AN ANALYSIS OF THE ASSOCIATION BETWEEN INFLUENZA COVERAGE AND OUTBREAK ACROSS DEMOGRAPHIC FACTORS IN THE UNITED STATES

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ABSTRACT

Despite the annual disease and economic burden of the influenza virus, just over 40% of American adults and slightly over 60% of American children receive the annual influenza vaccination. In 2009, in addition to the annual influenza season, a H1N1 (swine flu) pandemic occurred, resulting in a second potential immunization and a heightened awareness of the dangers of influenza. The purpose of this study was to determine how state-level demographic factors were associated with vaccination coverage rates in the four years following the 2009 H1N1 influenza pandemic, as well as to determine if there is a relationship between vaccination coverage rates and disease outbreak.

In regards to educational status, the results showed that the percentage of people not having graduated high school was negatively associated with vaccination rates for all flu seasons except 2011-2012, and having a high school education or higher was positively correlated with vaccination rates in all seasons except 2012-2013. The percentage of people listed as employed was positively correlated with vaccination rates for all seasons except 2011-2012, while being unemployed was negatively correlated with vaccination rates for all seasons. In terms of socioeconomic status, the percentage of people in poverty was negatively correlated with vaccination rates, and median family income was positively correlated with vaccination rates during all flu seasons studied except 2011-2012. These findings were consistent with a number of previous case studies examining how demographic factors relate to vaccination coverage rates. Almost all comparisons of race and vaccination coverage rates were statistically insignificant.

During only the 2009-2010 flu season, increased vaccination rates were associated with a decreased number of weeks of high influenza activity. Increased vaccination rates during the 2010-2011 and 2012-2013 flu seasons were correlated with higher mortality rates, which may
indicate that national influenza vaccination rates are not an accurate predictor of the magnitude of disease burden that impacts the healthcare system for that year. There are no readily available accurate measures of the influenza incidence in the general population that does not use any medical services. It is assumed that the mortality rates and numbers of high-incidence weeks are indicative of the impact in the general population but this is not confirmed. This lack of correlation may be a result of the vaccine effectiveness, which, for the influenza vaccine, often is around 45 – 60% in any given year. A review of the state flu incidence data did show that the elderly and pediatric populations are disproportionately affected.

In order to improve vaccine coverage to rates that are believed to convey herd immunity, the Centers for Disease Prevention and Control (CDC) creates campaigns to promote safe health practices and vaccination, some of which target groups at risk and groups less likely to immunize. As noted in the literature, challenges to reducing influenza in America include the perception that influenza is not harmful, a distrust of the medical community, not vaccinating up to herd immunity levels, and the low relative vaccine effectiveness of the influenza vaccination. This national data analysis confirmed the literature case studies and surveys regarding the vaccination rates in communities with these perceptions and challenges. Additional investigation is required to further elucidate the effectiveness of messaging campaigns in reducing influenza outbreak in America and if needed, reaching out into the community in novel ways to improve vaccination rates.
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Chapter 1: Introduction

Every flu season, influenza epidemics account for 3.1 million hospitalized days, 31.4 million outpatient visits, $10.4 billion in medical costs, and $16.3 billion in lost earnings due to illness (Molinari et al., 2007). Despite increased government recommendations for protection against the disease since the 2009-2010 flu season, a majority of adults still opt against receiving the vaccination. The Healthy People program, an initiative created by the United States Department of Health and Human Services (HTH), calls for 70-90% of the United States population to receive the influenza vaccination ("Immunization and Infectious Diseases," n.d.). However, during the 2015-2016 flu season, only 59.3% of children and 41.7% of adults were immunized ("Flu Vaccination," 2016). Previous studies have shown that demographic factors may play a role in vaccination rates. While there has been research on influenza vaccination coverage across a variety of socioeconomic parameters, no studies have examined if vaccination coverage is related to disease outbreak at the state level in combination with a state-level analysis of vaccination rates and demographics. This research will examine the correlation between the number of people who were vaccinated and the number of influenza cases by state in the United States across demographic factors after the 2009 pandemic, which appeared, at least initially, to raise awareness in the public about the negative health outcomes of an influenza outbreak.
Chapter 2: Literature Review

The influenza virus and vaccination have been well studied in literature. The following is a literature review on a brief history of the influenza vaccination in America, followed by a summary of practices and attitudes towards influenza, and finally, an overview of influenza disease outbreak in America.

2.1 History of Influenza in America

Since the isolation of the influenza virus in 1933, the medical community has become increasingly knowledgeable about the disease and its subsequent treatments. Initially, influenza vaccination research in the United States was conducted to protect the military. During the years 1943-1944, America experienced a mild influenza epidemic, leading Thomas Francis Jr., the head of the U.S. Army Commission, and Jonas Salk to conduct a series of experiments within the U.S. military to test the effectiveness of the influenza vaccine (Holland & Collins, 1944). With fewer subjects from the vaccinated group becoming ill than the control group, the scientists concluded that the immunization helped humans acquire resistance against influenza (Francis, Salk, Pearson, & Brown, 1945). Up until 1944, the vaccine was only used in experimentation and to protect American servicemen. Methods for creating the vaccine improved, and as a result, it became more readily available. Starting in 1945, the vaccine was available for civilians (Hannoun, 2013).

2.1.1 Early Outbreaks

Documented cases of influenza date back to the early 1800’s, but one of the largest known pandemics occurred in 1918. The case-fatality rates for the 1918-1919 influenza pandemic was >2.5%, compared to <0.01% of other pandemics (Taubenberger & Morens, 2006). Around the world, an estimated 500 million people were infected and between 50-100 million
deaths were reported. The 1918 pandemic, as well as additional pandemics that occurred in 1957 and 1968, resulted in greater planning by public health officials to protect the public against the virus (Iskander, Strikas, Gensheimer, Cox, & Redd, 2013).

2.1.2 2009 H1N1 Influenza Outbreak

Despite governmental planning efforts, the nation was unready for the “swine flu” pandemic of 2009. The World Health Organization reported at least 18,631 deaths worldwide (Simonsen et al., 2013). The large magnitude of the pandemic in 2009 can be attributed to the emergence of unfamiliar strains of the virus; the combination of genes responsible for causing the pandemic had never been encountered. Therefore, there was not an effective vaccination available at the time. Through research conducted by the Centers for Disease Control (CDC), the new influenza virus was sequenced and a subsequent vaccine was developed and administered late in the 2009-2010 influenza season ("The 2009 H1N1 Pandemic," 2010). Over the years, numerous strains of the virus have been identified, and a new form of the vaccination is developed annually to combat the strains predicted to be prevalent for the upcoming flu season.

2.1.3 Non-Influenza Disease Outbreaks and Vaccinations

In recent years, several disease outbreaks have occurred involving a number of other vaccine-preventable illnesses. In 2000, measles, a disease that affected almost all children alive before 1963 when a vaccination was created, was determined to be eliminated from the United States ("Frequently Asked," 2016). Since then, there have been a number of measles outbreaks, including one widely publicized occurrence at Disneyland in California ("Measles Cases," 2017). The outbreak affected at least 130 individuals from a number of different states. The disease is thought to have been carried in from another part of the world by a traveler and spread to unvaccinated individuals in America.
Pertussis, or the whooping cough, was once one of the most common causes of childhood mortality in the United States. After a vaccination was developed in 1942, the prevalence of the disease decreased by 80% (Hamborsky, Kroger, & Wolfe, 2015). However, several pertussis outbreaks that have occurred since 2010 have raised questions about the effectiveness of a new form of the pertussis vaccine, called diphtheria-tetanus-acellular pertussis DTaP, that the United States has been using since the 1990s. A study published in the journal of Pediatrics in 2016 found that the vaccine effectiveness of DTaP after the first year of vaccination was 68.8%, but dwindled to 8.9% after four years (Klein, Bartlett, Fireman, & Baxter, 2016). This is significantly lower compared to the previously used whole-cell vaccine, which was thought to be 70%-90% effective in protecting against pertussis, but was also associated with a number of adverse side effects ("Pertussis Vaccination," 1997).

