviews the adult who is most knowledgeable about the child's vaccinations. During the interview/survey, permission is sought from parents/guardians to contact their child's healthcare provider. After consent is obtained, a questionnaire/survey is mailed to that provider to obtain a vaccination history from the child's medical record. The NIS is conducted in each of the 50 states and 28 selected urban areas with a target population of children aged 19 to 35 months living in households in the United States at the time of the interview. This data was used to compare vaccination coverage level between New Jersey and the United States and to assess factors (e.g. income, insurance, maternal education) which impact these levels.

Morbidity and Mortality Rates

Three systems were used to calculate mobility and mortality rates. Mortality rates were calculated from the National Vital Statistics System Mortality component (NVSS-M)[15] which obtains information on deaths from the registration offices of each of the 50 states, New York City, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, Guam, American Samoa, and Northern Mariana Islands. States provide the National Center for Health Statistics (NCHS) with death records in electronic format and the NVSS-M data serve as the primary source of information on demographic, geographic, and cause-of-death information among persons dying in a given year. National, northeast region and New Jersey influenza-associated and influenza-specific mortality rates were calculated using causes of death categorized using the International Classification of Diseases, Tenth Edition (ICD-10)[16].

Hospitalization rates came from two different sources. National and region estimates were obtained from the Nationwide (National) Inpatient Sample (NIS)[17,18]. The NIS is a stratified probability sample of hospitals from the states that submit data to HCUP, which is weighted to provide national and regional estimates[19]. The complex sampling design of the NIS does not allow for state level estimates to be produced. Influenza hospitalization rates were acquired by querying the New Jersey State Health Assessment Data (NJSHAD) system[20] for New Jersey specific hospital discharges. For both the NJSHAD and NIS, overall influenza-associated hospitalization rates as well as rates stratified by age, gender, and race were calculated for the nation, the Northeast and New Jersey. Results specific to each project are detailed in the respective chapters.

The study received IRB approval from UMDNJ IRB body in November 2016.

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CHAPTER 1: DO VACCINE MANDATES WORK? ASSESSMENT OF INFLUENZA VACCINATION COVERAGE FROM 2007-2013 IN THE NEW JERSEY IMMUNIZATION INFORMATION SYSTEM AND THE EFFECT OF MANDATORY INFLUENZA VACCINATION POLICY IN CHILD CARE CENTERS IN NEW JERSEY

Introduction

Preschool-aged children are at increased risk for influenza-related illness and complications. Transmission of influenza in this age group is often facilitated by child care centers where there is interaction among many susceptible children. Annual influenza vaccination for children aged 6-23 months was first recommended by the Advisory Committee on Immunization Practice (ACIP) in 2004[1] and for children aged 24-59 months in 2006[2]. Even with these recommendations, national influenza vaccine levels among children aged 6–59 months in the 2011–12 season was 67.6%, the lowest among vaccines routinely recommended for this age group except for rotavirus and hepatitis A vaccines[3,4].

In the United States, nearly 11 million children under the age of 5 have a child care arrangement each week with children of working parents spending an average of 35 hours per week in child care[5,6]. In addition to the suboptimal vaccination levels and large numbers of children attending child care, there is a demonstrated increased risk of respiratory illness, including influenza, among these children[7-11]. All these factors combined can create the perfect storm for disease transmission.

In an effort to promote vaccinations and reduce disease transmission and outbreaks, all 50 states have legal requirements for specific immunizations for children attending schools and child care centers[12] with only a few states having legal requirements for influenza vaccine. New Jersey was the first states to enact this type of regulation. Since that time, Connecticut, Ohio and Rhode Island have enacted similar vaccine mandates[12]. The New Jersey regulation establishing the mandate was implemented on September 1, 2008, and required children six through 59 months of age attending any licensed child care center or preschool facility to receive at least one dose of influenza vaccine between September 1 and December 31 each year. Children who failed to comply with the mandate were excluded from the child care center until March 31 or until they received at least one dose of influenza vaccine. The mandate was to be fully implemented for the 2009-2010 school year; however, the mandate was suspended by the New Jersey Department of Health due to limited vaccine availability. The regulation was fully implemented during the 2010-2011 school year.

While studies have proven that state enacted vaccine mandates work to increase routine childhood vaccination rates[13,14], limited studies have been conducted to specifically determine if influenza vaccine mandates targeting children in child care centers are effective at increasing influenza vaccination coverage. Increases in vaccination coverage in Connecticut were noted after the implementation of this states' mandate[15], however, there are no studies to our knowledge that have been performed to evaluate the impact of the New Jersey mandate on influenza vaccination coverage.

Unlike previous studies where vaccination data associated with child care centers were available for analysis, data on influenza vaccinations in New Jersey child care centers were not collected prior to implementation of the mandate. While this specific data is not available, it is possible to evaluate vaccination coverage in the age group that is targeted by this mandate using provider reported vaccinations which have been recorded in a population based vaccine registry. This study was designed to determine if the mandate increased influenza vaccination coverage in the target population (i.e., children 6 to 59 months of age). Key socioeconomic variables were also examined to determine their impact on vaccination coverage. Other representative childhood vaccinations were also evaluated to determine if observed changes in influenza vaccination coverage are related to variations in vaccine uptake in the target population as a whole.

Methods

New Jersey Immunization and Information System (NJIIS)

System Overview

The New Jersey Immunization Information System (NJIIS) is a confidential, population-based online system that collects and consolidates vaccination data for New Jersey's residents. NJIIS is the official Immunization Registry per the Statewide Immunization Registry Act (NJAC 8:57-3). NJIIS consolidates immunization information from all providers into one record to provide an accurate electronic vaccine administration log.

In 2004, NJIIS began utilizing electronic birth records to automatically enroll all children born in New Jersey on or after January 1, 1998 into the registry. Prior to 2004, providers enrolled in the Vaccine for Children (VFC) program or providers who agreed to participate on a voluntary basis populated immunization records in NJIIS. VFC is a federally funded, state operated vaccine supply program that provides pediatric (i.e., birth to 18 years) vaccines at no cost to health care providers who serve children who might not otherwise be vaccinated because of inability to pay. There are over 1,200 medical offices enrolled in the New Jersey VFC program and the majority are private providers.

Providers can enter immunization data in to NJIIS manually using the web-based interface or through an electronic interface which allows immunization data (e.g., type of vaccine, site of vaccination, lot number) to be electronically transmitted from providers' medical records to the NJIIS system. To date, more than 900 providers have the ability to transmit vaccination information electronically while other providers manually enter vaccinations.

Beginning December 31, 2011, new state regulations (New Jersey Administrative Code, N.J.A.C. 8:57-3.16) were implemented requiring any health care provider immunizing children less than seven years of age to enroll and record immunizations in NJIIS. Providers can fulfill this requirement by either the manual or electronic transmission options.

Provider and Patient Selection

There is no mechanism currently available in the NJIIS system by which all vaccine records during the study period could be obtained. The mechanism to obtain records was to run data queries in the system which resulted in individual vaccine records from providers. This resource intensive process of obtaining data limited the number of records that could be requested from NJIIS. A sampling strategy was developed to limit the number of records requested. First, a list of all providers contributing to the NJIIS system prior to 2007 was obtained. A random sample of providers was then generated by first stratifying providers by county of practice and assigning a randomly generated number. The first 5 providers with the lowest randomly generated numbers in each of New Jersey's 21 counties having reported vaccination records into NJIIS for all study years (i.e., 2007 through 2013) were selected. Providers who did not report for any one study year were excluded and the next provider on the list was selected. For each provider, data queries were run in NJIIS and a file for all reported vaccinations across all study years was obtained. In addition to the vaccine type, lot, manufacturer and location of vaccine administered, the vaccine file contained a unique registry identifier for each individual patient reported, date of birth and information about the funding sources of the vaccine (i.e., VFC). In addition to the vaccine file, a patient master file was also obtained for each provider which included all patients seen and vaccinated at least once by that practice. The patient master file also contains a unique registry identifier, date of birth, residence of the child (i.e., city and zip code) and insurance used to pay for the vaccine. Data for a total of 105 providers were used in this analysis.

Merging Data

The vaccine file and patient master file were merged by matching the unique registry identifier and date of birth of each individual. Since neither the vaccine file or patient master file included county of residence, a zip code data base [16] was used to match records with valid New Jersey zip codes or if zip code was missing by city of residence to a valid New Jersey county.

Inclusion/Exclusions

After combing the vaccine and patient master file, a total of 3,404,086 individual vaccination records from all vaccination types for NJ residents were available from 2007 to 2013. Twenty-three percent of the records (n=797,015) representing 333,589 individuals were also excluded if the date of birth occurred after the date of first recorded vaccination, if the patient was older than 7 years of age, and if the unique registry identifier was not valid (i.e., was zero or did not match standard 7 digit code). An additional 23% of records (n=783,722) representing 92,114 individuals were excluded because they could not be matched to a county because of invalid zip code or city. All vaccines within the NJIIS system that were indicative of an influenza (e.g., Flu, Flu-Mist, H1N1 Flu), MMR, or PCV (e.g., PCV13, Pnuemo Conj) vaccine were included in the vaccine coverage analysis.

Influenza Vaccinations

Influenza vaccine coverage was assessed in two ways. First, vaccinations were evaluated based on strict criteria indicated in the mandate. For this evaluation, all children 6 to 59 months receiving at least one dose of influenza vaccine from September to December in each study year were tallied. Since 2007 ACIP recommendations[17] indicate that influenza vaccine should continue to be administered while influenza is still circulating, a second evaluation was conducted looking at vaccination coverage of children 6 to 59 months from September of one year to June of the next year (i.e., influenza season). ACIP recommendations[17] also indicate that some children should receive two doses of influenza vaccine in a given season and for both of these evaluations, only the first vaccination was included for analysis even if a second dose was administered in that same time period under evaluation.

Other childhood vaccinations

In an effort to understand if changes associated with influenza vaccine coverage were due to the mandate or were simply related to vaccine uptake more generally, an evaluation of other childhood vaccinations was also conducted to examine the overall temporal trend in vaccine uptake. Selecting vaccinations comparable to influenza is challenging because other childhood vaccinations are recommended for the entire population versus the New Jersey influenza mandate which targeted those attending child care centers. Additionally, influenza is an annual vaccination while other childhood vaccinations are given in a series based on the child's age. Pneumococcal conjugate vaccine (PCV) and measles mumps and rubella (MMR) vaccine were selected for this evaluation. The recommendation is to administer the first of two doses of MMR vaccine between 12-15 months of age and the second dose between 4-6 years of age[18]. PCV is a four dose series given at 2, 4, 6 and 12-15 months[19]. MMR and PCV were felt to be good comparison vaccinations as they are administered multiple times and both required doses to be administered at older ages (i.e., 4-6 years and 12-15 months, respectively).

Base Populations

Using the unique registry identifier, the number of unique patients in NJIIS stratified by study year (2007 through 2013) were identified. Base population one included those individuals who were 6 to 59 months of age from September to December of each study year. Base population one was used as the denominator in calculations which evaluated the September to December influenza vaccination coverage and also to evaluate other childhood vaccinations where a full year of vaccination data was evaluated. Base population two was calculated by extending the time frame and included unique individuals from July of one year to June of the following year. This denominator was used in calculations which evaluated the September to June influenza vaccination coverage.

Data Analysis

Percent vaccine coverage was calculated by using the number of vaccines administered divided by the representative base population for the vaccine being calculated. Influenza vaccine coverage was evaluated for those receiving a single dose of vaccine between September and December and again for those who received vaccine between September and June. A single dose of the two other childhood vaccinations were evaluated over the course of an entire year and the annual base population was used for these calculations. Overall vaccination coverage and coverage stratified by county were calculated. Beginning in April of 2009, an influenza pandemic associated with influenza A 2009 H1N1 occurred. Later that year, a separate pandemic virus influenza vaccination in addition to the seasonal influenza vaccination was offered. This may have created an artificial increase in influenza vaccine coverage, therefore, data were also analyzed by removing data from this period (i.e., 2009, 2010). In order to mirror calculations with influenza vaccine coverage, removal of this data and subsequent analysis was also conducted for PCV and MMR vaccinations.

The Mann-Kendall statistic was used to evaluate if a monotonic (i.e., gradual change over time in a consistent direction) trend was observed across time for both overall data and data stratified by county. A one-sided test statistic with a p-value less than 0.05 was used to declare significance. To assess the change of vaccination coverage, the relative difference in coverage from the pre-mandate (2007) to the post-mandate (2013) of the project period was calculated.

Factors influencing vaccination coverage

The association between vaccination status and participation in the vaccine for children (VFC) program was evaluated using a chi square test. This analysis was conducted for the influenza vaccine administered in the September to December timeframe, the extended timeframe from September to June, and for both PCV and MMR vaccinations. A chi square statistic with a p value less than 0.05 indicated statistical significance.

The individual NJIIS records obtained did not include individual socioeconomic status (SES). In an effort to assess if vaccine coverage varied by SES factors, SES variables in the U.S. Department of Health and Human Services, Area Health Resources File (AHRF)[20] were obtained for the state and all New Jersey counties. SES variables selected for evaluation included percent of the population who identify as non-white race, who identify as Hispanic, who have health insurance, who graduated from high school and the percent of the population below the poverty level. Relative change in each counties vaccination coverage from pre- to post mandate calculations were plotted against the counties SES factor. Linear regression analysis was conducted to assess if a linear relationship existed between vaccination and the selected SES factors.

All analyses were performed using SAS version 9.3 (SAS Corp, Cary, North Carolina) or Microsoft® Excel (2013).

Results

Overall data

After the patient and vaccine data files were merged and records excluded, the remaining files analyzed consisted of 1,823,349 vaccinations from 139,927 persons. Over the seven years of data represented here, each person on average had 13 vaccinations reported into NJIIS with a range of 1 to 50. On average, each provider reported vaccinations on 1,427 unique patients. From 2007-2013, 136,107 and 135,475 influenza vaccinations were recorded from September to December and September to June, respectively. All providers selected participated in the VFC program with 80% of all vaccination being covered by the VFC program.

Influenza vaccination coverage

As shown in Figure 1.1, the pre-mandate (2007) baseline for influenza vaccination coverage for children 6 to 59 months vaccinated between September and December was 31.17% and the post-mandate (2013) vaccination coverage was 48.00%. Influenza vaccination coverage increased by 42.89 percent from the pre- to post- mandate period. The percent influenza vaccination coverage for children 6 to 59 months vaccinated between September to December showed a statistically significant increasing trend (Mann-Kendall p=0.018) across the seven year study period (Figure 1.1). When the influenza vaccination period was extended to June, a similar statistically significant trend (Mann-Kendall p = 0.009) was also observed (Figure 1.2). Similar to the September to December data, there was a 39.32 percent increase in vaccine coverage from the pre- to post-mandate period. The pre-mandate (2007) baseline was 35.88% and the post-mandate (2013) vaccination coverage was 58.20%. When pandemic data was removed, the overall trend for September to December data was no longer significant but remained significant for the September to June data ($p=0.045$) (Table 1.1).

When the September to December vaccine coverage was stratified by county, ten counties (Atlantic, Bergen, Burlington, Cape May, Hunterdon, Mercer, Middlesex, Monmouth, Passaic, Somerset) were found to not have a statistically significant increase in trends across the study years (Table 1.1,1.2). When the time period was extended to June, four of the counties (Atlantic, Burlington, Hunterdon, Mercer) saw a statistically significant ($p<0.05$) increasing trend that was previously not seen when vaccination data were only considered until December (Table 1.1, 1.3). After dropping study years associated with the pandemic for September to December study period, two counties (Camden, Salem) that previously had a statistically significant trend were no longer significant. In three counties (Bergen, Middlesex, Passaic), a statistically significant trend was detected after removal of the pandemic data (Table 1.1). When extending the data to June, three counties (Burlington, Hunterdon, Mercer) no longer had a statistically significant trend but in three counties (Bergen, Middlesex, Passaic) a statistically significant trend was detected with the removal data associated with the pandemic data (Table 1.1).

In comparing differences in vaccine administration times (i.e., December, June) with pandemic data removed, 11 counties (Bergen, Cumberland, Essex, Gloucester, Hudson, Middlesex, Morris Passaic, Sussex, Union, Warren) had statistically significant increasing trends which remained when the time period was extended to include data until June. Three counties (Atlantic, Camden, Salem) became significant when the pandemic data was removed and the data was extended to June. The remaining counties did not have statistically significant trends identified. (Table 1.1).

In the September to December time period, all but two counties (i.e., Burlington, Cape May) saw an increase in influenza vaccine coverage between the pre- and post- mandate periods (Table 1.1). When the timer period was extended to June, an increase was observed in all counties including Burlington and Cape May. From September to December, the average percent change from pre- to post mandate period among all counties was 84.97 (range -28.91 to 273.44). When the time period was extended to June, the average change in percentages among all counties was 83.14 (range 2.54 to 272.36) (Table 1.1).

<u>Other childhood vaccination coverage</u>

Unlike what was observed for influenza vaccinations, a statistically significant trend was not observed in vaccination coverage for either the PCV or MMR vaccinations across all study years. Significance did not change when pandemic data was dropped. (Figures 1.3, 1.4). There was an 11.27 percent decline (Figure 1.3) in PCV vaccination coverage and an increase of 5.83 percent (Figure 1.4) in MMR vaccination coverage between the pre- and post- mandate period.

When PCV data was stratified by county, no statistically significant trend was observed for any county even when 2009 pandemic data was removed (Table 1.4, 1.5). A statistically significant increasing trend was observed in MMR vaccination coverage in four counties (Atlantic, Cumberland, Hudson, Salem). The statistically significant trend observed in these counties remained even after pandemic data was removed (Table 1.5, 1.6).

Overall, there was a decline in 19 counties for vaccine coverage with PCV vaccine and a decline was observed in 7 counties for MMR vaccine. Across all counties, there was an average percent decline of 13.57 (range -27.40, 5.37) PCV coverage from pre- to post-mandate period. Only Hudson and Passaic counties observed increases from pre- to post-mandate period for PCV vaccination coverage. MMR vaccination had an average 6.61 (range -10.25, 28.19) percent increase in vaccination coverage from the pre- to post-mandate period (Table 1.5).

Factors influencing vaccination coverage

Vaccinations provided under the vaccine for children (VFC) program were evaluated to determine if there was an association between being enrolled in the program and receiving a vaccination. A statistically significant association ($p<0.05$) was found overall and for every county except two. In Hunterdon and Bergen counties no statistically significant association was found for influenza vaccine administered between September and December. When the time period was extended until June, only Hunterdon County remained without a statistically significant association. For both PCV and MMR, a statistically significant association between VFC and vaccination was found both overall and for every county.

Assessment of the SES factors and their associated with vaccination coverage are presented in Table 1.7 and Figure 1.5-1.8. Statistically significant linear associations between the relative change in vaccination coverage from the pre- to post-mandate and the selected SES factors was not observed for influenza vaccination, regardless of time frame. For PCV vaccination, counties with greater insurance coverage, higher population in poverty and a greater proportion of Hispanics saw statistically significant greater changes in vaccination coverage from pre- to post- mandate. For MMR vaccination, counties with a larger proportion of high school graduates, greater insurance coverage, a higher population in poverty and a greater proportion of Hispanics saw statistically significant greater changes in vaccination coverage from pre- to post- mandate.

Discussion

To our knowledge, this is the first study conducted to evaluate changes in vaccination coverage associated with the New Jersey mandate requiring influenza vaccinations in licensed childcare centers. The findings of this study demonstrate that after the implementation of this type of mandate increased vaccine coverage was observed. Increases in influenza vaccination coverage were observed in the target population (i.e., 6 to 59 months of age) during the September to December timeframe which is the period targeted for vaccination by the mandate. A larger increase in influenza vaccination coverage was observed when the vaccination administration date was extended until June of the following year. In the September to December time periods, only two counties saw decreases in influenza vaccination coverage between the pre- and post- mandate period, however, increases were observed in all counties when the time period was extended until June.

Statistically significant increasing trends were observed for influenza vaccinations over the study period for both vaccine administration periods (i.e., December, June). Even after removal of data associated with the 2009 pandemic which may have artificially inflated vaccine coverage and misrepresented observed trends, the trends remained significant but only for vaccine administered until June. Decreases in vaccination coverage in 2013 was observed overall and in many counties which likely contributed to this finding.

While a number of studies have described differences in vaccination coverage among states and larger urban areas[21,22], few studies were found evaluating vaccination coverage at the county level. The analysis that we conducted at the county level revealed differences in vaccination coverage. We found that three counties (Cape May, Somerset, Monmouth) observed no statistically significant increase in influenza vaccination coverage trends across the study period and eight counties (Cumberland, Essex, Gloucester, Hudson, Morris, Sussex, Union, Warren) saw a consistent statistically significant increasing trends regardless of the time frame (i.e., December, June), or exclusion of pandemic data. The remaining ten counties saw an increasing trend in at least one time frame analysis with more statistically significant trends when vaccination data was evaluated until June. While data on medical and religious vaccination exemptions are not available for this study period, data[23] from 2013-2014 shows that medical exemptions are small and fairly consistent between counties (range 0.3-1.4%) but religious exemptions vary widely by county (range 1-7.1%). These exemptions could be contributing to at least some of the variability observed in county coverage. In addition, the diversity of New Jersey populations varies greatly from county to county and these findings demonstrates that county level stratification may be needed to best understand how county population characteristics impact vaccination coverage.

Similar to the timing of administration of influenza vaccines nationally[4], our study found that on average 82% of influenza vaccines were administered prior to December and an additional 15% by February of each study period. This would explain why vaccination rates in some counties improved when vaccinations beyond December were included. While the mandate requires a vaccination to be received prior to December 31, the similarity of these trends to national data likely reflect typical vaccine uptake and not an impact from the mandate. It should also be noted that additional children turning six months of age after January 1 would also become eligible for vaccination and could be contributing to this increase. Children who did not receive an influenza vaccination by the mandates deadline (i.e., December 31) and were excluded from childcare until they receive a single dose of vaccine could also be contributing to this increase. Our findings, however, suggest that analysis of vaccination coverage should be conducted with data that extends beyond December in order to get the most accurate estimate of coverage.

While increases were observed with influenza vaccination coverage, consistent increases in coverage overall and stratified by county for two other common childhood vaccinations (PCV, MMR) were not observed. MMR vaccinations had greater gains between the pre- and post-mandate period with 14 counties showing an overall increase in vaccination coverage but only 4 of these counties saw a statistically significant increasing trend. Only 2 counties showed gains pre- to post-mandate with PCV vaccination and a statistically significant increasing trend was not observed in any county.

While these childhood vaccinations are not completely comparable to influenza vaccinations, the lack of a statically significant trend in our study adds further evidence that the increases associated with influenza vaccination coverage were likely not associated with general increase in vaccinations or increases in vaccinations reported to NJIIS. This finding, especially for MMR vaccinations, is consistent with national trends in which vaccinations coverage rates have been relatively stable since the mid-1990's[24,25].

Our findings also illustrate that increases in influenza vaccination coverage did not correlate with improvement of vaccination coverage for other vaccines evaluated. If factors outside the mandate were associated with increasing vaccination coverage rates, counties which saw the most improvement in influenza vaccine coverage would also be expected to observe increases in other vaccine types. This was not observed in our data. For example, Sussex County has the largest gain from the pre- to post- mandate period (35.73) for influenza vaccine but this same county ranked near the bottom for percentage gains for the other two childhood vaccinations evaluated. Sussex County showed the 19th and 17th lowest gains for PCV and MMR vaccinations respectively. Only two counties (Hudson, Passaic) saw increases in vaccination coverage across the three vaccines evaluated.

Our analysis also further solidifies the importance of VFC programs in vaccine coverage rates. We found a statically significant association between VFC participation and vaccination status across all vaccinations studied. Stratification by county revealed only two counties (Hunterdon and Bergen) did not have a statistically significant association. These two counties had the lowest VFC participation among all counties and therefore a lack of association in these counties is not surprising. Our findings, similar to several other studies[26,27], highlight the important role that the VFC programs play on childhood vaccinations by breaking down financial and logistic barriers and improving overall vaccination coverage[28].

While demographic and socioeconomic data were not directly available in NJIIS, proxy data was used as these factors are also known to contribute to differences in vaccination coverage[22,29]. No statistically significant association between changes in vaccination coverage and the SES factors studied were identified with influenza vaccination. Unlike influenza vaccine, statistically significant linear associations were observed between selected SES factors and relative changes in vaccination coverage for both PCV and MMR vaccinations. For both PCV and MMR vaccination, counties with greater insurance coverage, higher population in poverty and greater proportion of Hispanics saw more change in vaccination coverage between the pre- and post-mandate period. For MMR vaccination, counties with a higher population of high school graduates also have greater increases in vaccination coverage. While our finding are interesting, some of the inconsistencies observed are likely related to application of these factors at an aggregate county level. Evaluation of these factors where individual level data are available would be more appropriate.

Studies conducted on the use of mandates to bolster immunization rates in schools and child care centers have shown promise in raising vaccination rates[13,14]. However, none of these studies specifically evaluated the use of mandates on influenza vaccination due to the limited number of states who have such a mandate. New Jersey was the first state to enact a regulation requiring influenza vaccination in child care centers. Since that time, Connecticut, Ohio and Rhode Island have enacted similar vaccine mandates[12]. To our knowledge, only one other study evaluating the impact of influenza vaccine mandates in child care centers has been conducted. This study looked at the Connecticut mandate which took effect in 2010 and found that influenza vaccination coverage increased by 16.3 percentage points from 2009 to 2013 in preschool age children[15]. Our study showed a 16-22% increase from 2007 to 2013 similar to what was observed in the study of the Connecticut data. The study conducted in Connecticut did not look at vaccination disparities at the county level nor did they evaluate demographic and socioeconomic factors and there is little data in the current literature to compare our findings to on these factors.

The strength of this study comes from the use of data from a population-based registry. Records were stratified by county and randomly selected and this method should provide for comparable results had all registry records been analyzed. While the ideal approach would have been to evaluate all vaccinations records in the registry, limitations on the NJIIS systems ability to extract this large quantity of data prohibited this from occurring. Despite this challenge, the subset of data resulted in a robust dataset with which to conduct these analyses. The findings of this study are likely similar to what would have been found if all records from NJIIS were utilized. Additionally, the large number VFC providers included in this study likely increased the accuracy of vaccinations reported. VFC providers are required to report via NJIIS as this is the mechanism by which they can get more vaccine supply.

This study has several limitations that should be noted. NJIIS does not record information on attendance at a child care centers which is the target population of this mandate. While our findings indicate increases in influenza vaccinations in the age group targeted by the mandate (i.e., children 6-59 months), it is not possible to directly estimate increases in only those who attend child care centers.

All providers who were selected for this study participated in the VFC program. It is possible that the practices of these providers are different than providers who do not participate in this program and have created bias in the results observed.

Annual influenza vaccination for children aged 6-23 months was first recommended by the Advisory Committee on Immunization Practice (ACIP) in 2004[1] and for children aged 24-59 months in 2006[2]. Our study began in 2007 and it is not possible to know how much of the increases observed are associated with general uptake of influenza vaccine as it relates to these newly implemented recommendations versus the impact from the mandate.

The implementation of this mandate was complicated by the 2009 H1N1 pandemic which introduced a non-seasonal vaccine containing the specific pandemic virus strain. Administration of this vaccine began in September 2009. Concerns over artificially inflated vaccination coverage because of these vaccinations were mitigated by conducting a sensitivity analysis with and without those years of data.

Beginning December 31, 2011, new state regulations, were implemented requiring any health care provider immunizing children less than seven years of age to enroll and record immunizations in NJIIS. The addition of this regulation in the middle of our study period may have artificially altered vaccine recorded in NJIIS post mandate. Since providers were selected only if they reported for all study years (2007-2013) and were reporting prior to this regulation taking effect, we feel that the impact of this regulation on our data is likely minimal.

Conclusion

The findings of this study support the notion that influenza vaccine mandates requiring vaccination of children in licensed child care facilities increases vaccination coverage in children most likely to attend child care centers. These findings are further supported by the lack of observed increases in other common childhood vaccinations evaluated. Studies which can specifically look at vaccination status among children attending child care centers would be more ideal for studying the impact of this mandate, however, New Jersey specific data was not collected prior to the mandates implementation and therefore this type of data is not available for study. Evaluation of trends in vaccination coverage in children attending child care centers even after the mandates implementation could further strengthen these findings. National dataset, such as the National Immunization Survey, could also provide further insight into vaccination coverage by providing data collected in a standardized way and allowing of comparisons to other states and national data.

