

2015

A retrospective cohort study to determine the association of MMR vaccination coverage and incidence of measles in the United States between 1996 and 2012

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Thesis

**A RETROSPECTIVE COHORT STUDY TO DETERMINE THE ASSOCIATION
OF MMR VACCINATION COVERAGE AND INCIDENCE OF MEASLES IN
THE UNITED STATES BETWEEN 1996 AND 2012**

by

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B.S., Worcester Polytechnic Institute, 2013

Submitted in partial fulfillment of the
requirements for the degree of
Master of Science

2015

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DEDICATIONS

I would like to dedicate this project to anyone who has suffered from measles due to the increase in intentionally un-vaccinated individuals as well as to all of the medical professionals and researchers who have developed and currently are developing ways to increase MMR vaccination coverage nationwide.

ACKNOWLEDGMENTS

This thesis could not have been completed without the incredible support of the many people along the way. I would like to personally thank the following individuals for all their help and support.

First, I would like to thank my thesis advisor and first reader on this paper, Dr. Davidson Hamer. Your insight and advice has been incredibly helpful in learning more about infectious diseases, scientific writing, and the execution of this project.

I would also like to thank my readers, Dr. Thomas Trivison and Stacey Hess Pino for their tremendous support in biostatistics and technical writing. They have been extremely helpful in the completion of this project.

I would like to extend my sincere gratitude to Boston University School of Medicine, the MSCI program, and all of my instructors and classmates along the way who have taught me about all aspects of clinical research and prepared me for a brilliant career in this field.

Lastly, I would like to thank all of my family and friends who have supported me through my pursuit of this graduate degree.

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ABSTRACT

Purpose: The purpose of this study was to investigate the potential relationship between MMR vaccination coverage and measles incidence in the US, as well as to examine the demographic characteristics and socio-economic status of unvaccinated individuals to determine if there are certain sub-populations who are routinely not receiving the MMR vaccine.

Methods/Procedures: This retrospective cohort study determined the MMR vaccination coverage per year and compared it to the measles incidence for the same year.

Results: Results from this study suggest that regional differences in MMR vaccination rates spanning across multiple sub-populations are associated with the increasing measles incidence in the US.

Conclusions: The correlations between MMR vaccination coverage and measles incidence in the US should be investigated further to determine what specific programs can be put in place to increase MMR vaccination rates state-wide and among vulnerable sub-populations.

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LIST OF ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
CI	Confidence interval
DF	Degrees of freedom
GI	Gastrointestinal
GMC	General Medical Council
HSD	Honest significant difference test
IRB	Institutional Review Board
MMR	Measles, mumps, and rubella
MMWR	Morbidity and Mortality Weekly Report
MSA	Metropolitan Statistical Area
NETSS	National Electronic Telecommunications System for Surveillance
NIS	National Immunization Survey
RNA	Ribonucleic acid
US	United States
VFC	Vaccines for Children

INTRODUCTION

Measles Virus

The measles virus is a single stranded ribonucleic acid (RNA) microbe which belongs to the *Paramyxoviridae* family. This family of viruses contains respiratory syncytial virus, mumps, and measles, among others. The specific genus that includes measles is *Morbillivirus*.¹ The measles virus is a spherical, enveloped particle with a central helical nucleocapsid containing a negative sense RNA genome. This specific structure allows the virus to enter host cells located in the lymphatic, respiratory, intestinal, and urinary systems therefore inducing viral transcription and replication.¹

The virus enters the body through the transmission of bodily fluids. These include saliva and/or mucous from coughing or sneezing or tears from the eye. An individual can be infected with measles for up to four days before producing symptoms and since measles can survive outside the body for as long as 2 hours, many people can unsuspectedly become infected.² Measles can affect many different organ systems although the main cause of complications from measles is not the virus itself, but from secondary infections such as otitis, pneumonia, and encephalitis.¹ Encephalitis is found in approximately 1 in 1,000 individuals who become infected with measles.¹ The most common symptoms include fever, runny nose, cough, and a rash covering the body.³

Measles is considered the most contagious diseases among vaccine preventable diseases. It is estimated that for every 1 person who contracts the measles virus, 12 to 18 people who were in contact with that individual will be susceptible to the disease.⁴ In

order to protect society from vaccine preventable diseases like measles, healthcare workers calculate the percentage of people who should be vaccinated to prevent a resurgence of measles. If this percentage is reached, healthcare workers can be confident in nationwide protection against measles but if the vaccination coverage drops below this level, there is a risk of outbreaks. Given its high rate of transmission, approximately 93% of the population needs to be vaccinated to ensure the safety of everyone. Thus, in order to eliminate measles permanently, 93% of the population needs to be vaccinated at all times.⁴ However, the average MMR immunization coverage in the US currently hovers around 90%; close to the ideal of 93% but also demonstrating that while some communities might be at 100% vaccination coverage, other communities may have only 80% vaccination coverage.⁵ This raises a significant issue for the general population's protection against measles.

History of Measles & MMR Vaccine

Evidence of the measles virus was found as early as the 7th century A.D. From this time until the mid-20th century, when more people were afraid of measles than smallpox, measles was just as common as the influenza virus is now. During this period, more than half of the population contracted measles by the time they were 6 years old, and an astonishing 90% of people contracted measles by the time they were 15.⁶ In the decade before the MMR vaccine was introduced in the US, an estimated 3 million people were infected with measles,⁷ resulting in approximately 500 deaths annually from the virus.³ In the late 1950s the first measles vaccine was tested and in 1963 the first measles vaccine was licensed and introduced into a regular vaccination schedule. Shortly after

this, a combination vaccine for measles, mumps, and rubella, (the MMR vaccine), was developed, and in conjunction with pervasive vaccination rates, lead to a dramatic drop in the incidence of measles. Ultimately, in 2000 this decrease in diagnosis and increase in vaccination rates led to a declaration that measles had been eliminated in the US.⁸

MMR Vaccine

The MMR vaccine is administered in two doses; the first dose administered between 12 and 15 months of age, and the second dose administered between 4 and 6 years of age. While the first dose of the MMR vaccine was shown to be 95% effective on its own, the second dose was introduced (in 1989) to enhance protection because approximately 2–5% of children did not respond to the initial dose.⁷ The second dose is administered to all children to ensure that everyone who received the two vaccines is protected (from measles, mumps and rubella). Furthermore, the MMR vaccine is also recommended for anyone over the age of 18 who has not previously received two doses of the vaccine, or who has been infected with one of the three viruses.⁹

Similar to other vaccines, the MMR vaccine comes with risks but medical professionals agree that the proven benefits of the MMR vaccine outweigh any potential risks. The potential risks associated with the MMR vaccine and their relative incidences⁹ are summarized in Table 1.

