2015

The Role of Religious Vaccination Exemptions in the Ocean County, New Jersey Pertussis Outbreak

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Walden University
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BS, Rutgers University, 1998

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

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Abstract

Pertussis, also known as whooping cough, is a vaccine-preventable disease that is on the rise in the United States, a trend which has been attributed to vaccination exemption. Indeed, the pertussis outbreak that occurred in February, 2012 in Ocean County, New Jersey was associated with vaccine exemption. Considering that pertussis is deadly to young children, it is important to understand why this disease rate is on the rise. The research questions were focused on whether a relationship existed between pertussis status (no, yes) and exemption status (no, yes), sex (male, female), and county type (Middlesex, Ocean, or Other), using a theoretical foundation of eco-social theory. The methodology used in the study was a retrospective case-control design. Archival data were collected on residents of Ocean County New Jersey; Middlesex County, New Jersey; and New Jersey as a whole using nonprobability purposive sampling (n = 63,000). A power analysis was conducted for sample size and chi square test of association was performed for data analysis. The results supported the hypotheses that a significant difference existed in the prevalence of pertussis between Ocean County, Middlesex County, and all other counties in New Jersey. The data showed that the odds of being afflicted with pertussis for those residents of Ocean County was greater than it was for those residents living in other counties in New Jersey, though sex was not found to be a significant variable. This study can promote social change by providing public health officials important knowledge about the nature of the outbreak, supporting public health practices designed for the population at risk. Resource allocation can be more specifically targeted to enhance disease reduction by creating programs designed to populations presenting the greatest risk of disease spread.

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Dedication

This dissertation is dedicated to my loving family. You have been with me through every part of this crazy journey. Your support and encouragement has been a beacon in the night.

To the Mighty Quinn and Lorelei the Magnificent: Thank you for all of your love and patience. You inspire me every day. You are pure magic.

To my loving husband: Thank you for all of your encouragement and support. You are where all my journeys end. Without you nothing in this life is possible.

To all of my friends and family: Thank you for your understanding in this crazy life. Every one of you is with me always.

Acknowledgments

I would like to offer my sincere thanks and gratitude to my chair person, Dr. John Nemecek, my committee member, Dr, Eric Oestmann, and my university reviewer, Dr. Michael Dunn, for all of your wisdom, guidance, and support through this process. I am grateful for having the chance to work with such a talented team.

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Chapter 1: Introduction to the Study

Introduction

Most school districts across the United States require children to show proof of vaccination against this disease and others before that child can attend school. However, there is a growing number of parents who are fighting against this vaccination and others like it; parents are frequently basing that fight off of their religious beliefs. They have cited various laws and exemptions in order to have their children attend school even though those children have not received the vaccinations that are required by law (Heininger, 2010). Pertussis, also known as whooping cough, is one of many diseases that have a vaccine (Bettiol et al., 2012). The concern is two-fold; the student may be in danger if he or she catches a disease, and the student may also spread that disease to others more easily (Klein, Jedlicka, & Pekosz, 2010; Lavelle, 2009). The outbreak of the disease occurred in Ocean County, New Jersey in 2012; whether exemptions were a contributing factor in the outbreak was the focus of this study. In this study, I examined the role of religious vaccine exemption on the pertussis outbreak in New Jersey in 2012. Understanding why the outbreak occurred would allow public health professionals to create initiatives targeted to at risk populations reducing pertussis rates and therefore promote social change. The purpose of the study, as well as the theoretical framework, and assumptions and limitations of the study are discussed in Chapter 1.

Background

Although vaccines can save lives, not all parents vaccinate their children. Many parents claim religious beliefs to avoid vaccination of their children. Such vaccination

exemptions are available in most states (Centers for Disease Control and Prevention [CDC], 2015). Even though such exemptions are available, the exemptions may be causing severe public health implications.

Vaccines significantly reduce the risk of disease. In a study conducted by Abrevaya and Mulligan (2011), longitudinal data on the use of varicella immunizations was used to determine the real effects of immunization requirements mandated by various governmental entities within the United States. Significant increases in vaccination rates were found to be the result of such mandates within the first year of adoption, peaking within two years of adoption, and with minimal effects on the rate thereafter (Abrevaya & Mulligan, 2011). Approximately 20% of increases in immunization adoption are attributed to mandates, and no differences were found in different socioeconomic groups when it comes to adoption rates (Abrevaya & Mulligan, 2011).

In a population-based retrospective cohort study, Feikin et al. (2000) examined all reported cases of measles and pertussis among children ages three to 18 in the state of Colorado. The authors found a 22.2 times greater likelihood of measles acquisition and a 5.9 times greater likelihood of pertussis acquisition amongst children exempted from vaccination due to religious exemption or philosophical reasons. Schools with outbreaks of these diseases also had higher numbers of religious/philosophical exempted students, and at least 11% of vaccinated children who acquired measles became infected through contact with an exempted child (Feikin et al., 2000). Feikin's research provides clear and concrete data for use in discussing the effects of religious exemption.

In another study, researchers found that states offering personal belief and other non-medical exemptions saw higher exemption rates from vaccines than states with religious only exemptions, as did states with easier exemption processes (Omer, Pan, Halsey, Stokley, & Salmon 2006). In both scenarios, incidence of pertussis was closely associated with the ease of obtaining exemptions and the availability of non-religious exemptions, and also correlated with actual exemption rates—the higher the rate of exemption, the greater the incidence of pertussis. While these results are largely expected, they are also more detailed than many and serve as highly important affirmations of the empirical evidence for the effects of religious and non-religious exemptions to mandated vaccinations.

In a 7-year, population-based retrospective cohort study of individuals aged 5-19, a mathematical model was developed to examine risks associated with measles vaccination, exemption, and infection, and to determine if other patterns could be observed (Salmon et al., 1999). Exemptors were determined to be 35 times more likely to contract measles than those that had been vaccinated, and populations of exemptors tended to be found within certain geographic pockets of close proximity, which contributed to outbreak behavior. The model also suggested that a large-scale outbreak was experienced in exemptor populations one year earlier than in the broader population; this has direct implications on the effects of religious exemptions on overall public health and safety (Salmon et al., 1999).

Such evidence is present after examining four outbreaks of pertussis in Massachusetts that were in close temporal proximity. It was concluded that religious and

philosophical exemptions among the populations of children involved in the outbreak was a primary contributing factor (Etkind, Lett, Macdonald, Silva, & Peppe, 1992). The religious and/or philosophical beliefs of many parents and children in these populations extended to a resistance toward the use of antibiotic prophylaxis or therapy as well, which also contributed to the growth and severity of the outbreak (Etkind et al., 1992).

Studies as to what contributed to the pertussis outbreak that occurred in Ocean County, New Jersey were not conducted. This creates a gap in the knowledge base as to why the outbreak occurred. Understanding why the outbreak occurred helps public health officials design strategic health initiatives to reduce pertussis outbreaks.

When a large percentage of the population is vaccinated, herd immunity is achieved. Unfortunately, herd immunity failed in the above noted instance. Understanding why herd immunity failed will allow health professionals to address such issues and adjust policy accordingly. As previously mentioned, Lakewood, New Jersey has a large Hasidic community where cultural norms in the community may have contributed to the outbreak.

Problem Statement

Outbreaks of a childhood disease known as pertussis (whooping cough) still occur throughout the United States, despite decades of immunizing children for this disease. A contributing factor to these outbreaks could potentially be exemptions based on religious views (Salmon et al., 1999). The most effective preventative measure against this illness is a pertussis vaccine, administered in one of several combination vaccines that contain

pertussis components. However, parents opting out of immunizing their children for Pertussis may be putting other children, and adults, at risk.

In February 2012, an outbreak of pertussis occurred in Ocean County New Jersey. There were 14 reported cases, all children under the age of five. The primary location of the outbreak was in the city of Lakewood, New Jersey (Nee & Brashir, 2012). No research has been conducted investigating potential factors that may have contributed to this outbreak, or outbreaks that possibly occurred in surrounding counties. Further investigations of outbreaks such as this, need to be conducted to explore why they continue to occur, despite our immunization efforts, and whether or not religion, or sex (male, female) is considered a factor.

Purpose of the Study

Outbreaks of a childhood disease known as pertussis (whooping cough) still occur throughout the United States despite decades of immunizing children for this disease. A contributing factor to these outbreaks may be religious exemptions. The purpose of this quantitative study was to examine the role of religious vaccination exemption in a pertussis outbreak in New Jersey

In February of 2012, an outbreak of pertussis occurred in Ocean County, New Jersey. There were 14 reported cases, all children under the age of five. The primary location of the outbreak was in the city of Lakewood, New Jersey (Nee & Brashir, 2012). Cultural norms in the community may have contributed to the outbreak, as Lakewood, New Jersey has a large Hasidic community. Further investigations of outbreaks like this need to be conducted to explore why they continue to occur, despite our immunization

efforts. The method of design was quantitative in nature. An investigation into whether a correlation exists between pertussis status, and exemption status (no, yes), county type (Ocean, Middlesex, Other), and sex (male, female) was conducted.

Research Questions and Hypotheses

Six research questions were used in the study to determine if relationship existed between pertussis status and exemption status, county type, and sex. Each research question is presented with its accompanying null hypothesis.

Research Question 1: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Middlesex, Other)?

$H1_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Middlesex, Other).

Research Question 2: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Other)?

$H2_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Other).

Research Question 3: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Middlesex)?

$H3_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Middlesex).

Research Question 4: What is the difference in pertussis outbreak between county type, (Ocean, Other)?

$H4_0$: There is no difference in pertussis outbreak between county type, (Ocean, Other).

Research Question 5: What is the difference in Pertussis outbreak between county type, (Middlesex, Other)?

$H5_0$: There is no difference in pertussis outbreak between county type, (Middlesex, Other).

Research Question 6: What is the difference in Pertussis outbreak between county type, (Middlesex, Ocean)?

$H6_0$: There is no difference in pertussis outbreak between county type, (Middlesex, Ocean).

Theoretical Framework

The ecological-social theory was used as framework in this study. Ecological-social theory integrates social and biological reasoning into the spread of infectious diseases. This theory incorporates social norms and inequalities into exploration into how disease is spread (Kreiger, 2004.) By using the ecological-social theory, the goal of the study was to understand how the social norms of the population understudy affect the spread of the infectious disease.

Vaccination adherence rates across the United States have been declining rather than increasing. For example, pertussis or whooping cough, once largely thought to have been controlled, and or inactive, is now making a comeback. Despite the fact the pertussis is a vaccine preventable disease, pertussis incidence is on the rise (Rivard & Viera 2014). Outbreaks of pertussis have been observed in religious communities that

are adverse to vaccinations (Matthias et al., 2014). Fears surrounding vaccines can create a culture of noncompliance (Salmon et al., 1999). Such a culture will be further discussed in Chapter 2. Understanding such a culture can help health officials combat such processes thus promoting future compliance for vaccination.

In terms of dealing with vaccine resistance for sociological reasons, the most difficult and dangerous obstacle is that of fear. While religious objectors will always exist, these pose a relatively small risk, given that they are confined to minority sects and are spread over a large geographic area allowing for herd immunity to stay intact (Salmon et al., 1999). Yet when you have a minority sect in a small geographic area that sect can pose a risk by increasing the proximity and quantity of non-vaccinators to those who are at risk for the disease. This can promote the spread of a communicable disease and decrease herd immunity. However, fear and distrust in vaccination is growing (Salmon et al., 1999). As it grows, so do fears about vaccines, noncompliance, and the spread of illnesses that were thought to have been cured.

Utilizing the ecological-social theory to understand vaccination noncompliance within the studied population it was anticipated the study would find that a relationship does exist between pertussis status and exemption status based on county type. Another anticipated finding was that a relationship does not exist between pertussis status and exemption status based on sex. Such findings allow public health administrators to create programs and initiatives to increase vaccine adherence in desired populations.

Nature of the Study

The nature of the study was a quantitative research design. I chose this design since comparisons between pertussis rates in the geographical area of Ocean County, New Jersey were compared to the pertussis rates of Middlesex County, another county with a large Hasidic population, and other counties in New Jersey. In addition, I investigated whether there was a correlation between the variables pertussis status and exemption status and sex.

In this study, I used data that were generated based on a retrospective cohort study of pertussis cases in the geographic area of Ocean County, New Jersey, as well as surrounding counties, during January 2012 and March 2012. Data were retrieved from the Ocean County Health Department through the Open Records Request Act. Data included immunization records of case participants. Names of case participants were redacted by Ocean County Health Department prior to being obtained for data collection. A data user agreement is included in Appendix A of the study.

Definitions

Cases were defined according to criteria set by the CDC as a cough illness lasting at least two weeks with one of the following: paroxysms of coughing, inspiratory *whoop*, or posttussive vomiting; and without other apparent cause. Probable cases were defined as a case that meets the clinical case definition but does not have a positive laboratory confirmation and is not epidemiologically linked to a laboratory confirmed case. Confirmed cases were defined as: (a) a case of acute coughing for any duration with a positive culture of B pertussis, (b) a case which is confirmed by positive polymerase

chain reaction assay for B pertussis DNA, or (c) a case that meets clinical definitions and has a direct epidemiological link to a confirmed case. The independent variable was pertussis status with the dependent variables being sex, exemption status, and county type.