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Figure 1.1 Influenza Vaccine Coverage, Children 6 to 59 Months, September to December, 2007-2013

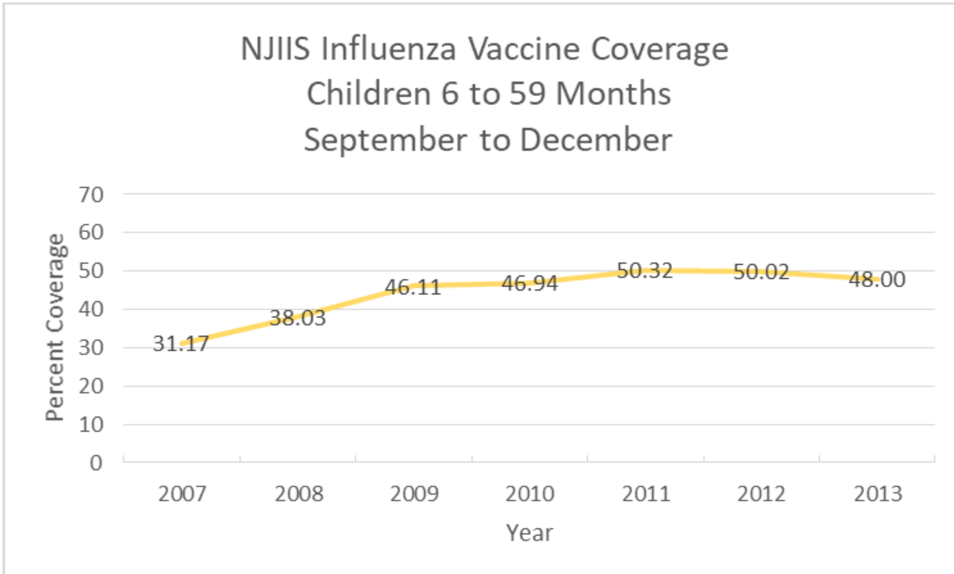


Figure 1.2 Influenza Vaccine Coverage, Children 6 to 59 Months, September to June, 2007-2013

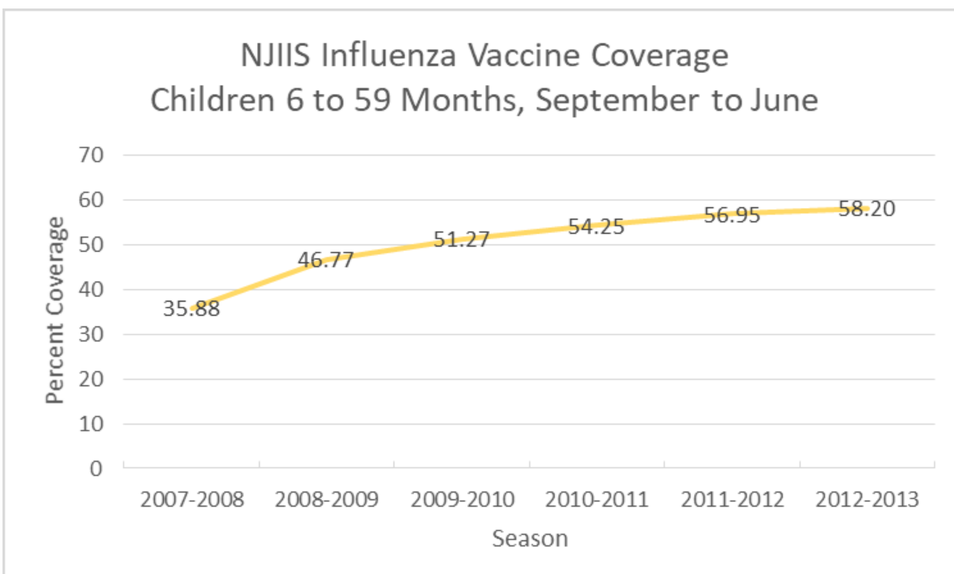


Table 1.1 Influenza Vaccine Coverage Statistic by County

County	September to December			September to June		
	Difference pre- and post-mandate	Mann-Kendall statistic (p value) All Study Years	Mann-Kendall statistic (p value) Drop Pandemic Period	Difference pre- and post-mandate	Mann-Kendall statistic (p value) All Study Years	Mann-Kendall statistic (p value) Drop Pandemic Period
New Jersey	42.89	0.018	0.231	39.32	0.009	0.045
Atlantic	2.62	0.184	0.403	42.20	0.004	0.045
Bergen	110.97	0.067	0.043	119.59	0.066	0.045
Burlington	-28.91	0.115	0.403	47.12	0.030	0.367
Camden	36.32	0.018	0.231	51.83	0.004	0.045
Cape May	-20.10	0.500	0.500	44.45	0.066	0.154
Cumberland	134.32	0.001	0.014	126.89	0.012	0.045
Essex	214.47	0.003	0.043	204.06	0.004	0.045
Gloucester	74.70	0.001	0.014	94.23	0.012	0.045
Hudson	94.88	0.018	0.043	55.18	0.030	0.045
Hunterdon	102.67	0.067	0.231	93.01	0.030	0.154
Mercer	19.57	0.115	0.231	22.61	0.030	0.154
Middlesex	91.72	0.067	0.043	56.79	0.226	0.045
Monmouth	86.65	0.067	0.110	70.53	0.066	0.154
Morris	158.83	0.008	0.043	151.43	0.012	0.045
Ocean	90.03	0.008	0.110	95.02	0.012	0.154
Passaic	49.80	0.115	0.043	13.26	0.130	0.045
Salem	48.38	0.036	0.110	36.28	0.030	0.045
Somerset	88.37	0.184	0.110	2.54	0.500	0.500
Sussex	273.44	0.008	0.043	272.36	0.012	0.045
Union	59.84	0.018	0.043	69.64	0.012	0.045
Warren	95.79	0.001	0.014	76.85	0.004	0.045

Note: Mann-Kendall test statistic with a p-value less than 0.05 used to declare significance.

The relative difference in coverage from the pre-mandate (2007) to the post-mandate (2013).

Table 1.2 Influenza Vaccine Coverage by County, Children 6 to 59 Months, September to December, 2007-2013

	Influenza Vaccine Coverage, September to December, 6 to 59 months																				
	2007			2008			2009			2010			2011			2012			2013		
County	**Percent**	**95% CI**		**Percent**	**95% CI**		**Percent**	**95% CI**		**Percent**	**95% CI**		**Percent**	**95% CI**		**Percent**	**95% CI**		**Percent**	**95% CI**	
Atlantic	37.34	35.81	38.69	36.86	35.46	38.12	45.54	44.48	46.51	44.78	43.82	45.67	46.79	45.88	47.63	45.67	44.76	46.51	38.32	37.30	39.25
Bergen	24.79	23.46	26.00	30.37	29.13	31.49	56.57	55.81	57.28	36.65	35.59	37.63	50.47	49.66	51.22	52.80	52.05	53.50	52.31	51.55	53.02
Burlington	38.98	38.14	39.75	25.29	24.32	26.19	50.86	50.22	51.47	51.31	50.79	51.80	54.25	53.77	54.71	55.23	54.76	55.68	27.71	27.01	28.37
Camden	38.99	38.15	39.77	42.74	41.94	43.48	44.15	43.42	44.82	51.38	50.74	51.98	54.22	53.66	54.75	54.01	53.44	54.54	53.15	52.57	53.69
Cape May	39.44	38.02	40.70	38.24	36.84	39.48	57.63	56.80	58.39	46.88	45.86	47.81	46.95	45.98	47.84	51.11	50.12	52.02	31.51	30.20	32.70
Cumberland	21.93	20.74	23.03	32.85	31.76	33.86	38.17	37.08	39.16	44.65	43.71	45.52	49.38	48.68	50.04	51.25	50.59	51.86	51.40	50.74	52.01
Essex	17.91	16.81	18.93	39.14	38.16	40.05	40.31	39.36	41.19	51.61	50.79	52.36	56.17	55.41	56.87	56.66	55.92	57.35	56.33	55.61	57.01
Gloucester	26.42	24.76	27.89	33.96	32.43	35.32	35.16	33.66	36.49	37.35	35.91	38.63	44.41	43.14	45.55	44.70	43.42	45.84	46.16	44.97	47.24
Hudson	25.44	24.26	26.52	32.23	31.04	33.31	25.17	23.95	26.28	41.60	40.67	42.46	48.48	47.67	49.23	46.44	45.64	47.18	49.58	48.82	50.28
Hunterdon	24.67	22.53	26.50	43.82	41.77	45.55	52.36	50.56	53.89	45.56	43.46	47.33	58.42	56.64	59.91	54.75	52.78	56.38	50.00	47.66	51.91
Mercer	46.90	46.13	47.61	52.92	52.22	53.58	57.11	56.45	57.73	56.28	55.59	56.92	61.08	60.49	61.64	58.79	58.14	59.40	56.08	55.40	56.72
Middlesex	24.61	22.73	26.25	30.04	28.21	31.63	55.63	54.56	56.60	35.25	33.56	36.74	39.61	37.92	41.10	38.83	37.30	40.19	47.19	45.72	48.48
Monmouth	27.50	26.45	28.48	40.54	39.60	41.40	42.97	42.06	43.81	53.51	52.73	54.23	51.97	51.18	52.70	49.05	48.21	49.84	51.34	50.54	52.08
Morris	21.51	18.64	23.84	36.50	34.15	38.46	45.77	44.07	47.23	44.25	42.39	45.85	53.79	52.22	55.14	56.23	55.02	57.29	55.67	54.54	56.68
Ocean	20.88	19.60	22.05	31.95	30.86	32.95	33.22	32.31	34.07	35.14	34.33	35.91	41.58	40.85	42.26	37.83	37.09	38.53	39.69	38.99	40.34
Passaic	36.05	34.90	37.10	32.04	30.64	33.30	51.90	50.74	52.94	60.92	60.26	61.53	42.88	42.00	43.69	43.16	42.31	43.96	54.00	53.34	54.61
Salem	34.00	32.28	35.51	49.01	47.74	50.14	44.80	43.45	46.00	46.41	45.13	47.55	47.35	46.18	48.40	47.77	46.59	48.83	50.45	49.30	51.48
Somerset	28.24	26.74	29.58	36.67	35.15	38.02	45.73	44.39	46.93	35.64	34.09	37.01	39.78	38.26	41.13	35.46	34.17	36.62	53.19	52.29	54.01
Sussex	14.75	12.54	16.62	36.59	34.55	38.32	50.80	49.31	52.10	49.18	47.88	50.33	52.81	51.74	53.78	56.01	55.26	56.70	55.09	54.34	55.78
Union	33.59	32.72	34.40	45.89	45.16	46.57	50.62	49.96	51.25	44.90	44.13	45.62	53.53	52.86	54.16	51.26	50.59	51.88	53.68	53.04	54.29
Warren	28.57	26.11	30.63	40.27	38.12	42.08	45.71	43.94	47.23	47.43	45.89	48.78	49.57	48.14	50.82	54.85	53.63	55.93	55.94	54.72	57.02

Notes: CI= Confidence interval

Table 1.3 Influenza Vaccine Coverage by County, Children 6 to 59 Months, September to June, 2007-2013

	Influenza Vaccine Coverage, September to June, 6 to 59 months																	
	2007-2008			2008-2009			2009-2010			2010-2011			2011-2012			2012-2013		
County	Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI	
Atlantic	38.90	37.48	40.17	39.68	38.42	40.81	46.91	45.92	47.81	52.17	51.33	52.95	52.30	51.46	53.06	55.32	54.54	56.04
Bergen	28.24	26.95	29.42	37.37	36.22	38.41	62.07	61.41	62.69	43.76	42.81	44.63	59.11	58.43	59.75	62.02	61.40	62.60
Burlington	41.63	40.82	42.38	31.79	30.87	32.64	49.19	48.61	49.74	58.56	58.11	58.99	62.93	62.53	63.31	61.24	60.83	61.63
Camden	41.21	40.39	41.98	48.14	47.41	48.83	49.56	48.88	50.19	55.65	55.06	56.20	60.54	60.04	61.01	62.58	62.10	63.02
Cape May	41.77	40.45	42.95	40.41	39.13	41.56	57.41	56.61	58.15	55.29	54.43	56.08	56.82	55.97	57.60	60.33	59.49	61.10
Cumberland	25.80	24.64	26.86	42.01	40.96	42.97	44.02	43.04	44.92	43.62	42.77	44.41	52.57	51.92	53.18	58.53	57.96	59.06
Essex	21.74	20.65	22.74	53.75	52.96	54.48	53.94	53.13	54.69	60.46	59.78	61.08	65.16	64.53	65.73	66.11	65.54	66.64
Gloucester	28.05	26.44	29.48	41.30	39.86	42.58	39.54	38.13	40.80	45.93	44.63	47.09	50.89	49.75	51.92	54.49	53.40	55.47
Hudson	37.43	36.28	38.47	50.29	49.35	51.15	34.32	33.18	35.37	52.12	51.34	52.85	55.42	54.73	56.07	58.08	57.43	58.69
Hunterdon	30.68	28.39	32.61	51.26	49.36	52.86	56.53	54.86	57.95	55.98	54.12	57.54	63.29	61.69	64.63	59.22	57.45	60.70
Mercer	53.42	52.73	54.05	63.25	62.68	63.79	64.56	64.00	65.08	65.51	64.96	66.02	67.70	67.20	68.17	65.50	64.94	66.01
Middlesex	29.73	27.90	31.32	42.79	41.11	44.24	61.14	60.20	61.99	47.36	45.79	48.73	43.71	42.15	45.08	46.61	45.19	47.86
Monmouth	35.14	34.13	36.06	59.14	58.47	59.76	56.11	55.36	56.80	61.25	60.59	61.86	62.90	62.27	63.49	59.92	59.23	60.56
Morris	24.26	21.43	26.56	35.19	33.12	36.96	48.50	46.90	49.89	55.65	54.02	57.04	53.30	51.89	54.54	60.99	59.95	61.92
Ocean	24.43	23.17	25.58	35.05	34.09	35.94	40.58	39.76	41.34	45.37	44.66	46.05	50.35	49.72	50.95	47.65	47.00	48.27
Passaic	46.08	45.02	47.04	50.05	48.76	51.19	53.39	52.31	54.36	60.77	60.15	61.35	50.86	50.07	51.60	52.19	51.46	52.86
Salem	41.66	40.14	43.00	54.11	52.98	55.13	51.51	50.31	52.58	55.92	54.86	56.88	55.39	54.37	56.31	56.77	55.76	57.68
Somerset	35.17	33.66	36.51	44.01	42.61	45.25	52.09	50.87	53.17	47.40	46.01	48.64	43.65	42.28	44.87	36.06	34.88	37.14
Sussex	16.54	14.32	18.42	40.71	38.80	42.35	46.00	44.56	47.27	52.99	51.84	54.01	50.71	49.74	51.60	61.60	60.94	62.21
Union	35.61	34.75	36.40	54.05	53.41	54.65	55.84	55.24	56.41	55.27	54.62	55.87	57.49	56.90	58.05	60.40	59.85	60.92
Warren	36.59	34.26	38.54	48.85	46.97	50.44	50.07	48.49	51.43	53.19	51.84	54.37	55.69	54.44	56.80	64.71	63.73	65.59

Notes: CI= Confidence interval

Figure 1.3 PCV Vaccine Coverage, 2007-2013

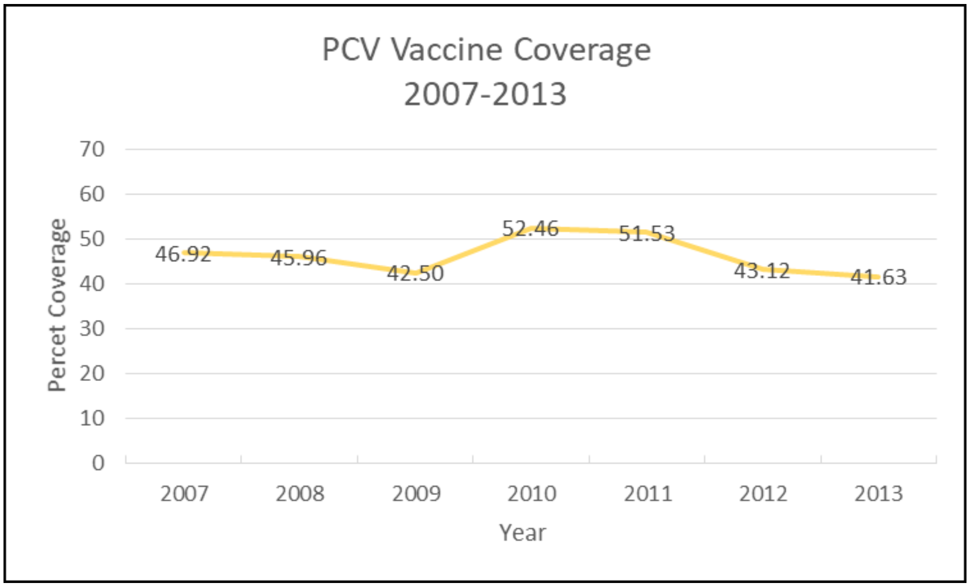


Figure 1.4 MMR Vaccine Coverage, 2007-2013

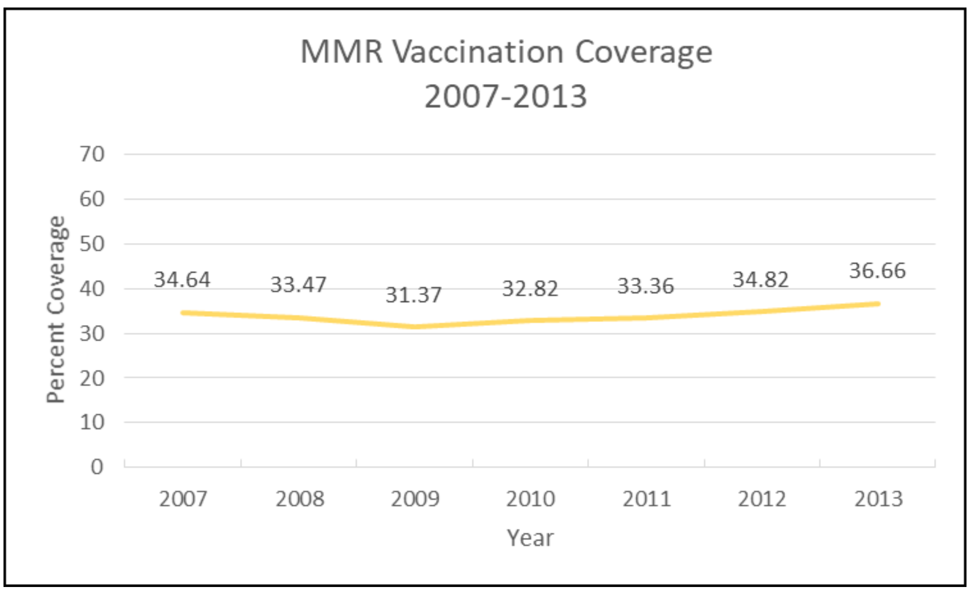


Table 1.4 PCV Vaccine Coverage by County, 2007-2013

	PCV Vaccine Coverage, September to December, 6 to 59 months																				
	2007			2008			2009			2010			2011			2012			2013		
County	Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI	
Atlantic	50.94	49.63	52.11	57.38	56.32	58.33	50.52	49.54	51.41	52.85	51.98	53.64	50.77	49.91	51.57	49.98	49.13	50.76	48.94	48.06	49.75
Bergen	44.97	43.80	46.03	47.61	46.56	48.57	38.44	37.44	39.37	55.71	54.88	56.47	51.83	51.05	52.57	38.66	37.76	39.50	37.60	36.68	38.45
Burlington	48.72	47.95	49.44	51.43	50.68	52.12	46.56	45.88	47.20	58.78	58.32	59.20	54.66	54.18	55.12	43.36	42.79	43.90	44.20	43.61	44.76
Camden	41.72	40.86	42.52	40.37	39.53	41.15	36.79	36.01	37.53	56.85	56.27	57.40	52.16	51.58	52.72	36.02	35.30	36.70	36.81	36.10	37.49
Cape May	54.78	53.62	55.82	57.14	56.07	58.10	44.75	43.72	45.69	50.00	49.02	50.89	50.47	49.55	51.32	46.19	45.13	47.16	48.11	47.00	49.12
Cumberland	48.26	47.26	49.17	45.81	44.84	46.70	46.09	45.11	46.99	49.93	49.05	50.74	54.94	54.30	55.54	48.34	47.67	48.97	43.85	43.13	44.53
Essex	46.01	45.04	46.90	50.07	49.21	50.86	41.58	40.65	42.45	44.25	43.33	45.10	52.74	51.93	53.49	43.22	42.31	44.06	38.64	37.70	39.50
Gloucester	50.36	49.00	51.56	45.81	44.44	47.04	44.04	42.67	45.26	54.22	53.05	55.26	53.49	52.38	54.50	45.72	44.47	46.84	42.40	41.16	43.52
Hudson	41.63	40.55	42.62	37.66	36.52	38.71	40.88	39.78	41.88	49.65	48.80	50.43	50.11	49.32	50.85	47.09	46.31	47.82	43.87	43.06	44.62
Hunterdon	42.27	40.32	43.93	38.20	36.03	40.04	35.64	33.45	37.49	44.56	42.42	46.35	46.48	44.33	48.28	35.75	33.28	37.79	30.00	27.19	32.29
Mercer	46.94	46.11	47.71	43.95	43.10	44.74	42.34	41.49	43.13	54.74	54.02	55.41	54.67	53.98	55.31	43.37	42.54	44.15	40.92	40.07	41.72
Middlesex	46.24	44.61	47.66	44.06	42.41	45.49	25.79	24.34	27.10	44.07	42.50	45.44	43.24	41.60	44.67	37.94	36.40	39.31	38.85	37.25	40.27
Monmouth	51.96	51.12	52.73	48.42	47.56	49.21	44.59	43.72	45.41	54.88	54.11	55.60	48.90	48.07	49.67	42.89	41.97	43.73	43.23	42.34	44.06
Morris	46.93	44.45	48.94	50.00	47.97	51.70	52.87	51.35	54.19	49.92	48.18	51.41	47.52	45.80	49.01	38.04	36.51	39.39	38.11	36.69	39.38
Ocean	49.52	48.46	50.48	46.44	45.49	47.31	52.60	51.90	53.25	59.88	59.32	60.40	57.61	57.06	58.13	49.39	48.77	49.98	44.21	43.56	44.81
Passaic	41.59	40.47	42.62	38.01	36.66	39.23	34.82	33.40	36.09	36.47	35.48	37.38	41.24	40.35	42.07	42.45	41.60	43.24	47.94	47.23	48.61
Salem	52.12	50.70	53.36	45.95	44.61	47.14	49.29	48.03	50.42	60.28	59.27	61.19	52.58	51.50	53.56	45.14	43.93	46.24	42.64	41.38	43.78
Somerset	44.91	43.58	46.09	44.66	43.24	45.91	38.99	37.55	40.28	48.22	46.86	49.43	47.68	46.29	48.91	43.63	42.45	44.70	38.19	37.11	39.19
Sussex	50.77	48.87	52.37	49.76	47.99	51.26	43.44	41.80	44.86	56.59	55.44	57.62	56.82	55.83	57.72	38.10	37.15	38.99	36.86	35.90	37.74
Union	45.60	44.81	46.34	42.27	41.48	43.02	37.69	36.90	38.43	48.04	47.30	48.73	45.36	44.59	46.07	39.14	38.37	39.86	36.08	35.27	36.84
Warren	51.17	49.17	52.85	48.09	46.12	49.75	39.35	37.46	40.98	47.19	45.64	48.55	49.13	47.70	50.39	42.40	40.95	43.68	38.71	37.18	40.07

Notes: CI= Confidence interval

Table 1.5 PCV and MMR Vaccine Coverage Statistic by County

County	PCV			MMR		
	Difference pre- and post-mandate	Mann-Kendall statistic (p value)		Difference pre- and post-mandate	Mann-Kendall statistic (p value)	
		All Study Years	Drop Pandemic Period		All Study Years	Drop Pandemic Period
New Jersey	-11.27	0.368	0.890	5.83	0.368	0.239
Atlantic	-3.93	0.964	0.957	26.64	0.008	0.014
Bergen	-16.40	0.726	0.769	0.90	0.500	0.500
Burlington	-9.28	0.726	0.569	15.20	0.382	0.403
Camden	-11.75	0.726	0.769	5.00	0.115	0.110
Cape May	-12.18	0.816	0.890	7.83	0.274	0.403
Cumberland	-9.13	0.500	0.597	24.02	0.036	0.014
Essex	-16.02	0.816	0.769	-2.89	0.933	0.957
Gloucester	-15.81	0.816	0.890	-5.44	0.726	0.763
Hudson	5.37	0.184	0.403	38.19	0.008	0.014
Hunterdon	-29.03	0.726	0.890	-10.25	0.500	0.597
Mercer	-12.82	0.816	0.890	-6.81	0.726	0.597
Middlesex	-15.98	0.885	0.957	-4.98	0.274	0.403
Monmouth	-16.79	0.885	0.890	-3.92	0.816	0.769
Morris	-18.79	0.885	0.769	4.01	0.274	0.231
Ocean	-10.73	0.618	0.769	7.07	0.115	0.110
Passaic	15.26	0.115	0.110	13.96	0.274	0.231
Salem	-18.18	0.816	0.890	16.22	0.036	0.043
Somerset	-14.94	0.816	0.890	-0.82	0.274	0.403
Sussex	-27.40	0.816	0.890	3.84	0.382	0.403
Union	-20.88	0.885	0.957	0.29	0.115	0.403
Warren	-24.35	0.993	0.957	10.76	0.184	0.500

Note: Mann-Kendall test statistic with a p-value less than 0.05 used to declare significance.

The relative difference in coverage from the pre-mandate (2007) to the post-mandate (2013).