2.1.4 The Anti-Vaccine Movement

The recent outbreaks of vaccine-preventable diseases, including both measles and pertussis, have been linked to the rise of the individuals intentionally neglecting to vaccinate themselves or their children for personal or philosophical reasons. The increased number of pertussis cases in recent years has been related to both the decline in effectiveness of the vaccination and vaccine refusal. One study found that the movement against vaccinations has put both the unvaccinated and vaccinated population at higher risk for contracting measles (Phadke, Bednarczyk, Salmon, & Omer, 2016). Another study titled “Vaccine hesitancy: More than a movement” examines the rise of vaccine hesitancy in America and investigates how the topic was discussed during a debate for the Republican Party’s 2016 presidential nomination (Callender, 2016). One of the frontrunners in the debate took a clear stance against vaccinations
and expressed his concerns about the harms of vaccines, exemplifying how widespread vaccine hesitancy has become in popular American media.

### 2.2 Influenza Immunization Suggestions and Goals

Federal organizations in the U.S. annually run campaigns to provide suggestions on how to protect against the influenza virus and to encourage the public to receive the vaccination. A series of recommendations and goals have been developed by the CDC and HHS in regards to influenza practices and vaccination coverage. Higher goals are set for coverage rates among those who are considered to be at risk for developing flu-related complications.

#### 2.2.1 Recommendations for Immunization

In 2004, the vaccine was added to the list of recommended vaccinations for all children above the age of 6 months in the U.S. Since then, recommendations have become more extensive, with the government encouraging a wider variety of the population to get vaccinated, especially individuals considered to be at risk for flu-related complications. Currently, the CDC Advisory Committee on Immunization Practices recommends that everyone above the age of 6 months without medical limitations receive the vaccination prior to the start of flu season (Grohskopf et al., 2015).

#### 2.2.2 Groups at Risk

Certain groups of individuals are considered to be especially at risk for developing complications if exposed to the virus. This includes children younger than 5 and adults 65 years of age or older, as well as pregnant women and those working in long-term care facilities ("People at High Risk," 2015). Furthermore, certain races, such as American Indians and Alaskan Natives, as well as individuals with certain medical conditions such as asthma and heart
disease, are also at risk of developing flu-related complications. The likelihood of hospitalization, chronic health problems, or death due to exposure to the virus is higher among these individuals.

2.2.3 Goals in the U.S.

The Healthy People program through the HHS creates disease-prevention goals and promotes positive health decisions among Americans. For thirty years, the program has created sets of goals intended for implementation over the subsequent decade. In 2010 following the 2009 pandemic, the Healthy People 2020 initiative outlined a set of objectives for the American people to be completed by the year 2020. In regards to the influenza vaccination, the program aims for annual vaccination rates of 70% for adults above the age of 18 and children between the ages 6 months and 17 years. Targets of 80-90% have been set for groups at higher risk, such as health care personnel, pregnant women, and adults over the age of 65.

2.2.4 Messaging from the CDC

In addition to creating annual influenza vaccination recommendation reports to the public, the CDC also has campaigns to communicate flu information and to encourage specific audiences to vaccinate. On the influenza website, the CDC has free resources including videos and podcasts, buttons and banners to promote immunizing, as well as more traditional print materials ("Influenza (Flu)," 2016). A number of the resources, including the print materials, are categorized for specific populations including health care professionals, pregnant women, those with high-risk conditions, and employers.

In 2005, the CDC created National Influenza Vaccination Week (NIVW) as an effort to further push the public to get vaccinated ("About National," 2016). NIVW is timed strategically in December before the holiday season to remind people that it is not too late to vaccinate. One of the messages communicated by NIVW is the fact that even if you have already gotten the flu,
you can still protect yourself from other strains and others that may be at high risk of developing complications. NIVW also aims to reach out to people at risk of developing flu-related complications, including young children, pregnant women, and the elderly, about vaccinating. The NIVW website includes a number of communication resources, as well as a map, to help the public locate a vaccination center.

The National Influenza Prevention and Vaccination Campaign is another component of the CDC’s seasonal flu prevention efforts. The specific goal of this campaign is to increase vaccination among health care professionals and populations at risk of developing flu-related complications. The CDC provides resources to help its campaign partners and the public aid in efforts to promote the flu vaccination. For example, the CDC offers email updates and subscriptions to flu-related media and materials that can be distributed, such as posters, flyers, videos, and radio PSAs. The CDC has also developed a social media campaign with the hashtag #FightFlu designed for use on Instagram, Facebook, Twitter, and Youtube. Overall, the CDC provides a breadth of resources about the importance of receiving the flu vaccination to its campaign partners and the public to promote and educate a variety of populations, with an emphasis on populations at risk.

2.3 Trends in Immunization

2.3.1 Adults versus Children

Since the 2009 pandemic, a higher percentage of Americans have received the flu vaccination (1.3% increase in adults, 15.6% increase in children). During the 2015-2016 flu season, 59.3% of children and 41.7% of adults were immunized against the virus ("Flu Vaccination," 2016). While the increase in children’s vaccinations has leveled off in the last three flu seasons, the percentage vaccinated increased from 44% to 59% since 2009. The adult
vaccination rates has fluctuated but generally stayed steady in the low 40% range. Figure 1 shows the annual vaccination coverage rate for seasonal influenza starting with the 2009-2010 flu season.

![Image](image.jpg)

**Figure 1.** Seasonal flu vaccination coverage by age group and season, United States, 2009-2016 ("Flu Vaccination", 2016)

### 2.3.2 Trends Due to Internal Factors

Studies show that internal factors may play a role in influencing populations’ decisions on whether or not to vaccinate. A review of the literature shows differences in opinions and resultant vaccination decisions, as well as vaccination coverage in populations, that can be correlated with race, socioeconomic class, and level of education.
**Race.** Studies have shown that minority groups may be less accepting of vaccinations. One study pulled data from the National Immunization Survey and examined influenza vaccination coverage among children 6 months to 23 months, a group at risk for the development of flu-related complications (Santibanez, Grohskopf, Zhai, & Kahn, 2016). The results showed that a smaller percentage of Hispanic and black children received the vaccination compared to other ethnic groups. Another study conducted after the 2009 pandemic examined minority acceptance of the influenza vaccination for children through a cross-sectional survey of parents and caregivers (Frew, Hixson, del Rio, Esteves-Jaramillo, & Omer, 2011). The results were consistent with previous data indicating that minority groups are less likely to have their children immunized against the flu than their white counterparts. Lack of acceptance may be attributed to negative perceptions about the vaccination and mistrust of the medical community based on previous negative experiences.

**Socioeconomic Class and Education Level.** Previous studies that link socioeconomic status with vaccination often also consider education level. Literature examining the influenza vaccination and vaccinations in general across socioeconomic class and income level varies by case study. A telephone survey conducted in France shows people of two different profiles opposing the H1N1 vaccine for different reasons (Peretti-Watel et al., 2014). The first group analyzed was men of lower socioeconomic class and education levels. The study attributed their opposition to immunizing to lack of knowledge and misinformation regarding vaccinations. A pattern of resistance was also observed among females with moderate education and income levels. The study attributed the reasoning of this category of people to be a result of their increased knowledge; individuals with higher education levels may be more likely to research the vaccine and analyze the arguments for and against it. Females also tend to evaluate the safety of the
vaccination with their children in mind, typically resulting in tougher criticism (Peretti-Watel et al., 2014).