TABLE 1: ADVERSE EVENTS ASSOCIATED WITH THE MMR VACCINE

	Adverse Event	Incidence
Mild Symptoms	Fever	1 in 6 people
	Mild rash	1 in 20 people
	Swelling of glands in cheeks or neck	1 in 75 people
Moderate Symptoms	Seizure caused by fever	1 in 3,000 doses
	Temporary pain and stiffness in the joints	1 in 4 mostly teenage or adult women
	Temporary low platelet count, leading to bleeding disorder	1 in 30,000 doses
Severe Symptoms (very rare)	Serious allergic reaction	< 1 in 1 million doses
	Deafness	These events have not occurred enough times to be measured against the population of vaccinated children
	Long-term seizures, coma, or lowered consciousness	
	Permanent brain damage	

Resurgence of Measles & Causes

Since the MMR vaccine was first introduced in 1963, multiple measles outbreaks have been recorded. From 1989 through 1991, 55,622 people contracted the measles virus with the majority of these cases occurring in children under the age of 5, resulting in 123 deaths.⁶ In looking closely at the diagnostic data, it was discovered that 90% of the children who died from measles prior to 1991 were not vaccinated against the virus. This pattern was concerning and underscored the efficacy of the vaccine as this level of

severity caused from the measles virus had not been seen in almost 20 years.⁶ Due to this fact, concern about the root cause of repeated outbreaks arose.⁶

Despite both the efficacy and availability of the vaccine, there has been a resurgence of the disease in the last decade, in the US (Figure 1).⁵ While the national average MMR vaccination coverage in the US is 90%, fifteen states have fallen below this rate.⁵ This lack of universal vaccination coverage and the recent increase in the incidence of measles can be attributed to several factors including: vaccine exemptions, increased travel into and out of the US, and vaccine-hesitance, a person's indecision to get the vaccine.⁵

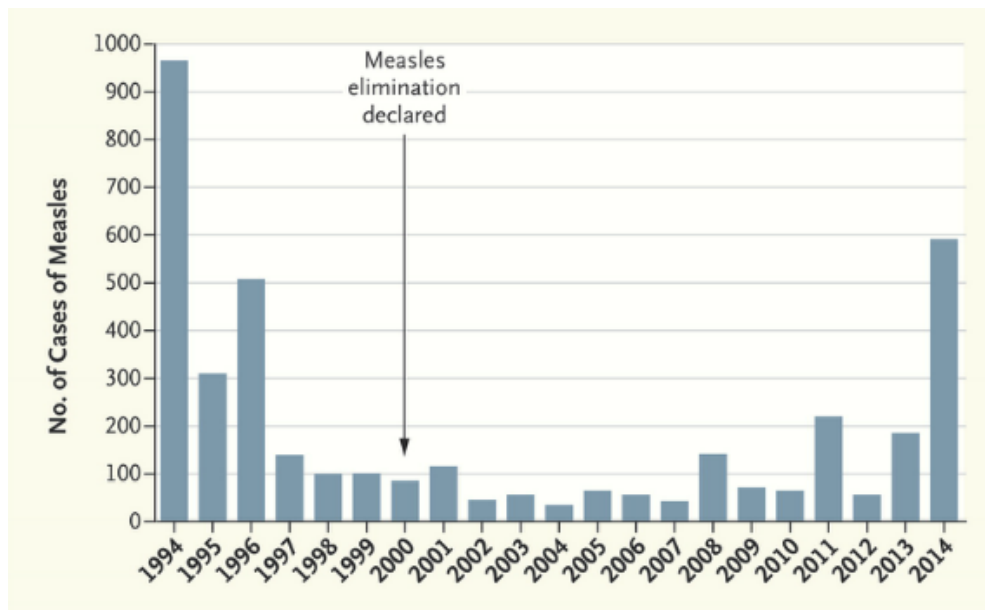


FIGURE 1: INCIDENCE OF MEASLES IN THE US, 1994–2014

Vaccine Exemptions

Medical Exemption

In the last decade, an increase in the number of people who are electing to not receive the MMR vaccine has been observed. For example, certain individuals are unable to receive the MMR vaccine for medical reasons, including those who are immunocompromised; those who are allergic to the vaccine; and those individuals who have an underlying moderate or severe illness whereby the vaccine would put their health at greater risk than the possibility of contracting measles.⁹ This segment of the population is relying on the vaccination of others – also known as herd immunity – to eliminate or minimize occurrences thus reducing their exposure and risk of contracting the measles virus. This form of herd immunity takes on even greater significance because while these individuals are unable to receive the MMR vaccine, due to medical contraindications, they are at greater risk of serious complications if they contract measles.

Religious Exemption

In addition to medical reasons for non-vaccination, there are also religious groups which do not condone the use of vaccinations as prevention for common communicable diseases. Not all religions have the same philosophies about vaccinations but the overarching attitudes can be summarized into three main categories: vaccinations are a violation of prohibitions against taking life, are a violation of dietary laws, and they interfere with natural order thereby interfering with the course of life events.¹⁰ Although the US ensures freedom of religion under the 1st Amendment, there is substantial evidence that not vaccinating in large groups affects not only individuals in that group but

also those outside that group,¹⁰ raising the question of whether an individual's right to waive vaccination supersedes the general populations' right to protection from the measles virus. An article published in *Vaccine* examined different religious beliefs about vaccines and the implications of large groups not vaccinating. In this journal, several studies were analyzed and found that the risk of contracting the measles virus was 6 to 35 times higher among people claiming exemption to immunization compared to a similar population of vaccinated individuals.¹⁰

Philosophical Exemption

More recently, statistics have shown that people are electing to not vaccinate their children for philosophical or personal reasons. They believe that the MMR vaccine is unsafe or unnecessary and they do not want to subject their children to a perceived danger.¹¹ In response to the decreasing rates of vaccination, Daniel A. Salmon and his colleagues at the CDC conducted a cohort study to assess the *Health Consequences of Religious and Philosophical Exemptions from Immunization Laws*.¹² This study found that people who did not receive the MMR vaccine were on average 35 times more likely to contract measles than people who received the vaccine. Due to the highly contagious nature of the measles virus, this increase in diagnosis depicts the escalation of risk and ultimately reinforces the need for MMR vaccination in everyone who qualifies. Full compliance by all eligible groups would, theoretically, reduce the overall risk of people who cannot be vaccinated due to medical reasons from contracting measles.

Introduction of Measles into the US

Another factor contributing to the recent measles outbreaks may be the introduction of the virus from individuals traveling into and out of the US. Without uniform vaccination laws or uniform vaccination recommendations worldwide, it is difficult to prevent viruses from being brought into the US. While almost all countries worldwide recommend their children receive at least the monovalent measles vaccine, many low or middle income countries have not attained the recommended 90% vaccination coverage. These countries have also not implemented routine immunization programs to ensure compliance with vaccination recommendations.¹³ Due to this lack of vaccination compliance, as people immigrate to or visit the US, the potential to introduce measles into the US population is increased. Similarly, if unvaccinated Americans travel abroad and contract the measles virus, and re-enter the US, a large portion of the US population is placed at risk.