Herd immunity. Herd immunity is a situation in which a sufficient proportion of a population is immune to an infectious disease (through vaccination and/or prior illness) to make its spread from person to person unlikely. Even individuals not vaccinated (such as newborns and those with chronic illnesses) are offered some protection because the disease has little opportunity to spread within the community. Also known as community immunity (CDC, 2012).

Outbreak. Outbreak is defined as a sudden appearance of a disease in a specific geographic area (e.g. neighborhood or community) or population (e.g., adolescents) (CDC, 2012).

Pertussis. Pertussis is also known as whooping cough. Pertussis is a bacterial infectious disease marked by a convulsive spasmodic cough, sometimes followed by a crowing intake of breath (CDC, 2012).

Assumptions

In this study, I assumed all archived participant information to be accurate. Because all participation was anonymous, it was assumed that all questions were answered honestly to the best of the participants' ability. Purposive sampling was used for the study. This procedure allowed quick identification of a targeted sample. It was

also be assumed the sample would be representative of the target population. Since the data used were secondary, data collection of archival data was assumed accurate.

Scope and Delimitations

An outbreak of pertussis occurred in a small geographic region of New Jersey. Pertussis is a vaccine preventable disease. The role of religious vaccine exemptions during this specific outbreak was studied. Gaining an understanding into the development of such an outbreak will allow lawmakers and health officials to develop new protocols and legislations to help prevent future populations from such outbreaks. The populations studied included case studies occurring in Ocean County, New Jersey. Other populations included the counties of Ocean, Middlesex County and surrounding counties in New Jersey. The population only included New Jersey populations. All information collected for the study was managed by representatives trained by the New Jersey State Health Department. Therefore, it was assumed that information entered into the system was accurate and therefore limited possible bias that could influence outcomes. Several theories that were not investigated for this study may play a role in the outbreak include localization to exposure and genetic susceptibility. Understanding why the outbreak occurred would allow public health officials to devise public health initiatives to increase vaccination adherence in designated populations reducing pertussis outbreaks as well as outbreaks for other vaccine preventable diseases. Participant characteristics were narrow, and therefore generalizations for future occurrences may be difficult to presume.

Limitations

I identified threats to internal validity. Such threats included accuracy of the medical history of participants and participant selection. Since participant selection was based on a specific geographic area, the representation of the participant group may not appropriately represent the desired group. External validity threats included selection and treatment interactions, as well as the history and treatment interactions. Participants may not have answered all data questions completely and honestly, which may limit the study. Since the study had a definitive start and end time, inaccuracies may occur for generalizing past and future occurrences. Biases due to religious beliefs could influence the study. Therefore questions of the religion of participants were not used in the study negating possible religious bias. Since the secondary data was inputted by individuals trained by the New Jersey State Health Department and Centers of Disease Control, medical histories and data questions should be considered accurate.

Significance

Pertussis is a highly contagious respiratory infection that is caused by *Bordetella Pertussis*. During 2012, more than 23,000 cases were reported across the US, including 13 deaths (CDC, 2012). Babies are most affected, and suffer from this disease gravely, with more than half of infants younger than one year of age, having to be hospitalized. Statistically, approximately 1 in 4 infants who contract pertussis end up with pneumonia, and as many as two thirds will have slowed or stopped breathing during their illness. Pertussis has been reported to kill 1-2 infants per 100 who are hospitalized (CDC, 2012). Determining if exemptions have been a direct effect of the outbreak of Pertussis provides

desired information to parents across the world who hesitate to vaccinate their child or their children due to religious reasons, or other reasons for that matter. The addition of this contribution of knowledge advances the field of Public health by providing a broader understanding of which populations to target with public health initiatives to increase vaccination adherence.

Identifying target populations with low vaccine adherence provides public health officials with valuable information to develop policies and initiatives specific to identified populations targeted at increasing vaccination adherence for pertussis and other vaccine preventable diseases. Targeting specific populations with low vaccine adherence allows for more effect allocation of funding to better address the needs of populations contributing to social change by increasing the health of such populations.

Summary

Parents who seek out and are granted religious exemptions from vaccination for their children may adversely affect prevention of pertussis, also known as whooping cough, in young children. When exemptions are granted, other children as well as adolescents and adults, may be exposed needlessly to Pertussis disease that might otherwise be avoided. The purpose of this study was to explore whether or not there was any impact on the occurrence of pertussis as influenced by those who were granted a religious exemption and those who were not, as well as between county type and sex. In chapter 2, a literature review is presented. The review will consist of literature review search strategies, the theoretical foundation, literature review based on key variables, as well as a summary and conclusions.

Chapter 2: Literature Review

Introduction

The focus of this study was an outbreak of pertussis in a small geographic area of New Jersey in 2012. Lack of vaccination may have contributed to the outbreak. Increases in outbreaks such as pertussis are on the rise in the United States. Even though pertussis is a vaccine preventable disease, pertussis incidence is on the rise (Rivard & Viera, 2014). Multiple outbreaks of pertussis have been observed in religious communities that are adverse to vaccinations (Matthias et al., 2014). In Chapter 2, the literature review will be discussed. Major sections include of literature review search strategies, the theoretical foundation, literature review based on key variables, as well as a summary and conclusions. .

Literature Search Strategy

Key search engines and databases used for the review included Medline, Academic Search Complete, CINAHL, and PubMed. Search terms used included *vaccination exemption, disease outbreak*, and *pertussis*. The literature review scope included research for two years from 2012 through 2014 and included sources such as peer reviewed medical and public health journals. Newspaper articles citing possible outbreaks throughout the United States were also used.

Theoretical Foundation

The theory that I used during the process of this study was the ecological social theory (Kreiger, 2004). The ecological social theory is a theory developed by Urie Bronfenbronner. Bronfenbronner (YEAR) showed how a person's development and

belief system is based on environmental factors or systems. The first system is the person's family, also known as a microsystem (Kreiger, 2004). The second system that influences the person's beliefs is the mesosystem (Kreiger, 2004). The mesosystem consists of an organization that helps control the environment of that person (Kreiger, 2004). The next is the exosystem or external system that helps control the environment of the person (Kreiger, 2004). An example of such a system is the community the person lives in (Kreiger, 2004).

Conscientious objectors to mandatory vaccination have been found to reduce herd immunity placing the public at large in danger of contracting vaccine preventable diseases (Siegel & Salmon, 2001). The use of ecological social theory has been applied to conscientious objectors as to understanding why such persons would not want to vaccinate (Siegel & Salmon, 2001). In trying to protect the religious freedoms, some states have established extremely broad religious exemption regulations that can place the public health at risk. Such circumstance allow for a large number of individuals to receive religious exemptions that decrease the number of individuals receiving vaccinations and therefore reduces herd immunity ("Religion's Hepatitis B shot," 2009).

The ecological social theory explains how a population such as a Hasidic population would not vaccinate their children even though the medical community has proven that vaccination is a safe and effective way of preventing diseases such as pertussis. The theory explains that a person's belief system is shaped first by the family, then by an organization such as a religion, then by the community of that person. If someone was born and raised in a religious family, and lives in a religious community the

person would maintain the same beliefs of that community (Kreiger 2004). Applying that theory to the study would suggest that a Hasidic community does not believe in vaccination than a person who was raised and lived in that community would also not believe in vaccination and therefore would not vaccinate their child.

Literature Review Related to Key Variables and Concepts

Religious exemptions have been a major cause of small outbreaks after a certain disease had been thought to be eradicated. There have been numerous reported examples all over the world. In 1982, there was a report of a 9-year-old girl who was not immunized and developed symptoms of an infectious disease. The girl developed a sore throat and listlessness at a religious camp in Colorado that did not approve of vaccinations. The girl was traveling back to her city with other children and adults who were not vaccinated as well. The girl's symptoms worsened and all routine tests were done. When admitted into the hospital, the girl was reported to have airway obstruction, cervical adenopathy, bleeding from gums and nose, and swelling. The course of treatment got more complex when the girl developed confusion and cardiac conduction abnormality. She passed away approximately two weeks after the first sign of symptoms. The throat culture of the girl revealed that she was infected by a very toxic strain of C. diphtheria (Morbidity and Mortality Weekly Report, 1982).

This case created a lot of unrest considering the amount of students and employees at the camp who were exposed to the girl. Cultures were taken from the 218 contacts, producing negative results from all cultures. Natural immunity may have protected those exposed from developing the disease. Flaws in the study included the lack

of understanding as to why others at the camp did not develop the disease (Morbidity and Mortality Weekly Report, 1982).

In the 1990's epidemiologists and public health officials believed people would not be against vaccines, but still, there were reported cases of tetanus even in years after 2000. Even in the 21st century, there were 11 reported children who developed tetanus (Fair et al., 2002). Children receive tetanus vaccines through the DTP or DTaP vaccine. These outbreaks were also because the children had not received immunizations because of religious exemptions (Fair, Murphy, Golaz, & Whartoon, 2002). Out of all the cases reviewed in the studies, the children who attained the disease were less than 15 years of age.

Even though there were no deaths, eight of the children who got tetanus required ventilation. This demonstrates the severity of the infection. Eighty percent of the children who contracted tetanus were unprotected due to not being vaccinated (Fair et al., 2002). The study failed to address possibilities as to why children who were vaccinated still developed the disease.

The eradication of the polio virus has been the top most agenda for numerous health organizations because the vaccine created against the polio vaccine has been highly successful. As laboratories work to identify new strains, this disease can be fully eradicated. A major reason why polio eradication is ideal is because of how fast it spreads and how the cases multiply every year (Zarocostas, 2006). As previously mentioned, Pakistan, India, Afghanistan, and Nigeria are the only four nations where the polio epidemic still causes damage to many children. The chairman of Advisory

Committee on Polio Eradication (ACPE) noted that it is important to remove polio from these regions because, if the disease remains, there could be an increase of a quarter million new cases every year around the world (Zarocostas, 2006).

There is a high threat of polio affecting people in other countries as well. According to the World Health Organization, there has been a tenfold increase in India's incidence from the previous year's rates, and a two fold increase in Nigeria (Zarocostas, 2006). The eradication of the disease depends on the politics of the area and the supply of the vaccines. Those who view vaccination against their religion can cause herd immunity to fail by creating a reservoir for the disease to spread.

In 1972, there was a recorded outbreak of polio at Daycrof, a boarding school of Christian Science in Greenwich, Connecticut (Foote, Kraus, Andrews, & Hart, 1973). Out of this outbreak, 11 children had some sort of paralysis due to contracting the disease. Twenty days after the first child became infected, health officials discovered that the disease was polio. Other students were later sent home because they did not feel well. Once the one child contracted polio, the disease spread to other children. It should be noted that, out of the 11 cases of polio, 10 of the children were not vaccinated against the disease. Similar to this outbreak, an Amish population in Pennsylvania, Wisconsin, Missouri, and Iowa had a total of 14 outbreaks of polio in 1979 (Morbidity and Mortality Weekly Report, 1997).

Polio is a disease that stayed in the United States merely because of the outbreaks of those who objected to vaccines because of their religion (Morrison & Embil, 1987). In 1978, there was an outbreak of polio in Holland. There were 110 cases diagnosed, and all

of the people belonged to a protestant sect that was completely against vaccines. When the members of this group travelled to Canada, they spread it to Canadians. In the same year, there were six cases of polio in Ontario, one case in Alberta, and two cases in British Columbia (Furesz, 1979). A year later, 13 more cases appeared in the United States, linked to a Canadian family from that religious group who had travelled to Pennsylvania (Van Wezel, 1979). Thus, polio spread between populations who had not taken the vaccines; the disease was shown to spread from Holland to Canada, and then to America. Failure to vaccinate due to religious beliefs may have resulted in or contributed to the spread of the disease.

In 2005 during an Amish gathering in Minnesota, five cases of polio among unvaccinated children were reported (Gardiner, 2005). Out of the five children who contracted polio, one girl was immunocompromised. This case resulted in death. Gardiner (2005) stated that groups of people who have not been vaccinated because of their own beliefs pose a great threat to the community. The vaccine that is present in many countries is actually a weakened or attenuated sort of the virus (Gardiner, 2005). This type of attenuated vaccine is available for polio and will give immunity to the people who are vaccinated and others that are in close vicinity to the person. However, a virus can mutate and become less susceptible to the vaccination. The genes of the virus can alter and become even more virulent, resulting in a more aggressive infection. This type of outbreak was seen when a strain of poliovirus left 21 people paralyzed in Dominican Republic and Haiti in 2000 and 2001 (Gardiner, 2005).