Another study examining the beliefs of parents opposing vaccination used data from the 2002 HealthStyles survey (Kennedy, Brown, & Gust, 2005). The results supported prior research that households with lower income levels were less likely to immunize their children. Similarly, an epidemiological study examining data from the 2009 National H1N1 Flu Survey found a positive correlation between income and education level and having received the 2009 H1N1 and seasonal flu vaccinations (Santibanez, Singleton, Santibanez, Wortley, & Bell, 2013).

In contrast, a survey conducted among Connecticut pediatricians found that, among the parents who refused vaccination for their child, a majority were from high socioeconomic classes and had higher levels of education (Leib, Liberatos, & Edwards, 2011). In sum, a review of literature connecting socioeconomic status, education level, and opinions towards vaccination show that trends vary by specific populations, but overall patterns link higher income and education level with increased likelihood of vaccination.

2.3.3 Trends Due to External Factors

Previous studies analyzing external factors show that elements of a person’s social environment may influence his or her opinion on vaccinations. A review of literature shows how health care professionals and the Internet have played a role in influencing society’s decision to immunize.

*Role of Health Care Professionals.* Studies show that the actions and opinions of health care professionals could influence whether or not patients opt to receive the vaccination. Most articles regard vaccination among health care professionals as positively influencing patient health (Ahmed, Lindley, Allred, Weinbaum, & Grohskopf, 2014). One article describes health care
professionals as having “the greatest influence on a parent's decision to vaccinate his or her child” (Healy & Pickering, 2011). In analyzing influenza vaccination among pregnant women, another study cited that one of the leading motivators for vaccination coverage was health care provider recommendation (Ball et al., 2013).

Despite being a population at risk and the national goals set by the U.S. government of 70-90% coverage, a large portion of health care workers choose not to receive the influenza vaccine annually ("Immunization and Infectious Diseases," n.d.). Data from the CDC shows that flu vaccination coverage for the 2014-15 flu season among health care professionals overall was at 64.3%, which is only slightly higher than the coverage for the U.S. population in general ("Influenza Vaccination Information for Health," 2015). Another study that surveyed registered nurses across the U.S. showed that, among those who opted out of receiving the vaccine, the most common reason against vaccination was due to the fear of vaccine-related complications (Clark, Cowan, & Wortley, 2009). In contrast, common motivators for vaccination among these individuals include wanting to protect themselves and their patients, as well as messaging influences from their workplace (Prematunga et al., 2014). Most literature concludes that patients are more likely to get the vaccination when their nurses and doctors receive it, and when these health care professionals actively encourage their patients to immunize (Kumar, Chandra, Mathur, Samdariya, & Kapoor, 2016).

**Role of the Internet.** The Internet has been shown to be increasingly impactful on the public’s attitudes towards or against vaccination. While both positive and negative views of vaccination can be found online, most evidence shows that the Internet primarily is used to propagate arguments against vaccination and oftentimes through the spread of rumors and myths (Kumar, Chandra, Mathur, Samdariya, & Kapoor, 2016). One study examined the accuracy of health care
information presented on the Internet, and specifically regarding the claim that the mumps, measles, and rubella vaccination is associated with autism in children. The results found that only 51% of information found using a Google search engine was accurate (Scullard, Peacock, & Davies, 2010). Websites that present information on vaccination often challenge arguments presented by health care authorities in order to promote the anti-vaccination movements (Bean, 2011). The Internet propaganda’s effectiveness can be explained in part to the fact that arguments presented online against vaccination use emotional appeal and are often formatted in a way that appears to use scientific information (Peretti-Watel et al., 2014). As a result, the Internet could be especially convincing to those who are already hesitant about vaccination, lack background knowledge on the topic, or both.

2.4 Common Motivators and Reasons for Hesitance

In addition to highlighting the factors that influence vaccination coverage across various facets of society, previous research also has examined the rationales behind decisions to or not to vaccinate. While motivators and reasons for hesitance vary across different studies, most surveys show general trends in how individuals justify whether or not they vaccinate.

2.4.1 Motivators

The most common motivators for vaccination revolve around individuals’ desire to protect themselves or their loved ones against the infectious disease. The recommendation of healthcare providers has also been noted to be a factor in patients’ decisions to vaccinate. For example, a qualitative study assessing influenza vaccination coverage among pregnant females found the predominant reasons for vaccinating were to protect themselves and their children, as well as to follow through with a provider recommendation (Ball et al., 2013).

2.4.2 Reasons for Hesitance
Studies show a trend of increasing hesitance in society towards vaccinations. In regards to the influenza vaccination, a negative shift in attitudes has been observed since the 2009 pandemic. Various factors contribute to vaccine hesitancy across the U.S.

**Misconceptions/Lack of Education.** A common reason for vaccine hesitance in the literature has been due to misconceptions and lack of education (Yaqub, Castle-Clarke, Sevdalis, & Chataway, 2014). Generally, studies have linked lower education levels among individuals with being less informed about vaccines. This lack of education about vaccines is a contributing factor to hesitancy (Kumar, Chandra, Mathur, Samdariya, & Kapoor, 2016). One study analyzed the lack of education about vaccines amongst parents, and how educational intervention could alter parental perceptions of vaccinations. After testing various methods of educating parents about vaccination, the results indicated that educational intervention may positively impact parents’ perceptions on vaccination and increase their likelihood to vaccinate their children (Sadaf, Richards, Glanz, Salmon, & Omer, 2013).

Public concerns regarding vaccination typically reference the safety of the vaccinations and potential vaccinate-related complications. One misconception is the association between vaccination and diseases such as autism in infants. One study shows that, despite the lack of evidence linking the two, some parents attribute the increase in number of cases of autism to the increase in number of vaccinations recommended for young children (Salmon, Dudley, Glanz, & Omer, 2015). In contrast, others have expressed hesitancy due to lack of concern about the severity of the flu or the risk of contracting diseases.

**Distrust of the Medical Community.** Healthcare professionals “have a central community leadership role in educating parents about the importance of H1N1 vaccination to mitigate any circulating misinformation in communities”; however, many have indicated that building trust
between themselves and patients has become a challenge (Yaqub, Castle-Clarke, Sevdalis, & Chataway, 2014; Frew, Hixson, del Rio, Esteves-Jaramillo, & Omer, 2011). A patient may be less inclined to take the advice of a healthcare professional with whom they have a weak relationship. Distrust of healthcare professionals is especially prevalent among individuals with lower education levels and among minorities (Kumar, Chandra, Mathur, Samdariya, & Kapoor, 2016).

**Among African American Communities.** Distrust of the medical community is especially prevalent among African Americans, and most studies point to prior experiences with discrimination within and outside of the healthcare system as a major contributing factor. The current distrust that exists among the African American community could be due in part to “a cultural memory of victimization and exploitation during clinical experiments” (Rajakumar, Thomas, Musa, Almario, & Garza, 2009). A history of abuse exists within the health care system towards African Americans, with one of the most well-known incidents being the Tuskegee Syphilis Study. The consequences of such experiments may still linger and serve to negatively impact the opinions of African Americans towards the health care system.

Individual experiences of discrimination may also play a role in determining the attitudes of African Americans towards the medical community. One study found that distrust might be linked to a pattern of racial discrimination in society in general; survey data indicated that prior experiences of discrimination, including non-health care experiences, are associated with distrust (Armstrong et al., 2013). Overall, most literature shows that, among the black population in the U.S., “a history of unsatisfying health system encounters” could be an influencing factor in decisions to vaccinate (Frew, Hixson, del Rio, Esteves-Jaramillo, & Omer, 2011).
2.5 Efficacy of the Influenza Vaccination

2.5.1 Seasonal Influenza Vaccination Effectiveness

Influenza viruses are always changing, so the vaccination must be recreated every year. Each season’s vaccine protects against three or four viruses that are anticipated to be prevalent during the upcoming flu season. The degree of efficacy of the influenza vaccination depends on how well it matches the influenza strains present during its flu season. Due to the variable nature of the virus, the CDC conducts a study to determine the potency of the influenza vaccine. The seasonal influenza vaccine is assessed by the CDC and researchers at universities and hospitals for its vaccine effectiveness (VE) ("Seasonal Influenza," 2016). The vaccine’s VE is a measure of its success at preventing outpatient medical visits due to cases of influenza. The adjusted overall VE for influenza seasons from 2009-2013 are listed in Table 1.