Table 1.6 MMR Vaccine Coverage by County, 2007-2013

	MMR Vaccine Coverage, September to December, 6 to 59 months																				
	2007			2008			2009			2010			2011			2012			2013		
county	Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI		Percent	95% CI	
Atlantic	31.68	30.08	33.09	35.61	34.20	36.88	32.62	31.44	33.70	34.01	32.96	34.98	36.17	35.17	37.09	37.14	36.16	38.05	40.12	39.14	41.02
Bergen	37.19	35.94	38.32	40.83	39.72	41.85	32.18	31.15	33.14	31.48	30.40	32.48	32.75	31.79	33.64	34.25	33.32	35.11	37.52	36.61	38.37
Burlington	34.36	33.46	35.19	33.04	32.12	33.89	35.11	34.35	35.82	35.06	34.44	35.65	32.64	32.02	33.24	33.74	33.12	34.32	39.58	38.97	40.16
Camden	33.94	33.04	34.78	33.31	32.44	34.12	28.88	28.08	29.64	31.45	30.66	32.19	33.58	32.87	34.25	33.94	33.23	34.62	35.64	34.92	36.31
Cape May	35.92	34.45	37.23	34.20	32.77	35.48	29.44	28.28	30.50	34.83	33.70	35.87	34.06	32.98	35.06	35.76	34.58	36.83	38.73	37.49	39.85
Cumberland	33.24	32.08	34.30	34.20	33.12	35.18	33.87	32.77	34.88	32.01	30.97	32.97	35.44	34.64	36.19	36.72	35.96	37.44	41.22	40.48	41.92
Essex	36.08	35.02	37.05	35.94	34.94	36.86	33.21	32.22	34.12	35.91	34.94	36.81	35.73	34.75	36.63	34.58	33.60	35.49	35.04	34.08	35.92
Gloucester	38.03	36.47	39.41	40.83	39.39	42.10	34.08	32.59	35.41	38.38	36.97	39.64	34.16	32.78	35.40	36.06	34.68	37.29	35.96	34.64	37.15
Hudson	24.72	23.54	25.81	24.84	23.63	25.95	23.42	22.22	24.52	25.67	24.65	26.62	30.39	29.44	31.27	31.26	30.35	32.10	34.17	33.28	34.99
Hunterdon	40.95	38.99	42.63	34.64	32.42	36.52	36.00	33.83	37.83	34.88	32.56	36.82	34.54	32.14	36.54	40.50	38.13	42.46	36.76	34.06	38.96
Mercer	36.23	35.32	37.08	33.21	32.28	34.07	36.07	35.18	36.89	32.15	31.22	33.01	33.78	32.90	34.60	35.84	34.95	36.68	33.77	32.86	34.61
Middlesex	39.64	37.90	41.15	32.54	30.74	34.11	20.79	19.35	22.09	31.75	30.03	33.26	33.33	31.57	34.88	35.67	34.11	37.05	37.66	36.04	39.09
Monmouth	36.07	35.06	36.99	35.49	34.51	36.39	30.45	29.46	31.36	35.19	34.22	36.09	32.95	31.99	33.85	34.38	33.40	35.28	34.65	33.69	35.54
Morris	34.92	32.14	37.17	31.22	28.80	33.25	31.01	29.10	32.66	29.29	27.21	31.07	32.07	30.10	33.77	36.48	34.94	37.84	36.32	34.88	37.60
Ocean	32.93	31.68	34.06	30.00	28.91	31.00	30.17	29.26	31.01	37.79	37.03	38.50	30.94	30.17	31.67	35.24	34.50	35.93	35.26	34.55	35.92
Passaic	31.92	30.72	33.01	29.40	27.99	30.67	25.26	23.80	26.57	21.18	20.16	22.12	29.27	28.31	30.16	35.45	34.55	36.29	36.37	35.55	37.14
Salem	34.24	32.51	35.75	36.40	34.93	37.70	33.25	31.76	34.57	34.52	33.09	35.79	36.16	34.87	37.33	38.50	37.20	39.66	39.79	38.49	40.96
Somerset	35.58	34.14	36.86	30.03	28.45	31.43	31.27	29.75	32.62	33.81	32.26	35.19	31.89	30.29	33.30	33.38	32.09	34.54	35.29	34.18	36.30
Sussex	30.27	27.96	32.21	30.57	28.46	32.37	26.63	24.80	28.22	25.00	23.44	26.39	28.55	27.20	29.77	29.27	28.26	30.21	31.43	30.45	32.35
Union	38.19	37.35	38.97	32.22	31.37	33.02	34.13	33.33	34.87	35.68	34.85	36.45	37.67	36.87	38.43	36.85	36.08	37.58	38.30	37.52	39.04
Warren	31.56	29.12	33.59	37.21	35.01	39.07	32.40	30.42	34.10	33.33	31.58	34.87	35.79	34.15	37.23	34.89	33.35	36.25	34.95	33.38	36.34

Notes: CI= Confidence interval

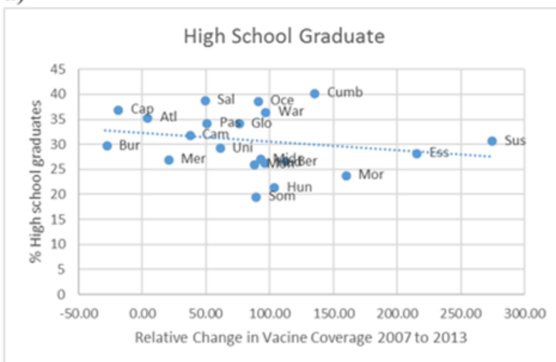
Table 1.7 Linear Regression Analysis – Association between Socioeconomic Factors and Relative Change in Vaccination Coverage from Pre- to Post-Mandate

SES Factor (expressed as % of population)	**Influenza (September to December)**		**Influenza (September to June)**		**PCV**		**MMR**	
	R-squared	***p***	**R-squared**	***p***	**R-squared**	***p***	**R-squared**	***p***
High school graduate	0.04	0.35	<0.001	0.93	0.05	0.31	0.21	**0.03***
Insurance coverage	0.04	0.38	0.01	0.62	0.25	**0.02***	0.34	**<0.01***
Below Poverty Level	<0.01	0.82	<0.01	0.77	0.38	**<0.01***	0.26	**0.02***
Non-white	<0.02	0.97	<0.001	0.09	0.05	0.31	0.01	0.67
Hispanic	<0.03	0.88	0.03	0.47	0.490	**<0.01***	0.24	**0.02***

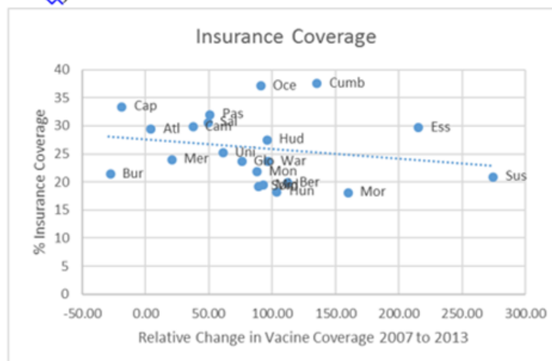
Note: R-squared is coefficient of determination from linear regression analysis. A p-value less than 0.05 used to declare significance.

Figure 1.5 – Relative Change in Influenza Vaccine Coverage (Season) in NJIIS from 2007-2013 by County and Demographic Factors

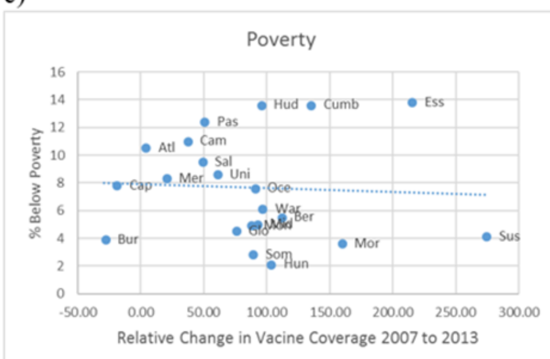
a)



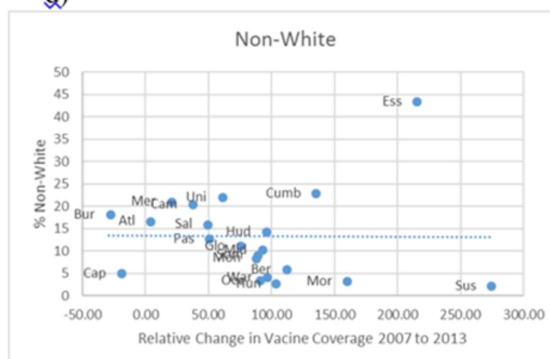
b)



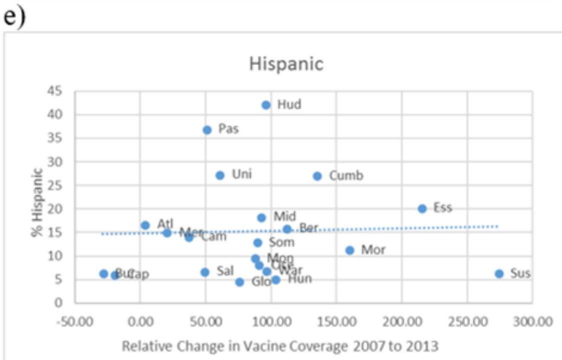
c)



d)



e)

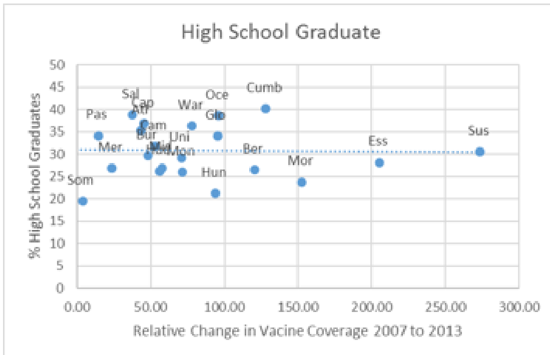


Note: Linear regression lines were not significant for any variable.

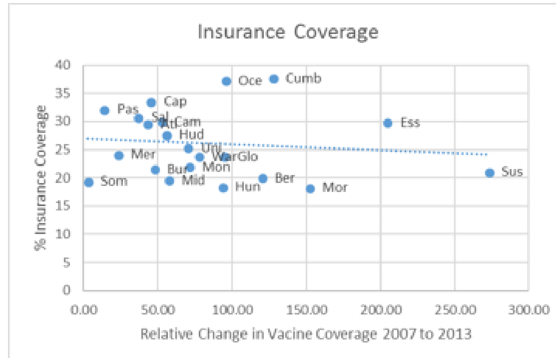
County Abbreviations: Atlantic (Atl), Bergen (Ber), Burlington (Bur), Camden (Cam), Cape May (Cap), Cumberland (Cumb), Essex (Ess), Gloucester (Glo), Hudson (Hud), Hunterdon (Hun), Mercer (Mer), Middlesex (Mid), Monmouth (Mon), Morris (Mor), Ocean (Oce), Passaic (Pas), Salem (Sal), Somerset (Som), Sussex (Sus), Union (Uni), Warren (War)

Figure 1.6 – Relative Change in Influenza Vaccine Coverage (Year) in NJIIS from 2007-2013 by County and Demographic Factors

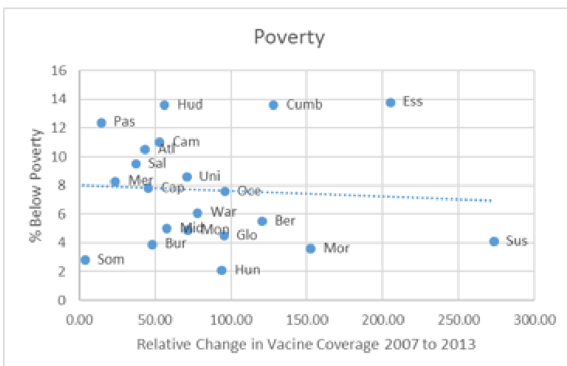
a)



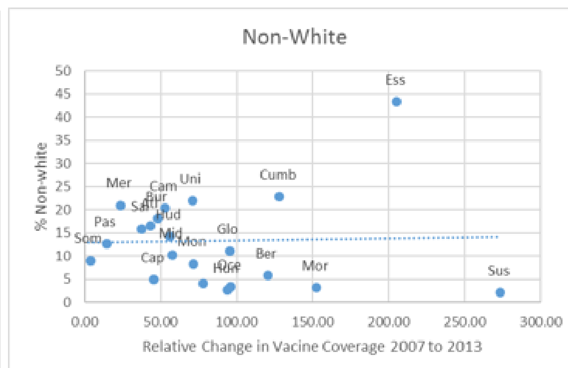
b)



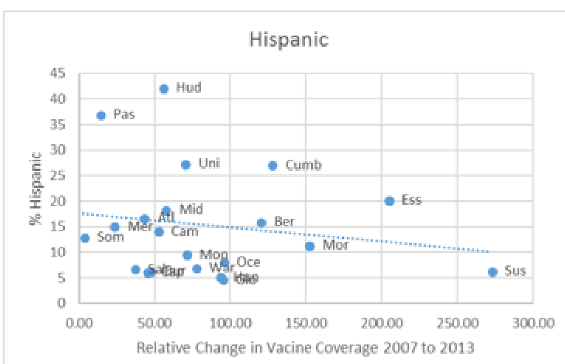
c)



d)



e)

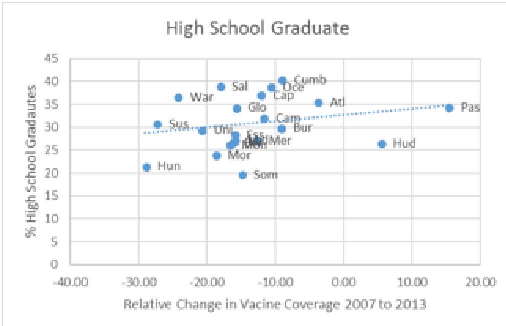


Note: Linear regression lines were not significant for any variable.

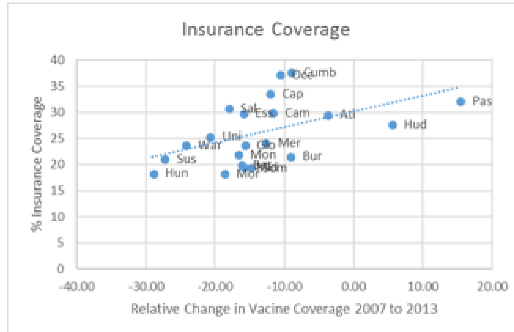
County Abbreviations: Atlantic (Atl), Bergen (Ber), Burlington (Bur), Camden (Cam), Cape May (Cap), Cumberland (Cumb), Essex (Ess), Gloucester (Glo), Hudson (Hud), Hunterdon (Hun), Mercer (Mer), Middlesex (Mid), Monmouth (Mon), Morris (Mor), Ocean (Oce), Passaic (Pas), Salem (Sal), Somerset (Som), Sussex (Sus), Union (Uni), Warren (War)

Figure 1.7 – Relative Change in PCV Vaccine Coverage in NJIIS from 2007-2013 by County and Demographic Factors

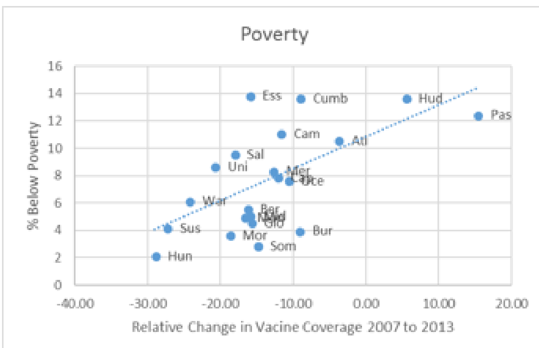
a)



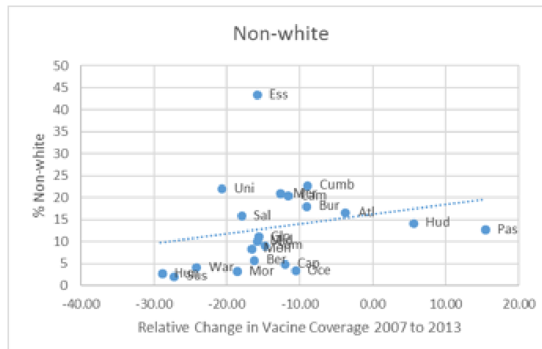
b)



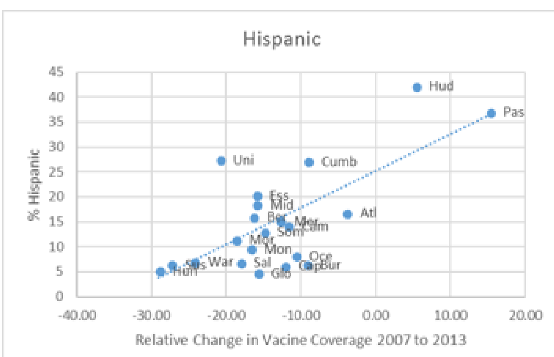
c)



d)



e)

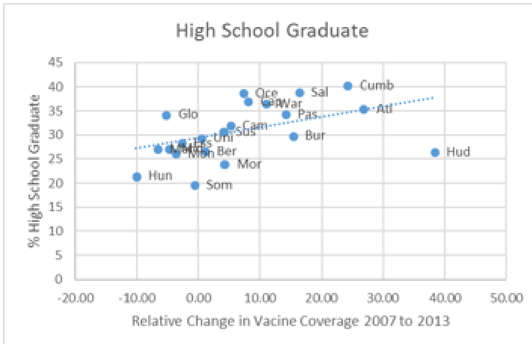


Note: Linear regression lines for graphs b,c and e had p values <0.05.

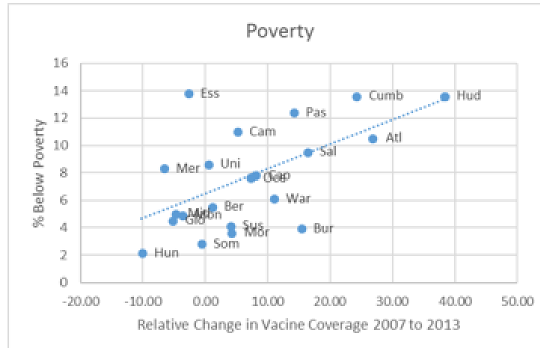
County Abbreviations: Atlantic (Atl), Bergen (Ber), Burlington (Bur), Camden (Cam), Cape May (Cap), Cumberland (Cumb), Essex (Ess), Gloucester (Glo), Hudson (Hud), Hunterdon (Hun), Mercer (Mer), Middlesex (Mid), Monmouth (Mon), Morris (Mor), Ocean (Oce), Passaic (Pas), Salem (Sal), Somerset (Som), Sussex (Sus), Union (Uni), Warren (War)

Figure 1.8 – Relative Change in MMR Vaccine Coverage in NJIIS from 2007-2013 by County and Demographic Factors

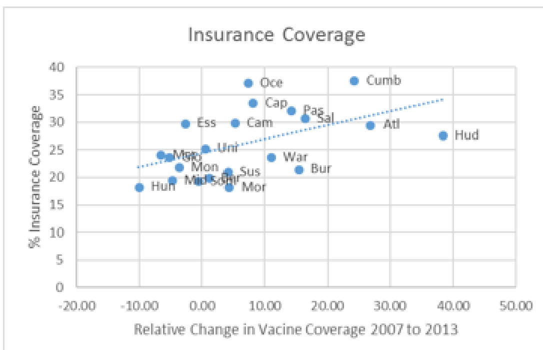
a)



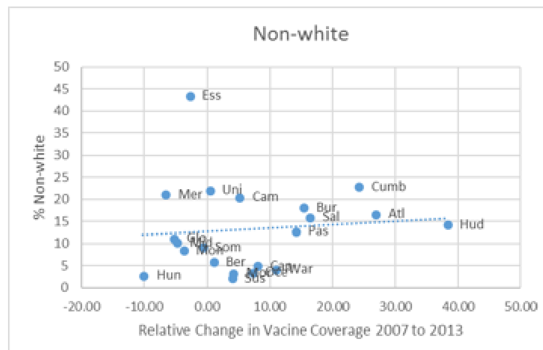
b)



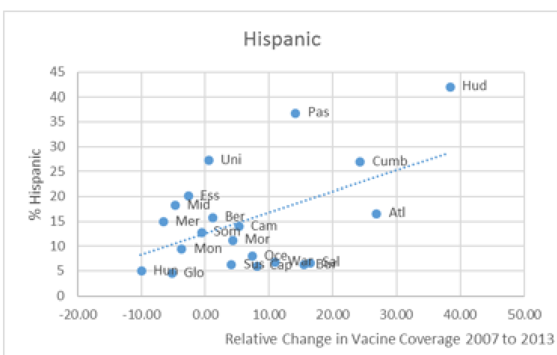
c)



d)



e)



Note: Linear regression lines for graphs a,b,c and e had p values <0.05.

County Abbreviations: Atlantic (Atl), Bergen (Ber), Burlington (Bur), Camden (Cam), Cape May (Cap), Cumberland (Cumb), Essex (Ess), Gloucester (Glo), Hudson (Hud), Hunterdon (Hun), Mercer (Mer), Middlesex (Mid), Monmouth (Mon), Morris (Mor), Ocean (Oce), Passaic (Pas), Salem (Sal), Somerset (Som), Sussex (Sus), Union (Uni), Warren (War)

CHAPTER 2: ASSESSING INFLUENZA IMMUNIZATION COVERAGE: A COMPARISON OF IMMUNIZATION COVERAGE FROM NEW JERSEY STATE BASED IMMUNIZATION REGISTRY AND THE NATIONAL IMMUNIZATION SURVEY

Introduction

In the United States (US), nearly 11 million children under the age of 5 have a child care arrangement each week with children of working mothers spending an average of 35 hours per week in child care[1,2]. Children who attend child care, compared to those who do not, are at an increased risk of acquiring respiratory illnesses, including influenza.[3-7]. Children also have a higher risk of influenza-related illness and play a major role in the spread of infections through a household[8,9]. This increased risk of illness is also associated with excess morbidity and other related medical costs for both these children and their household contacts[5,10]. Annual influenza vaccination is the most effective method for preventing influenza virus infection, reducing its complications and limiting the spread of infection to others[11,12]. Despite this proven prevention method and recommendations by the Advisory Committee on Immunization Practice (ACIP), influenza vaccination coverage levels in children lag behind that of other routine childhood immunizations. Annual influenza vaccination for children aged 6-23 months was first recommended by the ACIP in 2004[13] and for children aged 24-59 months in 2006[14]. In 2009, ACIP extended this recommendation to include all children 6 months to 18 years[15] and later in 2010 to include all individuals greater than 6 months of age[16]. Despite these recommendations, in the 2007-2008 influenza season, influenza vaccination coverage among children ages 6 months to 17 years was 31.1%[17]. During this same timeframe, vaccination coverage for other common childhood vaccinations ranged from 75-95%[18].

While there are a number of strategies that can be used to increase vaccination coverage levels, implementation of statewide vaccine mandates have been proven to increase routine childhood vaccination coverage[19,20]. In 2008, New Jersey was the first state to enact an influenza vaccination mandate in an attempt to increase vaccination coverage. Since that time, Connecticut, Ohio and Rhode Island have enacted similar influenza vaccine mandates in September 2010, March 2015, and August 2015, respectively[21]. The mandates vary slightly in each state but most are similar to New Jersey's mandate which requires children six through 59 months of age attending any licensed child care center or preschool facility to receive at least one dose of influenza vaccine between September 1 and December 31 each year. Children who fail to comply with the mandate are excluded from the child care center until March 31 or until they received at least one dose of influenza vaccine. While the NJ mandate was enacted in September 2008 and was to be fully implemented for the 2009-2010 school year; vaccine availability delayed full implementation until the 2010-2011 school year.

Despite the implementation of these mandates by states, there has been limited data available and limited studies to determine the impact these mandates have on influenza vaccination coverage. To date, only one study has been published addressing the impact of the Connecticut[22] mandate on influenza vaccination in child care centers. Analysis of the impact of the NJ mandate on the influenza vaccination coverage has been hindered by the lack of data available for study. Collection of data in NJ containing specific influenza vaccination coverage in child care centers only began at the end of 2013. Similar data is not available to make direct comparison to those years prior to implementation of the mandate and to evaluate changes in vaccination coverage over time. In order to evaluate the change in vaccine coverage levels from pre- mandate (2007) to post-mandate (2013) period, alternative vaccination coverage data needs to be used.

In Chapter 1, trends in influenza vaccination coverage were evaluated using New Jersey's statewide, population based vaccine registry known as the New Jersey Immunization and Information System (NJIIS). The findings of this study support the notion that influenza vaccine mandates requiring vaccination of children in licensed child care facilities increased vaccination coverage in children most likely to attend child care centers. However, this system did not contain individual demographic or socioeconomic factors for evaluation and direct comparison to the other states or to the US could not be made using data only from this system.

In this study, we look to use data from the National Immunization Survey (NIS) to determine if influenza vaccination coverage trends observed from this national survey sample are similar to those observed from NJIIS. The NIS will also be used to assess demographic and socioeconomic factors associated with vaccinations as these data were not available and therefore could not be assessed in the NJIIS data. Trends observed with influenza vaccination coverage will be compared to other childhood vaccinations reported in NIS to determine if observed changes in influenza vaccination coverage are related to variations in vaccine uptake in the target population as a whole. Finally, an evaluation will be conducted to determine how NJ compares to other states with and without mandates in place to assess possible impact of these mandates overall.

Methods

National Immunization Survey (NIS)

The National Immunization Survey (NIS) is federally funded, nationally representative survey sponsored by the National Center for Immunizations and Respiratory Diseases (NCIRD) and conducted jointly by NCIRD and the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention. The NIS began in April of 1994 with the purpose of monitoring childhood immunization coverage. Study procedures and methods of the NIS have been described in detail elsewhere[23-27]. In brief, the NIS uses random digit dialing (RDD) telephone survey methodology to identify households containing children in the target age range and interviews the adult who is most knowledgeable about the child's vaccinations. During the interview/survey, permission is sought from parents/guardians to contact their child's healthcare provider. After consent is obtained, a questionnaire/survey is mailed to that provider to obtain a vaccination history from the child's medical record. The NIS is conducted in each of the 50 states and 28 selected urban areas with a target population of children aged 19 to 35 months living in households in the United States at the time of the interview.

The official coverage estimates reported from the NIS are coverage of being up-to-date with respect to the recommended numbers of doses of all recommended vaccines. Vaccines tracked by the NIS include diphtheria and tetanus toxoids and acellular pertussis vaccine, diphtheria and tetanus toxoids and whole cell pertussis vaccine, or diphtheria and tetanus toxoids vaccine (DTaP/DTP/DT) – 4 doses; poliovirus vaccine (polio) – 3 doses; measles/mumps/rubella vaccine (MMR) – 1 dose; *Haemophilus influenzae* type b vaccine (Hib) – 3 or 4 doses depending on product type; hepatitis B vaccine (Hep B) – 3 doses; varicella zoster (chicken pox) vaccine (varicella), –1 dose; pneumococcal vaccine (PCV) – 4 doses; hepatitis A vaccine (Hep A), 2 doses; influenza vaccine – one dose annually; and rotavirus vaccine (RV) – 2 or 3 doses. The collection of each child's entire influenza vaccination history was added to the instrument in 2003.

Inclusion/exclusion

Publically available files from the NIS were downloaded for study years 2007 through 2013[28-34]. Data from United State Territories (i.e., Puerto Rico, Guam, and the United State Virgin Islands) was excluded as it was not consistently available across all study years. Analysis was conducted using only data for which complete provider data was available.

Analysis

The up-to-date (UTD) variables for the following vaccinations were evaluated: influenza; measles, mumps and rubella (MMR); and pneumococcal conjugate vaccine (PCV). UTD variables indicate confirmation with child's medical record that vaccination status meets criteria for that vaccination. For influenza vaccination status, a child is considered UTD for vaccination if the child was of age during the entire span of 9/1 through 12/31 for respective study year and received at least one influenza vaccine during this period. It should be noted that the influenza UTD variable only evaluates a single dose of vaccine and does not collect information on a second influenza vaccine dose which is recommended for children 6 months through 8 years getting vaccinated for the first time. Weights supplied in the data files were applied using surveyfreq procedures of SAS version 9.3 (SAS Corp, Cary, North Carolina). Application of these weights produced vaccine coverage estimates and associated confidence intervals which accounted for the complex sampling structure. Overall influenza vaccination coverage was calculated for every state as well as the US as a whole. NJ and US coverage stratified by sex, race, race/ethnicity, income (i.e., below poverty level, income <$75,000, income greater than $75,000), maternal education (e.g., no high school diploma, high school diploma, some post high school education) and private insurance were produced for each study year and for influenza, MMR and PCV vaccines. While estimates were produced for each study year, an assessment between the 2007 study year (i.e., pre-mandate) and 2013 study year (i.e., post- mandate) was also conducted. To assess the change of vaccination coverage, the relative difference in coverage from the pre-mandate (2007) to the post-mandate (2013) of the project period was calculated.

Chi-square analyses were performed to test for associations between vaccination status and selected demographic characteristics. Logistic regression analysis was performed for the 2007 and 2013 study years to determine variables associated with receipt of vaccine and how these changed after the mandates implementation. Odds ratios are reported with 95% confidence intervals. Data were weighted to adjust for NIS complex sampling design[23-27]. Due to small sample size at the state level, demographic variable (i.e., race, ethnicity, poverty status, maternal education) were collapsed to provide more accurate estimates. The Mann-Kendall statistic was used to evaluate if a monotonic (i.e., gradual change over time in a consistent direction) trend was observed across study years for each vaccine evaluated. A test statistic with a p-value less than 0.05 was used to declare significance.

New Jersey Immunization and Information System (NJIIS)

The system overview, record selection, record inclusion/exclusion and analysis of NJIIS was described in detail in the methods section of Chapter 1. Briefly, influenza vaccine coverage was assessed for all children 6 to 59 months receiving at least one dose of influenza vaccine from September to December in each study year. Since the NIS only includes children between the ages of 19 to 35 months[24], the prior methods used for NJIIS analysis were used to recalculate vaccine coverage to match this age cohort. Similar to NIS data, the difference in coverage from the pre-mandate (2007) to the post-mandate (2013) of the project period was calculated. NJIIS data does not include demographic data and so comparisons between NIS and NJIIS will only be made for the overall influenza vaccination coverage at the state level.

Results

Overall data

A total of 176,298 records were included in the public download files of the NIS. After exclusions were applied, a total of 173,706 records were included in the analysis. Of these, a total of 3,392 records were from NJ residents. After application of sampling weights, the weighted sample frequencies estimate a population of 42,175,349 for all included records and 1,157,395 for NJ across all study years.

Across all study years, the characteristics of study population remained fairly consistent (Tables 2.1 and 2.2) with the exception of those below the poverty line which appeared to increase over the study period in both the US and NJ populations. It was noted that the study population was older (age greater than 24 months), had a greater representation of whites, those living above the poverty level, and those with greater levels of maternal education. Characteristics were similar between New Jersey and US data, however, private insurance status was higher for NJ than in the US data.

In the data evaluated from the NJIIS system, after the patient and vaccine data files were merged and records excluded, the remaining files analyzed consisted of 1,823,349 vaccinations from 139,927 persons.

Influenza Vaccine Coverage- NIS

Overall

As shown in Figure 2.1, pre-mandate baseline influenza vaccine coverage in 2007 was 31.81% (95% CI: 30.25 - 33.38) and 39.24% (95% CI: 29.24 - 49.26) for the US and NJ, respectively. Post-mandate (2013) vaccination coverage was 50.75% (95% CI: 48.67 - 52.82) and 59.66% (95% CI: 50.70 - 68.63) for the US and NJ, respectively. An increase in 59.92% was observed for the US while NJ had a 52.01% increase from the pre- to post- mandate period. Vaccination coverage for NJ was higher than US in all study years except 2008 when US coverage was slightly higher (US 40.66%; NJ 39.65%). No overlap in the confidence intervals between US and NJ coverage was observed in 2010-2012 where NJ levels were higher. A statistically significant increasing trend in influenza vaccine coverage was observed across all study years in both the US (p=0.003) and NJ (p=0.018) data.