Prior to the invention of the measles vaccine in 1963, there were half a million cases of measles recorded every year in the United States. Of these cases, there were approximately 500 deaths each year because of measles (Novotny, Jennings, & Doran, 1988). Subsequent to the vaccination program, there has now been a 70% reduction in the quantity of cases since 1978. Also, there has been a 99% drop in the cases reported from when vaccination to the disease did not exist (CDC, 1985).

The reason persons with religious exemptions pose a threat is because they are spread out in different areas. The people in these areas can become vectors of transmission for this disease in such areas at any given time (CDC, 1985). People who cannot receive vaccination due to medical reasons, people that do not have full vaccination, and people who the vaccine is ineffective are then at risk for developing the disease. Of the 2813 cases reported in 1985, 90% of the cases occurred in persons who were religiously exempt (CDC, 1985).

Multiple outbreaks of measles occurred in 1985. One such outbreak occurred when a non-vaccinated individual vacationed in Alaska and contracted the disease. The individual returned from vacation and infected others in the school they attended. This eventually led to 125 cases of the disease out of 714 students. One hundred and twenty-one staff and family members were also affected. Three of the cases ended in death (Novotny et al., 1988).

In 2004, there were three cases of measles in Iowa. This occurred because of two Maharishi children, who were not vaccinated due to their beliefs. The most interesting thing to note is that the third case of measles occurred in a vaccinated adult (Dayan,

Ortega-Sanchez, LeBaron, Quinlisk, & Iowa Measles Response Team, 2005). Thus, the theory of the pathogen getting more virulent can be supported by this case. There are very few people who remember their booster doses. It is possible that this individual had not received his boosters, or his immune system was weakened. Nevertheless, he contracted measles despite being vaccinated.

There were four documented outbreaks of pertussis in Massachusetts in 1992. In all four outbreaks, individuals who were infected with the virus had obtained religious exemptions from their day care or schools to not be vaccinated (Etkind et al., 1992). These children and adults also refused to take any preventive antibiotic therapy or course of treatment. A major reason they contracted the disease was because they were not vaccinated (Etkind et al., 1992). Felik et al. (2000) revealed that non-vaccinated children between the ages of three and 18 were about six times more likely to be affected by pertussis than those who were vaccinated.

Pertussis, or whooping cough, is one of many diseases for which there is a vaccine (CDC, 2012). Most school districts across the United States require children to show proof of vaccination against this disease before school enrollment. However, there are a growing number of parents who are fighting the vaccination requirement and citing religious exemptions to avoid such requirements. The parents cite various laws and exemptions to have their children continue to attend school even though those children have not received the vaccinations that are required by law (Heininger, 2010). There are two concerns: the student may be in danger if he or she catches a disease, and the student may also spread that disease to others more easily (Klein et al., 2010; Lavelle, 2009).

Some parents who do not vaccinate out of fear for vaccination health risks may use religious exemption laws as a loophole for non-vaccination. Such fears are a result of studies that have shown that vaccinations may be linked to autism and other health problems (Bettiol et al., 2012). Even though such exemptions are available, the exemptions may be causing severe public health implications.

Pertussis is highly contagious and bacterial in nature (Cornia, Hersh, Lipsky, Newman, & Gonzales, 2010). Caused by Bordetella pertussis, some countries call the disease the cough of 100 days, or 100 days' cough, since its symptoms last so long in people, especially in children, who contract it (Zhang, Prietsch, Axelsson, & Halperin, 2012). Generally, the first symptoms are mild. The cough is present, but it is no more serious than a standard cough that would come with a cold or other respiratory issue. Eventually, pertussis develops to the point where the infected person has coughing fits. These fits produce the “whoop” sound that babies often make when they are infected by the disease (Zhang et al., 2012). The sound comes from the baby or child attempting to inhale enough air in between coughs; those who contract pertussis will cough like this for around six weeks before the disease finally runs its course (Bettiol et al., 2012).

Because of the disease’s severe symptoms in children, vaccination is deemed highly important; it is the easiest and best way for parents to protect their children and prevent the disease from spreading to others. There are treatments available for pertussis, usually in the form of antibiotics (Falco, 2010). Antibiotics cannot decrease the strength or severity of the symptoms, but they can assist in shortening the duration of symptoms. They also help the person to be less contagious and shorten the infectious period both of

which are very significant for the person and for people around him or her (Klein et al., 2010). When the actual infectious period can be shortened, that clearly offers a significant benefit to the general public.

Currently, 48.5 million people each year are affected by whooping cough, and nearly 300,000 people die from it (CDC, 2011). Despite these high numbers, those who use religious grounds as their reason for not vaccinating their children feel that the vaccine is more detrimental than the actual disease (Rong-Gong, 2010); this is disputed by doctors and medical professionals, the majority of whom feel that vaccinations save lives and help protect the population (Bettiol et al., 2012). Some people feel as though "just a cough" is not very serious, but pertussis can cause other problems for those who contract the disease.

For example, the cough is often severe enough to cause vomiting after the coughing fit has subsided, or sometimes during the fit. The combination of coughing, vomiting, and trying to inhale enough air to breathe can cause aspiration of the vomited contents of the stomach, resulting in serious respiratory issues (Lavelle, 2009). Rib fractures have occurred after a coughing fit caused by pertussis, as have hernias, urinary incontinence, fainting, subconjunctival hemorrhages, and vertebral artery dissection (Zhang et al., 2012). There is a period of incubation before symptoms, so it may be difficult to determine where and from whom the pertussis was contracted, especially in an environment that supervises children (Bettiol et al., 2012; CDC, 2012).

In young children and babies, seven to ten days is normal for an incubation period (CDC, 2011). After that, mild symptoms like runny nose, sneezing, and a mild cough are

seen. Many people think that they or their child are catching a cold. After a week or two, the coughing develops into severe coughing fits that are characteristic of pertussis, and the strong cough coupled with the whooping sound or the child attempting to inhale air are classic symptoms that should not be ignored (Bettiol et al., 2012). Seeing a healthcare professional at that time can lower the duration of the disease and chances of infecting others.

Occasionally, the coughing fits occur on their own; however, can also be brought on by yawning, sneezing, laughing, or other events (Zhang et al., 2012). Multiple episodes of coughing are generally seen hourly, and the coughing lasts from two to eight weeks in most people, or even longer (Zhang et al., 2012). Gradually, it subsides into a lesser cough and a lack of vomiting (Zhang et al., 2012). Without any intervention, the cough will eventually fade away on its own, and the body will return to normal. However, antibiotics can make the symptom duration shorter, and vaccination can be used to ensure that the person does not contract pertussis at all, especially for young children, babies, and those who have compromised immune systems or other medical conditions.

The best way to avoid pertussis is to vaccinate children (including babies) and adults (Plotkin, Orenstein, & Offit, 2008). Antibiotics for those who have been exposed to the disease but have no symptoms are also an option, but there are mixed results on the effectiveness of this treatment method (Grammatikos, Mantadakis, & Falagas, 2009; Plotkin et al., 2008). Currently, there is insufficient evidence to make a determination of what can or should be done with that area of treatment. This treatment is still used in

some people who are very high risk, including those that have been exposed but do not appear to be sick (Plotkin et al., 2008). Most commonly, this is done with babies, because they can die if they contract the disease. The vomiting, which causes dehydration and other problems, is often the culprit in these types of pertussis deaths, but there can be other factors, as well.

The pertussis vaccine is considered to be safe and effective by the World Health Organization and the CDC (Plotkin et al., 2008). In 2002, more than 500,000 lives were saved by providing the pertussis vaccine to those who wanted to receive it and/or provide it for their children (Klein, Jedlicka, & Pekosz, 2010). The vaccine is considered to be 71% to 85% effective, and more effectiveness is generally seen when the disease is more severe (Plotkin et al., 2008). Those who are vaccinated are protected for 5-10 years, after which they will need to be vaccinated again if they want their protection to continue. Of course, the greatest exposure and death risk is during childhood, which is why it is recommended to vaccinate infants and very young children (Grammatikos et al., 2009; Klein, Jedlicka, & Pokosz, 2010). That way, the protection they receive from the vaccine will cover them through childhood and keep them safe.

The vaccine is generally given along with other vaccines during childhood. Between 12 and 18 months is a common time for these vaccinations, but many children are also vaccinated earlier than that. Some are vaccinated later (Plotkin et al., 2008). There are various reasons why the vaccination schedule varies, and one of those comes from parents taking time to do their research and decide if they want their children vaccinated for pertussis, or if they would prefer to avoid vaccination and the risks

associated with them. Another study by the CDC (2011) showed that pertussis protection might last three to six years, instead of the previously assumed seven to 10 years (Rettner, 2011). Most people do not get a booster after the age 12, but they should to prevent them from transmitting it to babies and children when they are adults (Plotkin et al., 2008).

There has been a great deal of controversy surrounding the pertussis vaccine. Most of that took place in the 1970s and 1980s, when it was believed that, in very rare cases, the whole-cell pertussis component of the vaccine could cause something called pertussis vaccine encephalopathy, a brain injury (Grammatikos et al., 2009). Despite the low possibility of that problem occurring, the majority of doctors still recommended that everyone should be vaccinated against pertussis. The risk of contracting the encephalopathy was one in 310,000. That would translate to around 50 cases in the 15 million people who would have been immunized each year during that time period (Klein, Jedlicka, & Pokosz, 2010). Even though that was still frightening, there were many more deaths from pertussis before the vaccine was offered. Thousands of Americans died each year, and the vaccine could help avoid all of that (Klein, Jedlicka, & Pokosz, 2010).

There were studies conducted to further investigate the possible correlation, but none of them showed any type of causal connection. Additionally, studies performed later showed zero correlation between the brain injuries that occurred and any component of the pertussis vaccine. Even though it was thought that the vaccine induced brain damage, the problem was actually infantile epilepsy, which was an unrelated condition

(Plotkin et al., 2008). Still, rumors continued. Eventually, the *Journal of the American Medical Association* published information in 1990 that called the correlation "nonsense" and a "myth" (Klein, Jedlicka, & Pokosz, 2010). There were never any studies published that proved or even showed any correlation between the pertussis vaccine and any type of injury to the brains of children or babies.

Before that point, however, there were many rumors and opinions that were related to the pertussis vaccine and the perceived chance of permanent brain damage. Anecdotal reports were published that dealt with the vaccine and the damage that it had allegedly done to children. That resulted in a large movement where parents did not want their children vaccinated with the diphtheria, pertussis, and tetanus vaccine DPT, the combination shot that carried the pertussis vaccine. This movement occurred in the 1970s and lasted into the 1980s (Plotkin et al., 2008); there was a great deal of fear-mongering and negative publicity about the vaccine during that time. The rate of immunization for babies and children began to fall in several countries. Predictably, that was followed by a large increase in the cases of pertussis in countries, including Great Britain and Japan (Grammatikos et al., 2009; Klein, Jedlicka, & Pokosz, 2010; Plotkin et al., 2008).

Many vaccine suppliers were completely pushed out of the market due to unscientific and unsubstantiated claims that were made against the pertussis vaccine (Plotkin et al., 2008). The United States was not immune to this, and many of the manufacturers of the vaccine had stopped producing it by the early 1980s because there were so many lawsuits brought by people who claimed their children had been affected

by the vaccine. Even though there was no actual evidence, many manufacturers filed for bankruptcy due to the obligation to pay many claims (Klein, Jedlicka, & Pokosz, 2010). Those who survived went on to make other vaccines they felt posed less risk to their reputation, their finances, and other aspects of their business.

The pertussis vaccine is still available, but now it is a different type, introduced in 1992, that is deemed to be safer and has shown fewer side effects (Plotkin et al., 2008). Still, there are many people who remember the scares of the 1970s and 1980s, and they refuse to vaccinate their children for pertussis because of the real and/or perceived risks of the vaccine. Overall, there are many vaccines that some people avoid for their children, even though the majority of people in the United States do still have their children vaccinated for pertussis and other childhood illnesses. There are few adverse events every year, but the risk of the disease is often much worse than any risk undertaken by giving the child the vaccine (Klein, Jedlicka, & Pokosz, 2010).

Vaccines reduce the risk of disease. Guadino and Robison (2012) noted record low numbers of vaccine-preventable diseases—evidence that vaccination programs are working—has led to a dearth of research regarding parent-claimed exemptions for religion and other reasons. They investigated parental attitudes in identified "exemptor pockets" in Oregon, and found a general distrust of local doctors and heightened concerns about vaccines, regardless of religious or philosophical reasons for selecting exemption (p. 1138). No correlation was suggested by the researchers; however, this provides interesting context for the larger discussion of religious exemptions and their relation to

other medical attitudes, decisions, and possible effects or correlations with exemption selection.

Studies show that vaccinations of common illnesses reduce the rate of infection. Mandates for vaccination exist in every state in the United States. A study conducted on middle school aged students in Florida showed 61.8% compliance for mandated vaccines during the first year of the mandate (Mooi et al., 2009). The same study also showed 36.9% of the population was missing one or more doses, but were in process to reach compliance.