Table 1: Adjusted overall effectiveness as determined by the CDC for flu seasons between 2009-2013

<table>
<thead>
<tr>
<th>Influenza Season</th>
<th>Adjusted Overall VE (%)</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-10</td>
<td>56</td>
<td>23, 75</td>
</tr>
<tr>
<td>2010-11</td>
<td>60</td>
<td>53, 66</td>
</tr>
<tr>
<td>2011-12</td>
<td>47</td>
<td>36, 56</td>
</tr>
<tr>
<td>2012-13</td>
<td>49</td>
<td>43, 55</td>
</tr>
</tbody>
</table>

In contrast, the MMR vaccine, which protects against measles, mumps, and rubella is 97% effective against measles, 88% effective against mumps, and 97% effective against rubella after two doses ("Measles, Mumps," 2016). Even more effective is the chicken pox vaccination, which has a 98% VE after two doses ("Chickenpox," n.d.).

2.5.2 Herd Immunity
The influenza vaccination has been established to reduce the risks of developing influenza or influenza-related complications in vaccinated individuals. The vaccination also acts to prevent and control the spread of the influenza virus throughout the community by establishing herd immunity. The greater the number of individuals in a community that vaccinate, the lower the number of vulnerable hosts that the virus could infect, which means a lower rate of transmission. Herd immunity especially is critical because it affects individuals that are unable to vaccinate due to their risk of vaccination-related complications. The inability of a virus to successfully transmit through a population reduces the likelihood that a non-vaccinated individual or person at risk will come into contact with the virus. One study investigating the relationship between influenza coverage rates and herd immunity determined that the overall coverage goal against influenza of 80% for healthy persons and 90% for the population that are at risk for influenza-related complications and health care workers would be sufficient to establish herd immunity (Plans-Rubió, 2012). Based on this study, the nation’s coverage rate for the 2015-2016 flu season of 59.3% of children and 41.7% of adults would not be high enough to establish herd immunity.

**Role of Children in Establishing Herd Immunity.** A number of studies have shown the direct and indirect benefits of vaccinating children. Immunizing children can prevent them from contracting influenza, but since children have the highest levels of influenza transmission, vaccinating them can also offer protection to unimmunized members of the community (Tran et al., 2014). One study investigated the effect of mass influenza vaccination in children on the health of the elderly residing in the study areas during a 2001-2002 influenza epidemic (Ghendon, Kaira, & Elshina, 2006). Immunizations were conducted on eligible children in kindergartens and schools, and areas where less than 1% of children were immunized were used as control communities. In
addition, the morbidity of non-institutionalized elderly individuals residing in the study areas was measured throughout the flu season, based on the assumption that many of the elderly would have contact with these children during the flu season. Children in the group receiving the vaccination had 60.9-68.8% fewer influenza-like illnesses than the control group. In addition, there was a statistically significant reduction in influenza-like illnesses and overall morbidity in the elderly part of the immunized community.

Another similar observational study conducted in elementary schools in Bell County, Texas considered how the influenza vaccination protected immunized children and the overall community (Glezen, Gaglani, Kozinetz, & Piedra, 2010). The vaccination was administered to 4,951 (47.5%) of 10,418 children in the enrolled public schools, and influenza outbreaks were monitored throughout the 2007-2008 flu season. The study found that the outbreak rate for vaccine recipients was significantly lower than for unvaccinated children, and based on measured activity at intervention and comparison clinics in the community, about 2,500 medical visits were avoided as a result of the immunizations.

Finally, a controlled trial conducted in Canadian Hutterite communities tested how administering influenza vaccinations on children and adolescents in randomly assigned colonies would affect overall herd immunity (Wang et al., 2016). The study showed that individuals that did not receive the vaccination but lived in colonies with 83% of children and adolescents vaccinated had a 61% reduction in influenza compared to unvaccinated colonies. These studies suggest that because of their high rates of transmission, children play an important role in the establishment of herd immunity.

### 2.6 Epidemiology of Seasonal Influenza

#### 2.6.1 Groups Disproportionately Affected by Influenza Outbreak
While individuals of all age groups are susceptible to acquiring the influenza illness, there are two age groups that are disproportionately affected by outbreak: the elderly and pediatric populations. These groups of individuals are at higher risk of developing complications, and therefore have higher morbidity and mortality rates than the rest of the population.

**Elderly.** The majority of influenza-related deaths in America affect individuals that are 65 years of age or older. Secondary complications that occur as a result of influenza particularly affect the elderly and have the potential to lead to other illnesses such as pneumonia or congestive heart failure ("Estimating Seasonal," 2016). Despite the fact that they make up only 15% of the population in the United States, deaths among the elderly accounted for 87.9% of all yearly influenza-related deaths between 1967-2007 ("Estimates of Deaths," 2010).

**Long-Term Care Facilities.** Long-term care facilities, which are “institutions, such as nursing homes and skilled nursing facilities that provide health care to people (including children) who are unable to manage independently”, are often sites of influenza outbreaks in the community ("Interim Guidance”, 2017). Among individuals 65 or older, those living in long-term care facilities have an increased chance of being exposed to the virus. During influenza epidemics, the mortality rate among residents in such facilities surpasses 5% (Kingston & Wright, 2002). The CDC recommends that all patients, residents, and health care personnel at long-term care facilities get vaccinated. Studies have shown that higher rates of vaccination among residents and health care personnel are associated with a lower risk of influenza-related illness for both residents and personnel. Some institutions provide workplace vaccinations and educate their residents and health care personnel on risks associated with influenza as strategies to increase vaccination rates.
*Pediatrics.* Children under the age of 18, including both healthy children and those that have chronic health conditions, may be at risk for developing serious influenza-related complications such as pneumonia, encephalitis, and myocarditis. One study conducted by the CDC examining influenza-related pediatric deaths between 2004-2012 found that most fatal cases involved children that did not vaccinate (Wong et al., 2013). The results show that one-third of children died within three days of experiencing symptoms, and among the children that became seriously ill, 35% died before admission to the hospital. The results exemplify how quickly children can go from the onset of symptoms to mortality and highlight the importance of preventative vaccinations for children.

**Major Conclusions**

In sum, the number of individuals, including both children and adults, getting vaccinated for influenza has increased since the 2009 pandemic, but is still far less than levels recommended by the government. Literature shows that disparities exist among minorities, as well as across education and income levels, in regards to influenza vaccination coverage. Minority groups have been shown to be less likely to immunize or be accepting of the influenza vaccination, while the relationship between income and education level and likeliness of vaccination varies by community. Health care professionals have been shown to have the potential to influence patients’ attitudes towards the influenza vaccination, but many choose not to receive the vaccination because of their perceptions towards the severity of influenza or risk associated with the vaccine. Studies have shown that some members of the general public choose not to vaccinate because of hesitancy towards the vaccine for numerous reasons. Common reasons for neglecting to vaccinate include misconceptions about the vaccine and a distrust of the medical community. Research shows that some influencing external factors on the general public’s
attitudes towards vaccination include the Internet and the attitudes and actions of health care professionals, as noted above.