Factors associated with receipt of influenza vaccine

Influenza vaccination coverage levels for US stratified by selected demographic characteristics as well as accompanying graphical displays can be found the Appendix 1 (Figure 1 and Table 1). No variation in vaccination coverage between males and females was noted. Coverage was found to be greater for those with higher income, private insurance, and post high school maternal education. Those 19-23 months had the higher vaccination coverage than the other two age categories, except for 2007 and 2008 when coverage for those 19-23 months and 24-29 months were similar. Coverage was lowest for blacks and highest for whites and those identifying as other or multiple race. Similarly, Hispanic and non-Hispanic blacks saw lower coverage levels than non-Hispanic whites and other or multiple race. While differences were noted among the various demographic and socioeconomic characteristics in the US data, every group had an increase in vaccination coverage between pre- and post- mandate period.

Influenza vaccination coverage levels for NJ stratified by selected demographic characteristics as well as accompanying graphical displays can be found the Appendix 1 (Figure 2 and Table 2).

Vaccination coverage was higher in the 19-23 year age group except for 2013 when coverage was higher for those 24-29 months. Whites saw the highest vaccination coverage in four of the study years. Other/multiple races were higher in 2009 and 2013 while blacks saw higher coverage in 2012. Non-Hispanic whites had the highest coverage for the first 5 years of the study period but in 2012 vaccine coverage was highest in Hispanics and in 2013 it was highest in non-Hispanic other race/multiple. Coverage was found to be higher in those with incomes greater than $75,000 except in 2012 when those living below the poverty level had greater vaccination coverage. Those having private insurance saw the highest coverage across all study years. Post high school education in mother's had higher vaccination coverage in four of the study years (2007, 2008, 2010 and 2011) while those with less than high school degree had higher coverage in 2009. High school maternal education was associated with increased vaccination in 2012 and 2013. Similar to US data, every group had an increase in vaccination coverage between pre- and post-mandate period.

Results of the multivariable logistic regression models to examine the association between demographic factors and receipt of influenza vaccine while controlling for all other demographics in the model for both the US and NJ are presented in Table 2.3 and 2.4. For the US, age, ethnicity, poverty status and having private insurance were significantly associated with vaccination status in 2007. In 2013, significant associations were observed for age, private insurance and race but significant associations with poverty and ethnicity were no longer present. For NJ, no significant association were seen with vaccination status for any demographic factors evaluated in either 2007 or 2013.

Influenza Vaccine Coverage- NJIIS

As shown in Figure 2.2, pre-mandate baseline coverage in 2007 was 31.87%. Coverage increased by 37.12 % by the pre-mandate period (2013) with vaccination coverage at 43.70%. The percent influenza vaccination coverage noted in the NJIIS data also showed a statistically significant increasing trend (p=0.035) across the seven year study period.

MMR and PCV Vaccination Coverage- NIS

Overall

As shown in Figure 2.3, pre-mandate baseline MMR vaccine coverage in 2007 was 92.34% (95% CI: 91.68 - 93.00) and 91.22% (95% CI: 85.70 - 96.75) for the US and NJ, respectively. Post-mandate (2013) vaccination coverage in US was 91.85% (95% CI: 90.92 - 92.78) showing a small decline of 0.53 percent. In NJ, the post-mandate vaccination coverage was 95.61% (95% CI: 92.14 - 98.70) which was an increase of 4.80 percent from pre-mandate levels.

As shown in Figure 2.4, pre-mandate baseline PCV vaccine coverage in 2007 was 75.32% (95% CI: 74.19 - 76.45) and 69.27% (95% CI: 61.66 - 76.87) for the US and NJ, respectively. Post-mandate coverage in the US showed an increase of 8.89 percent with a vaccination coverage level of 82.01% (95% CI: 80.70 - 83.32). A larger percent increase of 25.05 was noted for NJ with a post mandate vaccination coverage of 86.61% (95% CI: 81.25 - 91.98).

Across all study years, the vaccination coverage for both MMR and PCV vaccines was higher than what was observed for influenza vaccine in both the US and NJ across all study years. Confidence intervals for vaccination coverage for all years and in both US and NJ overlapped except in 2012 for MMR vaccination when NJ levels were higher. A statistically significant increasing trend was noted in both US (p=0.036) and NJ (p=0.003) for PCV vaccinations. No significant trend was noted for MMR vaccination in either the US (p=0.726) or NJ (p=0.115) coverage estimates.

<u>Factors associated with receipt of MMR vaccine</u>

MMR vaccination coverage levels stratified by selected demographic characteristics for US as well as accompanying graphical displays can be found the Appendix 1 (Figure 3 and Table 3). Unlike what was observed with influenza vaccination coverage. There was little variation in the stratified groups with coverage being fairly consistent across study years. Overall, those 19-35 months and those without private insurance has lower vaccination coverage consistently across all year. Pre- to post mandate differences across all groups were minimal and varied by less than 3.5 percent.

MMR vaccination coverage levels stratified by selected demographic characteristics for NJ as well as accompanying graphical displays can be found the Appendix 1 (Figure 4 and Table 4). There was little variation in the stratified groups with coverage being fairly consistent across study years. All variables saw an increase in vaccination coverage from the pre- to post mandate period except for Blacks, non-Hispanic other, those above the poverty line (<$75,000) and those with a maternal education greater than high school where the vaccination coverage decreased by 2.71, 0.04, 2.13, and 0.93 percent, respectively. Those in the 19-23 month age group, Hispanics, below the poverty level and maternal education less than high school saw the largest gains in vaccine coverage from the pre- and post- mandate with increases of 10.92, 12.44, 15.34, and 30.23 percent, respectively.

Results of the multivariable logistic regression models to examine the association between demographic factors and receipt of MMR vaccine while controlling for all other demographics in the model for both the US and NJ are presented in Table 2.3 and 2.4.

For the US, age and being covered by private insurance were significantly associated with vaccination status in 2007. In 2013, the significant associations with private insurance were no longer seen but significant associations with maternal education in addition to age were found. For NJ, no significant association were seen with vaccination status for any demographic factors evaluated in either 2007 or 2013.

Factors associated with receipt of PCV vaccine

PCV vaccination coverage levels stratified by selected demographic characteristics for US as well as accompanying graphical displays can be found the Appendix 1 (Figure 5 and Table 5). In general, higher vaccination coverage was observed for whites, those with the highest income, those with private insurance and those where mom's education was greater than high school. All groups saw an increase in vaccination coverage between the pre- and post-mandate period with differences across all groups varying by less than 13 percent. Those above poverty making both less than and greater than $75,000 has the greatest gains with 12.34 and 12.02 percent increases, respectively, from pre- to post mandate period.

PCV vaccination coverage levels stratified by selected demographic characteristics for NJ as well as accompanying graphical displays can be found the Appendix 1 (Figure 6 and Table 6). There was little variation in the stratified groups for PCV vaccine in NJ with coverage being fairly consistent across study years. Higher vaccination coverage was observed for whites, those above the poverty level, those with private insurance and those where mom's education was greater than high school. All variables saw an increase in vaccination coverage from the pre- to post mandate period with greater gains observed in

NJ compared to US. Those 19-35 months of age, high school maternal education, and private insurance had the greatest gains in coverage from the pre- and post- mandate with increases of 41.22, 32.44, and 31.11 percent, respectively.

Results of the multivariable logistic regression models to examine the association between demographic factors and receipt of PCV vaccine while controlling for all other demographics in the model for both the US and NJ are presented in Table 2.3 and 2.4. For the US, only private insurance was significantly associated with vaccination status in 2007. In 2013, the association with private insurance was no longer seen but significant associations with ethnicity, maternal education, and poverty status were observed. For NJ, a significant association between vaccination status and sex and age was observed in 2007. In 2013, sex was no longer significantly associated with vaccination status but age, ethnicity and private insurance were found to have a significant association.

Evaluation of Influenza Vaccination Coverage Among Other States

During our study period, Connecticut was the only other state to have enacted a similar influenza vaccination mandate. The Connecticut mandate took effect in September 2010. Connecticut's vaccination coverage was 50.16% (95% CI: 39.70 – 60.62%) and 68.38% (95% CI: 58.76 – 78.01) for the pre- (2007) and post-mandate (2013) period, respectively. CT saw a 36.33 percent increase from pre- to post- mandate period compared to the 52.01 percent increase observed in NJ.

Looking at other states without formal mandates, in 2007, 30 states had vaccination coverage levels above US coverage levels with NJ and CT having the 11th and 3rd highest coverage levels, respectively. In 2013, only 26 states had coverage levels above US level with NJ and CT having the 10^{th} and 3^{rd} highest coverage levels, respectively. The difference in pre- and post-mandate periods among all states varied widely from an 8.65 percent decrease to 139.20 percent increase in coverage. As shown in Figure 2.11a and 2.11b, there were 9 states who had higher coverage levels than the US in 2007 but fell below the US coverage levels in 2013. There were 5 states who had lower coverage levels than the US in 2007 but rose above the US coverage levels in 2013. Nevada had the greatest gains from the pre- to post-mandate period with a 139.20 percent increase in coverage. Hawaii was the only state to see a decrease in coverage levels between the pre- and post- mandate period where coverage decreased by 8.65 percent. There were 28 states who had greater pre- to post- mandate increases in vaccinate coverage than NJ and 22 states with greater gains than overall US coverage.

Discussion

Similar to what was observed in NJIIS, the NIS data showed gains in NJ influenza vaccination coverage from the pre- to post-mandate period. The NIS produced influenza coverage levels that were greater in magnitude than what was observed in NJIIS. Gains were also observed in several states and the US overall with gains noted in both states with and without influenza vaccine mandates enacted during the study period. Substantial gains in vaccination coverage were not observed in the US for either MMR or PCV vaccine. Similarly, NJ did not see gains in MMR vaccine but some gains in coverage for PCV vaccine were observed. Demographic and socioeconomic factors previously known to be alter vaccination coverage were observed for all three vaccines evaluated.

In both NIS and NJIIS data, a statistically significant increasing trend was observed for NJ influenza vaccinations with both data systems showing increases in coverage from the pre- to post- mandate period. While increases in influenza vaccine coverage were noted, a difference in the magnitude of overall coverage levels between the NIS and NJIIS were noted. The average vaccine coverage level observed for NJ in the NIS data across all study years was 53.1% compared to the average coverage of 40.9% observed with the NJIIS data. The NIS also showed a far greater improvement in influenza vaccine coverage from the pre- to the post- mandate period a 52.01 percent increase compared to the 37.11 percent increase with the NJIIS data.

The observed difference between the NIS and NJIIS are not unexpected given the different data collection methods[24]. Differences between the NIS and state vaccine registries systems, similar to what we observed in this study, have also be reported elsewhere. In Minnesota, a comparison of the NIS to the Minnesota Immunization Information Connection (MIIC), Minnesota's state vaccine registry, revealed lower coverage levels from the registry data for most common childhood vaccinations[35]. Another study presented by the Centers for Disease Control and Prevention at the 45th National Immunization Conference in 2011 showed that the NIS was more likely to report the child to be up to date on vaccination and thus the NIS vaccination coverage rates were somewhat higher overall than what was observed from the state vaccine registries[36]. While the influenza vaccine coverage levels differed in magnitude, the overall increasing trend and positive increases in coverage between pre- and post-mandate periods were noted in both systems.

While increases were observed with influenza vaccination coverage, consistent increases in coverage for two other common childhood vaccinations (PCV, MMR) were not observed. US MMR vaccinations had a small decline while NJ MMR vaccinations had a small increase in vaccination coverage from the pre- to post- mandate period. A statistically significant trend was not observed with MMR vaccination for either US or NJ. PCV vaccinations had greater gains between the pre- and post-mandate period and saw a statistically significant increasing trend in both US and NJ data. For both MMR and PCV vaccinations, there was overlap in confidence intervals between US and NJ estimates for all years in the study except for MMR vaccination in 2012. These finding, especially for MMR vaccinations, are consistent with national trends which indicate vaccinations coverage rates at the state and national level have been relatively stable since the mid-1990's[18,37]. The lack of a consistent trend across other childhood vaccinations, particularly with MMR vaccination, suggest that increases associated with influenza vaccination coverage were likely not associated with general uptake in childhood vaccinations as whole. This lends evidence to the fact that increases observed with influenza vaccinations may have been, at least partially, related to the mandate.

The NIS contains variables on individual demographic and socioeconomic factors which were not available for analysis in NJIIS. These factors were analyzed to ascertain possible association with influenza vaccination coverage. Similar to other studies[17,38,39], we found vaccination coverage estimates to be higher in those with private insurance, those with higher incomes and in children with mothers who had education post high school. These factors were more pronounced in the US coverage estimates where confidence intervals were small. Similar observations were made for the NJ vaccination coverage estimates, however, the confidence intervals were much wider and these factors overlapped for almost all study years.

Multivariable logistic regression was conducted to assess the association between demographic factors and receipt of vaccine in both the pre-mandate (2007) and post-mandate (2013) period. This analysis was conducted to identify consistent barriers to vaccination between the pre- and post- mandate period and to identify any significant changes to the populations who are more or less likely to be vaccinated. For influenza vaccine, only two instances were noted when a significant association was consistently found in 2007 and in 2013. This occurred with influenza vaccine among children 19-23 months and those without private insurance in the US. The odds of receiving an influenza vaccine was higher in the younger age category (19-23 months) compared to those 30-35 months in both 2007 and 2013. Similarly, the odds of receiving an influenza vaccine was lower in those without private insurance compared to those with private insurance. These two factors have been documented in literature to be associated with influenza vaccine status[17,38]. Other statistically significant consistencies between the pre- and post- mandate period were not found within the influenza vaccination status. A similar consistent relationship between the pre- and post-mandate period was noted with MMR vaccine in the 19-23 months age group. Here, the odds of receiving MMR vaccine was lower for those 19-23 months compared to those 30-35 months. Consistent statistically significant associations between the pre- and post-mandate period were not observed with other demographic variable in MMR or PCV vaccines.

A comparison of NJ coverage estimates to other states with and without mandates enacted during the study period revealed that even states without mandates in place saw increases in influenza vaccination coverage and in some cases greater increases than states (i.e., CT, NJ) with mandates in place. Some are these increases are likely associated with nationwide recommendations for influenza vaccinations. Annual influenza vaccination for children aged 6-23 months was first recommended by the ACIP in 2004[13] and for children aged 24-59 months in 2006[14]. Our study began in 2007 and the ACIP recommendation likely had an impact on increasing influenza vaccination rates not just in the year the recommendations were made but throughout our study period. While there may be some geographic differences associated with compliance to these recommendations, general acceptance of these recommendations would likely not differ greatly among states and would not likely fully explain these observed state differences.

In general, the variation of vaccine coverage among states is one that is well described [40,41] and is observed among many childhood vaccinations, including influenza[42]. These differences are thought to be associated with a number of different factors including vaccine exemption (e.g., medical, religious) regulations, parental attitude towards vaccines, perceptions about safety and effectiveness, and access to vaccinations (e.g., insurance, income)[43-45]. Vaccine medical exemptions are present in every state and 46 states have religious exemptions[21]. Philosophical exemptions also exist but are smaller in number (n=18)[21]. Based on our findings of influenza vaccine coverage by state, there were no specific trends in influenza vaccine coverage observed among states with religious or philosophical exemptions. Except in states with influenza mandates (i.e., NJ, CT), these exemptions would not directly regulate influenza vaccine but their existence could result in missed opportunities for influenza vaccine to be offered in states with religious and philosophical exemptions.

In addition to ACIP recommendation and state-based exemptions, parental knowledge of and attitude towards vaccines, perceptions about safety and effectiveness, and access to vaccinations (e.g., insurance, income) also impact vaccine coverage. In an effort to address these factors, many states have programs for offering free or low-cost vaccine, improving Vaccine for Children Program enrollment, parental and provider education campaigns, and provider vaccine reminders[46-49]. It would be expected that each state would have different experiences with each of these factors thus impacting vaccine coverage in varying ways, however, the impact of these factors on state level coverage have not been well described.

Overall gains in influenza coverage may have also been impacted by the 2009 H1N1 pandemic which occurred from April 2009 to April 2010. The perceived risk associated with the pandemic and in subsequent years when the pandemic virus continued to circulate may have served to bolster influenza vaccinations. A study by Flood et al.[50] found that both the perceived severity of influenza and the likelihood of a child acquiring the infection were major drivers of parental decisions to vaccinate their child. Other studies found that the intense media focus on a particular disease, such as what occurred during the pandemic, can change how parents view the severity of influenza and also increase vaccination[51]. In this analysis, it is unclear what role the pandemic may have played in the coverage estimates, however, if the pandemic was truly the driving factor of the observed increases one would expect to see sharp declines after the hype of pandemic was over in 2010. Based on our analysis, influenza coverage estimates continue to increase after 2010 lending support that the increasing trends in our observations are not likely associated with influences solely due to the 2009 pandemic.

Strengths

The strength of this study comes from the use of NIS data which is a large nationwide sample of vaccination verified coverage in children 19-35 months of age. This data allowed for comparison of national and state specific coverage levels across a number of vaccinations and also allowed for evaluation of demographic and socioeconomic factors that contributed to differences in vaccination coverage. While coverage levels for NIS and NJIIS data differed in magnitude, both showed increasing coverage levels for NJ from the pre- to post- mandate period.

Limitation

While the NIS is a robust system, it presented some limitations for this analysis. Use of the NIS limited our study to children aged 19-35 months which is only a subset of children covered by the NJ influenza vaccine mandate. While this limits the age group for this analysis, we believe that these coverage estimates are likely representative of the overall experience of children covered by the mandate. Additionally, the NIS does not contain data on child care attendance and it is not possible to directly estimate increases in only those children who attend child care centers, which is the target population of the mandate.

Additional differences between the NIS and NJIIS levels may have been introduced in the sample inclusion procedures used for the NJIIS data. While every effort was made to re-create in NJIIS a similar age cohort to that used in NIS, uncorrected errors in the NJIIS data (e.g., date of birth, vaccination date) may be present and could have caused certain children to be included/excluded inappropriately from the NJIIS age cohort. While we believe these type of errors are minimal within this data, these types of data errors would have resulted in nondifferential misclassification bias which could have over or under inflated vaccination coverage levels in the NJIIS cohort.

Additional bias inherent to the use of data generated by a telephone survey requiring follow up also need to be considered. Bias associated with non-response and households without telephones need to be considered when looking at survey data such as that generated from the NIS. Our analysis only used NIS records which could be verified with providers' records. Provider non-response may have also introduced some bias into the analysis. Weights provider by NIS and used in this analysis should ensure that the estimates obtained are representative of all children 19-35 months, however, even with application of these weights, bias cannot be completely eliminated with the use of these survey methods[52].

Conclusion

Findings from both the NIS and NJIIS systems lend support to increasing influenza vaccination coverage levels from the pre- to post-mandate period in NJ. These findings are further supported by the limited increases in other common childhood vaccinations evaluated. Vaccination coverage was found to vary by a few, known demographic and socioeconomic characteristics. Despite the increase observed in NJ, other states without mandates saw similar or greater increases in influenza vaccine coverage which may be indicative of other effective initiatives bolstering vaccination coverage levels or increases in general update in influenza vaccination in a population as a whole. Overall, influenza vaccination coverage appears to be increasing in many states but additional studies are needed to pinpoint the driving force behind these increases in order to fully determine the impact of the NJ mandate compared to other types of initiatives.

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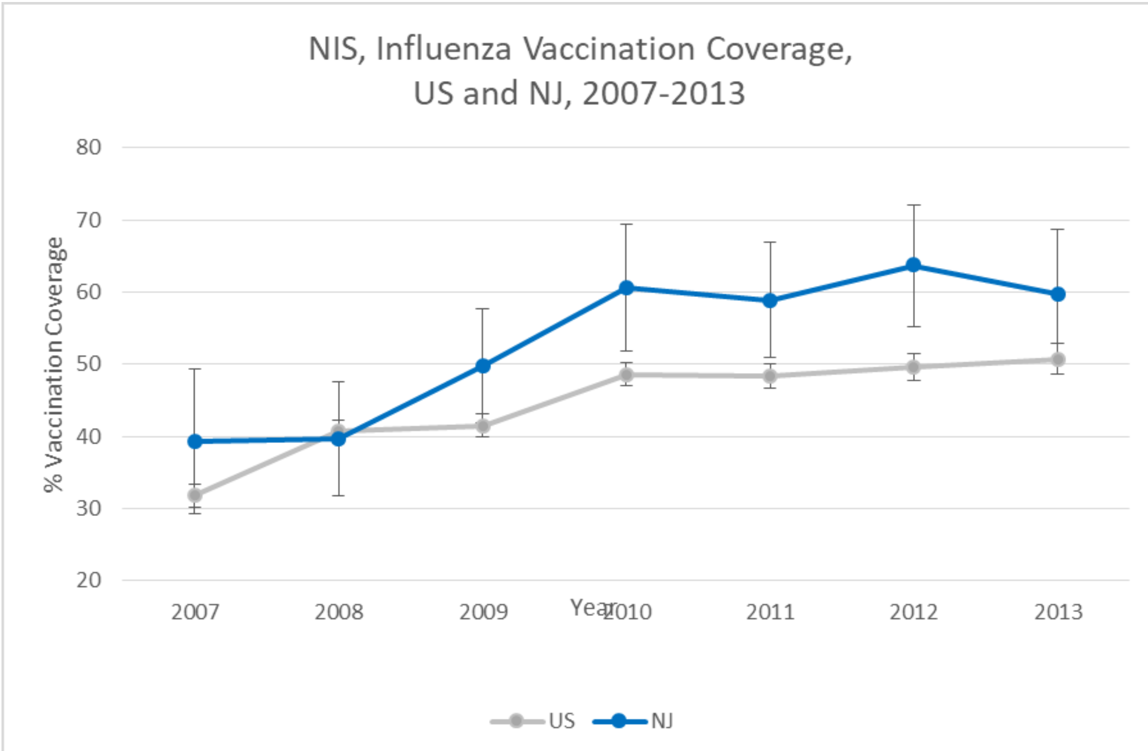
Table 2.1 National Immunization Survey, Characteristics of Study Population, United States, 2007-2013

	Study Year						
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Sex							
Male	51.19	51.19	51.20	51.14	51.18	51.17	51.19
Female	48.81	48.81	48.80	48.86	48.82	48.83	48.81
Age Group							
19-23 months	30.07	30.70	30.44	29.45	29.59	29.67	29.98
24-29 months	34.27	34.16	33.73	34.30	34.20	33.88	33.94
30-35 months	35.65	35.14	35.83	36.25	36.22	36.44	36.08
Race							
White	74.48	73.93	73.34	71.86	70.68	69.94	69.91
Black	14.56	14.55	14.61	15.21	15.19	15.32	14.74
Other/multiple	10.95	11.52	12.05	12.93	14.13	14.74	15.35
Race/Ethnicity							
Hispanic	27.51	28.00	28.04	27.59	27.87	27.34	27.20
Non-Hispanic white	51.25	50.69	50.30	49.25	47.91	47.11	47.90
Non-Hispanic black	12.53	12.55	12.66	13.17	13.15	13.63	12.66
Non-Hispanic other/multiple	8.72	8.76	9.00	9.98	11.06	11.92	12.24
Poverty (known)							
Above Poverty >75K	24.95	27.96	28.42	29.01	24.65	26.42	28.88
Above Poverty <75K	41.51	41.48	38.77	37.64	37.57	34.90	35.80
Below Poverty	27.42	30.56	32.81	33.35	37.78	38.68	35.32
Private insurance							
Yes	53.68	43.36	51.10	50.74	47.12	49.17	49.54
No	45.31	56.64	48.90	49.26	52.88	50.83	50.46
Mom's Education							
Less than 12 years	20.50	20.13	19.60	19.55	19.79	19.05	18.49
High school graduate	30.51	30.57	31.05	29.55	28.06	27.01	25.68
Post high school education	48.99	49.30	49.35	50.89	52.15	53.94	55.83

Table 2.2 National Immunization Survey, Characteristics of Study Population, New Jersey, 2007-2013

	Study Year						
	2007	2008	2009	2010	2011	2012	2013
Sex							
Male	51.17	51.34	51.31	50.94	51.24	51.05	51.26
Female	48.83	48.66	48.69	49.06	48.76	48.95	48.74
Age Group							
19-23 months	29.72	30.28	30.18	29.22	29.47	29.72	29.86
24-29 months	34.46	34.41	34.29	34.41	34.63	34.05	34.17
30-35 months	35.82	35.31	35.53	36.37	35.90	36.22	35.97
Race							
White	70.69	66.67	65.45	66.91	69.20	62.16	68.69
Black	17.92	16.81	20.39	16.66	16.30	16.95	14.55
Other/multiple	11.38	16.52	14.16	16.42	14.50	20.89	16.75
Race/Ethnicity							
Hispanic	27.42	29.56	28.76	29.12	31.71	28.44	29.82
Non-Hispanic white	48.13	42.32	47.00	45.87	43.05	39.98	44.25
Non-Hispanic black	14.49	13.83	13.64	14.14	13.57	13.52	12.97
Non-Hispanic other/multiple	9.96	14.29	10.59	10.87	11.67	18.06	12.95
Poverty (known)							
Above Poverty >75K	37.87	28.80	43.39	43.76	39.91	44.72	40.16
Above Poverty <75K	39.44	36.99	30.09	26.00	32.16	26.15	30.85
Below Poverty	22.69	34.21	26.52	30.25	27.93	29.13	29.00
Private insurance							
Yes	73.84	65.57	65.47	60.19	60.72	65.69	59.84
No	26.16	34.43	34.53	39.81	39.28	34.31	40.16
Mom's Education							
Less than 12 years	12.66	15.93	7.97	12.79	14.41	13.03	15.11
High school graduate	28.43	25.01	33.13	27.25	25.04	25.63	23.69
Post high school education	58.92	59.06	58.90	59.96	60.54	61.33	61.20

Figure 2.1 National Immunization Survey, Influenza Vaccination Coverage, US and NJ, 2007-2013



*Error bars represent 95% confidence interval.