While the mandates exist to protect public health, exemptions for religious reasons also exist. Unfortunately, protecting the freedoms of some may create a public health hazard for others. Populations depend on herd immunity to protect those who cannot be vaccinated. Herd immunity is defined as the number of individuals needed in a large group which are immune to a disease, disrupting disease transmission, resulting in self-contained, small outbreaks that will die out quickly (Shaka, 2011). New strains of pertussis with increased toxin production have been linked to the resurgence of pertussis worldwide. Such virulent strains may be linked to lessened herd immunity due to non-vaccination of certain groups (Mooi et al., 2009).

Longitudinal data on the use of varicella immunizations was used to determine the real effects of immunization requirements mandated by government entities within the United States. Significant increases in vaccination rates are found to be the result of such mandates within the first year of adoption, peaking within two years of adoption, and with minimal effects on the rate thereafter. Approximately 20% of short run increases in

immunization adoption are attributed to mandates, and no differences were found in different socioeconomic groups related to adoption rates (Abrevaya & Mulligan, 2011).

States offering personal belief and other non-medical exemptions saw higher exemption rates from vaccines than states with religious-only exemptions, as did states with easier exemption processes (Omer et al., 2006). In both scenarios, incidence of pertussis was closely associated with the ease of obtaining exemptions and the availability of non-religious exemptions, and also correlated with actual exemption rates—the higher the rate of exemption, the greater the incidence of pertussis. While these results are largely expected, they are also more detailed than many and serve as affirmation of the empirical evidence for the effects of religious and non-religious exemptions to mandated vaccinations (Omer et al., 2006).

Conscientious objectors to mandatory vaccination have been found to reduce herd immunity placing the public at large in danger of contracting vaccine preventable diseases (Siegel & Salmon, 2001). In trying to protect the religious freedoms, some states have established extremely broad religious exemption regulations that can place the public health at risk. Such circumstance allow for a large number of individuals to receive religious exemptions that decrease the number of individuals receiving vaccinations and therefore reduces herd immunity ("Religion's Hepatitis B shot", 2009).

Legal ramifications for such mandates from government can affect religious freedoms of individuals. Evidence shows that public health risk exists from religious exemptions, but the erosion of certain principles of liberty, if the mandates are not fitted with exemptions, does exist (Aspinwall, 1997). Though studying the issue explicitly

from a legal and ethical perspective, medical impacts and the larger medical findings and guidelines regarding vaccinations and exemptions were discussed in an attempt to determine what is and should be legal. The authors Ross and Aspinwall also discuss whether vaccination refusal can be viewed as child abuse from a legal standpoint. Again, both medical and legal questions are raised that provide extensive context for the research (Ross & Aspinwall, 1997).

Allowing only religious exemptions for non-medical exemptions of vaccinations leads to an inflated number of religious exemption claims (Knight, 2004). Such inflation can affect public health policy. Studies have shown that pediatricians may not have enough of knowledge base about exemption laws for vaccination, which may allow more exemptions to be granted for children (Hartog, Freeman, Kubilis, & Jankowski, 1999). Such increases to exemptions can place the public health at great risk by reducing herd immunity, allowing the disease to spread and infect those who cannot medically have such immunizations or those with compromised immune systems (Shaka, 2011).

When a large population in a geographic area is not vaccinated, a large outbreak can occur. An example of such an outbreak occurred in 1999 in the State of Virginia. This outbreak was one of the largest measles outbreaks in the United States that year. The outbreak was linked to an individual with unknown vaccination history returning from foreign travel. Others in the geographic area did not have complete vaccination history for measles, which allowed the infection to spread at an alarming rate (Rooney et al., 2004). The loss of herd immunity due to vaccination reduction in the United States

can have serious repercussions, including loss of herd immunity and increases in virulent strains of vaccine preventable disease.

One of the main issues with vaccinations for children and babies today is that some parents simply do not feel that vaccines are safe enough to be "worth it" when it comes to preventing disease. These parents may object because of their religion, but often, they object because of safety or other concerns. Rarely, a child has a medical condition where getting a vaccine would actually put that child at more of a risk than getting the disease (Richardson, 2011). Because all states allow for medical exemptions to vaccine requirements for public school, and most states allow for religious exemptions, parents who do not want to have their children vaccinated are careful to do their research into what cities and states would be the best choices for their family and their child's school attendance (Richardson, 2011). If the parents are not part of a religion that forbids vaccinations, they may either join that religion or simply claim that they belong to that religion, depending on the school's requirements for proof when a parent requests an exemption for a non-vaccinated child.

A religious exemption is generally the easiest to claim, because the vast majority of school districts do not ask a parent to name his or her religion (Richardson, 2011). Disclosure of religion goes against the idea of freedom of religion and is not a requirement. Thus, parents can simply sign a form saying that they understand the risks and it goes against their religion to vaccinate their children. Then, they give the form to the school. There are some caveats, however. Only 47 of the 50 states recognize the religious exemption for vaccination, and when there is any kind of serious outbreak of

disease at that school, the child will be removed from school until the outbreak has passed or until he or she is vaccinated. The parent must agree to those terms or the child will not be allowed to attend school (Richardson, 2011).

While this is a very serious issue for many parents, there are discussions in the school system that it is soon going to be more difficult for parents to exempt their children from vaccinations (Richardson, 2011). Many children are homeschooled as well, and that can help them avoid the need to worry about vaccinations. Private schools often require vaccinations, but have similar exemption requirements as public schools. No matter what the parents decide is best for their children, it is clear that there will always be some who object. Though understandable, it does present a risk where health and safety is concerned as more and more unvaccinated children are enrolled in public schools today.

Because of the perceived risk of vaccination and the very real risk of disease in those who are not vaccinated, the pro-vaccination supporters and anti-vaccination supporters are generally at odds with one another. It does not appear likely that there will be any agreement, but those who believe that they should not be required to vaccinate their children are vigorously defending their right not to vaccinate (Richardson, 2011). Education of school boards is one of the ways these parents are ensuring that others know religious exemptions are possible. When smallpox disease was appearing, mortality rates of more than 80% were reported, and vaccines were brought into existence (Link, 2005). Smallpox started with a high fever, leading to the appearance of blisters and pus sores. Sores would spread throughout the body and lead to backache, abdominal pain,

confusion, and vomiting. In the last stages of the disease, the person would enter a coma and eventually die. Those who did survive were scarred for life or were deformed in some way or another. The aggressive nature of the infection called for protective immunity. Chinese healers started the immunity procedure called variolation.

Variolation includes injecting people with a less severe form of smallpox so they would not contract the more severe form in the near future. This procedure went on to become popular and expansive, but had adverse reactions (Link, 2005). Edward Jenner, a country doctor in England, was also subjected to this form of vaccine and later worked on the basic concept to develop the first vaccine that eventually made the populations who were vaccinated immune to smallpox (Link, 2005).

When discussing vaccines, it is important to examine how many different types of vaccines there are. There is the live vaccine or live bacteria; killed bacteria or virus; purified parts of a bacteria or virus; and toxoids. Each type of vaccination type has potential advantages and disadvantages.

Live vaccines were created with animal matter such as mouse brains or ferret tissue. Formerly, this procedure was not performed in a laboratory settings, which led to a high occurrence of infection and contamination. When the procedure was moved to the laboratory setting, there remained prospects of contamination by undetected viruses (Link, 2005). A danger that occurred when the polio vaccine was introduced was contamination; this led to a large number of people being infected by the *simian vacuolating* virus 40 (SV), monkey virus. Even though this infection itself does not cause any damage, it may lead to an increased risk of brain cancer. When a live virus is

attenuated, or weakened, the virus is rendered incapable of causing disease, but can cause immunity.

Killing the microbe causing microbes produces inactivated vaccines. This is achieved by using heat, radiation, or chemicals. Such vaccines produce a weaker immune response. Due to this, additional vaccination is required in the form of booster shots (National Institute of Allergy and Infectious Disease, 2012).

Subunit vaccines do not use the entire microbe for vaccine production. Subunit vaccines instead use only antigens that produce the highest immune response. Since such vaccines do not use the whole microbe, adverse vaccination reactions are lower than in other types of vaccines. Subunit vaccines can use multiple antigens to produce an immune response, and therefore creating such a vaccine can be a costly and time-consuming process (National Institute of Allergy and Infectious Disease, 2012).

Toxoid vaccines are created when toxins produced by bacterium produce illness. To create this type of vaccine, a chemical process making the toxin harmless inactivates toxins. This inactivated toxin is then used to create an immune response in someone causing the body to develop immunity to the illness (National Institute of Allergy and Infectious Disease, 2012).

The first vaccine derived was from the cowpox virus; it was eventually used to immunize people against smallpox. The cowpox virus was the only animal virus in history that was efficiently used to make vaccines for humans (Vesikari & Kaikian, 1986). The monkey virus that was used in later studies caused diarrhea and fever in children, while the cowpox virus led to an increase in the production of antibodies in only

75% of the children (Vesikari & Kaikian, 1986). Even though live vaccines have a strong success rate, care should be taken when used on patients who are taking cortisone-like drugs, are on chemotherapy, or have a suppressed immune system. Another problem noted in the live vaccines was that it caused infections and actually caused cases of paralytic polio in the United States. Some vaccines, like the one for the Rubini strain of mumps, also renders the body incapable of protecting itself from natural infection (Goh, 1999).

Vaccines function in correlation with the immune system and enhance the immune system's capability to recognize and destroy pathogens. It is through vaccinations that infection rates for diseases, such as rabies, cholera, and typhoid fever, have been radically reduced. The immune system is made of many complex cells that interact with either real or imaginary cells in the body. The immunity that protects us from the plethora of viruses, bacteria and fungi has leukotrienes, cytokines, tumor necrosis factor, immunoglobulin, and heavy chains.

Even when individuals are healthy, bacteria exist on humans; this makes up the normal flora of the body and actually protects the body at times. Whenever an immune system falls weak, bacteria of normal flora become unregulated and imbalanced; that can then be damaging to a person's health. A vaccination depends on the ability of our immune system to recognize and remember a virus or pathogen that enters the body. If our immune system recognizes a pathogen, it knows how to fight it with the antibodies; then, it can respond appropriately if the pathogen is reintroduced later. Thus, vaccines,

whether live, attenuated or dead, are injected to train the immune system to recognize and fight certain bacteria or viruses that attack the human body.

Vaccines are important to reduce infection and diseases responsible for killing millions of people. Since vaccinations have been invented, disease eradication has been a major goal of health organizations all over the world. In the United States, mandatory vaccination laws for children's school admissions have been created as a strategy to prevent the spread of diseases.

Massachusetts passed the first immunization regulation in 1809, which mandated children to have smallpox vaccinations (Orenstein & Hinman, 1999). Exemptions do exist that allow a person to continue without vaccination; in the United States, this includes people who are immunocompromised, have a moderate or severe disease, allergies to the constituents of the vaccine, or merely medical contraindications (Salmon et al., 1999). Such exemptions are rightfully allowed and do not constitute exemptions based on religious or personal objections.

To eradicate infectious disease from a community, all people must be protected against it. People not only spread diseases to those in close contact, but also through stool, urine, and other bodily fluids; these can go in the water supply and contaminate it as well. Therefore, at a community level, it is important for all the people in the community to be vaccinated to prevent outbreaks through any route.

Even though vaccines can save lives on a large scale, many people have fears and doubts regarding vaccines. Anti-vaccination proponents are most pronounced in Protestant countries; these included the Quakers in England and the Baptists in Sweden.

Apart from Christians, there are Muslims and Jewish populations who cite religion as a reason to out of vaccinations (Hamdan, 1989).

The consumption of certain animals, such as pigs, are prohibited in Islam. This prohibition not only lies in the fact that Muslims can't eat pig meat, but also cannot take any treatment derived from such animals. Thus, many of the Muslims are hesitant to vaccinate their children. In addition to obtaining medical treatment from animal-related products, vaccines are also not recommended because they can alter the will of Allah (God; Hamdan, 1989).

Muslims have a steadfast belief in the creation of Allah and that all he does, regardless of how detrimental, is in the best interest of humans. Muslims believe that Allah made the human body so it would not be able to withstand infectious diseases. In other words, contracting infectious diseases and going through them was something that Allah intended. For many, immunization to prevent disease could be seen as humans attempting to play the role of God (Hamdan, 1989).

The importance of breastfeeding has been emphasized in the Quran, the holy book of Muslims. Women are told to nurse their children for at least two years. The breast milk provides antibodies of the mother to the child (Hamdan, 1989). The antibodies passed through maternal milk make the baby strong enough to fight off infections in a very natural manner. Another aspect of the Muslim religion revolves around the idea of destiny. Muslims believe that whatever happens is the will of Allah, and, if Allah sends the illness to a person, he is the one that will send the cure as well (Hamdan, 1989). Therefore, these are strong beliefs in the Muslim religion that render vaccinations

unnecessary or useless. In addition to these reasons, there are also many rumors in the Muslim world that scare people from vaccinating their children. The effort to eradicate polio was setback in 2003 when Muslim leaders and community leaders in Nigeria's state of Kano spread rumors that the vaccine would kill the children. (Zarocostas, 2006). The rumors also stated that the vaccines would render the children incapable of reproducing and make them sterile. Because of these rumors, the polio eradication program was halted until the following year. These false rumors allowed for possible disease spread to other countries (Zarocostas, 2006).