Between 2009-2013, the average vaccine effectiveness of the influenza vaccination was 53%, which is relatively low compared to other major vaccination. Previous studies have shown that herd immunity can reduce the rate of disease transmission, but the nation’s current vaccinate coverage rates are not high enough to establish herd immunity. Finally, the elderly and pediatric populations, who are groups at risk of developing flu-related complications are disproportionately affected by the morbidity and mortality the influenza illness.

The drawback of the literature is that much of it is based on case studies and not on state-level correlations between demographics and vaccination rates, and then between vaccination rates and influenza incidence. This thesis addresses this gap.
Chapter 3: Materials and Methods

3.1 Study Data

Data regarding influenza coverage, demographics, and outbreak were collected for the flu seasons between 2009-2013 to examine trends in the early years following the 2009 influenza pandemic. Influenza vaccination coverage rates were collected from FluView, a database produced by the CDC (Overview of Influenza Surveillance, 2016).

Demographic data was obtained from American FactFinder, an index of population statistics provided by the United States Census Bureau. The information on American FactFinder comes from censuses and surveys conducted by the Census Bureau. The data used was collected via the American Community Survey (ACS), which is a survey distributed by the U.S. Census Bureau to 1 in 38 U.S. households every year either through a written questionnaire or an online survey ("American Community," n.d.). At the time the demographic data was obtained, the most recent data sets were only available in 3-year estimates. Two different data sets with running three-year averages were used for the years 2009-2012 and 2010-2013. Demographic data between 2009-2012 was compared to influenza vaccination coverage rates for the 2009-2010 and 2010-2011 flu seasons, and demographic data between 2010-2013 was compared to influenza vaccination coverage rates for the 2011-2012 and 2012-2013 flu seasons.

Outbreak data was measured in two ways: using weekly influenza activity reports from FluView and measurements of the number of influenza-related hospitalizations and deaths from state health departments. FluView data is collected from a number of surveillance participants that report information about influenza in the United States from sources such as public health and clinical laboratories, outpatient health care facilities, and state health departments. The CDC divides influenza surveillance into five categories, which are virologic surveillance, outpatient
illness surveillance, mortality surveillance, hospitalization surveillance, and a summary of the geographic spread of influenza. A compilation of the data collected from the sources within each category comprises the information on the FluView influenza surveillance database. Outbreak data from FluView was used to determine the number of weeks each state had high influenza activity per flu season between 2009-2013. Activity level is determined weekly by comparing the average reported percent of patient visits to health care providers for influenza-like illnesses to the average percent of visits during non-influenza weeks. The number of weeks with high influenza activity was counted for the 2009-2010, 2010-2011, 2011-2012, and 2012-2013 flu seasons individually. Information regarding the number of influenza related cases, hospitalizations, and deaths per state was obtained from annual influenza summaries reported by state health departments. Data was used from an average of 10.4 states between 2009-2013. The lack of complete data is due to the fact that different states report varying statistics on influenza. In addition, a number of states reported data on deaths and hospitalizations for only the 2009-2010 flu season and not the years that followed. To standardize state reported influenza-related hospitalization and death data, annual population estimates from the Population Division of the U.S. Census Bureau were used to calculate hospitalization and death rates per 100,000 individuals.

3.2 Statistical Analysis

To compare overall influenza vaccination coverage rates to demographic factors, a Pearson’s correlation coefficient was computed using StatPlus, the statistical analysis tool through Microsoft Excel. The Pearson’s correlation coefficient assumes a linear relationship between the independent and dependent variables (Mukaka, 2012). For this study, the first correlation analyzed the potential relationship between demographic and socioeconomic factors
on vaccination rates during each flu season, with vaccination rate being the dependent variable.

Then, the correlation analysis was performed between the vaccination rate and the health outcomes, with the health outcomes being the dependent variable. These correlations were performed as two separate analyses because the influenza case data was not broken down by demographics, except for age, or socioeconomic status. The results provided a R value which measured how close the relationship between the variables was to a perfect line and a p value in order to be able to evaluate statistical significance of the R coefficient. A p value of <0.05 was considered statistically significant.
Chapter 4: Results and Discussion

4.1 Influenza Vaccination Rates versus Demographic Data

Table 2 summarizes the statistically significant correlations between influenza vaccination coverage in flu seasons between the years 2009-2013 and demographic and socioeconomic data for those years.

Table 2: The relationship between vaccination rates across demographic factors between 2009-2013

<table>
<thead>
<tr>
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</thead>
<tbody>
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<td>Education</td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>&lt;HS Education</td>
<td>-0.304</td>
<td>0.030</td>
<td>-0.112</td>
<td>0.434</td>
<td>-0.082</td>
<td>0.565</td>
<td>-0.099</td>
<td>0.488</td>
</tr>
<tr>
<td>HS Grad or Higher</td>
<td>0.304</td>
<td>0.030</td>
<td>0.112</td>
<td>0.434</td>
<td>0.100</td>
<td>0.483</td>
<td>0.080</td>
<td>0.577</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>0.412</td>
<td>0.003</td>
<td>0.313</td>
<td>0.025</td>
<td>0.248</td>
<td>0.079</td>
<td>0.286</td>
<td>0.042</td>
</tr>
<tr>
<td>Unemployed</td>
<td>-0.596</td>
<td>0.000</td>
<td>-0.426</td>
<td>0.002</td>
<td>-0.402</td>
<td>0.003</td>
<td>-0.422</td>
<td>0.002</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median Income</td>
<td>0.319</td>
<td>0.022</td>
<td>0.301</td>
<td>0.032</td>
<td>0.274</td>
<td>0.052</td>
<td>0.293</td>
<td>0.037</td>
</tr>
<tr>
<td>Median Family Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poverty All Families</td>
<td>-0.373</td>
<td>0.007</td>
<td>-0.256</td>
<td>0.070</td>
<td>-0.218</td>
<td>0.125</td>
<td>-0.242</td>
<td>0.087</td>
</tr>
<tr>
<td>Poverty All People</td>
<td>-0.358</td>
<td>0.010</td>
<td>-0.254</td>
<td>0.072</td>
<td>-0.213</td>
<td>0.133</td>
<td>-0.239</td>
<td>0.092</td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Private Insurance</td>
<td>0.466</td>
<td>0.001</td>
<td>0.463</td>
<td>0.001</td>
<td>0.413</td>
<td>0.003</td>
<td>0.447</td>
<td>0.001</td>
</tr>
<tr>
<td>With Public Insurance</td>
<td>0.104</td>
<td>0.469</td>
<td>0.066</td>
<td>0.643</td>
<td>0.179</td>
<td>0.208</td>
<td>0.124</td>
<td>0.384</td>
</tr>
<tr>
<td>No Health Insurance</td>
<td>-0.617</td>
<td>0.000</td>
<td>-0.592</td>
<td>0.000</td>
<td>-0.617</td>
<td>0.000</td>
<td>-0.616</td>
<td>0.000</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Alone</td>
<td>-0.030</td>
<td>0.833</td>
<td>-0.108</td>
<td>0.449</td>
<td>-0.130</td>
<td>0.363</td>
<td>-0.121</td>
<td>0.397</td>
</tr>
<tr>
<td>Black or African American</td>
<td>-0.224</td>
<td>0.114</td>
<td>0.011</td>
<td>0.939</td>
<td>0.039</td>
<td>0.787</td>
<td>0.025</td>
<td>0.861</td>
</tr>
<tr>
<td>American Indian and Alaska</td>
<td>0.072</td>
<td>0.614</td>
<td>-0.001</td>
<td>0.996</td>
<td>-0.049</td>
<td>0.730</td>
<td>-0.025</td>
<td>0.861</td>
</tr>
<tr>
<td>Asian Alone</td>
<td>0.223</td>
<td>0.116</td>
<td>0.112</td>
<td>0.433</td>
<td>0.116</td>
<td>0.418</td>
<td>0.116</td>
<td>0.417</td>
</tr>
<tr>
<td>Native Hawaiian or Other</td>
<td>0.307</td>
<td>0.029</td>
<td>0.164</td>
<td>0.251</td>
<td>0.172</td>
<td>0.227</td>
<td>0.171</td>
<td>0.230</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>0.249</td>
<td>0.078</td>
<td>0.117</td>
<td>0.414</td>
<td>0.133</td>
<td>0.352</td>
<td>0.127</td>
<td>0.373</td>
</tr>
</tbody>
</table>