Table 2.3 National Immunization Survey, Multivariable Logistic-Regression Analysis of Influenza, MMR, and PCV Vaccination Coverage Levels and Demographic Characteristics, United States, 2007 and 2013

	Influenza						MMR						PCV					
	2007			2013			2007			2013			2007			2013		
Demographic Characteristic	Adusted OR	(95%CI)		Adusted OR	(95%CI)		Adusted OR	(95%CI)		Adusted OR	(95%CI)		Adusted OR	(95%CI)		Adusted OR	(95%CI)	
Sex																		
Female	1.02	0.88	1.18	0.89	0.75	1.05	1.02	0.84	1.24	0.94	0.73	1.22	1.14	0.96	1.36	0.89	0.67	1.19
Male	Referent			Referent			Referent			Referent			Referent			Referent		
Age Group																		
19 - 23 months	1.70*	1.34	2.14	1.43*	1.12	1.82	0.72*	0.57	0.90	0.61*	0.45	0.83	0.94	0.76	1.17	0.86	0.60	1.22
24 - 29 months	1.56*	1.22	2.00	1.07	0.84	1.36	0.98	0.76	1.26	0.84	0.60	1.17	1.14	0.93	1.42	0.75	0.54	1.05
30 - 35 months	Referent			Referent			Referent			Referent			Referent			Referent		
Race																		
Non-white	0.84	0.70	1.01	0.76*	0.63	0.92	1.08	0.82	1.42	1.17	0.90	1.52	1.02	0.82	1.26	0.95	0.71	1.28
White only	Referent			Referent			Referent			Referent			Referent			Referent		
Race/Ethnicity																		
Hispanic	0.80*	0.65	0.98	0.81	0.63	1.04	1.14	0.85	1.52	1.42	0.96	2.08	1.27	0.99	1.62	1.49*	1.03	2.16
Non-Hispanic	Referent			Referent			Referent			Referent			Referent			Referent		
Maternal Education																		
12 years plus	1.17	0.90	1.53	1.07	0.81	1.42	0.95	0.67	1.34	1.63*	1.09	2.43	1.07	0.79	1.44	2.00*	1.37	2.91
Less than 12 years	Referent			Referent			Referent			Referent			Referent			Referent		
Poverty Status																		
Above poverty level	1.25*	1.00	1.57	1.08	0.85	1.36	1.02	0.71	1.46	1.13	0.82	1.55	1.03	0.77	1.39	1.65*	1.20	2.27
Below poverty level	Referent			Referent			Referent			Referent			Referent			Referent		
Private Insurance																		
No	0.59*	0.50	0.71	0.65*	0.53	0.80	0.65*	0.50	0.85	0.88	0.62	1.27	0.76*	0.61	0.94	0.83	0.57	1.22
Yes	Referent			Referent			Referent			Referent			Referent			Referent		

**P*<0.05 for comparison with referent group

Table 2.4 National Immunization Survey, Multivariable Logistic-Regression Analysis of Influenza, MMR, and PCV Vaccination Coverage Levels and Demographic Characteristics, New Jersey, 2007 and 2013

	Influenza						MMR						PCV					
	2007			2013			2007			2013			2007			2013		
Demographic Characteristic	Adusted OR	(95%CI)		Adusted OR	(95%CI)		Adusted OR	(95%CI)		Adusted OR	(95%CI)		Adusted OR	(95%CI)		Adusted OR	(95%CI)	
Sex																		
Female	1.71	0.68	4.34	0.68	0.30	1.51	1.07	0.29	3.98	5.60	0.91	34.58	3.47 *	1.23	9.79	7.20	0.49	106.73
Male	Referent			Referent			Referent			Referent			Referent			Referent		
Age Group																		
19 - 23 months	1.54	0.36	6.65	3.39	1.00	11.44	0.47	0.06	3.41	2.53	0.38	16.86	0.24*	0.07	0.77	0.20	0.03	1.21
24 - 29 months	0.88	0.19	4.00	3.34	0.93	11.94	0.89	0.21	3.73	1.92	0.39	9.45	0.81	0.27	2.48	22.77*	1.87	277.99
30 - 35 months	Referent			Referent			Referent			Referent			Referent			Referent		
Race																		
Non-white	0.34	0.10	1.19	0.71	0.29	1.75	0.96	0.18	5.11	0.61	0.11	3.42	0.34	0.11	1.01	0.52	0.04	6.87
White only	Referent			Referent			Referent			Referent			Referent			Referent		
Race/Ethnicity																		
Hispanic	0.89	0.28	2.85	0.94	0.30	2.95	0.78	0.13	4.75	0.71	0.14	3.59	0.41	0.12	1.40	0.08*	0.01	0.93
Non-Hispanic	Referent			Referent			Referent			Referent			Referent			Referent		
Maternal Education																		
12 years plus	0.39	0.05	2.96	1.81	0.40	8.17	2.04	0.19	21.65	0.29	0.03	2.70	0.83	0.09	7.84	3.90	0.28	53.84
Less than 12 years	Referent			Referent			Referent			Referent			Referent			Referent		
Poverty Status																		
Above poverty level	1.21	0.21	7.02	0.57	0.19	1.77	3.87	0.21	70.10	2.59	0.46	14.42	1.98	0.30	13.28	2.83	0.20	39.04
Below poverty level	Referent			Referent			Referent			Referent			Referent			Referent		
Private Insurance																		
No	0.21	0.03	1.32	0.89	0.34	2.31	2.07	0.17	24.52	0.27	0.05	1.64	0.70	0.18	2.81	11.49*	1.82	72.47
Yes	Referent			Referent			Referent			Referent			Referent			Referent		

**P*<0.05 for comparison with referent group

Figure 2.2 New Jersey Immunization Information System, Influenza Vaccination Coverage,

NJ, 2007-2013

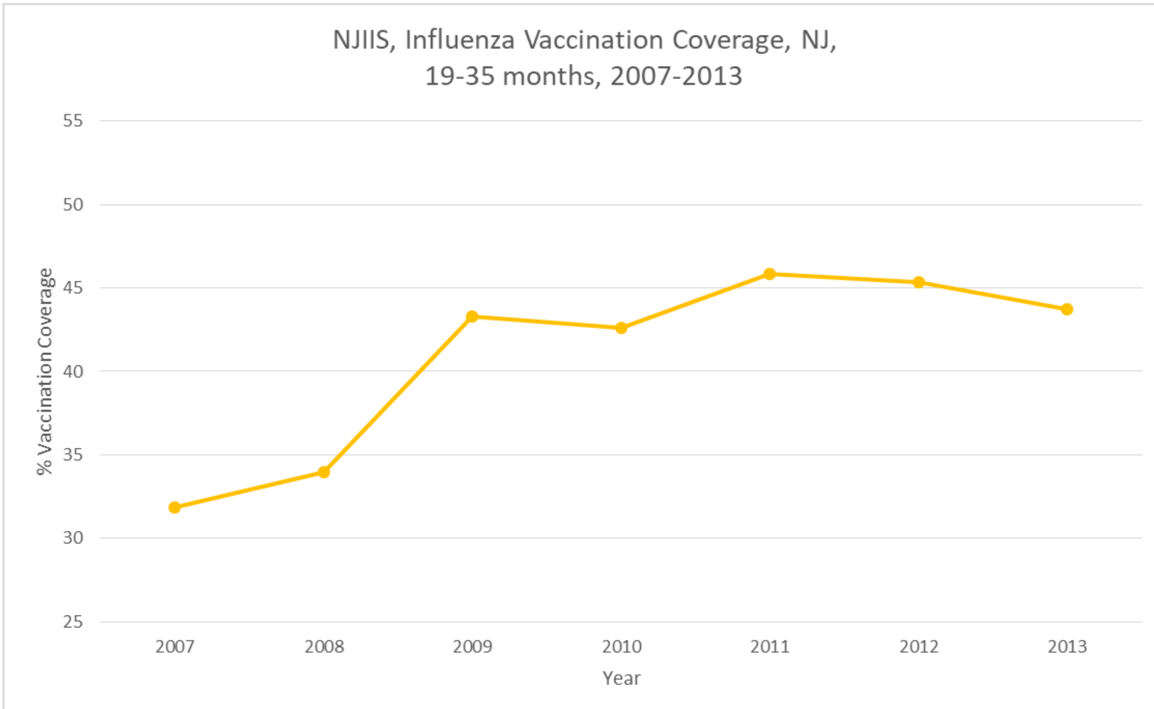
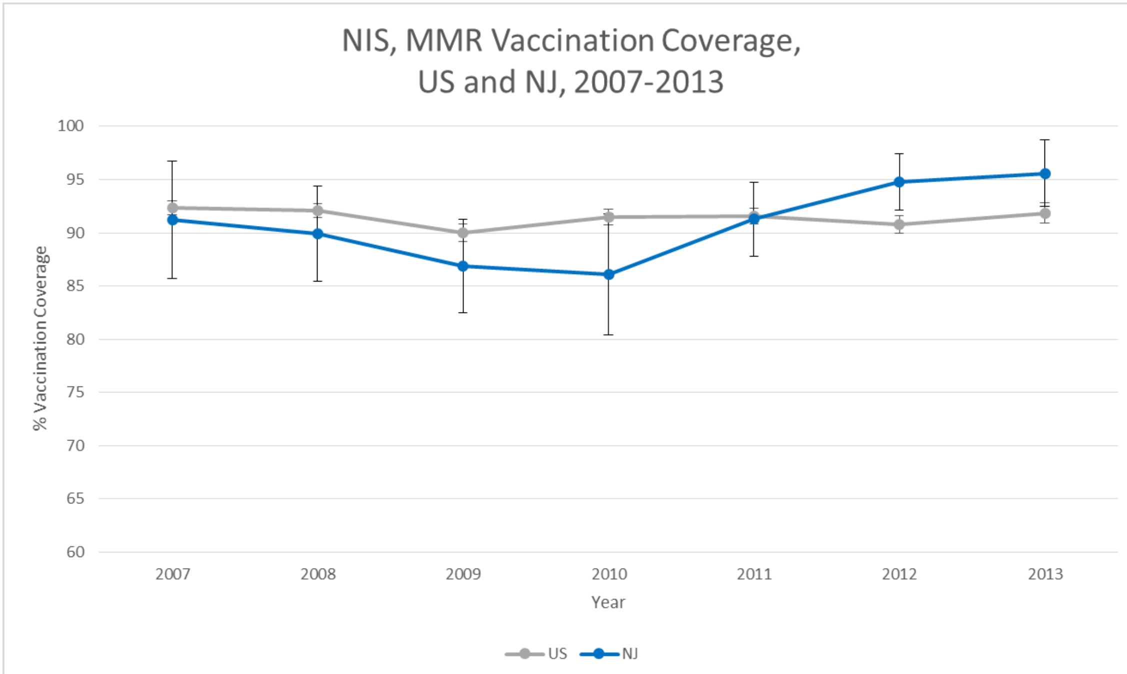
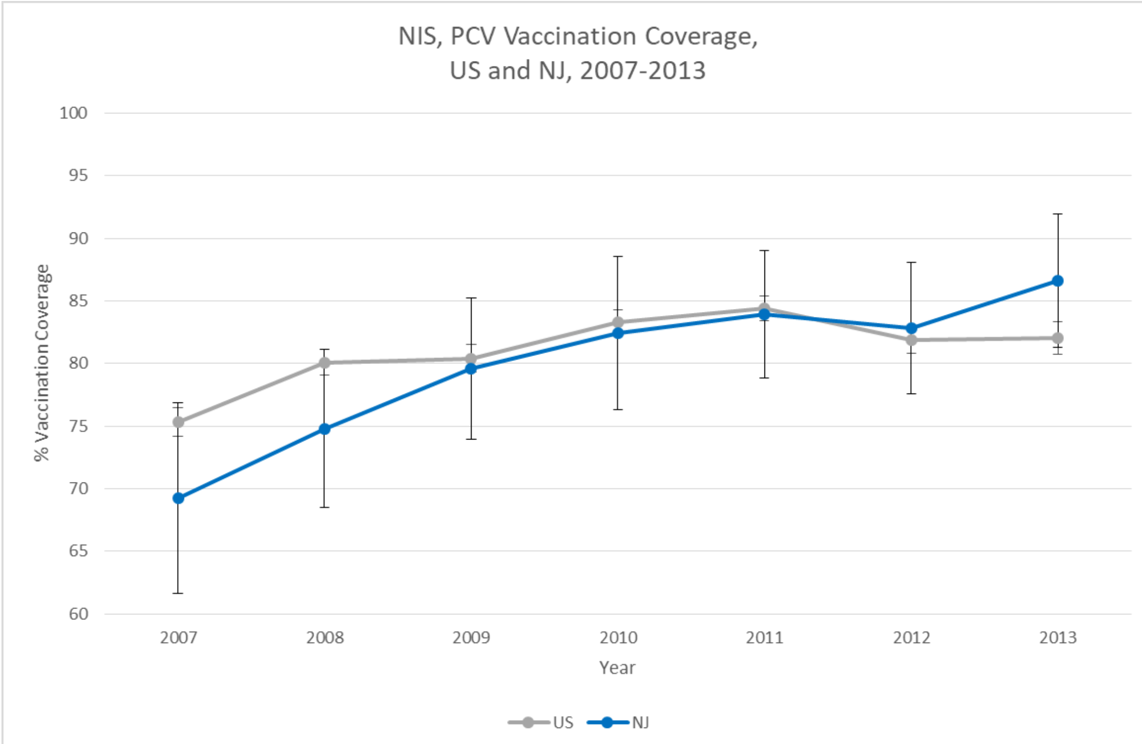


Figure 2.3 National Immunization Survey, MMR Vaccination Coverage, US and NJ, 2007-2013



*Error bars represent 95% confidence interval.

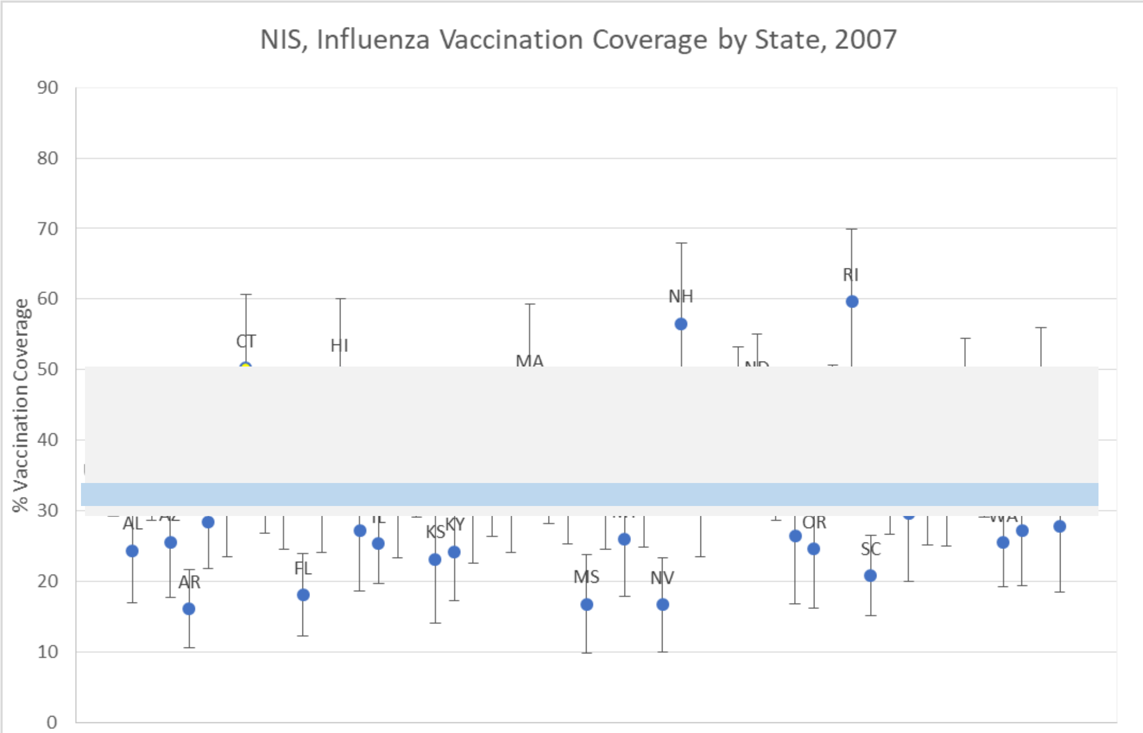
Figure 2.4 National Immunization Survey, PCV Vaccination Coverage, US and NJ, 2007-2013



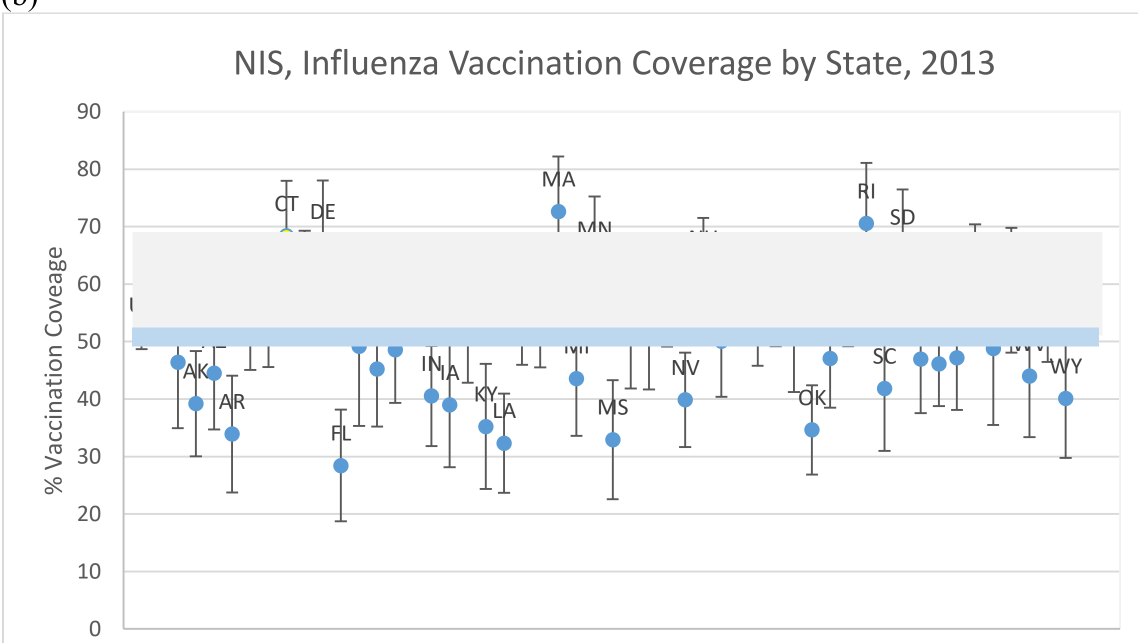
*Error bars represent 95% confidence interval.

Figure 2.5 National Immunization Survey, Influenza Vaccination Coverage by State, 2007 and 2013

(a)



(b)



*Error bars represent 95% confidence interval.

**Gray and blue shading represents state falling in NJ and US levels, respectively, including confidence intervals

CHAPTER 3: ASSOCIATION BETWEEN INFLUENZA VACCINE MANDATE IN CHILD CARE CENTERS AND HEALTH OUTCOMES IN NEW JERSEY POPULATIONS

Introduction

Annual epidemics of influenza with varying impact occur each year in the United States (US). Since 2010, it has been estimated that influenza results in between 9.2 million and 35.6 million illnesses and between 140,000 and 710,000 hospitalizations.[1-3] Hospitalization rates are highest for those greater than 65 and less than 4 years of age.[3] Evaluating seasonal influenza data from 1976 to 2006, influenza-associated deaths range widely with a low of approximately 3,000 to a high of about 49,000 deaths.[2] Influenza attack rates are generally higher in younger individuals while mortality is highest among older adults. Excess morbidity and mortality is commonly seen in a subgroup of individuals with certain high-risk medical conditions (e.g. cardiovascular, pulmonary, chronic metabolic conditions, renal dysfunctions, and immunodeficiency).[4]

Pediatric patients, specifically pre-school age children (3-4 years) tend to seek medical care (ambulatory and emergency) earliest in a seasonal outbreak and are thought to be sentinels of infection.[5] High infection rates in young children are likely due to lack of prior immunity and exposure to the virus.[6] The current thinking is that these children play a major role in the early stages of annual epidemics by first initiating and then continuing the transmission by infecting siblings and other household members resulting in additional morbidity, hospitalization and mortality. [4,5,7]

Several studies have demonstrated that there is an increase in respiratory illness, including influenza, in children who attend child care when compared to those children who do not attend child care.[8-12] With nearly 11 million children under the age of 5 in the US spending on average 35 hours per week in child care, the opportunity for infection and transmission of influenza viruses is great both in this population as well their household contacts.[13,14]

One suggested strategy to reduce influenza transmission and burden of influenza in child care and the subsequent infection of household members is to promote vaccination in the child care and school age populations.[15] Studies have found the vaccination of children in this age range reduces the number of reported respiratory illnesses in both children and adults residing in the household with the vaccinated child.[16] This relationship holds true even when sibling and household contacts are not vaccinated.[17] This evidence has prompted states to consider mandating influenza vaccine in this population with the goal of reducing transmission and subsequent morbidity and mortality.

On September 1, 2008, New Jersey (NJ) implemented a regulation requiring children six months through 59 months of age attending any licensed child care center or preschool facility to receive at least one dose of influenza vaccine between September 1 and December 31 each year. This mandate was to be fully implemented for the 2009-2010 school year; however, the mandate was suspended by the Commissioner of the New Jersey Department of Health due to limited vaccine availability. The regulation was fully implemented in the 2010-2011 school year. New Jersey was the first state to enact this type of regulation. Since that time, Connecticut, Ohio and Rhode Island have enacted similar vaccine mandates[18] in September 2010, March 2015, and August 2015, respectively.

This purpose of this study was to evaluate the impact of the New Jersey influenza vaccine mandate on morbidity and mortality during the study period 2007-2013. Influenza-associated hospitalization rates were assessed using data from the National Inpatient Sample (NIS) and the New Jersey State Health Assessment Data (NJSHAD). Mortality rates were assessed by using the National Vital Statistics System. Hospitalization and mortality rates in NJ were compared to those from the United States and the Northeast region to determine if NJ rates were impacted by the mandates implementation. In addition to these overall comparisons, comparisons were made for children less than 5 years of age which is the target population for the vaccine mandate. Epidemiologic factors, such as gender and race, were also evaluated to determine how these rates change based on these factors.

Methods

Mortality

Mortality Data Sources- National Vital Statistics System

The National Vital Statistics System Mortality component (NVSS-M)[19] obtains information on deaths from the registration offices of each of the 50 states, New York City, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, Guam, American Samoa, and Northern Mariana Islands. States provide the National Center for Health Statistics (NCHS) with death records in electronic format and the NVSS-M data serve as the primary source of information on demographic, geographic, and cause-of-death information among persons dying in a given year. For all years, causes of death are categorized using the International Classification of Diseases, Tenth Edition (ICD-10)[20]. While ICD-10 codes may have not been widely used during the study period. The NVSS-M records available after 1999 have all been re-coded using ICD-10 codes.

Inclusion/Exclusion

Data from NVSS-M was queried from 2007 to 2013. Previous studies have used selected groups of ICD-10 codes [21,22] to identify influenza-specific (J10-J11) and influenza-associated (J10-J18) deaths. Influenza-specific codes include those codes which specify an influenza diagnosis whereas influenza-associated includes other respiratory codes which often represent complications associated with an influenza infection. Influenza is often underreported on death certificates[23] as many deaths are associated with influenza complications, such as pneumonia or chronic obstructive pulmonary disease[24]. These conditions, rather than influenza, are often listed on the death certificate as the cause of death. Another complicating factor is providers are more likely to include influenza as a cause of death if influenza testing has occurred. This creates challenges in evaluating deaths certificates as influenza testing is not always performed, may be performed using tests with low specificity and sensitivity, or may be performed after the initial clinical course when the virus may no longer be detectable. For these reasons, the larger set of respiratory codes is likely more accurate in describing influenza-related deaths. Codes appearing in any of the 20 multiple cause of death fields were used to create two categories, influenza-specific and influenza-associated deaths. The pandemic associated with Influenza A 2009 H1N1 began in 2009 and, during this time, codes representing novel flu viruses were widely used. For this reason, novel influenza codes (J09) were also included across all years. Deaths among individuals who resided in US territories (i.e., PR, VI, GU, AS, MP) or in foreign countries were excluded from analysis. NCHS cleans data before release and completeness of demographic factors is good. Age was excluded if missing or not stated. Because we are evaluating if influenza circulation may have contributed to deaths, death in which the state of occurrence was different than state of residence were also removed as the exposure location may be different than location of death.

NVSS-M Analysis

A retrospective analysis was conducted to look at influenza-specific and influenza-associated deaths. All analysis was conducted using SAS software version 9.3 (SAS Corp, Cary, North Carolina) and was evaluated nationally, for the northeast region (i.e., Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Pennsylvania) and for New Jersey. The SAS survey means procedures was used to calculate confidence intervals associated with all rates. Overall influenza-specific and influenza-associated multiple cause of death rates as well as rates stratified by age, gender, and race were calculated using population estimates from the US Census Bureau (2010). Crude rates stratified by age group, race and gender were calculated using 2010 census data at the national, regional, and New Jersey levels. Crude rates were directly adjusted using the 2010 US population census age specific proportions. Confidence intervals were calculated for all rates. All rates are calculated per 100,000 person-years.

Hospitalization

Hospital Discharge Data Sources

Nationwide (National) Inpatient Sample (NIS)

The Nationwide (National) Inpatient Sample (NIS) is the largest publicly available all-payer inpatient database in the US.[25,26] The database is developed and maintained under the Healthcare Cost and Utilization Project (HCUP), a subsidiary of the federal government's Agency for Healthcare Research and Quality (AHRQ). The NIS covers all patients, including individuals covered by Medicare, Medicaid, or private insurance, and the uninsured and can be used to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcomes. HCUP is based on data from community hospitals, defined as short-term, non-Federal, general and other hospitals, excluding hospital units of other institutions (e.g., prisons). The unit of analysis is the hospital discharge (i.e., the hospital stay), not a person or patient. This means that a person who is admitted to the hospital multiple times in one year will be counted each time as a separate "discharge" from the hospital.

The NIS is sampled from the State Inpatient Databases (SID). The SID are state-specific files that contain all inpatient care records from participating states contributing to HCUP. The NIS is a stratified probability sample of hospitals from the states that submit data to HCUP, which is weighted to provide national and regional estimates[27]. The NIS sampling frame has grown from 8 States in 1988, to 22 States in 1998, to 46 States in 2011 covering 97 percent of the US population. The NIS is designed to approximate a 20 percent sample of US community hospitals. The 2012 NIS was redesigned to improve national estimates with a sample of discharges being drawn from all hospitals and renamed the National Inpatient Sample. Unique subject identifiers are used to conceal patient identity and prevent identification of multiple admissions for the same patient. The database discloses patient demographics, procedures, admission, and discharge status as well as primary and secondary discharge diagnoses. The NIS contains clinical and resource use information included in a typical discharge abstract. The number of states participating in HCUP was consistent across all years with the exception of Pennsylvania who did not participate in 2007.

NIS Inclusion/exclusion

Data from NIS database was queried from 2007 to 2013 to identify all patients who had a diagnosis of influenza. International Classification of Diseases, Ninth Edition (ICD-9)[28] codes 487.0 (influenza with pneumonia), 487.1 (influenza with other respiratory manifestations), 487.8 (influenza with other manifestations) were used. Beginning in 2009, when a pandemic associated with influenza A 2009 H1N1 occurred, codes representing novel flu viruses were widely used. ICD-9 codes 488.0 (influenza due to identified novel H1N1 infection) and 488.1 (influenza due to identified novel H1N1 infection with other manifestations) were also included in queries for years 2009 to 2013. Discharge diagnosis fields were expanded from 15 to 25 beginning with the 2009 data. Records were included if these ICD-9 codes appeared in any of the available discharge diagnosis fields for any given year. Records with missing or unknown information for age, race and sex were excluded.

NIS Analysis

A retrospective analysis was conducted to look at influenza-associated hospital discharges. Analysis was conducted both nationally and for the northeast region (i.e., Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Pennsylvania). The NIS Trend Weight files[29] were used to create national and regional estimates for trend analyses which allows for adjustment in NIS over time. Weights were applied to the data using survey means procedures of SAS software version 9.3 (SAS Corp, Cary, North Carolina) and associated confidence intervals were calculated to account for the sample weights and complex sample design.

Crude hospitalization rates, in addition to rates stratified by age, gender and race were calculated. Crude rates were directly adjusted using the 2010 US population census age specific proportions. Since, Pennsylvania did not participate in the 2007 NIS, population estimates for Pennsylvania were excluded when making overall rate calculations for 2007 data. Since it is important to determine if the mandate had an impact on the hospitalization of specific age groups, age specific rates were also age adjusted using the direct standardization method using age specific census estimates of the 2010 US census population.

New Jersey State Health Assessment Data (NJSHAD)

The complex sampling design of the NIS does not allow for state level estimates to be produced. Influenza-associated hospitalization rates were acquired by querying the New Jersey State Health Assessment Data (NJSHAD) system[30] for New Jersey hospital discharges. The query was created to mirror the data of the NIS with the same inclusion/exclusion criteria applied. Similar to NIS data, overall influenza-associated hospitalization rates as well as rates stratified by age, gender, and race were calculated using population estimates from the US Census Bureau (2010). Crude rates were directly adjusted using the 2010 US population census age specific proportions.

Overall analysis

While the United States typically experiences a similar influenza season, geographic variations in influenza infections can occur especially in areas which might experience more temperate climates[31]. These geographic variations can result in shifting of the season temporally and also change the measure of severity (i.e.., hospitalization and deaths). Comparison of influenza-associated and influenza-specific mortality and hospitalization rates are best made with regional rates (i.e., Northeast United States) which are likely to more closely mirror the impact of influenza experienced in New Jersey.

Annual influenza varies in severity and because of this comparisons from one year to the next may be difficult. While some geographic variation does occur, the mortality rate for the national and northeast level for any given year should be fairly representative of the rate of death given seasonal variation. Because of this, comparisons of age adjusted rates within a given year are a more accurate comparison than comparison from year to year.

While hospitalization and mortality rates from 2009 through 2011 have been produced, this represented a time when the 2009 H1N1 pandemic occurred throughout the United States. The pandemic which occurred in two waves in 2009 likely caused increases in hospitalizations and deaths. This also represented a time when the New Jersey vaccine mandate was being implemented. Therefore, the focus of the analysis will be on the pre-mandate period (i.e., 2007, 2008) and post-mandate (i.e., 2011, 2012, and 2013). Focusing on these time periods will likely reduce any bias introduced into the data because of the pandemic.

Results

Mortality Rates

A total of 16,918,861 records from the 2007 to 2013 NVSS-M were analyzed. Of these 1,322,446 and 12,000 influenza-associated and influenza specific deaths, respectively, were evaluated. For each year of the study, influenza-associated and influenza-specific deaths for New Jersey, the northeast and US are presented in Table 3.1. The number of influenza specific-deaths varied greatly by year and geographic region. The number of influenza-specific deaths identified in New Jersey was small (i.e., less than 25) in all years except 2013 (n=80; 2013). Rates calculated for New Jersey from this mortality data may be unstable and comparisons using this data are likely not reliable. Data for the national and northeast data did not have similar issues with sample size. Across all years and regions, influenza-specific deaths represented less than one percent of all reported deaths. Influenza-associated deaths did fluctuate slightly but appeared to be more stable across all years of data and within each region with one outlier noted in 2007 for New Jersey (13.33%). For the seven-year period evaluated, influenza-associated deaths represented 7-8% of all reported deaths in the three areas evaluated.