The Taliban and the Maulvis in Pakistan and Afghanistan, especially in the tribal areas, claim religious declarations that vaccination is present only to plot against and sterilize Muslims. Religious conflicts cause extremists to damage vaccinators. Many vaccinators have been kidnapped or beaten (Warraich, 2009). It is in part because of these religious issues that polio has still not been eradicated.

A major reason for attaining religious exemption for Christians is similar to Muslims, where there are some unclean animals that Christians should not put on or in their bodies. Some Christians, especially Catholics, are not in favor of vaccinations such as measles, mumps, chicken pox, and rubella, because they contain human diploid cells that were cultured from aborted fetuses (Eisenberg, 2003). Therefore, the use of fetal tissue in vaccines is a major reason for the anti-vaccine feelings harbored by Christians in many countries. Jewish beliefs rely on the notion that God walks with the simple ones, and therefore vaccines are not preferred by some of the Jewish faith (Eisenberg, 2003).

Their views are therefore similar to those of Christians and Muslims, such that whatever God puts them through, he will also take them out of it.

Many people use religion as an excuse to not get vaccinated at all. Others refuse to get vaccinated out of fear of contracting the illness for which vaccinations are administered. For instance, in 1989, there was a measles outbreak in schools with vaccination levels more than 98% (Hamdan, 1989). The World Health Organization discovered that someone who is vaccinated against measles is 15 times more likely to contract the disease. There were some instances of the whooping cough recurrence in 1986 in Kansas; in those people, about 90% of the people were vaccinated against pertussis (Hamdan, 1989). Some cases of diphtheria actually increased after the introduction of vaccinations. In France, an increase of 30% was reported, whereas in Hungary, there was an increase of 55% (Hamdan, 1989). It is argued that religious exemptions might not be a major reason why parents are doubtful about vaccinating their children.

There are schools in the United States that make it a rule for children to be vaccinated before they are admitted into school. The same rule applies to children admitted in day care, college, and other types of educational institutions (Salmon, 2003). Vaccination rules in many states are extremely strict, where mandates define which vaccines and how many doses are required by state health office or a board of health (Hinman, 2000). Vaccinations for public school became mandatory during the 1950s to 1970s, because school aged children were the most affected by diseases. For the state to provide non-medical exemptions, there must be either a psychosocial, personal, or

religious issue. All states except Mississippi and West Virginia, do not allow non-medical vaccine exemptions (Mercola, 1996).

Currently, 1% of the United States population does not believe in vaccinations for different reasons (Salmon, 2003). As stated earlier, vaccines are required to protect the general health of people and the community. The powers of the police can also be used to force states to carry out this public interest activity. However, individuals have used the first amendment to protect their right to religious exemptions. Many argue that everyone has a right to practice religion however they want. Thus, if a person wishes to be exempt from vaccinations because of his or her own religion, they should be allowed to maintain that.

The courts, however, have ruled that immunization against dangerous diseases is not contrary to first amendment protection. Many courts argue that the choice of child vaccinations should be left to the parent. However, in choosing to not vaccinate, parents may expose other children and adults of the community to disease.

The Mississippi Supreme Court stated that if a person goes on to attain religious exemption, they are violating the fourteenth amendment, which ensures equal protection for all citizens. Thus, the state argued that equal protection to children is in place when it requires masses to get vaccination. Exemptions, by contrast, create situations where unvaccinated children interact with children who have been vaccinated.

It is important to explain what exactly an outbreak is. The definition of outbreak was mentioned by Tuyen and Bisgard (2000) regarding the outbreak of pertussis. An outbreak occurs when the number of cases reported exceeds the number expected. In this

scenario, the number of expected outbreaks is the number anticipated on during a given time period. The population studied can be from a number of countries, a larger area, or a large metropolitan area (Tuyen & Bisgard, 2000).

A study conducted by Salmon et al. (1999) looked at certain populations of children from 1985 to 1993. Their research on measles used data from the Measles Surveillance System of the CDC. The study group consisted of children aged 5-19 years. The objective of the study was to see how measles spread in communities that had an adequate amount of vaccinated children and children with exemptions. The studies revealed that, on average, those who were exempted from vaccinations were 35 times more likely to attain measles than vaccinated children (Salmon et al., 1999).

The analysis of Salmon et al. (1999) analysis found that the studies focused on the population density of non-vaccinated people in a geographic area. Populations that do not vaccinate tend to live in clusters, and therefore do not pose a risk for vaccinated populations. Even though this might reduce the spread to vaccinated people, it nevertheless increases that community's risk (Salmon, 2003). Salmon also revealed that those with exemptions went on to infect those who were vaccinated. In areas where the population of exemptors increased to double the amount there is now, the risk of measles for the people who were vaccinated increased correspondingly. The risk of contracting measles increased from 5.5% to 30.8%. It should be noted that the risk of disease could also be due to their vaccination failing or them not being vaccinated due to a medical reason. Therefore, it should be noted that medical reasons may influence the decision not to vaccinate.

Feikin et al. (2000) examined the reported cases of pertussis and measles in Colorado from 1987 to 1998. The major objective was to see and compare the risk of these two infectious diseases among the children who were and were not vaccinated. Children from ages three to 18 were chosen. The studies revealed that exemptors were 22 times more likely to attain measles and about six times more likely to attain pertussis. Since schools are by far the most common place for these younger children to interact with each other.

A look at the schools in this region revealed that schools that had more exemptors were more likely to experience an outbreak. Schools where 4.7% of students were not vaccinated experienced the pertussis outbreak, while schools where the number of non-vaccinated children was less than 1.3% did not have any cases of outbreaks of pertussis (Feikin et. al, 2000). This may indicate that herd immunity failed in schools where non-vaccinated rates were highest. The study did not focus on the level of vaccination needed to obtain herd immunity.

Summary and Conclusions

Vaccines can prevent illness and help maintain healthy populations. Some choose not to vaccinate due to religious beliefs. Such non-vaccinated individuals may place others at risk for contracting diseases by reducing herd immunity. Such a reduction allows for disease survival and spread. Protecting religious freedom is important, but may put others in the population at risk. Religious exemption prevalence can vary geographically within a given state. Higher exemption rates may result in higher rates of disease. Understanding why religious exemptions are obtained can help find appropriate

education avenues for select groups to increase vaccination adherence. Non-medical exemptions in geographic clusters may contribute to outbreaks for certain vaccine preventable diseases such as pertussis. Unvaccinated people place themselves and others at risk for contracting vaccine preventable illness (Salmon et al., 1999). While no vaccine is 100% effective, vaccination against an illness will greatly reduce disease transmission and can reduce the severity of such illness if transmission does occur (Salmon et al., 1999). Anti-vaccination populations endanger public health by preventing disease eradication of certain vaccine preventable diseases. Abstaining from vaccination can result in outbreaks especially where larger clusters of exemptors live in close geographic proximity allowing for easy transmission of such diseases. Understanding why such outbreaks occur and why certain populations do not vaccinate can aid in disease prevention and eradication though public health initiatives focusing on the desired populations. Without identification of such population pockets initiatives cannot be conducted for reduction.

Several reasons may exist why the data has not currently been evaluated. First, the topic is highly sensitive due to the involvement of ethnic populations and civil rights; researchers may not want to initiate data evaluation out of fear of infringing on such civil rights. Another reason for lack of evaluation may be the lack of qualified personnel to initiate and evaluate such a study in the county or state health departments. A final reason may be lack of funding. Such research is costly and time consuming. Budget cuts have greatly affected public health funding. Health departments are struggling to meet core health standards for populations and therefore may not have adequate resources to

facilitate such an intense study. Understanding the cause of the outbreak which occurred in Ocean County will help public health officials address needs of a population extending the understanding of why outbreaks occur for diseases that are vaccine preventable.

In chapter 3, I will discuss the methodology of the study. The sections will include an introduction, research design and rationale, methodology, threats to validity, and summary of findings. I will discuss why the design is best suited to explain the gap in research on the topic.

Chapter Three: Methodology

Introduction

The difference in the prevalence of the pertussis outbreak between county type (Ocean, Other) was investigated in the study, as well as determining if the difference depended on exemption status (exempt, nonexempt). Chapter 3 includes the research methodology used in the study. Major sections of chapter 3 include research design and rationale, methodology, threats to validity, and summary of findings.

Research Design and Rationale

In February 2012, an outbreak of pertussis occurred in Ocean County, New Jersey (Nee & Brashir, 2012). Of the 14 reported cases, all were children under age 5. The primary location of the outbreak was Lakewood, New Jersey (Nee & Brashir, 2012). The study consisted of one independent variable (pertussis status) and three independent variables (county type, exemption status, sex). Pertussis status was scaled at the nominal level with response options being either 0 = *no* or 1 = *yes*. Pertussis status was assessed and examined via archival data from the CDRSS. County type was defined as Ocean County, Middlesex County, or other. County type was scaled at the nominal level with response options being either 1 = *Ocean*, 2 = *Middlesex*, and 3 = *Other*. County type was examined via the CDRSS. Exemption status was defined as either exempt or nonexempt (*no*, *yes*).

Any participant who did not receive vaccination or was not vaccinated completely as per guidelines from the CDC was considered exempt. Participants who received full vaccination were considered nonexempt. Exemption status was scaled at the nominal

level with response options being either 0 = *no* and 1= *yes*. Exemption status was examined via the CDRSS. Sex was defined as one of two forms of individuals distinguished respectively as biologically male or female, based on the basis of their reproductive organs and structures at birth (Merriam-Webster, 2013). Sex was measured at the nominal level with response options being either *male* or *female*. Sex was examined via the CDRSS.

The study was quantitative in nature and used a retrospective case-control design. The study plan consisted of an investigation into the role of vaccination exemption on the pertussis outbreak which occurred in New Jersey. The data that I collected were archival in nature, and gathered from the Communicable Disease Reporting and Surveillance System (CDRSS). This design was chosen because retrospective quantitative analysis would provide the best design analysis for understanding why the pertussis outbreak occurred. Possible confounding variables included exposure to pertussis, as well as natural immunity to the disease.

Understanding the causes of the outbreak may support the development of appropriate legislation to prevent future outbreaks of pertussis or other diseases. Using a retrospective case-control design allowed for a timely analysis of the outbreak information. Providing a timely analysis of the data allows for officials with the knowledge to increase vaccination adherence by providing initiatives to increase vaccination adherence.

Methodology

Population

The population that I studied consisted of men and women who were residents of Ocean County, New Jersey; Middlesex County, New Jersey; and the other surrounding 19 counties. The estimated population of Ocean County during the time of the study was 580,470. Of that population, 23.5% were under the age of 18 years, meaning approximately 13,600 were under the age of 18, while 566,870 were at least 18 years of age or older. The population in Middlesex County during the time of the study was 809,858, consisting of 22.9% (185,458) inhabitants under the age of 18. New Jersey as a whole had a population of 8,864,590 inhabitants, consisting of 22.9% (2,029,991) under the age of 18.

Sampling and Sampling Procedure

The sample for the study consisted of the Hasidic community in Ocean County, New Jersey. The county had a Hasidic population of approximately 63,000. There were no limitations on sex and ethnicity for the study, meaning both men and women and all ethnicities were eligible to participate.

The sampling procedure I used was a nonprobability purposive sampling technique. Purposive sampling was used for the study since it is commonly known that the population sampled does not often vaccinate children for common childhood illnesses. This procedure allowed quick identification of a targeted sample. However, nonprobability sampling may not have provided a representative sample of the population; as such, generalization to the population may be limited.

The analysis that I conducted was a power analysis. Power, expected effect size, and critical alpha was used to ensure an appropriate sample size used in the study. Power, which is the probability that a statistical difference between designated groups will be found, was set at 80%. This means that there was an 80% chance that a difference will be found between the designated groups given a sample size.

Effect size describes the degree of variance shared by the designated groups. Effect size was defined by Cohen (1992) in terms of Cohen's as small = 0.10, medium = 0.30, and large as 0.50. Critical alpha describes in probability terms that a significant finding happened by chance. For the social sciences, it is common for critical alpha to be set at 0.05. This indicates that there is a 5% chance that a true null hypothesis will be rejected.

For this study, I chose a medium expected effect size of 0.30. A formal power analysis was conducted for the study using the sample size power analysis program G*Power 3.0.10. The parameters were set at (a) power = .80, (b) expected effect size = .30, and (c) critical alpha=. 05. The results of the analysis stipulate that 88 (n = 88) participants were needed to produce an 80% probability of rejecting the null hypothesis (Faul, Erdfelder, Lang, & Buchner, 2007).