The scenarios stated above have a cumulative effect in that while the MMR vaccination rate in the US continues to decrease resulting in a larger percentage of the general population being unprotected, the potential for a wide-spread outbreak increases. Similarly, infected persons who enter the US increase the likelihood they could transmit the virus to another individual who was not vaccinated and begin an outbreak. The cycle continues to escalate as people who are not vaccinated become infected and infect others. The serious implications of decreasing vaccination rates continues to plague the US even though just one dose of the MMR vaccine is 95% effective at preventing the transmission of measles.⁷

Dr. Andrew Wakefield

The lower vaccination rates observed in those who claim philosophical or personal exemptions could be due, in part, to a paper written by Wakefield et al., published in the Lancet in 1998. Wakefield et al. conducted a study to determine if there was a correlation between “children with chronic enterocolitis and regressive developmental disorder”.¹⁴

Study Design

This study was conducted in 12 children, 11 of whom were boys. Children were chosen as study subjects if they were referred to a pediatric gastroenterology unit with “previously normal acquired skills but recent loss of these skills along with the occurrence of gastrointestinal (GI) discomfort”.¹⁴ The children were examined intensely to assess the gastroenterological, neurological, and developmental systems in order to associate a cause to their recently developed regression. The tests included laboratory, endoscopic, and histological analysis to get a full picture of the child’s health.¹⁴

Study Results

This study concluded that in 8 of the 12 pediatric subjects the onset of behavioral symptoms, including the loss of acquired skills such as language, was associated with the MMR vaccine.¹⁴ The association between the onset of developmental symptoms and the MMR vaccine was linked by either the child’s physician or their parents for these eight children. Five of the eight children experienced adverse reactions to the vaccine itself and all eight children developed the loss of acquired skills within approximately two weeks (1–14 days) of getting the vaccine.¹⁴

Bias & Limitations

The authors describe many sources of bias in the article, the most concerning being selection bias of the parents who had already decided that the MMR vaccine had caused their child's autism spectrum disorder.¹⁴ Wakefield and his colleagues attempted to alleviate this concern by noting that the link between GI symptoms (similar to those seen in this population) had already been shown to be associated with autism spectrum disorders. The link was first published by Asperger H, et al. in the *Annals of Pediatrics* in 1961.¹⁴ Wakefield et al. cites this paper noting that these children developed GI symptoms with associated laboratory and histologically confirmed findings after receiving the MMR vaccine and that these GI symptoms had already been shown to be associated with autism spectrum disorders.¹⁵ Another bias that was seen in this study was the selection of the study population. The population that was chosen for this study did not represent the population as a whole. Autism is 3 times as likely to occur in boys than in girls,¹⁶ and since 11 out of 12 of the subjects were boys, Wakefield's results were biased towards him finding a correlation between the MMR vaccine and autism.

Discussion

Since the publication of the Wakefield study in 1998, 11 of the 13 authors have retracted their findings and *The Lancet* retracted the paper from their journal in 2010. Andrew Wakefield was investigated by the General Medical Council (GMC) for the unethical conduct of his study, as well as the results he found. The council determined that his conduct was "irresponsible and dishonest", citing that his results could not be replicated, the equipment he used was not routinely maintained, and the samples were

contaminated with the measles virus before they were tested. Lastly, and most importantly, the committee determined that Wakefield put the children at higher risk than was acceptable by doing hundreds of tests on them including a spinal tap and colonoscopy. The enormous risk to the children in the study would have become apparent had the study had gone through an ethics committee approval but the study was never submitted to London's Royal Free Hospital's ethics committee. According to the committee, Wakefield acted with "callous disregard to the distress and pain the children might suffer".¹⁷

In May of 2010, after the GMC had ruled against Wakefield on all charges, his name was removed from the United Kingdom Medical Registrar. This was the harshest punishment ever given by the GMC; they claimed that Wakefield had "brought the medical profession into disrepute" and that nothing short of removing his name from the register would be appropriate.¹⁷

Even with the investigation and invalidation of Wakefield's work, the public's perception of the safety of the MMR vaccine was irreparably harmed. Since the publication of Wakefield's fraudulent study, many researchers have worked relentlessly to prove that the MMR vaccine is safe and efficacious, unfortunately the conclusive data has not swayed the opinions of a small percentage of parents who believe any level of risk of side effects is unacceptable.¹⁸

Studies in Response to Wakefield's Article

MMR Vaccine – Worries are not justified

In 2001, Bedford Elliman published an article in *The Journal of the Royal College of Paediatrics and Child Health*, detailing the history of the MMR vaccine and the recent events that caused controversy over this vaccine. He specifically mentions Wakefield's study and how even though the author's stated that they "had not *proven* a link between the vaccine and the disorders", many people failed to interpret that correctly and the media hysteria over the article quickly ensued.¹⁹ Elliman also mentions that between 1998 and 2001 many researchers set out to specifically investigate the correlation between the MMR vaccine, autism, and bowel disease, resulting in, inconclusive findings on the subject. Two studies were conducted investigating the time interval between the MMR vaccine and the supposed onset of autism; one was performed with an interval of 1 year between MMR vaccination and onset of autism, and another executed with a three year period between the two events. In both studies, it was found that there was no link between MMR vaccination and onset of autism.¹⁹ There were also two meta-analyses performed of both published and unpublished data. The results were presented at the American Academy of Pediatric conference where it was reported that "available evidence does not support the hypothesis that MMR vaccine causes autism or associated disorders, or inflammatory bowel disease." Ultimately, Elliman concluded that "there is no good scientific evidence to support a link between MMR vaccine and autism" and that "there is mounting evidence that shows no link". He goes on to say that the MMR

vaccine is both safe and effective and that trying to find a new vaccine for the prevention of measles, mumps, and rubella is only taking a step backward.¹⁹

No Effect of MMR Withdrawal on the Incidence of Autism: A Total Population Study

One year later a study was conducted for the same purpose as Elliman's investigation to disprove any correlation between the MMR vaccine and autism. Unlike Elliman's article, this study hoped to disprove Wakefield's claims with clinical data. This study was conducted in central Japan, a country that had similar vaccination laws to the US until 1993 when MMR vaccination laws were terminated due to an increase in cases of aseptic meningitis, a suspected side effect of the MMR vaccine.²⁰ With no vaccination laws in place for the MMR vaccine, not a single MMR vaccination was administered in central Japan after 1993. Dr. Hideo Honda and his colleagues determined that this location would be the most ideal environment to study the effects of the MMR vaccine on the incidence of autism. Their hypothesis was that if the rates of autism decreased after 1993, there was a good chance that the MMR vaccine might have played a role in the development of autism. Conversely, if the incidence of autism stayed the same or even increased, this would suggest a lack of an association. The study examined the cumulative incidence of autism for children born from 1988 until 1996 in Yokohama, Japan. The children were followed from birth to the age of 7 to determine incidence of autism. The study looked at the incidence of autism in the years before MMR vaccination laws were repealed (1988–1992) compared to those seen in the years where not a single MMR vaccine was given (1993–1996). Honda et al. found that rates in the incidence of autism continued to rise (0.476% in 1988 compared to 1.17% in 1996) while the rates of

MMR vaccine use were close to 0%.²⁰ Due to the nature of the study, the results do not prove a causal relationship but these results add circumstantial data to the mounting evidence that there is no link between the MMR vaccine and autism.²⁰ Conclusions from this study were not surprising to medical professionals but did help ease the mind of parents who were trying to decide whether or not to vaccinate their children against the measles virus.