While influenza-specific rates were calculated for all regions, the rates for New Jersey are unstable due to small counts, therefore, this study will only evaluate influenza-associated mortality rates. For all years, age adjusted rates for both influenza-associated and influenza- specific mortality for NJ were lower than both the national and northeast rates (Tables 3.2 and 3.3). During the pre-mandate period, age adjusted influenza-associated mortality rates in NJ period were lower than both the National and Northeast rates. The NJ rate had 11.0 and 13.01 fewer deaths per 100,000 persons than the National rate and 8.98 and 9.68 fewer deaths per 100,000 persons than the Northeast for years 2007 and 2008 respectively. During the post-mandate period, age adjusted influenza-associated rates for NJ were also lower than National and Northeast rates. The NJ post-mandate rates had 14.17, 15.44 and 13.24 fewer deaths per 100,000 persons than the National rate and 12.50, 12.15, and 10.19 fewer deaths per 100,000 persons than the Northeast rate for years 2011, 2012, and 2013, respectively. While the mortality rates varied by year, the overall reduction was larger in the NJ mortality rates in the post-mandate years when compared to either the National or Northeast rates.

In comparison, the age adjusted influenza-associated mortality rates for the Northeast were more stable between the pre- and post-mandate periods. During the pre-mandate period, the Northeast rate has 2.02 and 3.33 fewer deaths per 100,000 persons than the National rate for 2007 and 2008, respectively. During the post mandate period, the Northeast rate has 1.68, 3.29 and 3.14 fewer deaths per 100,000 persons than national rate for year 2011, 2012, and 2013, respectively. This subtle decline can be further displayed if pre- and post- mandate rate are averaged. The averages of pre-mandate years are 62.61, 59.93 and 50.61 for the Nation, Northeast and NJ, respectively, compared to the post-mandate average rates of 60.97, 58.27, and 46.69 for the Nation, Northeast and NJ, respectively. The change from the pre- to the post-mandate period was largest for NJ.

Mortality Rates Target Population (children < 5 years)

As shown in Table 3.4, the adjusted influenza-associated mortality rates for NJ in the group targeted by the vaccine mandate (i.e., less than 5 years of age) are lower than both Northeast and National rates. It should be noted that the New Jersey mortality rates for the target group are unstable due to small cell counts but no other data are available for comparison. The difference in rates for each geographic area in the target age group varied greatly across all study years. The rate differences in the target group were much smaller than that observed in the overall mortality rates. The rate differences between NJ and the Northeast were small across all years with the largest difference occurring in 2008 (1.28) and 2012 (0.72) with no large consistent differences noted between the pre- and post- mandate periods. The average of pre-mandate years rates per 100,000 persons are 3.94, 3.34, and 2.40 for the Nation, Northeast and NJ, respectively, compared to the post-mandate average rates per 100,000 persons of 3.04, 2.28, and 1.90 for the Nation, Northeast and NJ, respectively. While there was a drop in the morality rate for NJ, larger declines were noted for this target population in both the Northeast and the Nation.

Non-target age groups

Across all other age groups, the influenza-associated mortality rates for NJ were lower than the National and Northeast regions with consistent trends observed over time (Table 3.4). During the post-mandate period, there were large differences in NJ rates from both the Northeast and National rates. Rates for children 5-19 years for NJ had 0.24 and 0.30 fewer deaths per 100,000 persons than Northeast rate for years 2012 and 2013 respectively. In comparison, the pre-mandate rates had only 0.18 and 0.07 fewer deaths per 100,000 persons than Northeast rates. Differences in pre- and post- mandate rate averages were similar for other age groups with minimal reductions observed in the post-mandate period. The largest reduction in average rate occurred in those greater than 85 years in NJ where the average rate declined by 73 deaths per 100,000 persons between the pre- and post- mandate time period.

Demographics

Findings for gender were similar to data presented for the overall age-adjusted rates (Table 3.5). There was variability between regions and between years. Overall, the rates were similar for males and female in all years and all regions. Across all year and across all regions, the influenza associated rates for whites were greater than rates for black and for other race categories (Table 3.6). Similar to previous comparisons, rates for NJ were lower than for the Northeast and the Nation across all categories and across all years. Similar variations observed with overall age adjusted data were also observed across years.

<u>Hospitalization Rates</u>

A total of 54,134,428 HCUP NIS records from the 2007 to 2013 were evaluated. Using the provided weights, national estimates should be representative of the 260,498,447 actual discharges recorded nationally. A total of 8,931,965 NJ hospital discharges from the 2007 to 2013 were evaluated.

The overall trend in age adjusted hospitalization rates across all years was similar within each region (Table 3.7). During the pre-mandate period, the age adjusted hospitalization rates nationally and for the Northeast were very similar to each other while the rates for NJ were lower than both the National and Northeast data with a large difference noted in

2007. As expected, sharp increases in hospitalization rates were observed in 2009 and were likely associated with the 2009 H1N1 pandemic[32]. During the post-mandate period, the age-adjusted hospitalization rate was higher for NJ than for other regions in both 2011 and 2013 but lower in 2012. The NJ rates for 2012 and 2013 were outside the confidence intervals for the National and Northeast rates during both of these years. The average rates for pre-mandate years were 18.7, 19.3, and 15.9 for the Nation, Northeast and NJ, respectively. Compared to the post-mandate average rates of 30.1, 32.2 and 35.6 for the Nation, Northeast and NJ, respectively. For the post-mandate period, there was an increase in hospitalization rates across all regions.

Hospitalization Rates Target Population (children < 5 years)

While the magnitude of hospitalization rates varied by region, the overall trend observed with the adjusted hospitalization rates for those targeted by the mandate (children less than 5 years) was similar across all years (Table 3.8). Adjusted rates for children less than 5 years in New Jersey was higher across all years when compared to both national and northeast rates with larger increases in 2009 and 2013. During the pre-mandate period, the rate in 2007 was similar in all regions, however, in 2008 the NJ rate was much higher (123.65) and was different than the national and northeast rate. During the post mandate period, the NJ rate was higher in the target group across all three years. In 2011 and 2013, the NJ target group hospitalization rate was almost double the rate for both the National and Northeast rate.

Non-target age groups

A trend in hospitalization rates similar to that observed in the target group was noted in children 5-19 years with higher rates in NJ data than in National or Northeast (Table 3.8). This trend did not continue for other age groups in that hospitalization rates for those aged 20-64 years in NJ closely mirrored rates observed in the Northeast and National except in 2013 where NJ rate was higher than both the Northeast and National. The rates observed in the remaining age groups showed lower rates in NJ than for Northeast and National rates with similar trends in data across all years.

Demographics

With a few exceptions, there was little difference between the hospitalization rates for gender and race (Table 3.9 and 3.10). Rates for males and females were similar across all years and all regions (Table 3.9). The NJ hospitalization rates for both males and females were lower in 2007 and higher in 2013 when compared to National and Northeast rates. The trends across all years and regions were similar in all race categories evaluated.

Discussion

In this evaluation, there does not appear to be an overwhelming difference in rates of influenza- associated hospitalizations and influenza-associated deaths when comparing the pre- and post- vaccine mandate periods. When comparing rates from New Jersey to the Northeast where influenza circulation is often similar each year, some overall reductions in influenza-associated mortality in the post vaccine mandate period compared to the pre-mandate period were observed. No overt reductions in hospitalization or mortality rates were observed from pre- to post- mandate periods in the population targeted by the mandate (children < 5 years of age). The same was true for the other age groups except for hospitalization rates in those children 5-19 years where some reduction in rates were observed in the post mandate period. Little changes in hospitalization or mortality rates were observed with other demographic characteristics assessed.

To date, there have been no studies conducted to assess the impact of the NJ influenza vaccine mandate on morbidity and mortality and assessing this impact is challenging. Ideally a cohort enrolled prior to the mandates implementation and followed closely over time with several re-assessments after the mandates implementation would be the ideal. However, this cohort was not formed and therefore we must rely on inferences made from external data to provide information on the impact of the mandate. Use of this external data is further complicated by the natural fluctuations in influenza morbidity and mortality and the use of preventive vaccines which also have varying rates of uptake and effectiveness each year. Subtle differences observed from the pre- to post- mandate period during this evaluation and within different age groups may be explained by shifting of predominant influenza virus strains circulating each year. The circulating influenza virus subtype impacts both the severity of the illness, the number of deaths, and the effectiveness of available vaccines. These factors can alter hospitalization and mortality rates from year to year.[1,3,33] In particular, the circulation of influenza AH3N2 virus in any given season is often associated with more severe disease and excess mortality.[4,34] Additionally, geographic variations in circulation of influenza[31] can occur and can also affect hospitalization and mortality rates. All these factors make utilization of existing external data sources challenging as it is difficult to determine whether hospitalization and mortality rates are impacted by the mandate or by these other factors. However, all of these factors (e.g., subtype, severity, and vaccine effectiveness) would have been impacting all regions and all individuals at relatively the same rate and at the same period of time. This coupled with the fact that our study looked at not only how NJ compared to the nation as a whole but also the Northeast region should limit any geographic variation. If these premises hold true, even modest effects observed could indicate potential impact of the mandate.

Another factor which needs to be considered is that even with the mandate in place, influenza vaccination coverage levels in the overall population are low. High vaccination coverage levels in the overall population and not just this target group may be necessary to reach a herd immunity status capable of impacting hospitalization and mortality rates. While the impact of the NJ vaccine mandate was not proven in this study, some successes with influenza vaccine mandates have been noted. Currently only three other states (Connecticut, Ohio, and Rhode Island) have influenza vaccine mandates for children in child care centers. Only one study, published from Connecticut, could be found describing the positive impact of these mandates. The study[35] assessed information collected as part of the Influenza Hospitalization Surveillance Network (FluSurv-NET). This is a national system of 11 states, including Connecticut, conducting active surveillance for laboratory-confirmed, influenza-associated hospitalizations. This surveillance system also collects clinical and epidemiologic data for each identified case, including vaccination status. This study found that from the 2007–08 to 2012-2013 influenza season, among children ages less than or equal to 4 years, Connecticut had the greatest percentage decrease (12%) in the influenza-associated hospitalization rates among 11 participating sites. Additionally, the ratio of the influenza-associated hospitalization rates among children aged ≤4 years to the overall population rate (0.53) was lower than for any other site. While this study demonstrates that vaccine mandates can impact influenza-associated hospitalization, numerous long-standing surveillance systems capturing detailed information were used to make these assessments. This type of active surveillance is not conducted in NJ and might have also showed promising results had these types of systems been put in place prior to the implementation of the vaccine mandate. To date, no studies have been found for evaluating the impact of these mandates on New Jersey mortality.

Strengths of this analysis include the use of large datasets that represent hospitalization and mortality nationally. Even after exclusion of certain data, these datasets yielded large amounts of data for inclusion in the analysis. While all United States hospital discharges were not used for this analysis, the application of weights in the NIS data make the data scalable and should be representative of data collected from the population for the US and regions.

There are several limitations with this analysis. As previously mentioned, hospitalization and mortality data only serve as a proxy to estimate the impact of the NJ vaccine mandate and cannot conclusively indicate if any changes in data are directly associated with the vaccine mandate.

Use of ICD codes in the identification of influenza-associated hospitalization and deaths can present challenges. Several studies have indicated the undercounting of influenza related hospitalizations and deaths in using ICD coding as a proxy for cases diagnosed with influenza.[36-38] Findings indicate that an ICD code of influenza may only be utilized if there was a positive result on diagnostic testing. Utilization of the larger ICD code set which has been used by other researchers[21,22] to evaluate both hospitalization and death likely prevented significant undercounting of cases. Additionally, the hospitalization data was coded using ICD-9 codes while mortality data was coded using ICD-10. While, in theory, these coding systems should be comparable there may be issues with re-classification using the new coding.

Another limitation to use of the NIS data for evaluation of hospitalization rates was the lack of data from Pennsylvania in study year 2007. Pennsylvania data was available and included in this study for 2008. Rates calculated for 2007 for the Northeast region to not contain Pennsylvania and therefore comparison made during 2007 are not fully representative and may not be comparable to other study years.

It was not possible to calculate state estimates using NIS data due to the complex sampling design. An alternative data source which included all NJ hospital discharges was evaluated to establish NJ rates. While the robust sampling plan of the NIS along with application of appropriate weight should create rates that are representative of the population, there can be some issues with comparing hospitalization data from two different sources. Additionally, the sample frame for NIS was changed in 2012. While applying appropriate weights should make the data comparable over time, this change may cause variation in the 2012 and 2013 National and Northeast rates produced using the NIS data.

Finally, small cell sizes especially in mortality data for NJ rates did occur making these rates unstable. Any findings associated with these rates should be interpreted with caution.

Conclusions

Findings from this analysis do not provide substantial evidence that the New Jersey influenza vaccine mandate for children 6-59 months attending child care centers is impacting overall influenza-associated hospitalizations or deaths. Changes in rates may be due to seasonal changes in influenza and other factors which impact disease occurrence (i.e., circulating subtype, severity, and vaccine effectiveness). It is possible that subtle changes (e.g., overall difference in mortality) observed with the data analyzed could be indicative of change associated with the vaccine mandate but a number of issues that cannot be controlled for in this analysis make it impossible to determine the impact of the mandate with any great certainty. Extending the study data beyond 2013 when compliance with the mandate may have improved could yield different findings. A cohort study specifically following children impacted by the mandate and following over time to assess impact would be ideal.

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Table 3.1: Total, Influenza-associated, and Influenza-specific Deaths, National Vital Statistics System Mortality (NVSS-M), 2007-2013

	Pre-Mandate								Post-Mandate							
	2007		2008		2009		2010		2011		2012		2013		Total (2007-2013)	
United States	N	% of Total	N	% of Total	N	% of Total	N	% of Total	N	% of Total	N	% of Total	N	% of Total	N	% of Total
Total Deaths	2347711		2395245		2361410		2392012		2438412		2465635		2518436		16918861	
Influenza Specific Deaths	534	0.02%	2133	0.09%	1743	0.07%	350	0.01%	1580	0.06%	1345	0.05%	4315	0.17%	12000	0.07%
Influenza Associated Deaths	186785	7.96%	199853	8.34%	188040	7.96%	182951	7.65%	191192	7.84%	182270	7.39%	191355	7.60%	1322446	7.82%
Northeast																
Total Deaths	447385		451677		443352		445278		455408		452932		460630		3156662	
Influenza Specific Deaths	81	0.02%	338	0.07%	250	0.06%	46	0.01%	333	0.07%	204	0.05%	857	0.19%	2109	0.07%
Influenza Associated Deaths	36104	8.07%	37929	8.40%	35517	8.01%	34602	7.77%	37259	8.18%	34447	7.61%	36416	7.91%	252274	7.99%
New Jersey																
Total Deaths	34844		66643		65054		66241		67340		67305		68105		435532	
Influenza Specific Deaths	6	0.02%	11	0.02%	22	0.03%	7	0.01%	25	0.04%	7	0.01%	80	0.12%	158	0.04%
Influenza Associated Deaths	4644	13.33%	4855	7.29%	4356	6.70%	4286	6.47%	4481	6.65%	4093	6.08%	4581	6.73%	31296	7.19%

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.

Table 3.2: Age adjusted influenza-specific mortality rates* by Year (2007-2013) and Geographic Region (US, NE, NJ)

		Pre-Mandate												Post-Mandate								
Flu Specific		2007			2008			2009			2010			2011			2012			2013		
	Region	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
All cause age adjusted rate per 100,000	**National**	0.17	0.16	0.19	0.69	0.66	0.72	0.56	0.54	0.59	0.11	0.10	0.13	0.51	0.49	0.54	0.44	0.41	0.46	1.40	1.36	1.44
	Northeast	0.14	0.07	0.20	0.55	0.43	0.66	0.43	0.32	0.54	0.08	0.03	0.12	0.54	0.42	0.66	0.33	0.23	0.42	1.37	1.19	1.55
	NJ	0.06	-0.01	0.14	0.12	-0.01	0.25	0.25	0.03	0.46	0.07	-0.02	0.17	0.27	0.04	0.49	0.08	-0.05	0.20	0.85	0.47	1.23

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
Age adjusted using 2010 US Census
*Rate per 100,000 persons

Table 3.3 Age adjusted influenza-associated mortality rates* by Year (2007-2013) and Geographic Region (US, NE, NJ)

		Pre-Mandate												Post-Mandate								
Flu Associated		2007			2008			2009			2010			2011			2012			2013		
	Region	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
All cause age adjusted rate per 100,000	National	60.50	60.23	60.76	64.73	64.46	65.00	60.90	60.64	61.17	59.26	59.00	59.52	61.93	61.66	62.19	59.04	58.77	59.30	61.98	61.71	62.25
	Northeast	58.48	57.40	59.56	61.40	60.30	62.50	57.68	56.61	58.76	56.04	54.99	57.09	60.25	59.16	61.34	55.74	54.69	56.79	58.84	57.76	59.92
	NJ	49.50	46.96	52.04	51.72	49.14	54.30	46.48	44.05	48.91	45.64	43.21	48.08	47.76	45.24	50.27	43.60	41.23	45.97	48.74	46.24	51.24

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
Age adjusted using 2010 US Census
*Rate per 100,000 persons

Table 3.4 Age adjusted influenza-associated mortality rates* by Year (2007-2013), Age group and Geographic Region (US, NE, NJ)

		Pre-Mandate												Post- Mandate								
Flu Associated		2007			2008			2009			2010			2011			2012			2013		
All cause rate per 100,000	Age Group	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
US	<5 years	3.85	3.58	4.12	4.03	3.76	4.31	3.98	3.71	4.26	3.18	2.94	3.43	3.29	3.04	3.54	2.82	2.59	3.05	3.04	2.80	3.28
	5-19 years	0.95	0.87	1.02	0.88	0.81	0.96	1.18	1.10	1.27	0.74	0.67	0.80	0.87	0.79	0.94	0.75	0.69	0.82	0.76	0.70	0.83
	20-64 years	15.57	15.39	15.75	16.84	16.66	17.03	17.75	17.56	17.94	16.15	15.97	16.34	17.21	17.02	17.40	16.34	16.16	16.52	17.32	17.13	17.51
	65-84 years	237.52	235.93	239.12	251.40	249.76	253.04	234.75	233.17	236.33	228.05	226.49	229.61	235.63	234.05	237.22	225.58	224.03	227.13	235.75	234.16	237.34
	85 years plus	1346.61	1337.06	1356.16	1453.75	1443.84	1463.67	1310.18	1300.76	1319.61	1321.98	1312.51	1331.45	1386.49	1376.80	1396.18	1320.01	1310.55	1329.48	1387.04	1377.34	1396.74
NE	<5 years	3.57	2.91	4.22	3.13	2.52	3.74	2.70	2.13	3.27	2.20	1.69	2.71	2.61	2.05	3.16	2.02	1.53	2.51	2.23	1.72	2.75
	5-19 years	0.75	0.59	0.92	0.64	0.49	0.79	0.74	0.57	0.90	0.55	0.41	0.69	0.77	0.61	0.94	0.70	0.54	0.86	0.64	0.49	0.79
	20-64 years	13.95	13.56	14.35	14.69	14.29	15.10	15.51	15.09	15.93	14.23	13.83	14.63	15.40	14.98	15.81	14.33	13.92	14.73	14.71	14.30	15.11
	65-84 years	232.30	228.69	235.92	242.96	239.27	246.65	227.73	224.15	231.31	218.35	214.84	221.85	227.49	223.91	231.07	212.90	209.43	216.36	222.28	218.74	225.82
	85 years plus	1323.75	1303.53	1343.96	1398.68	1377.91	1419.45	1259.06	1239.33	1278.80	1273.23	1253.39	1293.07	1408.60	1387.76	1429.44	1286.74	1266.79	1306.69	1388.51	1367.81	1409.21
NJ	<5 years	2.96	1.51	4.41	1.85	0.70	2.99	1.48	0.45	2.50	2.03	0.83	3.23	2.59	1.23	3.94	1.29	0.34	2.25	1.85	0.70	2.99
	5-19 years	0.57	0.22	0.93	0.57	0.22	0.93	0.29	0.04	0.54	0.46	0.14	0.77	0.69	0.30	1.07	0.46	0.14	0.77	0.34	0.07	0.62
	20-64 years	12.21	11.28	13.15	13.10	12.13	14.06	12.32	11.39	13.26	11.87	10.95	12.79	13.28	12.31	14.26	11.53	10.63	12.44	13.27	12.29	14.24
	65-84 years	196.94	188.40	205.48	202.81	194.14	211.47	185.42	177.13	193.71	175.78	167.70	183.86	180.75	172.55	188.94	168.13	160.22	176.04	181.74	173.52	189.96
	85 years plus	1106.28	1058.37	1154.19	1168.08	1118.89	1217.27	1014.41	968.49	1060.34	1039.47	992.99	1085.95	1074.54	1027.30	1121.79	987.13	941.79	1032.47	1130.78	1082.34	1179.22

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
Age adjusted using 2010 US Census
*Rate per 100,000 persons

Table 3.5 Influenza-associated mortality rates* by Year (2007-2013), Gender and Geographic Region (US, NE, NJ)

		Pre-Mandate												Post- Mandate								
		2007			2008			2009			2010			2011			2012			2013		
	Gender	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
US	Male	60.81	60.42	61.19	64.15	63.76	64.55	61.51	61.12	61.89	60.11	59.73	60.49	62.53	62.14	62.92	59.95	59.57	60.33	62.62	62.22	63.01
	Female	60.20	59.82	60.57	65.29	64.90	65.68	60.32	59.95	60.70	58.43	58.06	58.80	61.34	60.96	61.72	58.15	57.78	58.52	61.36	60.98	61.74
NE	Male	64.76	63.81	65.70	67.45	66.49	68.41	64.39	63.44	65.33	63.66	62.72	64.59	67.76	66.79	68.72	63.47	62.54	64.41	65.86	64.91	66.81
	Female	65.75	64.83	66.67	69.62	68.67	70.57	64.04	63.13	64.95	61.51	60.62	62.40	66.98	66.04	67.91	61.14	60.25	62.03	65.80	64.88	66.73
NJ	Male	52.36	50.23	54.50	53.21	51.06	55.35	50.96	48.86	53.07	49.37	47.30	51.45	50.59	48.49	52.69	47.08	45.06	49.11	52.48	50.35	54.62
	Female	53.25	51.16	55.34	57.13	54.97	59.30	48.20	46.21	50.19	48.16	46.17	50.15	51.33	49.27	53.38	46.05	44.10	48.00	51.75	49.68	53.81

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
*Rate per 100,000 persons

Table 3.6 Influenza-associated mortality rates* by Year (2007-2013), Race and Geographic Region (US, NE, NJ)

		Pre-Mandate												Post- Mandate								
		2007			2008			2009			2010			2011			2012			2013		
	Gender	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
US	White	72.90	72.55	73.24	78.07	77.72	78.42	73.10	72.75	73.44	71.17	70.83	71.51	74.54	74.20	74.89	70.76	70.42	71.09	74.10	73.76	74.45
	Black	46.90	46.22	47.58	49.14	48.44	49.83	47.13	46.45	47.81	45.44	44.78	46.11	46.46	45.78	47.13	45.10	44.44	45.77	47.62	46.94	48.31
	Other	12.03	11.71	12.34	13.40	13.06	13.73	13.58	13.25	13.92	13.32	12.98	13.65	13.98	13.64	14.32	14.12	13.78	14.47	15.47	15.11	15.83
NE	White	78.90	78.07	79.73	82.94	82.10	83.79	77.11	76.29	77.93	75.36	74.55	76.17	80.94	80.10	81.78	74.70	73.90	75.51	78.71	77.88	79.53
	Black	47.39	45.73	49.05	48.65	46.97	50.34	47.68	46.01	49.34	44.64	43.03	46.25	48.62	46.94	50.31	46.01	44.38	47.65	49.02	47.33	50.71
	Other	6.82	6.23	7.40	7.84	7.21	8.47	8.55	7.90	9.21	8.61	7.95	9.27	9.90	9.19	10.60	8.94	8.26	9.61	10.57	9.84	11.30
NJ	White	66.66	64.66	68.66	68.91	66.88	70.94	61.33	59.41	63.25	61.27	59.35	63.19	64.02	62.06	65.98	58.38	56.50	60.26	64.83	62.86	66.81
	Black	44.74	40.98	48.50	49.72	45.75	53.68	46.15	42.33	49.97	40.50	36.92	44.08	42.66	38.99	46.34	39.34	35.81	42.87	44.32	40.58	48.07
	Other	5.52	4.35	6.69	6.48	5.22	7.75	6.55	5.28	7.82	6.68	5.39	7.96	6.87	5.57	8.17	6.36	5.10	7.61	8.86	7.38	10.34

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
*Rate per 100,000 persons

Table 3.7 Age adjusted influenza hospitalization rates* by Year (2007-2013) and Geographic Region (US, NE, NJ)

	Pre-Mandate												Post-Mandate								
	2007			2008			2009			2010			2011			2012			2013		
	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
US	10.19	8.77	11.60	27.22	24.06	30.39	50.37	44.84	55.90	9.85	8.18	11.52	24.99	22.15	27.83	20.12	18.79	21.44	45.32	43.00	47.65
NE	10.62	6.65	14.60	27.96	16.86	39.06	66.80	49.88	83.73	8.39	5.20	11.58	25.74	17.51	33.97	21.72	18.00	25.43	49.01	42.89	55.12
NJ	6.62	5.49	7.74	25.14	22.92	27.35	82.42	78.63	86.21	11.28	9.83	12.72	28.86	26.48	31.24	16.95	15.15	18.75	60.93	57.41	64.44

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
Age adjusted using 2010 US Census
*Rate per 100,000 persons

Table 3.8 Age adjusted influenza hospitalization rates* by Year (2007-2013), Age group and Geographic Region (US, NE, NJ)

Region		Pre-Mandate												Post-Mandate								
		2007			2008			2009			2010			2011			2012			2013		
	Age Group	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
US	<5 years	52.35	43.50	61.20	78.98	62.58	95.39	186.73	156.11	217.34	44.97	33.17	56.78	68.41	56.06	80.75	53.78	48.37	59.20	85.54	77.14	93.93
	5-19 years	5.94	5.03	6.85	8.13	6.57	9.69	40.26	33.78	46.74	5.04	3.72	6.36	9.67	7.90	11.44	8.18	7.24	9.12	12.12	10.69	13.55
	20-64 years	4.66	4.19	5.12	13.85	12.68	15.01	38.43	35.70	41.16	6.59	5.94	7.25	16.34	14.90	17.78	11.15	10.62	11.68	26.64	25.64	27.63
	65-84 years	17.96	15.71	20.21	72.52	66.56	78.48	50.52	46.67	54.37	13.35	11.97	14.72	54.10	49.50	58.70	49.35	46.81	51.88	126.76	121.92	131.60
	85 years plus	41.18	34.46	47.90	220.37	197.92	242.83	66.51	59.00	74.01	23.41	19.18	27.65	148.70	132.29	165.11	150.54	140.92	160.17	392.92	373.77	412.08
NE	<5 years	48.30	30.19	66.41	81.48	22.44	140.51	261.14	152.27	370.01	37.14	16.15	58.13	52.32	26.84	77.80	55.32	41.06	69.57	97.85	76.61	119.09
	5-19 years	4.30	2.72	5.87	9.93	2.94	16.92	53.94	34.23	73.65	4.11	1.41	6.80	6.91	2.60	11.22	7.43	4.79	10.06	13.42	9.71	17.13
	20-64 years	4.93	3.23	6.63	13.83	9.77	17.88	48.84	42.45	55.23	5.66	4.39	6.94	17.41	12.62	22.20	12.48	10.98	13.99	24.93	22.53	27.32
	65-84 years	21.82	13.27	30.36	72.31	53.22	91.39	66.83	53.81	79.86	11.28	8.64	13.91	61.42	44.96	77.87	53.42	46.05	60.79	146.17	131.78	160.57
	85 years plus	65.54	38.26	92.83	233.79	164.82	302.76	105.17	78.44	131.91	25.35	13.85	36.86	198.93	145.40	252.47	172.81	144.32	201.30	474.70	423.61	525.80
NJ	<5 years	48.43	42.56	54.29	123.66	114.29	133.02	378.36	361.98	394.74	50.65	44.65	56.64	112.93	103.98	121.89	69.13	62.12	76.13	210.16	197.95	222.37
	5-19 years	3.71	2.81	4.62	14.23	12.46	15.99	118.62	113.52	123.71	8.23	6.88	9.57	24.63	22.30	26.95	15.54	13.69	17.39	51.48	48.12	54.84
	20-64 years	2.54	2.11	2.97	16.07	14.99	17.15	49.17	47.28	51.05	8.32	7.54	9.09	19.93	18.73	21.13	11.70	10.78	12.62	38.23	36.57	39.89
	65-84 years	7.35	5.68	9.03	27.13	23.91	30.34	27.33	24.10	30.55	8.84	7.01	10.68	26.13	22.98	29.29	15.10	12.70	17.50	86.85	81.09	92.60
	85 years plus	18.93	12.57	25.29	81.29	68.10	94.47	48.44	38.26	58.62	16.70	10.73	22.68	86.85	73.23	100.48	30.06	22.05	38.08	221.59	199.82	243.36