I used secondary data for the study. All data extracted for this study were collected and entered into the CDRSS by individuals trained by the New Jersey State Health Department. Data were entered by trained county individuals, then examined by state employees. Data entry protocol consisted of trained individuals inputting patient data regarding reportable communicable diseases reported to the health department from

doctors. Cases were then sent to the New Jersey State Health Department, where each case was examined to ensure all relevant information was entered and each file was complete. The data were collected from January 01, 2012 through March 31, 2012. A request for the data was filed through the Freedom of Information Act. A data user agreement located in appendix A was then drafted between the author and Ocean County Health Department. All identifiable markers were redacted prior to the author gaining access to the data. IRB approval for this study, study number 03-11-14-0190534 was obtained through Walden University.

Instrumentation and Operationalization of Constructs

Information on vaccination of pertussis cases based on the parameters outlined for the study was retrieved from the CDRSS. All information entered into the CDRSS were entered by personnel appointed by health officers for each health department. The information was then corroborated by staff of the New Jersey State Health Department. Such staff included Registered Environmental Health Specialists, nurses, and epidemiologists working for local, county and state health departments. Such information was appropriate for the study, since the information allowed the most accurate information in both reliability and validity regarding the vaccination, and whether there was a difference between the occurrences of the outbreak and county type (*Ocean, Middlesex, Other*), exemption status (*exempt, nonexempt*), and sex (*male, female*).

Operationalization of Variables

Pertussis Status. In February 2012, an outbreak of pertussis occurred in Ocean County, New Jersey (Nee & Brashir, 2012). Of the 14 reported cases, all were children

under age 5. The primary location of the outbreak was Lakewood, New Jersey (Nee & Brashir, 2012). Pertussis status was scaled at the nominal level with response options being either 0 = *no* or 1 = *yes*. Pertussis status was assessed and examined via archival data from the CDRSS.

County Type. County type was defined as Ocean County, Middlesex County, or other. County type was scaled at the nominal level with response options being either 1 = *Ocean*, 2 = *Middlesex*, and 3 = *Other*. County type was examined via the CDRSS.

Exemption Status. Exemption status was defined as either exempt or non-exempt (no, yes). Any participant who did not receive vaccination or was not vaccinated completely as per guidelines from the CDC was considered exempt. Participants who received full vaccination were considered non-exempt. Exemption status was scaled at the nominal level with response options being either 0 = *no* and 1= *yes*. Exemption status was examined via the CDRSS.

Sex. Sex was defined as one of two forms of individuals distinguished respectively as biologically male or female, based on the basis of their reproductive organs and structures at birth (Merriam-Webster, 2013). Sex was measured at the nominal level with response options being either *male* or *female*. Sex was examined via the CDRSS.

Data Analysis Plan

Analyses of hypotheses were conducted using SPSS 22.0. Six hypotheses were tested using archival data derived from county data recorded in 2012. Six research questions were used in the study to determine if relationship existed between pertussis

status and exemption status, county type, and sex. It can be assumed that participant information was accurate, based on the archival data gathered. Participation was anonymous; therefore it was assumed participants had answered the questions completely and honestly. Secondary data were used for the study. It was assumed that during primary data collection, the methods used were accurate. It was also assumed that convenience sampling would provide a representative sample of the target population.

The research questions and hypotheses included:

Research Question 1: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Middlesex, Other)?

$H1_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Middlesex, Other).

Research Question 2: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Other)?

$H2_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Other).

Research Question 3: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Middlesex)?

$H3_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Middlesex).

Research Question 4: What is the difference in pertussis outbreak between county type, (Ocean, Other)?

$H4_0$: There is no difference in pertussis outbreak between county type, (Ocean, Other).

Research Question 5: What is the difference in Pertussis outbreak between county type, (Middlesex, Other)?

$H5_0$: There is no difference in pertussis outbreak between county type, (Middlesex, Other).

Research Question 6: What is the difference in Pertussis outbreak between county type, (Middlesex, Ocean)?

$H6_0$: There is no difference in pertussis outbreak between county type, (Middlesex, Ocean).

I used the six tests to determine if pertussis outbreak was dependent on county type. Chi-square test of association was chosen for this analysis since the study tested whether an association between two categorical variables exists. Each category is both mutually exclusive and exhaustive. This means that each category (county type, pertussis vaccination status, sex, and pertussis) can only fit in one category and that each category covers every possible case. Other criteria met for the chi square test of association is that all observations are independent of each other and the data are categorical in nature. Odds ratio of greater than 1 is considered to be an indicator of association and confidence intervals of 95% were used in the study.

I derived descriptive data from county records to answer the research questions. For Middlesex, there were 823,196 participants currently residing in the county. Of those, the pertussis outbreak rate was .004%. For Ocean, there were 580,945 residents living in

the county with a pertussis outbreak rate of .024%. For all other counties there were 8,867,749 residents living in the county with an outbreak rate of .016%.

Statistical assumptions that I made included that participant information was accurate, based on the archival data gathered. It was also assumed that participants would answer the questions completely and honestly. It was also assumed that convenience sampling would provide a representative sample of the target population. Data used were secondary data; therefore it was assumed that data collection methods for the primary collection were accurate. It was also assumed that participant medical histories were accurate.

Threats to Validity

Threats to external validity include history and treatment interactions and selection and treatment interactions. Because the study had a defined start and end time, generalizing results for past or future situations or occurrences may be inaccurate. The characteristics of the participants were narrow, and therefore it may be difficult to generalize results for future occurrences. Additionally, it cannot be guaranteed the participants answered every question completely and honestly.

Threats to internal validity included accuracy of participants' medical histories and participant selection. Participant selection was based on a select geographical area and therefore may not properly represent the selected group.

Ethical Procedures

I obtained a user agreement for data from the Ocean County Health Department and is included in Appendix of the document. I also obtained Institutional Review Board

(IRB) prior to data collection to ensure all ethical procedures to data collection were followed. The data were retrieved from the CDRSS from the State of New Jersey. Under the Freedom of Information Act, data were requested with all identifiable markers of participants redacted. Data were requested, and permission granted from Ocean County Health Department. A user agreement is located in Appendix A of this document. All data collected for this study were archival data, and all personally identifying data was alpha-numerically coded P1...P88 (participant 1.88) to protect confidentiality and anonymity. All data is stored on a sky drive and an external hard drive owned by the researcher, and will be retained for a period of no less than five years. The researcher will be the only person with access to the information.

Summary

In February 2012, an outbreak of pertussis occurred in Ocean County, New Jersey (Nee & Brashir, 2012). Of the 14 reported cases, all were children under age 5. The primary location of the outbreak was in Lakewood, New Jersey (Nee & Brashir, 2012). The most effective preventative against this illness is the pertussis vaccine (Mayo Clinic, 2005). Research has shown the higher the rate of non-medical vaccination exemptions, the higher the rate of pertussis (Omer et al., 2006). Lakewood New Jersey has a large Hasidic community, and cultural norms in the community may have contributed to the outbreak.

The study consisted of a retrospective quantitative case control study to gain an understanding as to whether vaccination exemptions caused a pertussis outbreak

occurring in Ocean County, New Jersey. Gaining an understanding as to whether religious exemptions to vaccination contributed to the outbreak, will allow researchers to tailor vaccine program design specifically for this community. This may promote social change by increasing vaccine compliance and enhance the design of legislation to prevent future outbreaks, while still protecting rights of citizens. Major sections discussed in Chapter 4 include an introduction, data collection, results, and a summary of findings.

Chapter 4: Results

Introduction

The purpose of the study was to identify whether vaccination exemption was a contributing factor to the pertussis outbreak which occurred in Ocean County, New Jersey in 2012. I used inferential statistics to draw conclusions from the sample tested. The Statistical Package for the Social Sciences (SPSS) was used to code and tabulate scores collected from archival sources and provide summarized values where applicable including frequency and count information. Chi-Square test of association and odds ratio (OR) were used to determine effect and level of confidence. The research questions and accompanying null hypotheses for the study included:

Research Question 1: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Middlesex, Other)?

$H1_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Middlesex, Other).

Research Question 2: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Other)?

$H2_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Other).

Research Question 3: What is the difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Middlesex)?

$H3_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Middlesex).

Research Question 4: What is the difference in pertussis outbreak between county type, (Ocean, Other)?

$H4_0$: There is no difference in pertussis outbreak between county type, (Ocean, Other).

Research Question 5: What is the difference in Pertussis outbreak between county type, (Middlesex, Other)?

$H5_0$: There is no difference in pertussis outbreak between county type, (Middlesex, Other).

Research Question 6: What is the difference in Pertussis outbreak between county type, (Middlesex, Ocean)?

$H6_0$: There is no difference in pertussis outbreak between county type, (Middlesex, Ocean).

Major sections to be discussed in Chapter 4 include an introduction, data collection, results, and a summary of findings.

Data Collection

Data that I used were secondary data that I collected from the Ocean County Health Department. The data were collected from January 01, 2012 through March 31, 2012. Discrepancies in data collection discussed in Chapter 3 were not identified. Such discrepancies included inaccurate data entry, false or inaccurate data, and incomplete data such as incomplete medical histories.

The population studied consisted of men and women who were residents of Ocean County, New Jersey; Middlesex County, New Jersey; and the other surrounding counties

19 counties. The estimated population of Ocean County was 580,470. Of that population, 23.5% were under the age of 18 years, meaning approximately 13,600 were under the age of 18, while 566,870 were at least 18 years of age or older. The population in Middlesex County was 809,858 consisting of 22.9% (185,458) inhabitants under the age of 18. New Jersey as a whole had a population of 8,864,590 inhabitants consisting of 22.9% (2,029,991) under the age of 18.

The population for the study included a large Hasidic population residing in Ocean County, New Jersey. The county had a Hasidic population of approximately 63,000. Hasidic communities do not vaccinate their children normally.The study did not have any limitations on sex and ethnicity, meaning men and women, as well as all ethnicities, were eligible to participate. While the large Hasidic population may not represent the population of New Jersey as a whole, the population did allow for examination of a large nonvaccinated population living in close geographical proximity.

Results

I conducted an analyses of hypotheses using SPSS 22.0. Six hypotheses were tested using archival data derived from county data recorded in 2012. The six tests were used to determine if pertussis outbreak was dependent on county type. Chi-square test of association was chosen for this analysis since the study is testing whether an association between two categorical variables exists. Each category is both mutually exclusive and exhaustive. This means that each category (county type, pertussis vaccination status, sex, and pertussis) can only fit in one category and that each category covers every possible

case. Other criteria met for the chi square test of association was that all observations are independent of each other and the data are categorical in nature.

I derived descriptive from county records were used to answer the research questions. For Middlesex, there were 823,196 participants currently residing in the county. Of those, the pertussis outbreak rate was .004%. For Ocean, there were 580,945 residents living in the county with a pertussis outbreak rate of .024%. For all other counties there were 8,867,749 residents living in the county with an outbreak rate of .016%.

Statistical assumptions that I made included that participant information was accurate, based on the archival data gathered. It was also assumed that participants would answer the questions completely and honestly. It was also assumed that convenience sampling would provide a representative sample of the target population. Data used were secondary data; therefore it was assumed that data collection methods for the primary collection were accurate. It was also assumed that participant medical histories were accurate.

I also collected vaccination rates in order to determine if rate of vaccination was dependent on county type. Chi-square tests of association were used to test if residents of Middlesex vaccinated more or less compared to Ocean or Other counties. In addition, Chi-square test of association was used to determine if residents of Ocean vaccinated more or less compared to Other counties.

Hypothesis 1

$H1_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Middlesex, Other).

The chi-square test of association was performed to assess if a difference exists between male pertussis cases based on female pertussis cases by county type (Middlesex, Other) $x^2(1, n = 699) = 0.02$, $p = 0.887$ or $p = 0.00887\%$. The odds of being afflicted with pertussis and male compared to females was not significantly greater for Middlesex county residents compared to those residing in other counties; $OR = 1.00$. Based on test results, the null hypothesis that a difference exists between sex and county type (Middlesex, Other) should be retained.

Table 1

Contingency Table of Vaccination Counts Middlesex and All Other Counties

Variable		Sex	
		Male	Female
County	Middlesex	16	17
	Other	692	727

Hypothesis 2

$H2_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Other).

The chi-square test of association was performed $x^2(1, n = 1558) = .64$, $p = 0.423$ or $p = 0.00423\%$ with an odds ratio of 1.63. The test shows that there is not a statistical

significance between male pertussis cases compared to female pertussis cases based on county type (Ocean, Other) and therefore the null hypothesis should be retained.

Table 2

Contingency Table of Vaccination Counts Ocean and All Other Counties

Variable		Sex	
		Male	Female
County	Ocean	7	12
	Other	692	727

Hypothesis 3

$H3_0$: There is no difference in male pertussis cases compared to female pertussis cases by county type, (Ocean, Middlesex).

The chi-square test of association was performed to assess if a difference occurred in male pertussis cases compared to female pertussis cases based on county type (Ocean, Middlesex), $x^2(1, n = 23) = .27$, $p = 0.603$ or $p = 0.00603\%$. The odds of being afflicted with pertussis and male compared to females was not significantly greater for Ocean county residents compared to those residing in Middlesex county; $OR = 1.61$. Therefore, therefore the null hypothesis should be retained, as a difference does not exist between male and female cases based on county type (Ocean, Middlesex).