Media Coverage of the Measles-Mumps-Rubella Vaccine and Autism Controversy and its Relationship to MMR Immunization Rates in the US

Even though many researchers had disproved Wakefield's correlation between the MMR vaccine and autism, people remained skeptical as to whether they should vaccinate their children. To further investigate the public's perceived safety of receiving the MMR vaccine, Smith et al. conducted a study in 2004 looking at the rate of MMR vaccination in relation to media stories using key words such as "measles", "MMR", and "autism". The National Immunization Survey (NIS) was used to determine the rate of MMR vaccination in the US each year between 1995 and 2004.²¹ Information on media coverage was collected through the LexisNexis database; which compiled all news stories on a national and local level. The primary objective of the study was to determine if there were trends toward selective non-receipt of the MMR vaccine. That is, were parents allowing their children to receive every other childhood vaccination except the MMR vaccine or were they just not receiving any vaccinations at all? The researchers wanted to know the true effect of Wakefield's article and the media coverage that followed on MMR vaccination rates. Surprisingly, the study found that the rate of MMR vaccine use

did not have any statistically significant correlation to media coverage in the US.²¹

Although the vaccination rate did decline, lower vaccination rates were not seen in parts of the country with the most media coverage and vice versa as was hypothesized. The concern about media coverage and the MMR/autism scandal was and still is an important and justifiable issue in the US. Smith et al.'s contribution was important because it eliminated one more factor from the debate over MMR vaccination.

Lack of Association between Measles Virus Vaccine and Autism with Enteropathy: A Case-Control Study

Similar to the articles mentioned previously, a case-control study was conducted in 2008 to “determine whether children with GI disturbances and autism were more likely than children with GI disturbances alone to have the measles virus and/or inflammation present in their bowel tissues and if autism and/or GI episode onset related temporally to receipt of MMR”.²² While Wakefield reported that the measles virus was found in the bowel tissue of children with autism spectrum disorders and GI disturbances, numerous studies have proven no association with the MMR vaccine and autism. Unfortunately, there is not conclusive data as not many studies have looked specifically for the presence of the measles virus in the bowel of children who suffer from autism and GI disturbances.²²

This study took samples from children who were already undergoing clinically indicated testing for their GI problems. The two groups included 25 children with autism and GI disturbances compared to a group of 13 children who had GI disturbances with no diagnosis of autism. Blinded tests were performed on samples obtained from all children

and the relationship between the onset of GI episodes and autism in relation to the timing of MMR vaccination was determined using a real-time reverse transcriptase polymerase chain reaction (PCR).

The study results found that there was no difference between the group of children with autism and GI disturbance and those with only GI disturbance in the presence of the measles virus in the bowel tissue and that GI symptoms were unrelated to MMR timing. The authors report that this study “provides strong evidence against association of autism with persistent the measles virus in the GI tract or MMR exposure.”²²

Public Health Concern

Although the studies cited above and many other similar investigations have shown a lack of association between MMR vaccination and the onset of autism, a large portion of parents do not believe that the vaccine is safe enough to administer to their child. Historical data showing an increase in the number of reported cases of measles was published in the September 2014 Morbidity and Mortality Weekly Report (MMWR): Summary of Notifiable Diseases.²³ Figure 2 depicts how the incidence of measles went from being extremely high in 1978 to almost non-existent in 1998. It also reflects the resurgence of cases beginning in 2008.

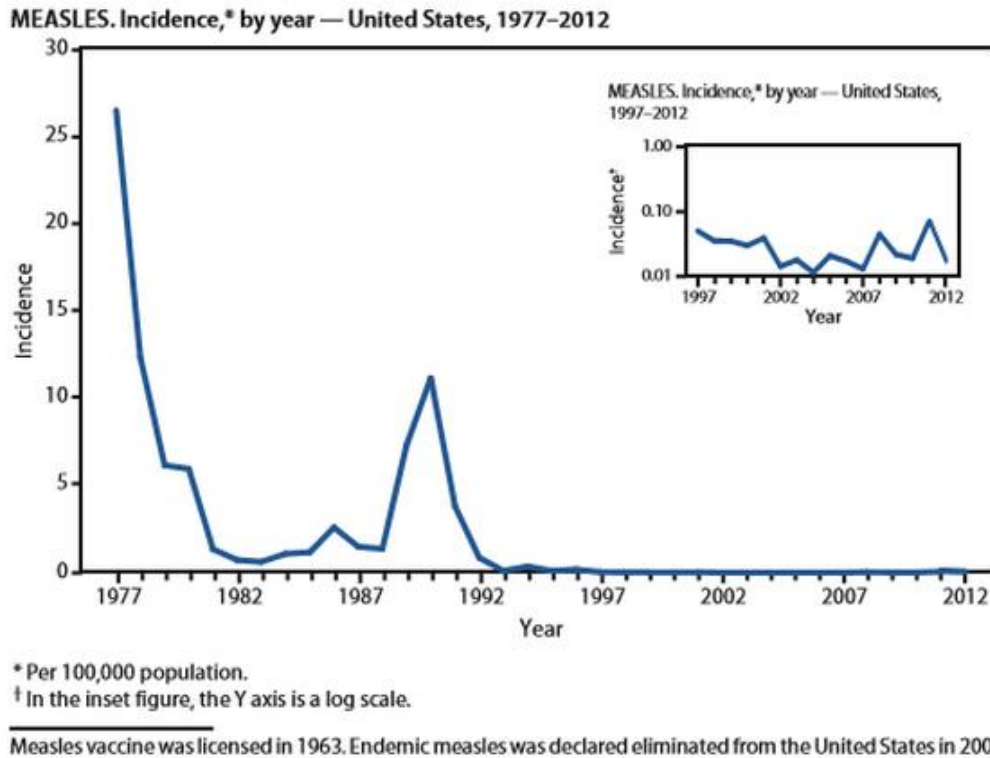


FIGURE 2: INCIDENCE OF MEASLES IN THE US, 1977–2012

An editorial published in the *New England Journal of Medicine* in October 2014 cites that “more measles cases have been reported in the US so far in 2014 – 592 cases from January 1 to August 29 – than during any year in the past two decades”.⁴ The article, titled “Mounting a Good Offense against Measles” was in response to the astounding number of measles cases seen in the US during this time. Dr. Walter Orenstein and his colleague Katherine Seib wrote the article in hopes that it would bring into focus the dangers of not receiving the MMR vaccine and how the outbreaks of measles could begin to adversely affect the US.⁴ One of the most important aspects of this article is how diagnosis of the measles virus can be used as an indicator of the