4.1.1 Education

In regards to education, not having graduated high school was associated with decreasing vaccination coverage rates during all flu seasons and having a high school education or higher was positively correlated with vaccination coverage rates. However, for both categories, only the
2009-2010 flu season results were statistically significant. For the less educated populace, the reduction in both the R value (weak negative correlation in 2009-2010 became weaker and not statistically significant) over the four flu seasons may indicate that more people in this education category opted to be vaccinated. However, the inverse was seen for the population that has a high school diploma, at a minimum. For that group, the weak positive correlation in 2009-2010 became weaker and not statistically significant over the four years studied, indicating that potentially fewer people in this education category received the vaccine. Figure 2 illustrates the correlations between vaccination rates and the percent of the population without a high-school diploma for the four flu seasons.

![Correlation plots](image)

**Figure 2.** Correlations between vaccination rates and the percent of the population without a high school diploma between 2009-2013 in the United States
These results are similar to the findings of a study conducted in an urban community in Ohio examining factors affecting adults’ opinions towards vaccination. In comparison to those with a high school education or beyond, individuals with less than a high school education were significantly more likely to state transportation, vaccine expenses, the time required to get a vaccination, and a dislike of needles as factors affecting their immunization practices (Sevin, Romeo, Gagne, Brown, & Rodis, 2016). In contrast, Leib, Liberatos, & Edwards (2011) noted that education level was not necessarily predictive as being supportive of vaccination. People with higher education levels were shown to be more concerned about the safety of vaccines, including citing the discredited studies linking vaccination to autism in children. Additional studies can also be found in Section 2.3.1.

4.1.2 Employment

Being employed was significantly positively correlated with vaccination rates for all seasons except 2011-2012, while being unemployed was negatively correlated with vaccination rates with statistical significance for all seasons. These correlations are illustrated in Figures 3 for employment and 4 for unemployment.
Figure 3. Correlations between vaccination rates and the percent of the population that is employed between 2009-2013 in the United States
Figure 4. Correlations between vaccination rates and the percent of the population that is unemployed between 2009-2013 in the United States

This may be, in part, a result of employers taking steps towards promoting vaccination in the workplace. The CDC and Occupational Safety and Health Administration have released information specifically to employers on how to encourage employees to prepare themselves for flu season (Lee et al., 2010). In 2010, CDC released a report addressing the 2009-2010 H1N1 pandemic, providing recommendations to businesses and employers of non-health care workers on actions to take to decrease the spread of influenza in the workplace (“Guidance for Businesses,” 2010). In addition, some employers offer influenza vaccinations at the worksite. In 2003, a vaccine manufacturer created an immunization campaign at a company with over 1,500 employees (Strunk, 2005). The immunization rate among employees went from 34% in 2002 to 76% after implementation of the program. In a post-campaign survey, 99% of respondents
indicated that they felt comfortable receiving the vaccination in the workplace, supporting previous studies have that have found that convenience of location is a factor that influences employees’ decisions to vaccinate in the workplace (Lee et al., 2010). Unemployed individuals, which are defined as all civilians over the age of 16 without a job but were actively looking for one, would not have experienced those influences from the workplace.

4.1.3 Socioeconomic Status

Socioeconomic status in this study was measured by income and poverty levels. Poverty of all people is measured by the percentage of individuals that fall below the poverty threshold for that year. Family size and composition were considered in determining the rate of poverty in all families. Figures 5, 6, and 7 show the correlations between vaccination coverage rates and poverty, median family income, and percent of families in poverty, respectively.

During the 2009-2010 flu season, poverty in all people and in families was negatively correlated with vaccination rates. However, that statistically-significant relation did not exist for the flu seasons that followed. While the overall median income level in each state was not significantly correlated to vaccination rates, median family income was positively correlated with vaccination rates during all flu seasons studied except 2011-2012. According to the Census Bureau, median family income is the overall income of the household plus related individuals 15 years or older living in the household. A number of previously cited studies have also shown that higher socioeconomic status was associated with increased vaccine coverage. Santibanez et al. (2013) showed that adults with a household income of $75,000 a year had higher vaccination coverage in 2009 compared to adults in households with income below $75,000, at the poverty
level, or below the poverty level. Additional studies can be found in section 2.3.

Figure 5. Correlations between vaccination rates and the percent of the population that is in poverty between 2009-2013 in the United States.
Figure 6. Correlations between vaccination rates and median family income between 2009-2013 in the United States
4.1.4 Race

The only significant relationship between vaccination coverage and race was a positive correlation between native Hawaiian or other and vaccination rates during the 2009-2010 flu seasons, suggesting that when race is examined in the groups considered by the CDC and at a state-level, it does not have a significant relationship overall with vaccination rates in America. This was unexpected, given the literature on the attitudes towards vaccination and the overall medical community in African-American and Hispanic communities.
4.2 Influenza Vaccination Rates versus Outbreak Data

Outbreak data was measured using weekly influenza activity levels reported by the CDC and data on hospitalization and deaths reported by state health departments. Table 3 illustrates the correlations between vaccination coverage rates and the number of weeks of high incidences across the United States.

Table 3: Relationship between vaccination coverage rates and the number of weeks with high incidences in the United States between 2009-2013

<table>
<thead>
<tr>
<th>Vaccination Coverage by Season</th>
<th>Number of Weeks with High Incidences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>2009-2010</td>
<td>-0.28460</td>
</tr>
<tr>
<td>2010-2011</td>
<td>-0.13064</td>
</tr>
<tr>
<td>2011-2012</td>
<td>-0.05675</td>
</tr>
<tr>
<td>2012-2013</td>
<td>-0.08832</td>
</tr>
</tbody>
</table>

In comparing vaccination coverage rates in the fifty states and the number of weeks with high incidences by state as determined by the CDC, a statistically-significant negative correlation was detected during the 2009-2010 flu season. The negative correlation in the other years was not statistically significant. This suggests that during that flu season, increasing coverage rates were associated with a decreasing number of weeks with high incidences, indicating that the vaccination may have played a role in decreasing influenza activity in the United States during the 2009 pandemic. In the years after the pandemic, the correlation trended negative, but was not statistically significant, indicating that vaccination coverage might have been a factor in reducing the number of weeks of high incidence. Throughout the four years of data, the R value approached zero and the p-value approached one, indicating that any effect from the H1N1
pandemic fears on vaccination did not have a lasting effect on numbers of high-incidence weeks. However, it is not possible to know whether this was because the more distant the memory, the less recall of the concern, or whether the vaccine effectiveness in those years had an effect on incidence rates.

To examine the association between vaccination rates and outbreak from a different angle, vaccination rate data was compared to the number of influenza-related hospitalizations and deaths in states reporting morbidity and mortality data in flu seasons between 2009-2013. Table 4 shows the resulting correlations.