Table 3

Contingency Table of Vaccination Counts Ocean and Middlesex County

Variable		Sex	
		Male	Female
County	Ocean	7	12
	Middlesex	16	17

Hypothesis 4

$H4_0$: There is no difference in pertussis outbreak between county type, (Ocean, Other).

The chi-square test was performed to assess whether a difference exists between county type and the pertussis outbreak $x^2(1, n = 1551) = 20.28$, $p < .001$ or $p < .00001\%$. The odds of being afflicted with pertussis was significantly greater for Ocean county residents compared to those residing in all other counties; *OR* = 1.49. The hypothesis that a difference exists in the pertussis outbreak by county type (Ocean, Other) should be accepted and the null hypothesis rejected.

Table 4

Contingency Table of Vaccination Counts Ocean and All Other Counties

Variable		Pertussis Cases	
		Pertussis	Non-pertussis
County	Middlesex	823196	32
	Ocean	580945	139

Hypothesis 5

$H5_0$: There is no difference in pertussis outbreak between county type, (Middlesex, Other).

The chi-square test of association was performed to assess if a difference exists between county types and pertussis $x^2(1, n = 1551)$ $p < .001$ or $p < 0.00001\%$. The odds of being afflicted with pertussis was significantly greater for Other county residents compared to those residing in Middlesex county; *OR* = 4.11. That is, all other county residents were 4.11 times more likely to be afflicted with pertussis compared to

Middlesex county residents. The tests conducted show a difference does exist in pertussis outbreaks between county types (Middlesex, other) and therefore the null hypothesis should be rejected.

Table 5

Contingency Table of Vaccination Counts Middlesex and All Other Counties

Variable		Vaccination	
		Vaccinated	Non-vaccinated
County	Middlesex	42864	44557
	Other	500969	525125

Hypothesis 6

$H6_0$: There is no difference in pertussis outbreak between county type, (Middlesex, Ocean).

Hypothesis 6 assessed the difference in the pertussis outbreak based on county type (Middlesex, Ocean). A chi square test of association was performed x^2 (1, n = 2110.65) = p = .0001 or p = 0.00001% and showed Ocean county residents were more likely to be vaccinated. Thus, the null hypothesis can be rejected in favor of the alternative.

Table 6

Contingency Table of Vaccination Counts for Middlesex and Ocean Counties

Variable		Vaccination	
		Vaccinated	Non-vaccinated
County	Middlesex	42,864	44,557
	Ocean	26,081	27687

Summary

The results of the study support the hypotheses that a significant difference exists in the prevalence of pertussis between Ocean County, Middlesex County, and all other counties in New Jersey. The results of the study do not support the hypotheses that a statistically significant difference exists between the odds of being afflicted with pertussis and male compared to female in Ocean County, Middlesex County, and all other counties in New Jersey. The data shows the odds of being afflicted with pertussis for those residents of Ocean County is greater than for those residents living in other counties in New Jersey.

Vaccination does not offer 100% immunity, but herd immunity can be reached if a certain threshold of the population is immunized. This population threshold is different for every disease. Such a threshold is based on virulence of each disease, vaccination efficacy and population contact parameters (Link, 2005). Person to person transmission of contagious diseases is higher among populations that are unvaccinated. Widespread non-vaccination of a population can compromise herd immunity.

Current mathematical models of herd immunity efficacy apply only to homogenous populations. The model for herd immunity is based on small numbers of unvaccinated spread throughout a large vaccinated population. Since the numbers of vaccinated individuals is large and the non-vaccinated individuals are spread over a geographic area, there is little contact between unvaccinated individuals and therefore disease transmission cannot occur. Since the disease cannot be transmitted between individuals the disease can be eradicated in that area.

If, however, the population of unvaccinated individuals is in close geographical proximity to one another mathematical models for herd immunity fail. This places the population at risk for a contagious disease. Further discussions involving this study and the implications for the study are presented in chapter 5. The review includes implications for reduction in future outbreaks, potential lines of inquiry, and positive social impacts of the study.

Chapter 5: Discussion, Conclusion, and Recommendations

Introduction

Outbreaks of a childhood disease known as pertussis (whooping cough) still occur throughout the United States despite decades of immunizing children for this disease. The disease is spread through the air by respiratory droplets from the mouth or nose when an infected person coughs, sneezes, or speaks. A contributing factor to these outbreaks may be religious exemptions.

In February 2012, an outbreak of Pertussis occurred in Ocean County, New Jersey. The purpose of the study was to find if vaccination exemptions may have contributed to the outbreak. The nature of the study was quantitative. Comparisons between pertussis rates in the geographical area of Ocean County, New Jersey were compared to the pertussis rates of Middlesex County and other counties in New Jersey. In addition, this study investigated whether there was a correlation between pertussis status and exemption status and sex.

Key findings of the study show the prevalence of pertussis in Ocean County, Middlesex County, and other counties in New Jersey differ significantly, with the greatest odds of being afflicted with pertussis for residents living in Ocean County. The data does not show significant differences in pertussis rates for gender, and does not show significant differences in vaccination rates. This chapter provides an overview of the study, summary of the findings, discussion of results, implications for practice, and recommendations for further research and practice.

Interpretation of the Findings

The study results indicate Middlesex County residents were more likely to be vaccinated than residents living in Ocean County, but the difference was not statistically significant. There was no greater odds of being vaccinated in other counties compared to Middlesex County. Residents of Ocean County were more likely to develop pertussis than residents of Middlesex County or residents of all other counties in New Jersey. There was no correlation found between sex and vaccination status and sex and pertussis status.

Findings of the study were somewhat surprising. While the outcomes of no relationship between pertussis rates and sex that the rates of pertussis in Ocean County were expected; the result of no difference of vaccination rates by county was not. Further study to understand why such an outbreak occurred is needed to prevent future outbreaks from occurring.

I originally hypothesized that there was no difference in vaccination rates, pertussis rates, or sex between county types. Results derived from testing the hypotheses supported the alternative hypotheses for 4, 5, and 6; indicating that pertussis rates were dependent on county types. However, the null hypotheses for 1, 2, and 3 were retained. This means that no difference in vaccination rates, or sex between county types was found. The data showed that vaccination rates or sex were not dependent on county types.

Literature that I analyzed for the study indicated that pertussis and other communicable infection rates in similar outbreak investigations higher in populations

which had fewer vaccinated individuals (Abrevaya & Mulligan 2011; Etkind et al., 1992; Falco, 2010; Feikin et al., 2000; Guadino & Robison, 2012). I expected that pertussis rates would be dependent on vaccination rates.

Residents of Ocean County were more likely to develop pertussis than other counties. The odds of those residing in Ocean County were significantly greater than for residents of Middlesex County and all other counties in New Jersey. Statistically significant differences in odds for residents of Ocean County, Middlesex County, and Other counties in New Jersey based on sex and vaccination status were not found. Although higher rates of vaccination for Middlesex County compared to Ocean County were found, statistical significance was not established.

I expected that higher rates of vaccination in Middlesex County and other counties in New Jersey would be responsible for lower rates in pertussis in such counties compared to Middlesex County. The results of no statistical significance in vaccination rates were found was surprising. Reducing the geographical area for the research may provide a statistical difference, as those affected by pertussis may reside in a smaller geographical area in Ocean County. Those individuals residing in said geographical area may also have a higher than average rate of vaccination exemption.

I used the ecological social theory as framework in this study. Ecological social theory integrates social and biological reasoning into the spread of infectious diseases. This theory incorporates social norms and inequalities into exploration into how disease is spread (Krieger, 2004). Vaccination rate differences were not statistically different for the counties in New Jersey. I expected that social norms of the Hasidic population

located in Ocean County resulted in the outbreak due to lack of vaccination by such populations. A statistical difference was found between Ocean County, Middlesex County, and Other counties in New Jersey but the findings were not statistically significant. Further studies are needed to evaluate whether such a correlation exists to further understand the development of the 2012 pertussis outbreak.

Limitations of the Study

I based participant selection on a select geographical area and therefore may not properly represent the selected group. Threats to external validity include history and possible treatment interactions from unrelated illness, as well as selection and treatment interactions. Because the study had a defined start and end time, generalizing results for past or future situations or occurrences may be inaccurate. Also, the study did not find the reason for the outbreak occurrence and therefore further research is needed to understand why such an outbreak occurred.

Recommendations

Further research into geographical proximity of affected persons compared to other counties, as well as possible population susceptibility, is needed to further understand the nature of the outbreak. A mixed methods project including interviews with participants conducted by a Hasidic male to respect religious observances would increase understandings of why vaccinations were not given would be useful. This information would provide public health officials with knowledge to provide public health initiatives to increase vaccination in the desired populations. Typing of the infections that affected individuals would also be useful to determine if persons were

infected with the same or similar strains. Research regarding the effectiveness of various vaccines should be conducted to further understand whether vaccine effectiveness played a role in the outbreak. This would provide valuable information to health officials regarding the virility of the strains as well as vaccine effectiveness.

Implications

Understanding why pertussis rates were higher in Ocean County than other counties in New Jersey is imperative to preventing or reducing further outbreaks of pertussis and other communicable diseases. Mapping where geographically in Ocean County the outbreak occurred would allow for determining possible reasons for the outbreak occurrence. Such mapping would also allow for more precise targeting of at risk populations. Such targeting provides public health officials the ability to better design programs and protocols for outbreak reduction in the desired population and therefore increasing the health of that community and evoking positive social change.

Conclusion

An outbreak of pertussis occurred in Ocean County New Jersey in February 2012. I found a difference in the prevalence of pertussis rates between Ocean County, Middlesex County, and other counties in New Jersey between January 2012 and March 2012. Ocean County had the highest rate of pertussis compared to Middlesex County and other counties in New Jersey. It was found that the odds of being diagnosed with pertussis were not significantly different between males and females. Ocean County had the lowest rate of vaccination and the highest rate of pertussis. While a statistically significant difference was not found between vaccination rates and pertussis rates by

county, further research to explain the differences in pertussis rates and vaccination rates should be explored.

References

Abrevaya, J., & Mulligan, K. (2011). Effectiveness of state-level vaccination mandates: Evidence from the varicella vaccine. *Journal of Health Economics, 30*(5), 966-976.

Aspinwall, T. (1997-8). Religious exemption to childhood immunization statutes: Reaching for a more optimal balance between religious freedom and public health. *Loyola University of Chicago Law Journal, 29*, 1-33.

Bettiol, S., Wang, K., Thompson, M. J., Roberts, N. W., Perera, R., Heneghan, C. J., & Harden, A. (2012). Symptomatic treatment of the cough in whooping cough. *Cochrane Database Systematic Reviews, 2012*, *5*. doi:10.1002/14651858.CD003257.pub4

Centers for Disease Control and Prevention. (1985). *Measles-United States*. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/00000743.htm

Centers for Disease Control and Prevention. (2011). *Pertussis (Whooping Cough) Outbreaks*. Retrieved from http://www.cdc.gov/pertussis/outbreaks/about.html

Centers for Disease Control and Prevention. (2012). Chapter 15: Pertussis. In W. Atkinson, S. Wolfe, & J. Hamborsky, *Epidemiology and prevention of vaccine-preventable diseases* (12th ed.; pp. 215–232). Washington DC: Public Health Foundation.

Centers for Disease Control and Prevention. (2015). *Immunization managers: laws and regulations*. Retrieved from http://www.cdc.gov/vaccines/imz-managers/laws/

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155-159.

Cornia P. B., Hersh, A. L., Lipsky, B. A., Newman T. B., & Gonzales R. (2010). Does this coughing adolescent or adult patient have pertussis? *Journal of the American Medical Association, 304*(8), 890–896.

Dayan, G., Ortega-Sanchez, I. R., LeBaron, C. W., Quinlisk, M. P., & Iowa Measles Response Team. (2005). The cost of containing one case of measles: Economic impact on the public health infrastructure—Iowa, 2004. *Pediatrics*, 116, e1-e4.

Eisenberg, D. (2003). *The ethics of smallpox immunization*. Retrieved from http://www.aish.com/ci/sam/48943486.html

Etkind, P., Lett, S., Macdonald, P., Silva, E. & Peppe, J. (1992). Pertussis outbreaks in groups claiming religious exemptions to vaccinations. *American Journal of Diseases of Children, 146*(2), 173-176.

Fair, E., Murphy, T. V., Golaz, A., & Wharton, M. (2002). Philosophic objection to vaccination as a risk for tetanus among children younger than 15 years. *Pediatrics, 109*(1), E2.

Falco, M. (2010). *Ten infants dead in California whooping cough outbreak*. CNN. Retrieved from http://www.cnn.com/2010/HEALTH/10/20/california.whooping .cough/index.html

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175-191.