compliance and efficacy of the US' immunization program as a whole. While there have been gaps in the immunization program in the past, the measles virus was always the first of the vaccine preventable viruses to present itself as an increasingly common occurrence. The measles outbreaks that is currently ongoing is a good indicator that low immunization coverage has become a significant public health issue.⁴

The paper attributes the increase in cases of measles in the US to three factors, including a lack of support for global immunization programs, lack of a standardized system worldwide for detecting certain strains of measles in the infected population, and a hesitancy to vaccinate.⁴ First, they argue that implementing a global vaccination strategy would allow for universal vaccination coverage for people traveling into and out of different countries, thereby decreasing the potential for cross-continental infections. Secondly, if it is known that some strains have been eliminated but certain strains keep reappearing, more research can be done to determine how the strain differs from the others and how best to prevent it in the future. Lastly, and most importantly, the hesitancy to vaccinate against measles in the US is directly undermining the possibility of eliminating the virus for good. Determining exactly why parents are hesitant to vaccinate and why physicians are willing to allow exemptions, will provide important insight as to how to tailor educational and support programs that will lead to increased vaccination rates.⁴ Unfortunately, the paper also states that the lack of perceived risk from the measles virus is impeding any progress scientists and healthcare workers have made i.e. measles only makes news when outbreaks are observed.⁴ Since the US has so many residents, a mere 588 cases over an 8 month period seems relatively small. It is only

when you consider the alarming trend in comparison to previous years' cases that you realize the current impact and potential escalation of the measles virus in the US.⁴

Possible Solutions

Among the mounting evidence regarding the lack of correlation between the MMR vaccine and autism, are articles addressing how to change the public's perception of the safety of the MMR vaccine and vaccines in general. These articles bring attention to the harsh reality that the media too often opts sensationalism over accuracy and does not always focus on the correct stories. For example, the lay person may not understand the results or outcomes of a clinical trial, and that the best way to overcome the immunization epidemic in the US is to re-educate parents and healthcare providers on the importance of vaccinating against vaccine preventable diseases and the very real risks associated with contracting a vaccine preventable disease such as measles.²⁴

Communicating Science to the Public: MMR Vaccine and autism

An article published in *Vaccine* in 2003, which focused on the disconnect between scientists and the general public with regards to publishing results from clinical trials, explained the importance of disseminating critical information to the public, including determining how false reports of the association between the MMR vaccine and autism were developed; ways that this association was disproved how the study and similar studies have been communicated to the media; and ways to improve communication in order to give the public more accurate information.²⁴

Details of Wakefield's hypothesis and the studies performed to disprove it have

been discussed at length and do not need repeating but Offit's perspective on how study results are communicated to the media and therefore the general public and ways to improve communication are of important public interest.

There are three characteristics that can have an effect on how the public perceives medical information, including the way in which the media catches the public's attention; the confusion between results reported from a clinical trial and what they actually mean; and the lack of knowledge surrounding how the scientific process works.²⁴

As seen in most parts of our society, the most interesting things to people are uncommon, dramatic, and sensational. The same can be seen with news reports; people are more interested in things that are not the status quo, or things that challenge what we have always known to be correct. In this sense, news stations, newspapers, and radio stations are more likely to report the uncommon statistics rather than more common and mundane statistics. These reports, especially when it comes to medical conditions or adverse events of any kind, often include emotional and dramatic stories to catch the public's attention.

This problem is exacerbated by the fact that not everyone understands how the results published in a medical journal correlate to changes they should be making in their personal healthcare. It is not well known that cohort studies cannot actually show a causal relationship and that this type of relationship can only be proven in a randomized, double-blind, placebo-controlled clinical trial. There is a wide belief that when an *association* is reported, it means that something causes something else. What is really

being reported is that there is evidence to support that the two events being investigated did not just happen by chance and that they might be connected in some way. It is hard to relay this information to the public especially when the media does not preface its news stories with an interpretation of the meaning of the results.²⁴

The same is true for the public's understanding of the scientific process. In science, and especially clinical trials, investigators are not allowed to say that they have determined that an intervention is *not* associated with a certain outcome or, for example, that the MMR vaccine does not cause autism. This oftentimes causes confusion because it leaves the interpretation of the results up to the media and the public, i.e. that "there is no evidence that the MMR vaccine causes autism" does not imply that *the MMR vaccine does not cause autism*, only that there is no evidence to support this claim. Unfortunately, the public oftentimes misunderstands this type of statement, with people concluding that a correlation may exist, and that scientists simply cannot be sure either way.

All of these issues have contributed to the decrease in vaccination rates and especially MMR vaccination in the US but Offit does propose a couple of solutions. First, he proposes making it known to the media what is at stake if they keep reporting only one side of the story. Initiating a conversation about how reports on the correlation between the MMR vaccine and autism have a real effect on those who receive the vaccine as well as how watching your child suffer and die from the measles virus can be just as dramatic and emotional as your child *developing autism from the vaccine*, would help the public realize that not vaccinating your child is putting them in more danger than vaccinating them.²⁴

Similarly, informing the public on how results of clinical studies can be correlated to healthcare decisions and explaining how the scientific process works can help alleviate some of the confusion and panic that ensues when a study shows results that go against what has been previously thought. Lastly, and most importantly, scientists, physicians, and the media need to begin informing the public on the increasing incidence of measles in the US and the dangers associated with contracting the virus if individuals are not vaccinated.