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
Age adjusted using 2010 US Census
*Rate per 100,000 persons

Table 3.9 Influenza hospitalization rates* by Year (2007-2013), Gender and Geographic Region (US, NE, NJ)

		Pre-Mandate												Post-Mandate								
		2007			2008			2009			2010			2011			2012			2013		
	Gender	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
US	Male	10.16	9.09	11.22	25.73	23.45	28.00	39.91	36.01	43.81	9.69	8.36	11.01	23.48	21.47	25.49	19.12	18.25	20.00	42.34	40.84	43.85
	Female	10.22	9.29	11.15	28.67	26.41	30.93	43.10	39.68	46.52	10.00	8.91	11.10	26.45	24.34	28.57	21.07	20.19	21.96	48.20	46.57	49.83
NE	Male	10.30	7.65	12.95	27.06	19.29	34.83	65.40	51.02	79.78	8.07	5.41	10.74	24.79	18.17	31.42	16.19	14.18	18.19	47.23	45.12	49.34
	Female	10.85	7.85	13.85	30.38	22.36	38.40	65.66	55.34	75.98	8.50	6.20	10.80	28.31	21.30	35.32	17.86	15.90	19.82	54.91	52.40	57.41
NJ	Male	6.96	6.17	7.75	24.84	23.35	26.33	82.79	80.07	85.51	11.64	10.61	12.66	28.69	27.09	30.30	16.50	15.28	17.71	58.37	56.08	60.66
	Female	6.03	5.31	6.74	25.00	23.54	26.46	78.78	76.20	81.37	10.66	9.71	11.61	28.63	27.07	30.19	17.02	15.82	18.22	63.03	60.71	65.34

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
*Rate per 100,000 persons

Table 3.10 Influenza hospitalization rates* by Year (2007-2013), Race and Geographic Region (US, NE, NJ)

		Pre-Mandate												Post-Mandate								
		2007			2008			2009			2010			2011			2012			2013		
Region	Race	Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI		Rate	95% CI	
US	White	5.85	5.13	6.58	21.15	18.96	23.35	32.11	29.06	35.15	6.75	6.07	7.44	19.33	17.67	20.98	16.14	15.41	16.87	38.64	37.19	40.09
	Black	7.67	6.20	9.14	21.96	16.83	27.09	51.20	43.37	59.02	14.50	11.41	17.60	29.45	24.30	34.59	26.10	23.96	28.24	48.15	44.76	51.54
	Other	10.21	7.84	12.57	21.54	17.49	25.58	84.04	69.74	98.34	16.74	11.75	21.73	27.71	21.96	33.46	25.07	22.60	27.55	52.41	48.28	56.53
NE	White	9.22	6.41	12.02	27.40	20.84	33.95	46.57	38.19	54.96	5.01	3.65	6.37	22.08	16.99	27.17	14.88	13.10	16.65	46.01	41.68	50.33
	Black	9.62	5.14	14.10	34.10	12.96	55.25	92.59	52.83	132.35	17.35	8.92	25.79	39.53	20.67	58.39	18.70	14.58	22.82	57.86	48.01	67.71
	Other	13.79	8.86	18.72	29.32	19.00	39.64	123.77	81.55	165.99	17.25	9.36	25.14	36.23	15.05	57.41	25.73	19.58	31.88	68.70	55.08	82.31
NJ	White	6.58	5.94	7.23	24.85	23.59	26.10	64.97	62.94	67.00	8.79	8.04	9.54	25.38	24.11	26.65	13.40	12.48	14.33	52.01	50.20	53.83
	Black	7.80	6.22	9.38	23.49	20.75	26.23	79.93	74.88	84.97	16.68	14.38	18.99	34.94	31.61	38.28	22.24	19.58	24.91	67.31	62.68	71.94
	Other	5.07	3.95	6.19	26.32	23.77	28.87	142.38	136.46	148.30	15.92	13.94	17.90	36.53	33.52	39.53	25.55	23.04	28.06	89.55	84.85	94.24

Note: Hashed columns indicate years when 2009 H1N1 pandemic occurred and was not included in pre-/post-mandate evaluation.
CI=confidence interval
*Rate per 100,000 persons

OVERALL CONCLUSION

Preschool-aged children are at increased risk for influenza-related illness and complications. Transmission of influenza in this age group is often facilitated by child care centers where there is interaction among many susceptible children. Annual influenza vaccination is the most effective method for preventing influenza virus infection, reducing its complications and limiting the spread of infection to other. Despite proven prevention method and recommendations by the Advisory Committee on Immunization Practice (ACIP), influenza vaccination coverage levels in children lag behind that of other routine childhood immunizations. In an effort to both bolster influenza vaccination coverage and decrease disease burden, New Jersey, in 2008, became the first state to pass a mandate requiring children attending licensed child care or preschool center to receive and annual influenza vaccine. This study was designed to determine if influenza vaccination coverage in the target population (i.e., children 6 to 59 months of age) has changed and to determine if health outcomes (i.e., hospitalization and deaths) have been altered because of the mandates implementation. To date, no other published have been conducted evaluating New Jersey influenza vaccination mandate.

The findings of our first study which evaluated data from New Jersey's immunization registry support the notion that influenza vaccine mandates requiring vaccination of children in licensed child care facilities increases vaccination coverage in children most likely to attend child care and preschool centers. These findings were further supported by the lack of observed increases in other common childhood vaccinations evaluated.

The findings of our second study which compared data from the New Jersey registry to the National Immunization Survey found the both the NIS and NJIIS systems found increases in influenza vaccination coverage levels from the pre- to post-mandate period in NJ. Similar to study one, limited increases in other common childhood vaccinations were also observed. Despite the increase observed in NJ, other states with and without mandates saw similar or greater increases in influenza vaccine coverage which may be indicative of other effective initiatives bolstering vaccination coverage levels. Overall, influenza vaccination coverage appears to be increasing in many states but additional studies are needed to pinpoint the driving force behind these increases in order to fully determine the impact of the NJ mandate compared to other types of initiatives.

The last study sought to determine the impact of the mandate on health outcomes (i.e., hospitalizations or deaths). While there were some observed declines in overall influenza-associated mortality, this analysis did not provide substantial evidence that the New Jersey influenza vaccine mandate for children 6-59 months attending child care or preschool centers is impacting overall influenza-associated hospitalizations or deaths. Changes in rates may be due to seasonal changes in influenza and other factors which impact disease occurrence (i.e., circulating subtype, severity, and vaccine effectiveness).

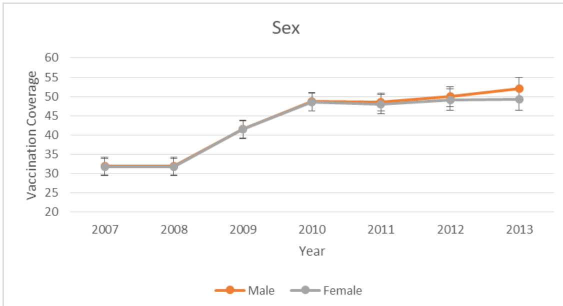
Overall, our studies found indications that influenza vaccination coverage in New Jersey is increasing. Additional studies extending the time frame beyond 2013 would be helpful in determining if these observed trends are continuing. In addition, a cohort study specifically following children attending child care centers and following them over time to assess impact specific to the target population would be ideal.

APPENDICES

Appendix 1

Appendix Figure 1 National Immunization Survey, Factors Influencing Influenza Vaccination Coverage, US, 2007-2013

(a)



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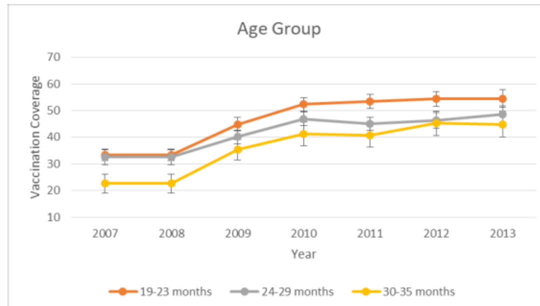

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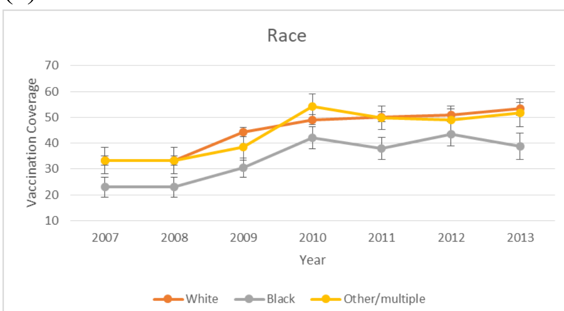

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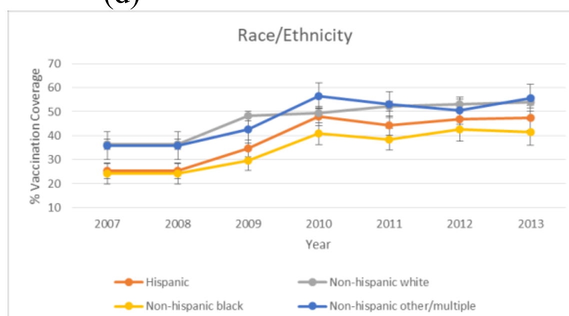

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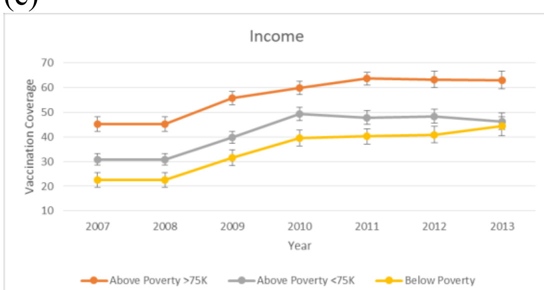

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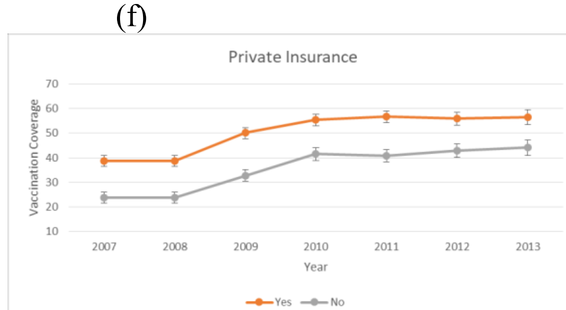

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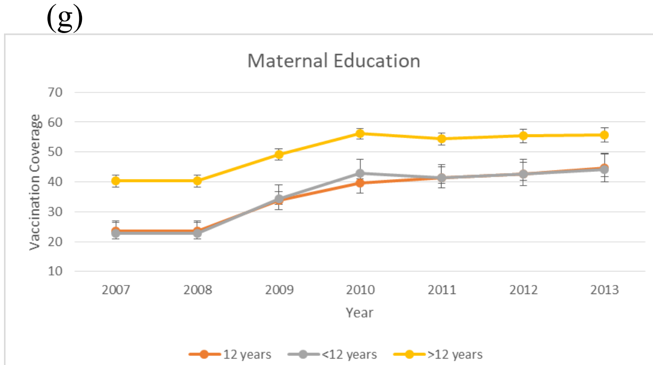


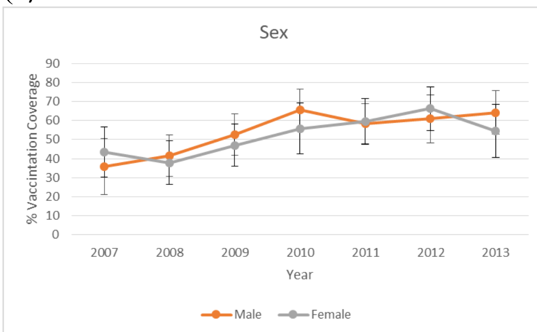
*Error bars represent 95% confidence interval.

Appendix Table 1 National Immunization Survey, Influenza Vaccination Status by Select Demographic Factors, United States, 2007-2013

Demographic Characteristics	2007			2008			2009			2010			2011			2012			2013		
	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*
Sex			0.88			0.19			0.99			0.95			0.73			0.69			0.20
Male	31.93	2.28		31.93	2.22		41.49	2.21		48.66	2.34		48.58	2.25		49.96	2.53		52.10	2.88	
Female	31.69	2.14		31.69	2.22		41.49	2.39		48.58	2.37		47.99	2.55		49.20	2.75		49.38	3.00	
Agegroup			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
19-23 months	33.41	2.10		33.41	2.22		44.85	2.55		52.35	2.49		53.44	2.69		54.32	2.86		54.51	3.22	
24-29 months	32.50	2.79		32.50	2.18		40.17	2.49		46.93	2.54		45.13	2.45		46.41	2.90		48.50	3.18	
30-35 months	22.67	3.60		22.67	1.62		35.35	3.79		41.30	4.43		40.62	4.25		45.23	4.54		44.90	4.78	
Race			<0.01			<0.01			<0.01			<0.01			<0.01			0.02			<0.01
White	33.33	1.81		33.33	2.06		44.30	1.87		49.02	1.94		50.18	2.01		50.99	2.22		53.27	2.48	
Black	23.05	3.86		23.05	1.64		30.52	3.80		42.16	4.32		38.03	4.28		43.58	4.68		38.79	5.13	
Other/multiple	33.28	5.12		33.28	1.57		38.54	5.21		54.34	4.83		49.83	4.66		49.09	5.16		51.69	5.35	
Race/Ethnicity			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
Hispanic	25.29	3.17		25.29	2.19		34.66	3.61		48.10	3.96		44.25	3.98		46.86	4.44		47.40	5.19	
Non-hispanic white	36.46	2.04		36.46	2.13		48.16	1.98		49.51	2.00		52.19	2.06		52.97	2.21		53.92	2.45	
Non-hispanic black	24.24	4.28		24.24	1.43		29.56	4.02		40.85	4.47		38.52	4.58		42.58	4.96		41.39	5.39	
Non-hispanic other/multiple	35.91	5.76		35.91	1.27		42.64	5.86		56.60	5.28		52.96	5.25		50.41	5.68		55.68	5.66	
Poverty (known)			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
Above Poverty >75K	45.12	2.95		45.12	1.69		55.68	2.67		59.94	2.70		63.62	2.57		63.21	3.34		63.04	3.53	
Above Poverty <75K	30.85	2.36		30.85	2.24		39.79	2.49		49.25	2.71		47.86	2.89		48.31	2.83		46.31	3.30	
Below Poverty	22.55	3.07		22.55	2.33		31.58	3.27		39.48	3.26		40.17	3.00		40.87	3.36		44.30	3.82	
Private insurance			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
Yes	38.73	2.10		38.73	2.21		50.12	2.07		55.57	2.12		56.83	2.22		56.08	2.52		56.62	2.82	
No	23.64	2.23		23.64	2.21		32.81	2.47		41.57	2.61		40.76	2.44		42.94	2.72		44.16	3.16	
Mom's Education			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
12 years	23.66	2.73		23.66	2.21		33.78	3.00		39.56	3.31		41.45	3.48		42.69	3.97		44.65	4.62	
<12 years	22.88	4.02		22.88	2.13		34.39	4.73		42.79	4.75		41.45	4.36		42.72	4.93		44.15	5.50	
>12 years	40.33	1.98		40.33	2.09		49.08	1.90		56.10	1.85		54.39	2.02		55.40	2.19		55.75	2.39	

Appendix Figure 2 National Immunization Survey, Factors Influencing Influenza Vaccination Coverage, NJ, 2007-2013

(a)



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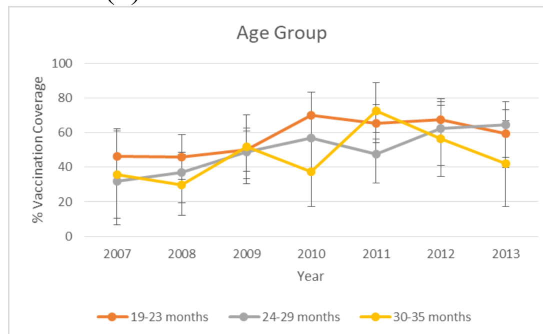

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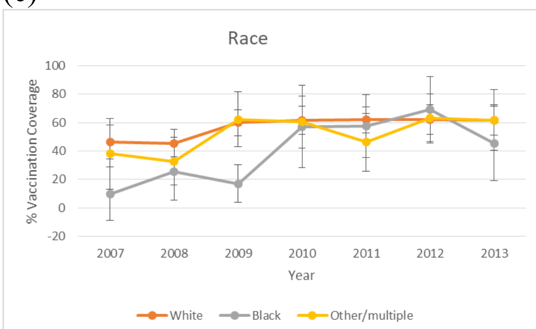

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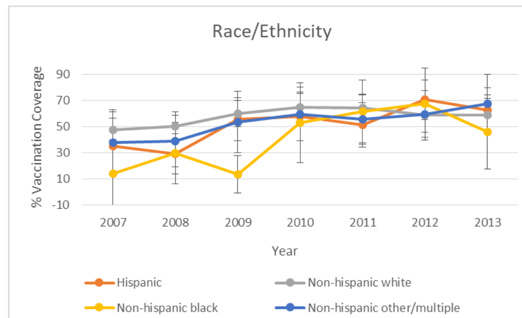

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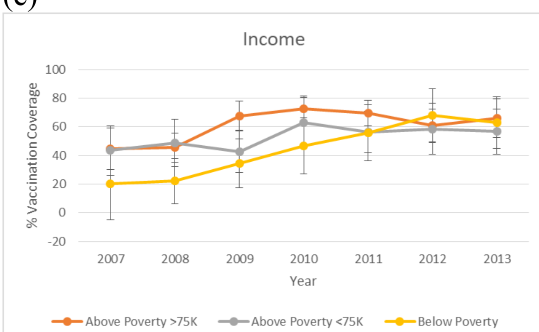

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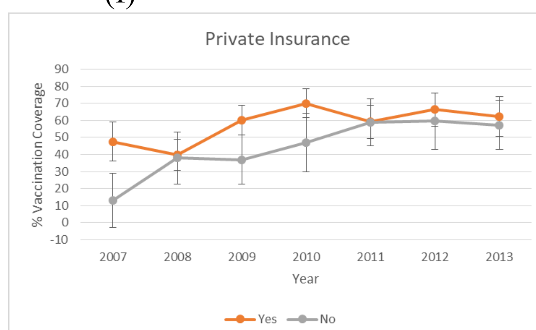

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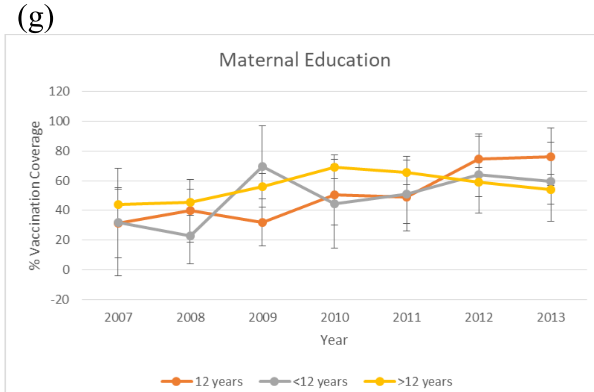


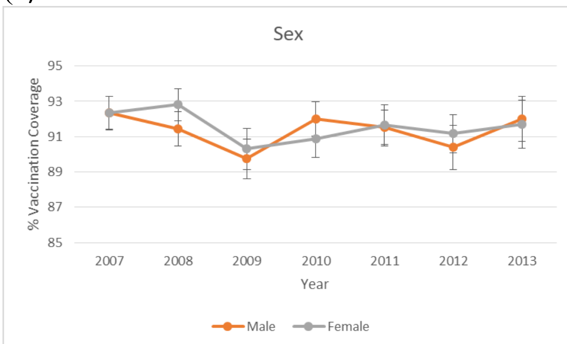
*Error bars represent 95% confidence interval.

Appendix Table 2 National Immunization Survey, Influenza Vaccination Status by Select Demographic Factors, New Jersey, 2007-2013

Demographic Characteristics	2007			2008			2009			2010			2011			2012			2013		
	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*
Sex			0.44			0.63			0.48			0.26			0.87			0.54			0.29
Male	35.64	14.70		41.60	10.95		52.63	11.00		65.66	10.91		58.22	10.49		60.89	12.53		64.09	11.42	
Female	43.39	13.24		37.76	11.48		46.98	11.16		55.81	13.50		59.51	12.09		66.19	11.36		54.51	13.77	
Agegroup			0.36			0.32			0.97			0.05			0.03			0.67			0.29
19-23 months	46.46	15.67		45.91	13.10		50.01	12.45		70.03	13.54		65.31	11.04		67.30	12.42		59.28	13.75	
24-29 months	31.71	14.24		37.03	11.73		48.82	12.04		56.83	12.96		47.36	12.67		62.43	13.47		64.67	13.16	
30-35 months	35.50	25.26		29.58	17.62		51.81	18.32		37.27	20.05		72.47	16.37		56.39	21.57		42.11	24.88	
Race			0.04			0.14			<0.01			0.95			0.37			0.85			0.48
White	46.27	11.98		45.46	9.55		59.92	9.17		61.56	9.77		61.97	9.12		62.25	10.52		61.85	10.58	
Black	9.88	18.69		25.34	19.81		16.98	13.17		57.24	29.02		57.61	22.10		69.15	23.32		45.38	26.24	
Other/multiple	37.97	24.70		32.82	16.98		62.34	19.23		60.38	18.41		46.13	20.45		63.35	16.77		61.87	21.18	
Race/Ethnicity			0.25			0.16			<0.01			0.83			0.55			0.68			0.67
Hispanic	35.18	21.10		29.08	15.37		55.62	16.24		57.90	18.75		51.35	17.02		70.58	15.14		62.47	17.11	
Non-hispanic white	47.58	13.51		50.22	11.22		59.93	10.16		64.75	10.41		64.24	10.01		58.91	13.08		58.87	12.71	
Non-hispanic black	14.00	25.85		29.74	23.52		13.61	14.52		52.98	30.66		61.56	24.09		67.27	27.56		46.06	28.23	
Non-hispanic other/multiple	37.97	24.70		39.04	19.64		53.70	23.47		59.62	20.29		55.61	19.36		59.48	17.80		67.48	22.37	
Poverty (known)			0.28			0.04			<0.01			0.03			0.28			0.73			0.7
Above Poverty >75K	44.48	14.51		45.46	10.32		67.71	10.02		72.41	9.26		69.74	8.92		60.69	11.92		66.15	13.47	
Above Poverty <75K	43.36	17.13		48.90	16.58		42.40	14.50		62.92	17.52		56.36	14.56		58.60	17.78		56.69	15.73	
Below Poverty	20.09	25.07		22.00	15.71		34.44	17.00		46.51	19.62		55.78	19.79		68.05	18.52		62.83	17.99	
Private insurance			<0.01			0.81			<0.01			0.02			0.98			0.48			0.6
Yes	47.64	11.60		40.00	9.12		60.07	8.78		70.06	8.42		59.12	9.87		66.33	9.67		62.26	11.71	
No	13.02	15.82		37.90	15.21		36.95	14.41		46.87	17.23		58.90	13.89		59.60	16.63		57.29	14.47	
Mom's Education			0.59			0.16			0.02			0.11			0.22			0.35			0.22
12 years	31.12	23.35		39.75	21.03		31.74	15.81		50.33	20.27		48.82	17.66		74.57	17.11		76.17	19.23	
<12 years	32.10	36.12		22.64	18.74		69.69	27.45		44.54	29.94		51.23	24.95		64.08	25.76		59.29	26.48	
>12 years	44.18	10.88		45.46	9.03		56.21	8.40		69.24	8.03		65.57	8.44		58.90	9.81		54.08	10.06	

Appendix Figure 3 National Immunization Survey, Factors Influencing MMR Vaccination Coverage, US, 2007-2013

(a)



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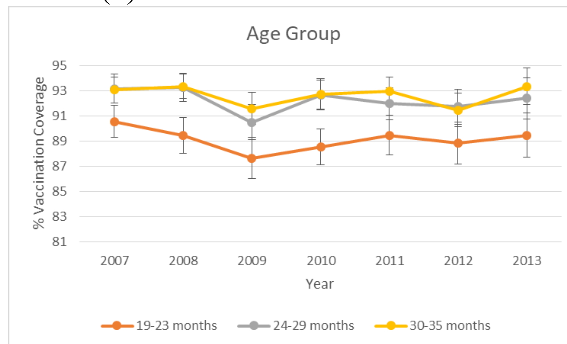

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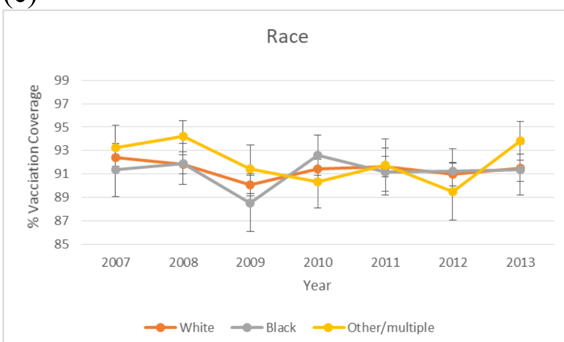

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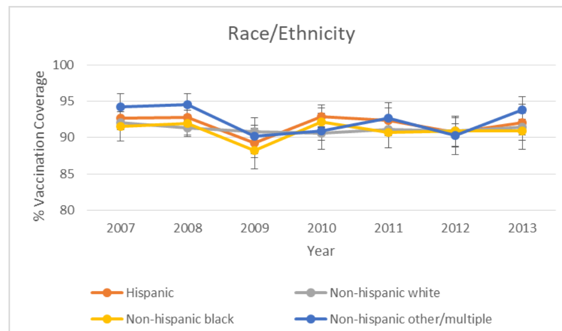

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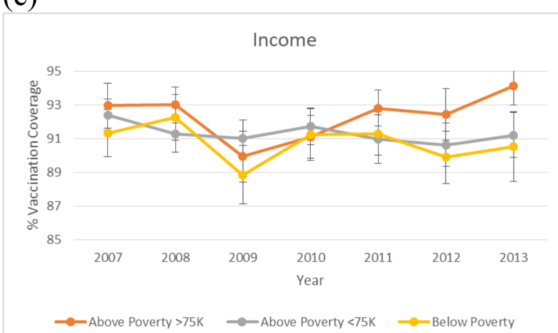

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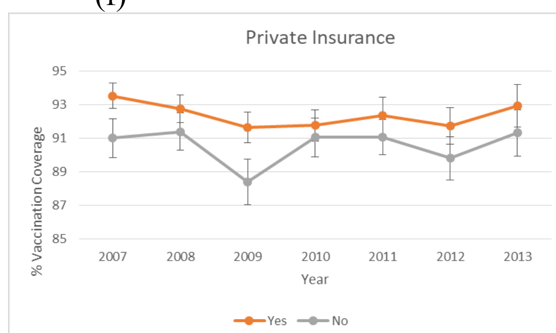

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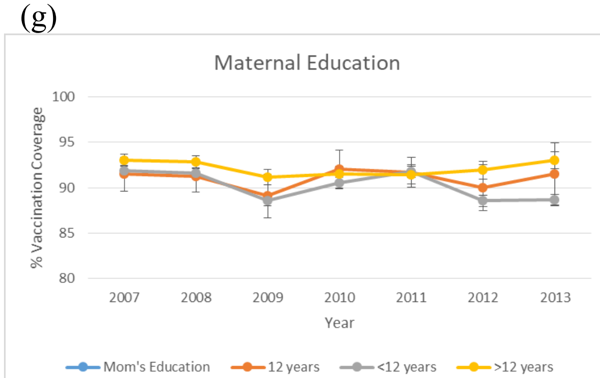


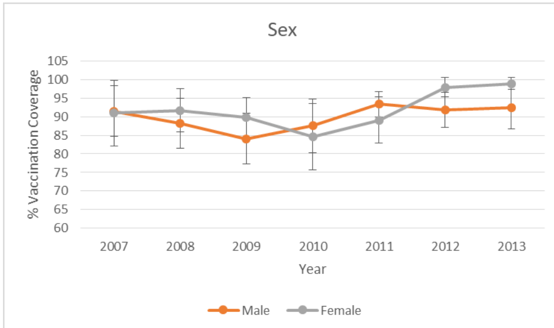
*Error bars represent 95% confidence interval.