Feikin, D., Lezotte, D. C., Hamman, R. F., Salmon, D. A., Chen, R. T., & Hoffman, R. E. (2000). Individual and community risks of measles and pertussis associated with

personal exemptions to immunizations. *Journal of the American Medical Association*, *284*(24), 3145-3150.

Foote, F., Krauss, H., Andrews, C., Hart, A. (1973). Polio outbreak in a private school. *Connecticut Medicine, 37*, 643-44.

Furesz, J. (1979). Poliomyelitis outbreaks in the Netherlands and Canada. *Canadian Medical Association Journal, 120*, 905-906.

Gardiner, H. (2005, November 8.). Five cases of polio in Amish group raise new fears. *New York Times*. Retrieved from http://www.nytimes.com/2005/11/08/national/08polio.html?pagewanted=all&_r=0

Goh, K. T. (1999). Resurgence of mumps in Singapore caused by the rubini mumps virus vaccine strain. *The Lancet*, *354*, 1355–1356.

Gordis, L. (2009). *Epidemiology*. Philidelphia, PA: Saunders

Grammatikos, A. P., Mantadakis, E., & Falagas, M. E. (2009). Meta-analyses on pediatric infections and vaccines. *Infectious Disease Clinics of North America, 23*(2), 431–457.

Guadino, J., & Robison, S. (2012). Risk factors associated with parents claiming personal-belief exemptions to school immunization requirements. *Vaccine*, *30*(6), 1132-1142.
DOI:10.1016/j.vaccine.2011.12.206

Hamdan, A. (1989). *Immunizations: Harmful to your child or not?* Retrieved from http://www.missionislam.com/health/immunizationhurtornot.htm

Hartog, M., Freeman, M., Kubilis, P., & Jankowski, R. (1999). Pediatricians' and social

workers' knowledge and opinions of Florida's religious immunity laws. *Southern Medical Journal, 92*(4), 362-368.

Heininger, U. (2010). Update on pertussis in children. *Expert review of anti-infective therapy, 8*(2), 163-173.

Hinman, A R. (2000). How should physicians and nurses deal with people who do not want immunizations? *Canadian Journal of Public Health, 91,* 248–51.

Klein, S. L., Jedlicka, A., & Pekosz, A. (2010). The Xs and Y of immune responses to viral vaccines. *Lancet Infectious Diseases, 10*(5), 338–49. doi:10.1016/S1473-3099(10)70049-9

Knight, A. (2004). Religious exemptions to North Carolina's childhood immunization requirements. *School Law Bulletin* (Fall), 12-19.

Krieger, N. (2004). Ecosocial theory. In N. Anderson (Ed.), *Encyclopedia of health and behavior* (pp. 293-295). Thousand Oaks, CA: Sage.

Lavelle, P. (January 20, 2009). "A bad year for whooping cough". *Australian Broadcasting Corporation*. Retrieved from http://www.abc.net.au/health/thepulse/stories/2009/01/20/2469770.htm

Link, K. (2005). *The vaccine controversy: The history, use, and safety of vaccinations*. Westport, CT: Praeger.

Matthias, J., Dusek, C., Pritchard, S. P., Rutledge, L., Kinchen, P., & Lander, M. (2014). Notes from the field: outbreak of pertussis in a school and religious community averse to health care and vaccinations - Columbia County, Florida, 2013. Retrieved from www.cdc.gov/mmwr/preview/mmwrhtml/mm6330a3.html.

Mayo Clinic. (2005). *Whooping cough*. Retrieved from http://www.mayoclinic.com/health/whooping-cough/DS00445/DSECTION=3

Mercola, J. (1996). *How to legally get a vaccine exemption*. Retrieved from http://articles.mercola.com/sites/articles/archive/2011/12/27/legal-vaccine-exemptions.aspx

Merriam Webster. (2013). *Sex*. Retrieved from http://www.merriam-webster.com/dictionary/sex

Morrison, E., & Embil, J. (1987). Poliomyelitis in North America: The disease is not dead yet. *Canadian Medical Journal Association, 137*(12), 1085-1087.

Mooi, F., van Loo, I., van Gent, M., He, Q., Bart, M., Heuvelman, K., & Mertsola, J. (2009). Bordetella pertussis strains with increased toxin production associated with pertussis resurgence. *Emerging Infectious Diseases, 15*(8), 1206-1213.

Morbidity and Mortality Weekly Report. (1997). *Epidemiologic notes and reports follow-up on poliomyelitis*. Retrieved from http://www.cdc.gov/mmwr//preview/mmwrhtml/00050435.htm

Morbidity and Mortality Weekly Report. (1982). *A case of diphtheria in Wisconsin.* Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/00001176.htm

National Institute of Allergy and Infectious Disease. (2012, May). *Vaccine types*. Retrieved from http://www.niaid.nih.gov/topics/vaccines/understanding/pages/typesvaccines.aspx

Nee, D., & Brashir, G. (2012, February 22). *14 cases of whooping cough confirmed in*

Ocean County. Retrieved from http://tomsriver.patch.com/articles/14-cases-of-whooping-cough-confirmed-in-ocean-county

Novotny, T., Jennings, C. E., Doran, M. (1988). Measles outbreaks in religious groups exempt from immunization laws. *Public Health Reports, 103*(1), 49-53.

Omer, S., Pan, W., Halsey, N., Stokley, S., & Salmon, D. (2006). Nonmedical Exemptions to School Immunization Requirements. *Journal of the American Medical Association,* 296(14), 1757-1763.

Orenstein, W., & Hinman, A. (1999). The immunization system in the United States: The role of school immunization laws. *Vaccine*, *17*(3), S19-24.

Plotkin, S., Orenstein, W., & Offit, P. (2008). *Vaccines* (5th ed). New York, NY: Saunders.

Religion's Hepatitis B Shot: The Arkansas General Assembly Established An Overly Broad Religious Exemption To Mandatory Immunization After The District Court Invalidated The Original Religious Exemption-Mccarthy V. Ozark School District. (2009). *Creighton Law Review, 42*(4), 777-836.

Rettner, R. (2011). Whooping Cough Vaccine Protection Fades After 3 Years. *My Health News Daily*. Retrieved from http://www.livescience.com/35923-whopping-cough-pertussis-vaccine-immunity.html

Richardson, D. (2011). *No shots, no school, not really*. National Vaccine Information Center. Retrieved from http://www.nvic.org/NVIC-Vaccine-News/July-2011/No-Shots,-No-School,-Not-Really-.aspx

Rivard, G., & Viera, A. (2014). Staying ahead of pertussis. *Journal of Family Practice*,

63(11), 658-669.

Rong-Gong, L. (2010, September 7). Diagnoses lagged in baby deaths. *Los Angeles Times*. Retrieved from http://www.livescience.com/35923-whopping-cough-pertussis-vaccine-immunity.html

Rooney, J. A., Milton, D., Hackler, R. L., Harris, J. H., Reynolds, D., Tanner, M., & Taylor, E. (2004). The largest outbreak of measles in the United States during 1999: Imported measles and pockets of susceptibility. *Journal of Infectious Diseases, 189*, S78-S80.

Ross, L., & Aspinwall, T. (1997). Religious exemptions to the immunization statutes: Balancing public health and religious freedom. *The Journal of Law, Medicine, & Ethics*, *25*(2-3), 202-9.

Salmon, D. A., Haber, M., Gangarosa, E. J., Phillips, L., Smith N. J., & Chen R. J. (1999). Health consequences of religious and philosophical exemptions from immunization laws: individual and societal risks of measles. *Journal of the American Medical Association*, *282*(1), 47-53.

Shaka, L. (2011). *How do we know herd immunity exists?* Retrieved from http://www.vaccinetimes.com/how-do-we-know-that-herd-immunity-exists/

Siegel, A., & Salmon, D. (2001). Religious and philosophical exemptions from vaccination requirements and lessons learned from conscientious objectors from conscription. *Public Health Report, 116*(4), 289-95.

Tuyen, J., & Bisgard, K. (2000). *Community setting*. Retrieved from http://www.cdc.gov/vaccines/pubs/pertussis-guide/downloads/chapter10.pdf

Van Wezel, A. (1979). Follow-up on poliomyelitis - United States, Canada, Netherlands. *Morbidity Mortality Weekly Report, 28*, 345-346.

Vesikari, T., & Kaikian, A. (1986). A comparative trial of rhesus monkey (RRV-1) and bovine (RIT) rotavirus vaccines. *The Journal of Infectious Diseases*, *153*(5), 832-39.

Warraich, H. (2009). *Religious opposition to polio vaccination.* Retrieved from http://wwwnc.cdc.gov/eid/article/15/6/09-0087_article.htm#r2

Zarocostas, J. (2006, October 16). Polio epidemic lurks in four nations; Nigeria, India, Afghanistan, Pakistan targeted for eradication measures. *The Washington Times,* pp. A17.

Zhang, L., Prietsch, S. O. M., Axelsson, I., & Halperin, S. A. (2012). Acellular vaccines for preventing whooping cough in children. *Cochrane Database of Systematic Reviews,* (3), Art. No: CD001478. Doi. 10.1002/14651858.CD001478.pub4

Appendix A: Data Use Agreement

DATA USE AGREEMENT

This Data Use Agreement ("Agreement"), effective as of March 5, 2014, is entered into by and between Siobhan Pappas and Ocean County Health Department. The purpose of this Agreement is to provide Data Recipient with access to a Limited Data Set ("LDS") for use in research in accord with the HIPAA and FERPA Regulations.

1. Definitions. Unless otherwise specified in this Agreement, all capitalized terms used in this Agreement not otherwise defined have the meaning established for purposes of the "HIPAA Regulations" codified at Title 45 parts 160 through 164 of the United States Code of Federal Regulations, as amended from time to time.

2. Preparation of the LDS. Ocean County Health Department shall prepare and furnish to Siobhan Pappas a LDS with all personal identifiers redacted.

3. Data Fields in the LDS. No direct identifiers such as names may be included in the Limited Data Set (LDS). In preparing the LDS, Ocean County Health Department shall include the **data fields specified as follows**, which are the minimum necessary to accomplish the research: Vaccination status, sex, pertussis status and county status.

4. Responsibilities of Data Recipient. Data Recipient agrees to:

a. Use or disclose the LDS only as permitted by this Agreement or as required by law;

b. Use appropriate safeguards to prevent use or disclosure of the LDS other than as permitted by this Agreement or required by law;

c. Report to Data Provider any use or disclosure of the LDS of which it becomes aware that is not permitted by this Agreement or required by law;

d. Require any of its subcontractors or agents that receive or have access to the LDS to agree to the same restrictions and conditions on the use and/or disclosure of the LDS that apply to Data Recipient under this Agreement; and

e. Not use the information in the LDS to identify or contact the individuals who are data subjects.

5. Permitted Uses and Disclosures of the LDS. Data Recipient may use and/or disclose the LDS for its Research activities for a doctoral dissertation.

6. Term and Termination.

a. Term. The term of this Agreement shall commence as of the Effective Date and shall continue for so long as Data Recipient retains the LDS, unless sooner terminated as set forth in this Agreement.

b. Termination by Data Recipient. Data Recipient may terminate this agreement at any time by notifying the Data Provider and returning or destroying the LDS.

c. Termination by Data Provider. Data Provider may terminate this agreement at any time by providing thirty (30) days prior written notice to Data Recipient.

d. For Breach. Data Provider shall provide written notice to Data Recipient within ten (10) days of any determination that Data Recipient has breached a material term of this Agreement. Data Provider shall afford Data Recipient an opportunity to cure said alleged material breach upon mutually agreeable terms. Failure to agree on mutually agreeable terms for cure within thirty (30) days shall be grounds for the immediate termination of this Agreement by Data Provider.

e. Effect of Termination. Sections 1, 4, 5, 6(e) and 7 of this Agreement shall survive any termination of this Agreement under subsections c or d.

7. Miscellaneous.

a. Change in Law. The parties agree to negotiate in good faith to amend this Agreement to comport with changes in federal law that materially alter either or both parties' obligations under this Agreement. Provided however, that if the parties are unable to agree to mutually acceptable amendment(s) by the compliance date of the change in applicable law or regulations, either Party may terminate this Agreement as provided in section 6.

b. Construction of Terms. The terms of this Agreement shall be construed to give effect to applicable federal interpretative guidance regarding the HIPAA Regulations.

c. No Third Party Beneficiaries. Nothing in this Agreement shall confer upon any person other than the parties and their respective successors or assigns, any rights, remedies, obligations, or liabilities whatsoever.

d. Counterparts. This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

e. Headings. The headings and other captions in this Agreement are for convenience and reference only and shall not be used in interpreting, construing or enforcing any of the provisions of this Agreement.

IN WITNESS WHEREOF, each of the undersigned has caused this Agreement to be duly executed in its name and on its behalf.

DATA PROVIDER	DATA RECIPIENT
Signed: D-O-E-R-O	Signed: Siobhan Pappas 03/07/14
Print Name: Daniel E. Regeaye	Print Name: Siobhan Pappas
Print Title: Public Health Coordinator	Print Title: REHS