A pilot study on the effects of individually tailored education for MMR vaccine-hesitant parents on MMR Vaccination Intention

Along the same lines as the paper written by Paul Offit, a pilot study was conducted investigating educational programs regarding the increasing awareness and importance of the MMR vaccine and how those educational programs influenced a parent's decision to vaccinate their child.²⁵ In this study, a group of 77 parents who had originally been screened as vaccine-hesitant were given 1 of 2 interventions. The first intervention was an educational web-page which specifically addressed concerns that had been raised in the scientific and medical community about the vaccine. These included everything from side-effects that had been fraudulently reported, to the importance of protecting children against the measles virus. The second intervention was a similar educational web-page but only included information about the vaccine, similar to what the doctor provides to a patient before any vaccine. This information includes statistics on the efficacy of the vaccine, the vaccine schedule, and potential side effects.²⁵

Although larger studies are needed to definitively prove that a tailored educational program is more efficacious in changing the parent's opinion on whether or not to vaccinate, the authors concluded that a tailored education strategy may be an effective way to improve vaccination compliance among vaccination-hesitant parents.²⁵

Rationale for Study

Due to the resurgence in the spread of measles, and because the decision to vaccinate against this virus are important and controversial issues with serious public health consequences, it would be beneficial to determine the proportion of people who are vaccinated with the MMR vaccine each year versus the proportion of people who contract the measles virus annually in the US. This study aimed to investigate the potential relationship between these two factors, as well as to examine the demographic characteristics and socio-economic status of unvaccinated individuals to determine if there are certain sub-populations who are not receiving the vaccine.

This investigation will prove useful to policymakers and the CDC in terms of developing and implementing strategies to address the current measles epidemic in the US.

Thesis Questions

1. What is the relationship between the MMR vaccination coverage and the incidence of measles from 1996 to 2012 in the US?
2. What is the relationship between demographic characteristics and socio-economic status and MMR vaccination coverage?

METHODS

Institutional Review Board (IRB) approval was obtained from the Boston University Medical Campus IRB prior to initiating any research activities.

Study Design

This study aimed to determine the relationship between MMR vaccination coverage and incidence of measles in the US. The study also investigated if demographic characteristics and socio-economic status had any correlation to MMR vaccination coverage.

This study was conducted using a retrospective cohort design where subjects were chosen based on exposure to the MMR vaccine and analyzed to determine the presence of the outcome variable, measles.

Outcome Measures

The primary outcome measure of this study was the relationship between MMR vaccination coverage and incidence of measles in the US as seen in Figure 3.

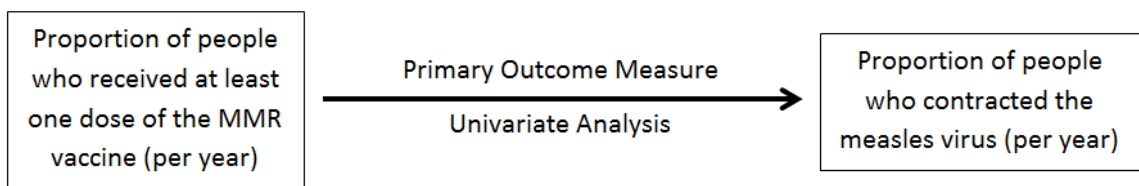


FIGURE 3: PRIMARY OUTCOME MEASURES

The secondary outcome measure was to determine if certain sub-populations were at higher risk of not receiving the MMR vaccine (Figure 4).

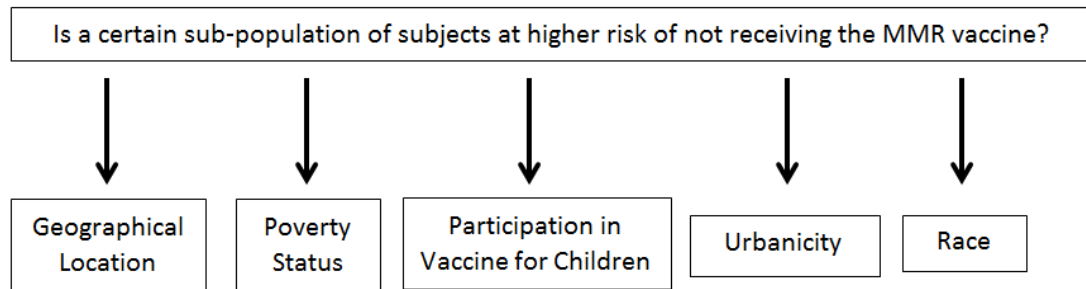


FIGURE 4: SECONDARY OUTCOME MEASURES

The data that were collected to determine primary and secondary endpoints for this investigation is detailed below. Data for MMR vaccination coverage between 1996 and 2012 in the US was obtained from the NIS, whereas data on the incidence of measles between 1996 and 2012 in the US was obtained from the CDC-WONDER publically available database.²⁶

Subject Population

The criteria for qualification for this study included individuals who:

1. Currently live or have lived in the US.
2. Have partaken in any one of the NIS.
3. Have contracted measles while living in the US.

People who have lived in the US for the last 100 years could have potentially been included in the analysis. The study period begins in 1996, if an individual was diagnosed with measles at age 90 they would have been born in 1900. Although the MMR vaccine

was not licensed until well after that, individuals would have either contracted measles and become immune, or they would have received that vaccine when it became available. Lastly, data was only collected on the individuals who contracted measles. For the purposes of this paper, it was assumed that the US population during any particular year minus the cases of measles in that same year would amount to the people who did not contract measles in the US that year.

Statistical Analysis

Data Sources

National Immunization Survey (NIS)

Data were collected from multiple sources for this analysis. Immunization data were collected from the NIS publically available database. The NIS was established in 1994 in order to monitor childhood immunization coverage. Sponsored by the National Center for Immunizations and Respiratory Diseases, the National Center for Health Statistics, and the CDC, the NIS collected immunization data from children who were between the ages of 19 and 35 months at the time that they took the survey. The survey consisted of a list-assisted random-digit-dialing telephone survey²⁷ which was then followed by a mailed survey to the child's immunization provider.²⁷

In 1998, the methodology used for analyzing the results of the NIS was improved. The new methodology in which the survey was conducted accounts for biases such as vaccination history nonresponse, where provider data were not obtained, by putting data into weighted groups on the likelihood that the group will have adequate data.²⁸ This

methodology still introduced some bias but “the overall extent of bias reduction was 0.5%, suggesting that provider nonresponse bias was small”²⁸.

Data were collected on MMR vaccination coverage (point estimate and 95% confidence interval (CI)) by state, poverty status, participation in the Vaccines for Children program (VFC), urbanicity, and race/ethnicity. VFC is a federally funded program which supplies vaccines to children who would not otherwise be able to get them. Children who are uninsured or underinsured and would not be able to afford the vaccine are eligible for this program.²⁹ All data were collected from 1996–2012 and stratified by geographical location, national totals, the 50 states, and the District of Columbia. Descriptions of each data set are detailed below.

- MMR vaccination coverage on a state level for each year from 1996–2012, this included the 50 states as well as the District of Columbia and a national total.
- MMR vaccination coverage for people who lived at or above the poverty line or below poverty.
- MMR vaccination coverage was reported for children whose providers participated in the VFC program as well as children whose providers did not participate in the VFC program.
- MMR vaccination coverage for levels of urbanicity. The levels of urbanicity included Metropolitan Statistical Area (MSA) Central City, MSA non-central city, and non-MSA central city. A MSA was defined as

an area which had “at least one urbanized area of 50,000 or more population, plus adjacent territory that had a high degree of social and economic integration with the core as measured by commuting ties”.³⁰ Similarly, the identification of central city (also known as a principal city) took into account incorporated places and census designated places.³⁰ MMR vaccination coverage reported for each of the three classifications was broken down by state for each year.