**Table 4: The relationship between influenza vaccination rates and hospitalization rates and deaths due to influenza between 2009-2013**

<table>
<thead>
<tr>
<th></th>
<th>2009-2010</th>
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<th>2011-2012</th>
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<th>2012-2013</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>p</td>
<td>R</td>
<td>p</td>
<td>R</td>
<td>p</td>
<td>R</td>
<td>p</td>
</tr>
<tr>
<td>Hospitalizations per 100,000</td>
<td>0.51435</td>
<td>0.11930</td>
<td>0.17097</td>
<td>0.62139</td>
<td>0.58083</td>
<td>0.13690</td>
<td>0.45637</td>
<td>0.26786</td>
</tr>
<tr>
<td>Deaths per 100,000</td>
<td>-0.00135</td>
<td>0.99627</td>
<td><strong>0.93123</strong></td>
<td><strong>0.00823</strong></td>
<td>0.72251</td>
<td>0.10152</td>
<td><strong>0.83694</strong></td>
<td><strong>0.04186</strong></td>
</tr>
</tbody>
</table>

During the 2010-2011 and 2012-2013 flu seasons, increased vaccination coverage was correlated with higher mortality rates. This finding was contradictory to previous studies examining the relationship between the flu vaccine and disease outbreak, such as one done in 2014 on flu-related pediatric intensive care unit (PICU) admissions. That study found that the flu vaccine decreased admission into the PICU by 74% during the 2010-2011 and 2011-2012 flu seasons ("Vaccine Effectiveness," 2017). Another study examining hospitalizations in individuals 50 years of age or older found that vaccination decreased participants’ risk of getting hospitalized by 57%. The positive correlations between vaccination coverage rates and hospitalization and death rates, as well as overall lack of correlation between vaccination rates
and outbreak may also be representative of the vaccine effectiveness of the influenza vaccination. Between 2009-2013, the average vaccine effectiveness was 53%, meaning that the vaccination was only able to reduce the risk of transmission by just over half. The results may suggest that state-level influenza vaccination coverage rates are not an accurate predictor of the magnitude of disease burden for that year.

4.3 Elderly and Pediatric Groups Disproportionately Affected

Because not all states report on age specific data, and the ones that do may not report every year, national averages were not established for influenza outbreak across age groups. However, among states providing outbreak data across age groups, a trend was observed where the elderly and pediatric populations were disproportionately affected by influenza disease outbreak. For example, of the 94 confirmed influenza-associated deaths in New York State in 2009, 27 were pediatric mortalities. A number of states also report on the annual number of outbreaks that occurred in long-term care facilities, which are common areas where influenza is transmitted among a particularly vulnerable population. In 2010, Colorado reported 35, Connecticut reported 10, and Minnesota reported 54 outbreaks in long-term care facilities. Figure 5 shows how certain age groups were disproportionately affected by influenza outbreak in Colorado during each individual flu season between 2009-2013.
After the 2009 pandemic, the CDC created an audience-specific campaign to target specific populations during the 2010-2011 flu season, including groups such as parents, pregnant women, health care workers, and minority groups (Sheedy 2010). The theme was “The Flu Ends With U”, and the initiative’s focus was to message to the public that protecting one’s self against influenza is imperative for protecting others, especially groups at risk for developing influenza-related complications. Information regarding the importance of receiving the influenza vaccination was conveyed to the public through education to health care workers, social media campaigns, and outreach to organizations that are partners with the CDC.

The overall campaign focused on learning about and responding to the motivations and perceptions of certain populations. Research on health care workers, for example, showed that
nurses and allied health care providers held misconceptions regarding the severity and necessity of flu vaccines. As a result, the CDC developed a strategy to educate health care workers through their workplaces and worked with partner organization, such as the American Nurses Association and the American Hospital Association, to encourage workplaces to offer vaccinations during National Influenza Vaccination Week. Such group-specific messaging may have been effective. While the adult vaccination rate only increased 1.1% from the 2009-2010 flu season to the 2012-2013 flu season, the vaccination rate among health care workers increased by 10% ("Influenza Vaccination," 2013). Figure 3 shows how the percentage of vaccinated health care workers increased in the years after the 2009 H1N1 pandemic.

![Figure 3](image_url)

Figure 3. Vaccination coverage rates among health care workers in the U.S. during the 2009-2013 flu seasons

4.5 Challenges to Reducing Influenza in America

This study found that there are several challenges in decreasing the transmission of influenza in the United States. One challenge is the vaccine’s relatively low vaccine
effectiveness compared to other common vaccinations. That, in combination with the fact that society does not vaccinate up to herd immunity rates, which one study determined to be about 80-90%, poses a barrier to decreasing the transmission of the virus.

Influenza vaccination coverage rates in America may reflect certain beliefs held by the public. False claims that vaccines are harmful and a distrust of the medical community have been cited as reasons against vaccinating. Some also hold the notion that influenza is not harmful. While a healthy individual between the ages of 18-65 may be able to manage having the flu, the virus can lead others that are immunocompromised, under the age of 18, or over 65 to develop flu-related complications. Those individuals are especially at risk for hospitalization or death as a result of getting influenza.

4.5.1 Future Messaging

Initiatives to increase vaccination coverage rates by the CDC have targeted both individuals at risk of developing flu-related complications and the general public. Campaigns to reach out to healthy people often express the notion that vaccinating protects not only their health, but also the health of everyone around them, especially individuals at risk. Messaging that expresses the importance of vaccinating for the safety of family members seems to be well received by the public. One study done created a workplace campaign for vaccinations with the overarching message being “Protect yourself, your loved ones, and your colleagues... Get an influenza immunization and reduce the risk of transmitting the disease” (Strunk, 2005). After the campaign, vaccination rates increased by 42%, likely due to a combination of the messaging tactics and convenience of offering vaccinations in the workplace. In the future, messaging campaigns that convey the importance of vaccinating for individuals at risk of developing flu-related complications as it relates to protecting loved ones and family would likely resonate the
most with the public. Messaging also will need to target those groups found in this study whose member percentages tend to be negatively correlated with vaccination rates. The three groups highlighted in this study were those living below the federal poverty line, those considered unemployed, and those who did not complete high school. For these groups, messaging focusing on their challenges and how to make the flu vaccine easy to access may be constructive.
Chapter 5: Conclusion

Since the creation of an influenza vaccination in 1945, the United States government has been increasingly encouraging the public to vaccinate, and in recent years, has created vaccination goals for various groups in the United States. However, Americans do not vaccinate up to target vaccination levels, and despite the increased awareness of influenza since the H1N1 pandemic in 2009, the vaccination coverage rate in adults only increased 1.3% between 2009-2016.

Prior studies have shown demographic correlations regarding the public’s opinions towards vaccination and decisions to vaccinate. Previously observed relationships that were confirmed by the results of this study include the association between education, employment status, and socioeconomic status and vaccination coverage rates, which were aggregated at the state level across the United States during 2009 pandemic and in the years that followed.

Furthermore, previous case studies in specific communities have shown the ability of the influenza vaccination to reduce the risk of transmission. While the results of this study showed that in 2009, increasing vaccination coverage rates were associated with a decreasing number of weeks with high flu activity in the fifty states, the relationship did not exist for the years following the pandemic. In addition, during the 2010-2011 and 2012-2013 flu seasons, increased vaccination coverage was correlated with higher mortality rates. These results and the overall lack of correlation between coverage rates and outbreak data across the parameters in this study may be an indication that state-level influenza vaccination rates are not representative of the level of disease burden. The results could also reflect the relatively low level of vaccine effectiveness of the influenza vaccination, as well as the fact that the states do not vaccinate up to levels that establish herd immunity.
The rise of vaccine hesitancy and the anti-vaccine movement may contribute to negative perceptions about the influenza vaccination and ultimately the public’s decision not to vaccinate. Many of the stated reasons for vaccine hesitance in literature revolve around concerns for one’s self, including the notion that influenza is not harmful or that the vaccination could produce adverse effects. Not commonly considered are ideas that vaccination will protect others, especially those at risk of developing influenza-related complications, such as the elderly and pediatric populations. The increase in vaccination rates in certain populations, such as health care workers, since the 2009 pandemic may indicate that group specific messaging is effective. In campaigns to raise awareness of the risks associated with influenza and encourage the public to vaccinate, the CDC messages to the public that protecting one’s self against influenza is imperative in protecting others, especially groups at risk for developing influenza-related complications. Such campaigns, including those that explain the importance of vaccination in the context of protecting one’s friends and family members, may be one of the most effective ways to reach the public.