Appendix Table 3 National Immunization Survey, MMR Vaccination Status by Select Demographic Factors, United States, 2007-2013

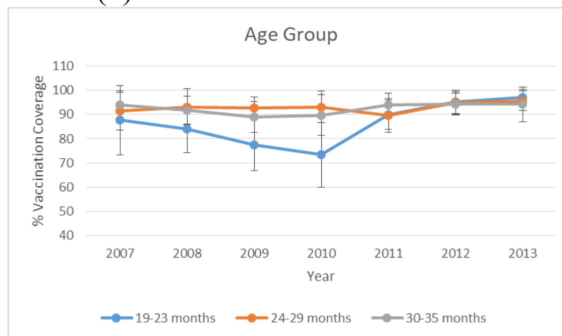
Demographic Characteristics	2007			2008			2009			2010			2011			2012			2013		
	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*
Sex			0.98			0.05			0.50			0.13			0.89			0.35			0.74
Male	92.33	0.96		91.44	0.97		89.75	1.13		92.01	0.98		91.54	0.98		90.40	1.26		92.01	1.28	
Female	92.35	0.92		92.81	0.91		90.30	1.18		90.89	1.06		91.64	1.16		91.18	1.08		91.69	1.35	
Agegroup			<0.01			<0.01			<0.01			<0.01			<0.01			0.01			<0.01
19-23 months	90.56	1.26		89.44	1.42		87.65	1.62		88.52	1.43		89.46	1.58		88.85	1.65		89.47	1.76	
24-29 months	93.16	1.15		93.24	1.11		90.49	1.39		92.68	1.12		91.96	1.30		91.74	1.40		92.38	1.65	
30-35 months	93.05	1.05		93.35	0.95		91.59	1.25		92.70	1.23		92.98	1.08		91.46	1.31		93.34	1.46	
Race			0.42			0.05			0.19			0.28			0.92			0.45			0.13
White	92.40	0.72		91.83	0.81		90.09	0.95		91.42	0.85		91.64	0.87		90.95	0.99		91.53	1.19	
Black	91.36	2.27		91.86	1.75		88.50	2.39		92.60	1.72		91.21	1.98		91.22	1.91		91.36	2.18	
Other/multiple	93.26	1.89		94.23	1.36		91.40	2.07		90.34	2.24		91.74	2.23		89.50	2.47		93.81	1.66	
Race/Ethnicity			0.27			0.03			0.17			0.07			0.41			0.97			0.37
Hispanic	92.64	1.56		92.80	1.37		89.29	2.00		92.92	1.58		92.36	1.77		90.69	2.03		92.11	2.49	
Non-hispanic white	92.05	0.80		91.34	0.94		90.85	0.88		90.57	0.93		91.13	0.91		90.93	0.97		91.45	1.07	
Non-hispanic black	91.52	2.01		91.98	1.84		88.20	2.57		92.14	1.89		90.76	2.17		90.90	2.07		90.88	2.46	
Non-hispanic other/multiple	94.25	1.76		94.56	1.46		90.23	2.48		90.89	2.47		92.65	2.16		90.26	2.64		93.86	1.78	
Poverty (known)			0.21			0.13			0.09			0.79			0.15			0.06			<0.01
Above Poverty >75K	92.95	1.33		92.99	1.06		89.93	1.53		91.10	1.27		92.79	1.07		92.43	1.53		94.11	1.11	
Above Poverty <75K	92.40	0.94		91.29	1.12		91.03	1.08		91.71	1.06		90.96	1.44		90.62	1.29		91.21	1.35	
Below Poverty	91.32	1.40		92.26	1.37		88.83	1.74		91.25	1.56		91.29	1.29		89.88	1.56		90.51	2.07	
Private insurance			<0.01			0.05			<0.01			0.35			0.10			0.02			0.10
Yes	93.51	0.75		92.73	0.83		91.63	0.93		91.75	0.92		92.32	1.10		91.73	1.08		92.91	1.28	
No	91.00	1.15		91.37	1.10		88.38	1.37		91.05	1.15		91.04	1.05		89.79	1.29		91.32	1.37	
Mom's Education			0.15			0.13			0.04			0.44			0.95			<0.01			<0.01
12 years	91.49	1.39		91.28	1.47		89.09	1.68		92.02	1.35		91.69	1.48		90.01	1.58		91.52	1.64	
<12 years	91.90	1.87		91.59	1.75		88.63	2.38		90.52	2.16		91.74	1.64		88.55	2.54		88.64	3.42	
>12 years	93.05	0.69		92.84	0.71		91.15	0.85		91.50	0.85		91.48	1.03		91.95	0.98		93.07	0.94	

Appendix Figure 4 National Immunization Survey, Factors Influencing MMR Vaccination Coverage, NJ, 2007-2013

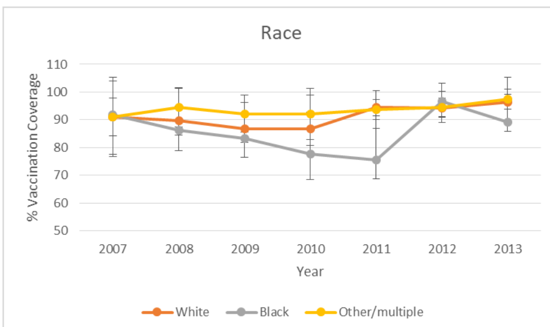
(a)



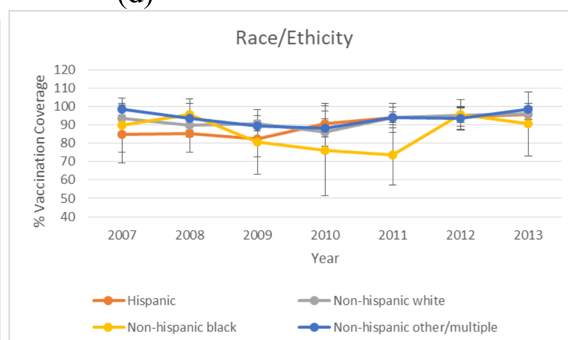
(b)



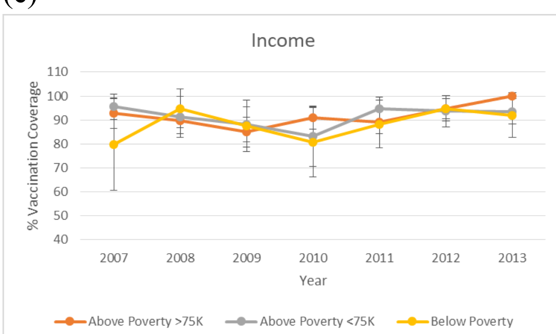
(c)



(d)



(e)



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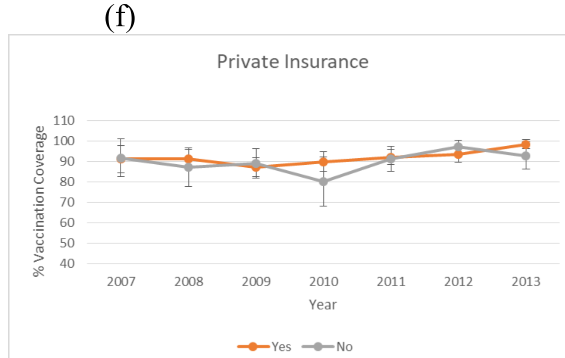
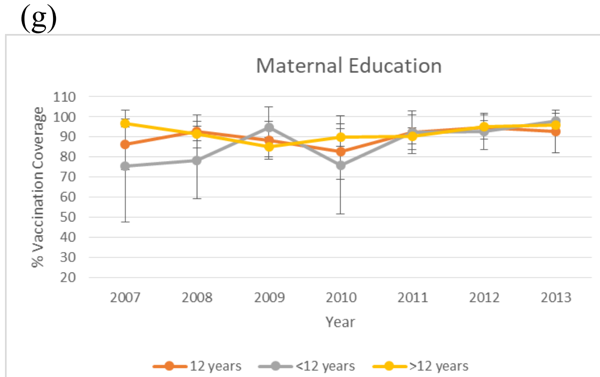


(g)



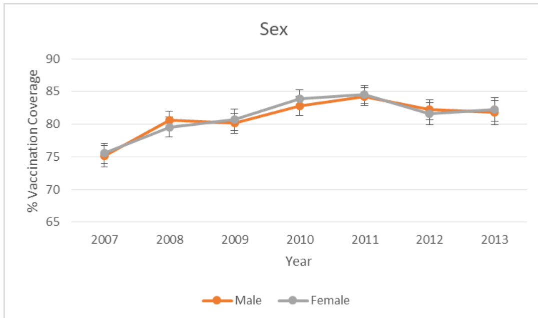
*Error bars represent 95% confidence interval.

Appendix Table 4 National Immunization Survey, MMR Vaccination Status by Select Demographic Factors, New Jersey, 2007-2013

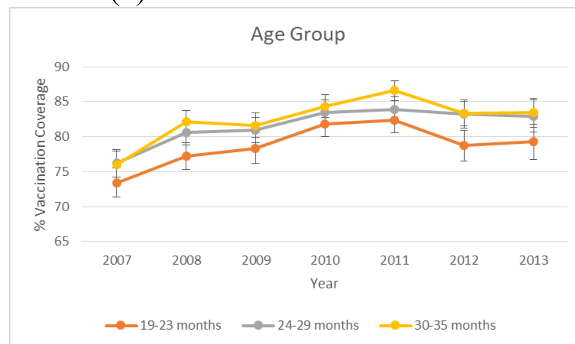
Demographic Characteristics	2007			2008			2009			2010			2011			2012			2013		
	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*
Sex			0.92			0.45			0.19			0.61			0.19			0.03			<0.01
Male	91.50	6.83		88.25	6.72		84.07	6.85		87.55	7.20		93.36	3.40		91.79	4.62		92.51	5.73	
Female	90.93	8.74		91.67	5.76		89.79	5.25		84.65	8.86		89.07	6.14		97.91	2.52		98.87	1.61	
Agegroup			0.62			0.23			0.01			0.01			0.54			0.97			0.67
19-23 months	87.66	14.24		83.95	9.80		77.47	10.74		73.32	13.38		90.05	6.03		95.17	5.00		97.23	3.19	
24-29 months	91.46	7.80		93.18	7.58		92.86	4.36		93.15	6.47		89.63	7.01		94.85	4.51		95.70	4.15	
30-35 months	93.96	5.85		91.84	5.69		89.03	6.37		89.77	8.34		93.86	4.90		94.41	4.46		94.17	7.09	
Race			1.00			0.58			0.49			0.35			<0.01			0.85			0.19
White	91.12	6.79		89.73	5.13		86.83	5.05		86.76	6.02		94.47	2.95		94.35	3.44		96.49	2.65	
Black	91.75	12.16		86.17	15.25		83.28	13.05		77.63	21.26		75.51	14.70		96.65	6.52		89.27	15.98	
Other/multiple	91.06	14.31		94.49	7.16		92.15	6.66		92.17	9.25		93.71	6.87		94.58	5.59		97.49	3.52	
Race/Ethnicity			0.30			0.46			0.28			0.46			<0.01			0.97			0.54
Hispanic	85.06	15.61		85.36	10.26		82.56	9.82		90.55	7.16		93.96	5.70		94.35	5.34		95.64	4.45	
Non-hispanic white	93.66	4.93		89.99	6.43		90.68	4.15		85.95	7.61		94.15	3.01		95.23	3.79		96.24	3.32	
Non-hispanic black	89.80	14.86		95.57	8.57		80.69	17.69		75.99	24.40		73.67	16.50		95.80	8.14		90.52	17.40	
Non-hispanic other/multiple	98.50	2.99		93.63	8.23		89.50	8.84		88.17	13.42		93.84	7.80		93.73	6.43		98.45	3.06	
Poverty (known)			0.05			0.69			0.83			0.29			0.34			0.95			<0.01
Above Poverty >75K	92.96	6.39		89.59	5.25		84.97	6.24		90.85	4.59		89.02	4.70		94.62	4.19		99.93	0.13	
Above Poverty <75K	95.53	5.27		91.32	8.45		88.28	7.32		83.10	12.68		94.79	4.79		93.65	6.47		93.50	5.31	
Below Poverty	79.77	19.02		94.85	8.18		87.44	10.75		80.71	14.61		88.29	9.95		94.79	5.29		92.00	9.33	
Private insurance			0.92			0.42			0.69			0.08			0.81			0.16			0.05
Yes	91.04	6.74		91.04	4.88		87.09	4.69		89.87	4.76		92.08	3.82		93.46	3.76		98.39	2.17	
No	91.66	9.27		86.95	9.44		88.92	7.22		80.09	12.14		91.22	6.15		97.18	3.09		92.82	6.78	
Mom's Education			0.01			0.11			0.52			0.29			0.92			0.86			0.50
12 years	86.40	12.48		92.82	8.06		88.29	9.50		82.77	13.83		92.33	8.51		94.95	5.87		92.81	10.49	
<12 years	75.39	27.82		78.49	19.31		94.76	10.14		76.09	24.38		92.35	10.62		92.80	8.89		98.19	3.60	
>12 years	96.95	2.11		91.76	3.77		84.98	4.94		89.79	4.28		90.58	3.82		95.14	3.08		96.05	2.78	

Appendix Figure 5 National Immunization Survey, Factors Influencing PCV Vaccination Coverage, US, 2007-2013

(a)



(b)



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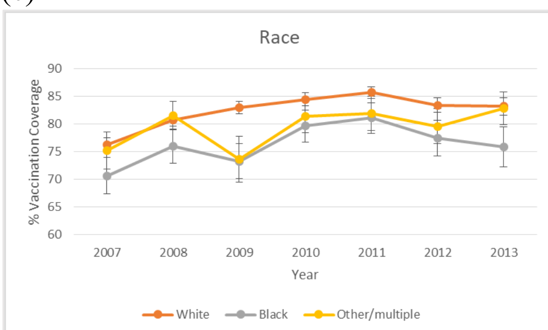
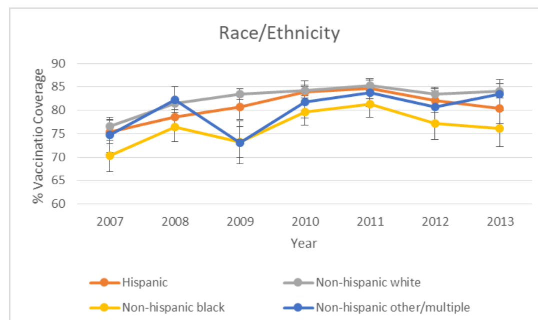
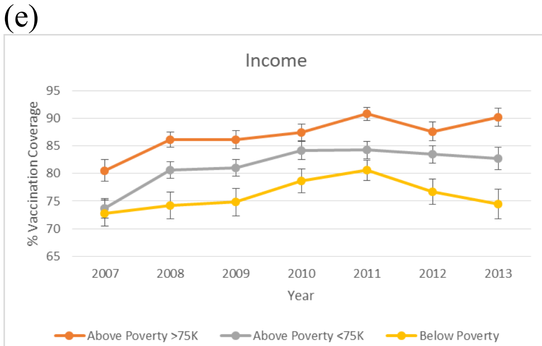


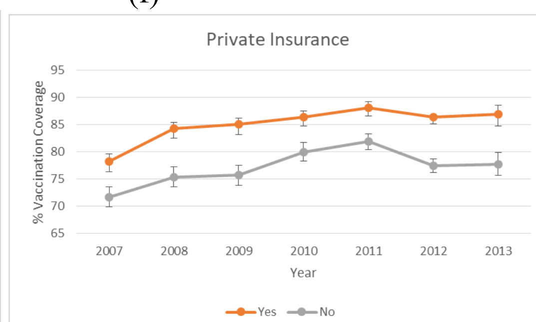
(d)



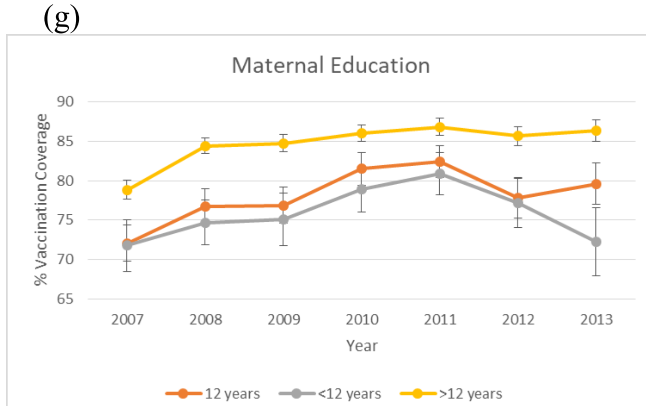
(e)



(f)



(g)



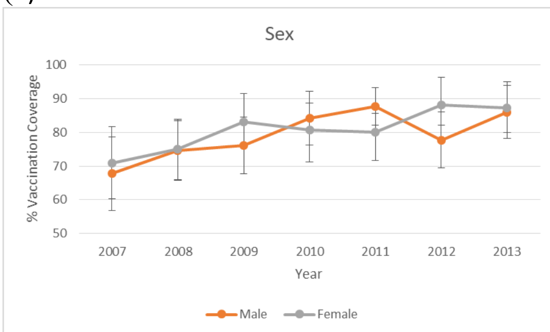
*Error bars represent 95% confidence interval.

Appendix Table 5 National Immunization Survey, PCV Vaccination Status by Select Demographic Factors, United States, 2007-2013

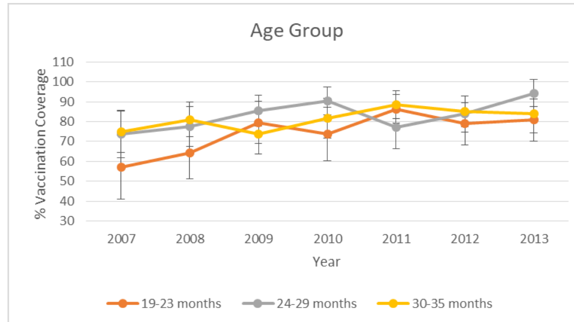
Demographic Characteristics	2007			2008			2009			2010			2011			2012			2013		
	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*
Sex			0.71			0.32			0.62			0.28			0.75			0.60			0.71
Male	75.11	1.66		80.61	1.40		80.13	1.49		82.76	1.48		84.25	1.37		82.20	1.51		81.77	1.89	
Female	75.54	1.53		79.56	1.49		80.69	1.63		83.86	1.35		84.56	1.35		81.60	1.70		82.27	1.82	
Agegroup			0.10			<0.01			<0.01			0.12			<0.01			<0.01			0.03
19-23 months	73.44	2.03		77.21	1.93		78.33	2.19		81.78	1.82		82.33	1.81		78.70	2.19		79.27	2.50	
24-29 months	76.20	1.99		80.60	1.75		80.96	1.81		83.46	1.76		83.89	1.77		83.21	1.99		82.95	2.31	
30-35 months	76.05	1.86		82.13	1.65		81.65	1.76		84.38	1.64		86.58	1.43		83.30	1.74		83.40	2.06	
Race			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
White	76.25	1.28		80.70	1.18		82.94	1.16		84.42	1.13		85.62	1.06		83.38	1.30		83.14	1.58	
Black	70.65	3.30		75.95	3.07		73.27	3.14		79.64	2.90		81.03	2.74		77.44	3.22		75.84	3.62	
Other/multiple	75.18	3.36		81.48	2.54		73.65	4.14		81.35	2.91		81.91	3.05		79.57	3.14		82.82	2.99	
Race/Ethnicity			<0.01			<0.01			<0.01			0.03			0.08			0.01			<0.01
Hispanic	75.39	2.53		78.61	2.40		80.63	2.54		83.93	2.30		84.62	2.14		82.07	2.54		80.41	3.29	
Non-hispanic white	76.60	1.40		81.45	1.22		83.40	1.16		84.23	1.18		85.27	1.19		83.48	1.35		84.11	1.53	
Non-hispanic black	70.26	3.36		76.40	3.13		73.22	3.27		79.70	2.95		81.31	2.84		77.14	3.45		76.11	3.81	
Non-hispanic other/multiple	74.80	3.74		82.30	2.76		73.09	4.58		81.70	3.32		83.77	2.93		80.75	3.42		83.47	3.15	
Poverty (known)			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
Above Poverty >75K	80.54	1.95		86.13	1.37		86.14	1.66		87.44	1.47		90.84	1.17		87.62	1.69		90.22	1.69	
Above Poverty <75K	73.70	1.77		80.60	1.49		81.02	1.55		84.20	1.60		84.27	1.61		83.47	1.62		82.79	2.03	
Below Poverty	72.83	2.36		74.22	2.42		74.82	2.51		78.70	2.14		80.62	1.85		76.67	2.31		74.46	2.71	
Private insurance			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
Yes	78.19	1.39		84.29	1.10		84.98	1.20		86.33	1.15		88.01	1.20		86.38	1.23		86.81	1.66	
No	71.69	1.87		75.39	1.79		75.67	1.87		79.94	1.68		81.84	1.45		77.38	1.87		77.72	2.08	
Mom's Education			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01			<0.01
12 years	72.05	2.27		76.69	2.25		76.88	2.28		81.48	2.12		82.42	2.01		77.81	2.54		79.61	2.64	
<12 years	71.76	3.23		74.70	2.85		75.12	3.32		78.95	2.90		80.89	2.64		77.17	3.14		72.23	4.30	
>12 years	78.84	1.24		84.41	0.99		84.72	1.07		86.03	1.06		86.80	1.11		85.63	1.24		86.35	1.36	

Appendix Figure 6 National Immunization Survey, Factors Influencing PCV Vaccination Coverage, NJ, 2007-2013

(a)



(b)



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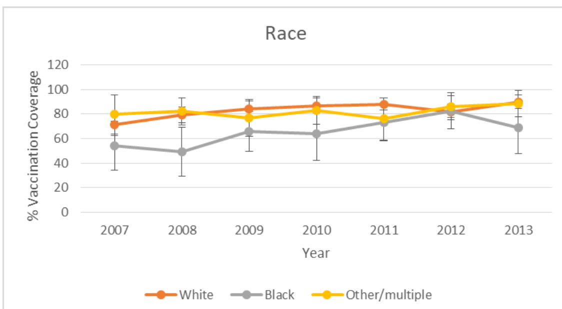
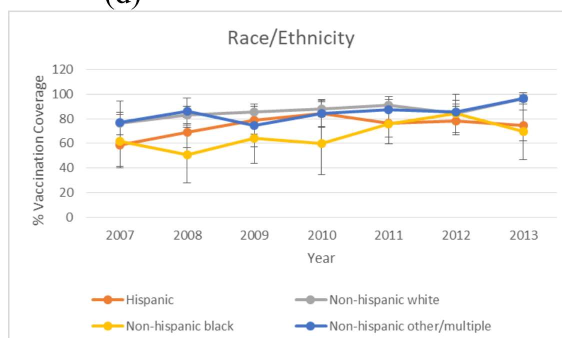


(d)



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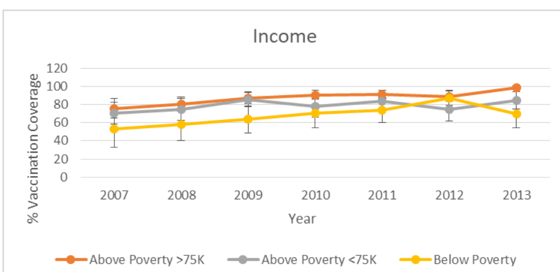
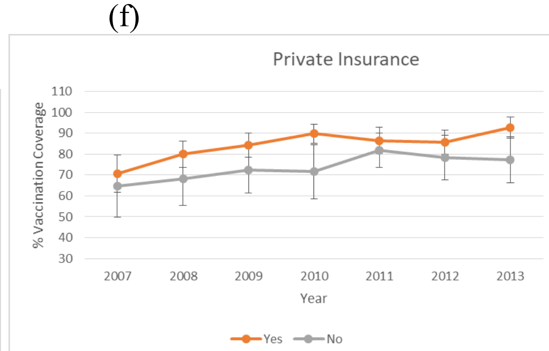
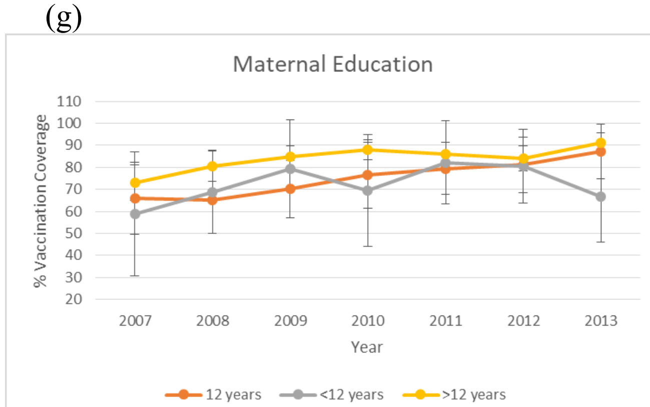


(f)



(g)



*Error bars represent 95% confidence interval.

Appendix Table 6 National Immunization Survey, PCV Vaccination Status by Select Demographic Factors, New Jersey, 2007-2013

Demographic Characteristics	2007			2008			2009			2010			2011			2012			2013		
	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*	%	±95% CI	*P*
Sex			0.69			0.96			0.21			0.57			0.12			0.04			0.83
Male	67.78	10.93		74.61	8.83		76.13	8.48		84.14	7.96		87.69	5.56		77.76	8.33		86.03	7.83	
Female	70.83	10.57		74.97	9.05		83.16	7.23		80.66	9.33		79.99	8.44		88.11	5.94		87.23	7.29	
Agegroup			0.11			0.07			0.23			0.08			0.11			0.62			0.12
19-23 months	57.22	16.10		64.34	13.24		79.53	10.71		73.87	13.48		86.45	7.21		78.91	10.52		80.81	10.72	
24-29 months	73.70	11.71		77.49	9.94		85.47	7.85		90.46	7.03		77.10	10.75		83.84	9.12		94.42	6.83	
30-35 months	74.99	10.59		81.10	8.75		73.85	10.30		81.72	10.23		88.48	6.95		85.07	7.75		84.02	9.76	
Race			0.12			<0.01			<0.01			0.02			0.06			0.82			0.02
White	71.40	9.06		79.38	6.40		84.47	5.93		86.87	6.11		88.10	4.93		81.80	6.74		89.97	5.52	
Black	54.25	20.05		49.24	20.25		65.69	16.14		64.18	22.23		73.24	15.33		82.62	14.90		68.63	20.76	
Other/multiple	79.67	15.73		82.23	11.05		76.76	14.97		82.89	11.44		76.12	17.30		86.02	8.89		88.47	10.83	
Race/Ethnicity			0.18			<0.01			0.09			0.01			0.04			0.77			<0.01
Hispanic	58.55	17.31		68.89	12.25		78.58	11.22		84.36	11.28		76.62	11.68		78.36	11.74		74.73	12.45	
Non-hispanic white	76.08	9.12		83.04	7.16		85.81	6.38		87.77	6.27		91.00	4.80		84.31	7.33		96.68	2.66	
Non-hispanic black	61.78	21.78		50.67	22.57		64.11	20.25		59.88	25.09		75.79	16.31		84.23	15.50		69.53	22.65	
Non-hispanic other/multiple	76.75	17.49		85.85	10.81		74.31	17.42		84.07	10.68		87.23	10.81		85.50	9.73		96.69	4.61	
Poverty (known)			0.09			0.05			<0.01			0.01			0.01			0.05			<0.01
Above Poverty >75K	75.63	10.73		80.43	7.57		87.07	5.95		90.62	4.80		91.33	4.60		88.89	5.69		98.62	1.94	
Above Poverty <75K	70.47	11.78		74.46	12.15		85.55	8.09		78.11	12.56		83.68	8.56		74.96	12.80		84.51	9.36	
Below Poverty	52.82	19.81		58.42	17.78		63.56	14.98		70.36	16.14		73.65	13.76		87.24	8.10		69.67	14.94	
Private insurance			0.50			0.08			0.05			<0.01			0.38			0.20			<0.01
Yes	70.73	8.91		80.02	6.36		84.29	5.81		89.73	4.60		86.56	6.38		85.66	5.70		92.74	5.12	
No	64.81	14.92		68.33	12.81		72.46	11.19		71.54	12.95		81.93	8.21		78.32	10.58		77.28	10.96	
Mom's Education			0.50			0.13			0.08			0.11			0.62			0.88			0.01
12 years	65.83	16.36		65.15	15.23		70.17	13.06		76.49	14.89		79.51	11.88		81.28	12.59		87.19	12.56	
<12 years	58.96	28.19		68.81	18.92		79.26	22.29		69.63	25.38		82.26	18.89		80.56	16.77		66.93	20.80	
>12 years	73.14	8.14		80.47	6.82		84.87	4.89		87.86	4.47		86.17	5.03		83.95	5.71		91.25	4.53	