- MMR vaccination coverage for race/ethnicity reported the MMR vaccination coverage by state for each of the following races/ethnicities; white, black, Hispanic, American Indian or Alaska Native, and Pacific Islander.

Since all data mentioned above were reported as point estimates with 95% CI, total population numbers for each MMR vaccination coverage category and state were obtained from the US Census Bureau.

Summary of Notifiable Diseases

Data on the incidence of measles per year in the US was obtained from the MMWR: Summary of Notifiable Disease reports that were published by the Department of Health and Human Services and CDC. The data presented in these reports was collected from various sources including the Epidemiology Program Office, the CDC, and state and territorial health departments.³¹ The CDC encourages health professionals to report laboratory confirmed cases of measles to their local health department within 24 hours.³² The data are then compiled in the National Electronic Telecommunications

System for Surveillance (NETSS). The CDC uses the compiled data to look for national trends for notifiable diseases.³¹

The report included total reported cases of measles per year. Cases of measles were also reported by geographic region, including reports from the 50 states, the District of Columbia, and total US reported cases.

Some categories of the data included population totals for the relevant year and variables but similar to the NIS data, the total number of residents was obtained from the US Census Bureau if not reported in the MMWR.

Although the data reported in the MMWR: Summary of Notifiable Diseases was very helpful in looking for trends, there were many caveats in using this data. Some diseases, which do not have severe clinical symptoms, might have been under-reported because they were either so uncommon that doctors would not think to diagnose them or the symptoms were treated while the underlying disease was never known. Similarly, reporting of these diseases depended on the facilities that were present to test for certain diseases, measures in place to determine the sensitivity and specificity of these tests, as well as how likely state and local officials were to actually report all cases of notifiable diseases. Lastly, it was hard to compare rates of measles incidence over a long time period due to constant innovation and introduction of new diagnostic tests. There could have been more people who were actually contracting measles or the development of technology could be simply detecting more cases of measles.³¹

Analysis Objectives

The primary outcome in the study was the proportion of people who received the MMR vaccine each year compared to the proportion of people who contracted measles each year. The MMR vaccination coverage nationally each year was compared to the number of cases reported nationally each year. Similarly, MMR vaccination coverage by state each year was compared to reported cases of measles by state each year.

The secondary objective of this study was to determine if there was a certain sub-population of people who had different MMR vaccination coverage than other sub-populations. A correlation model was applied to the data to determine if geographical location, poverty status, participation in VFC, urbanicity, or race/ethnicity had any correlation with decreased MMR vaccination coverage.

Statistical Procedures

The primary outcome measure for this study was analyzed by comparing the national MMR vaccine coverage each year with the national incidence of measles for the same year. The Pearson product-moment correlation model was then applied to the data to determine if there was a statistically significant association ($p < 0.05$) between MMR vaccination coverage and measles incidence. The same analysis was then performed on state level data to determine if individual states had different or similar results compared to national totals. In order to do this analysis, it was determined that even a decrease of 2% in MMR vaccination rates would be significant enough to worry healthcare workers.⁴

To analyze the secondary outcome measure, only data from the NIS were used.

The data were analyzed using a one-way ANOVA test to determine if a certain sub-population of people were less likely to receive the MMR vaccine. The one-way ANOVA test was used to determine if there was evidence of significant differences between any of three or more independent groups. The ANOVA test tested the null hypothesis:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \dots = \mu_k$$

where μ = the group mean (mean incidence of measles for each sub-population) and k = the number of groups. This test determined if there was sufficient evidence to suggest that two population subgroups were statistically different from each other. When this was the case, a post hoc test was done to determine which two groups were different from each other.³³ The post hoc test considered, if a p-value <0.05 was reported from the one-way ANOVA, was the Tukey's honest significant difference (HSD) test.

Data were analyzed separately for poverty status, participation in VFC, urbanicity, and race/ethnicity. For each of these sub-populations state MMR vaccination coverage was compared to national MMR vaccination coverage. The results were considered to be statistically significant if the p-value was <0.05.

Measures to Adjust for Multiplicity, Confounders, Heterogeneity, Etc.

All data obtained for this analysis were reported at a group level. There were many caveats with using aggregate data which included: unknown confounders, missing information, and difficulties in correlating the results to individual persons or regions. Unfortunately, the above mentioned caveats were inherent in the study design and type of

data used. Limitations to this study due to the type of data used are discussed in a later section.

RESULTS

MMR vaccination coverage

The first analysis that was performed was to determine the actual MMR vaccination coverage over the given time period. As depicted in Table 2 and Figure 5, MMR vaccination coverage between 1996 and 2012 ranged from 90.33% to 93%. MMR vaccination coverage hovered around 90% for 1996 and 1997 but in 1998 there was a sharp increase to 92% coverage. Rates slowly decreased to about 90% in 2000 (the point at which measles was declared eradicated from the US). MMR vaccination coverage increased to its highest level, 93%, in 2003 and 2004, while slight coverage increases were observed in 2005–2007. From 2006 to 2012 the MMR vaccination rates continued to decrease to 91%.

MMR vaccination coverage was given as a point estimate with a 95% CI. The *average* MMR vaccination coverage, presented in Table 2 and Figure 5, was used for this analysis. That percentage was then compared to the total population for that year and the number of people vaccinated was calculated (Table 2). A box-plot was created using national MMR vaccination coverage to pictorially present the national MMR vaccination coverage from 1996 to 2012 in the US.