The results of this study indicate that there may be a need to message specific populations, including those with a low education status, low socioeconomic status, and unemployed individuals. In addition to messaging, there might be other audience-specific intervention strategies that need to be further studied. Previous studies have shown that individuals have cited transportation, cost of vaccination, and lost wages as reasons why they chose not to vaccinate. While this study was able to show associations between vaccination rates and socioeconomic status, further studies must be done to elucidate underlying factors that serve as barriers to certain populations’ decisions to vaccinate. Further studies must also be done to assess the role
that the influenza vaccination plays in reducing disease outbreak, potentially at a city or county level.
### Chapter 6: Appendix A

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<thead>
<tr>
<th>Demographic Factor</th>
<th>2009-2010</th>
<th>2010-2011</th>
<th>2011-2012</th>
<th>2012-2013</th>
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<td>0.228</td>
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<tr>
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<td>0.036</td>
<td>-0.228</td>
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<td>Management, Business, or Professional</td>
<td>0.226</td>
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<td>Production, Transportation</td>
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<td>Socio-economic Status</td>
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<tr>
<td>Median Income</td>
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<td>0.209</td>
<td>0.141</td>
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<td>Median Family Income</td>
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<td>0.022</td>
<td>0.301</td>
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<td>Female Household Family, No Spouse</td>
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<td>Poverty All Families</td>
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<td>0.070</td>
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<td>Demographic Factor</td>
<td>2009-2010</td>
<td>2010-2011</td>
<td>2011-2012</td>
<td>2012-2013</td>
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<td>R</td>
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<td>Poverty All People</td>
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<td>With Private Insurance</td>
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<td>0.463</td>
<td>0.001</td>
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<td>With Public Insurance</td>
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<td>0.078</td>
<td>0.117</td>
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References


Chickenpox. (n.d.). Retrieved February 6, 2017, from Vaccines.gov website:
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http://dx.doi.org/10.1111/j.1750-2659.2012.00374.x

http://dx.doi.org/10.1136/adc.2009.168856


http://dx.doi.org/10.1371/journal.pmed.1001558


Academic Vita of Naseem Zomorodi

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Education
The Pennsylvania State University, Middletown, PA

Bachelor of Science: Life Science
Expected Graduation: May 2017
Schreyer Honors College
Deans List: Fall 2013-Present
Thesis: An Analysis of the Association Between Influenza Vaccination Coverage and Disease Outbreak Across Demographic Factors in the United States
Thesis Supervisor: Shirley Clark

Research and Presentations

Research Intern, Milton S. Hershey Medical Center
June 2014-Present
- Currently conducting orthopaedic research on the pathomechanisms involved in chronic rotator cuff injury
- Conducted microbiological/immunological research towards the development of a cancer vaccination
- Accepted into INTREPID, a two year summer research program through the National Institute of Health

Poster Presentation, Orthopaedic Research Society’s Annual Meeting
March 2017
- Presented “Role of Transplanted Bone Marrow Cells in Development of Fatty Degeneration of Rotator Cuff Muscles Following Chronic Rotator Cuff Tear” in San Diego, CA

Research Associate, Emergency Medical Research Associate Program
Spring 2016
- Shadowed doctors in the Emergency Room at the Hershey Medical Center while pre-screening patients for their eligibility in various research studies

Oral Presentation, West Coast Biological Sciences Undergraduate Research Conference
April 2015
- Presented “CD8+ T Cell Activation with Minimal Epitopes from the SV40 T Antigen” in San Diego, CA

Presenter, Summer Undergraduate Research Poster Symposium
August 2014, 2015
- Selected to give an oral presentation in 2014 and presented a poster in 2015 at the Hershey Medical Center

Work Experience

Tutor, Russell E. Horn Sr. Learning Center, Penn State Harrisburg
Supervisor: Janice Smith
August 2014-Present
- College Reading and Learning Association Level 1 certified tutor
- Tutor peers individually and in small groups in inorganic chemistry, organic chemistry, and biology

Peer Leader, School of Science, Engineering, and Technology, Penn State Harrisburg
2014-2016
Supervisor: Thomas Eberlein
- Assisted chemistry and biology professors in running lectures
- Aided in distributing, collecting, and organizing course materials
- Acted as a resource to students by answering questions and providing guidance during interactive class periods

Activities and Leadership
Peru Service-Learning Program through the Schreyer Honors College
January 2017-Present
- Enrolled in a service-learning course involving a trip to Peru
- Learned about cross-cultural understanding in three different Peruvian contexts
- Engaged with experts while traveling around ecologically and culturally diverse regions of Peru
- Currently creating a service-learning project to develop a framework to increase messaging to Peruvian natives about the dangers of mercury pollution as it relates to illegal gold mining operations
**Ambassador, Global Ambassadors**  August 2016-Present
- Invited to be an ambassador after serving as a Global Lion Mentor
- Promote multiculturalism by organizing large cultural events on campus and volunteering in the community

**President, STEM Club**  2015-2016
**Vice President**  2014-2015
- Coordinated weekly meetings with club members to discuss club matters
- Organized club activities, guest speakers, and community service opportunities

**Vice President, Lion Ambassadors**  2015-2016
**Morale Committee Chair**  2014-2015
- Led tours given to prospective students and visitors around the campus
- Aided in coordinating and executing community service projects
- Took part in the execution of large philanthropic events around campus, raising money for organizations such as THON and the Feel Your Boobies Foundation

**Mentor, Global Lion Mentors**  August 2014-April 2016
- Served as a mentor to first year international students at Penn State Harrisburg to ease their transition to America
- Served as an Orientation Leader during the International Student Orientation

**Mentee, Bridge Mentorship Program**  August 2015-April 2016
- Accepted into a pre-medicine mentorship program conducted by medical students at the Hershey Medical Center
- Attended seminars conducted by doctors and learned about various medical specialties

**Community Liaison, Student Government Association**  August 2014-April 2015
- Served on the SGA executive board and as a Penn State representative at Middletown Borough Council Meetings
- Planned and organized community service opportunities for the student body
- Featured on the front page of the local newspaper for community outreach efforts

**Student Moderator, Schools Application at Penn State Harrisburg**  August 2014-August 2015
- Assisted with the launch of an admissions phone application in 2014
- Served as a resource to prospective students by answering questions and providing general information

**Member of Leadership Team, SAF Crowdfunding Campaign**  2014-2015
- Created and shared a profile for a campaign to raise money for the Student Assistance Fund, which provides monetary aid to students in need at Penn State Harrisburg

**Penn State University Leadership Conference**  August 2014

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**Honors, Awards, and Grants**

**STEM Scholar**, National Science Foundation  Fall 2013-Present

**Outstanding Science Student Award**, Penn State Harrisburg  2017

**Schreyer International Study Scholarship**, Schreyer Honors College  2017

**Honors International Travel Grant**, Penn State Harrisburg  2017

**Hartzler Travel Award**, Penn State Harrisburg  2017

**International Office Study Tour Travel Award**, Penn State Harrisburg  2017

**Evan Pugh Scholar Award**, Pennsylvania State University  2016, 2017

**Excellence in Honors Award**, Honors Program at Penn State Harrisburg  2016

**Penn State Harrisburg Alumni Society Award**  2015

**President Sparks Award**, Pennsylvania State University  2015

**JoAnn Day Student of the Year Award Nominee**, PennAce  2015

**Freshman President’s Award**, Pennsylvania State University  2014