TABLE 2: NATIONAL MMR VACCINATION COVERAGE STATISTICS

Year	Population	Percent MMR vaccination coverage	Number of People Vaccinated
1996	269,394,284	90.33	243,343,856
1997	272,646,925	90.40	246,472,820
1998	275,854,104	92.00	253,785,775
1999	279,040,168	91.50	255,321,753
2000	282,162,411	90.50	255,356,981
2001	284,968,955	91.40	260,461,624
2002	287,625,193	91.60	263,464,676
2003	290,107,933	93.00	269,800,377
2004	292,805,298	93.00	272,308,927
2005	295,516,599	91.50	270,397,688
2006	298,379,912	92.30	275,404,658
2007	301,231,207	92.30	278,036,404
2008	304,093,966	92.10	280,070,542
2009	306,771,529	92.10	282,536,578
2010	309,326,295	91.50	283,033,559
2011	311,582,564	91.60	285,409,628
2012	313,873,685	90.80	284,997,305

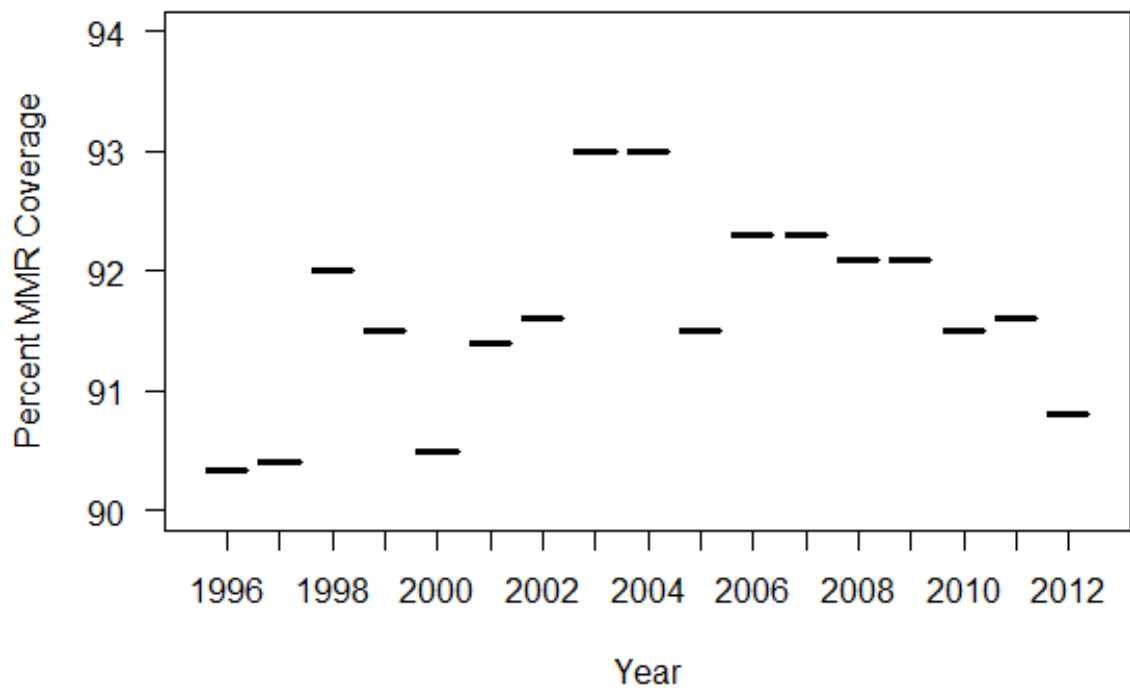


FIGURE 5: NATIONAL MMR VACCINATION COVERAGE FROM 1996–2012

Measles Incidence

Measles incidence was reported as the number of cases per year. The US population is presented in Table 3 for reference. A box-plot was also included to determine, pictorially, if any trends were seen in the incidence of measles over the 17 years. Both Table 3 and Figure 6 show a steady decrease in measles incidence until 2008 where the rate of measles more than tripled from the previous year. The incidence of measles then reduced by half until 2011 when another drastic increase was seen.

TABLE 3: NATIONAL MEASLES INCIDENCE STATISTICS

Year	Population	Measles Incidence
1996	269,394,284	508
1997	272,646,925	138
1998	275,854,104	100
1999	279,040,168	100
2000	282,162,411	86
2001	284,968,955	116
2002	287,625,193	44
2003	290,107,933	56
2004	292,805,298	37
2005	295,516,599	66
2006	298,379,912	55
2007	301,231,207	43
2008	304,093,966	140
2009	306,771,529	71
2010	309,326,295	63
2011	311,582,564	220
2012	313,873,685	55

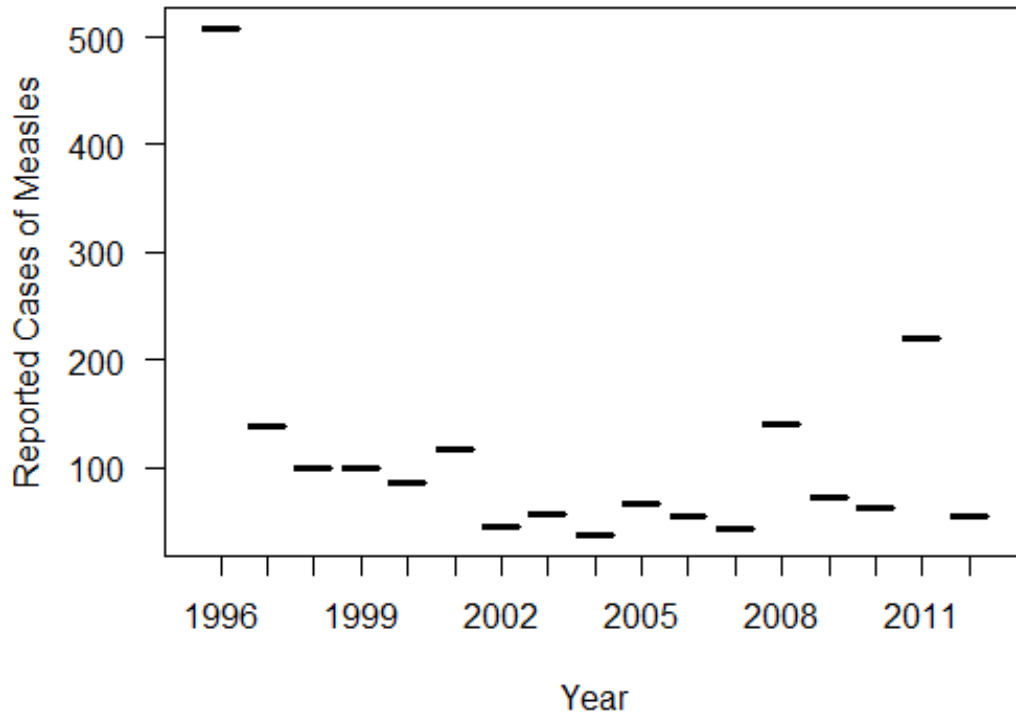


FIGURE 6: NATIONAL MEASLES INCIDENCE FROM 1996–2012

Primary Analysis

Table 4 shows the correlation between MMR vaccination coverage and measles incidence in the US. The average percentage of MMR vaccination coverage values was converted to an approximate number of people vaccinated per state using the total population of that state. This was then compared to the amount of measles cases that were reported in that state each year.

The national MMR vaccination coverage and measles incidence had a medium negative correlation of -0.45. While the p-value was just above the level of significance for the national level, Alaska, Colorado, Nevada, North Dakota, and Oregon displayed highly significant correlations between MMR vaccination coverage and measles incidence. Alaska, Colorado, Nevada, and Oregon all had medium negative correlations, similar to those seen on the national level. North Dakota, on the other hand, showed a medium positive correlation between MMR vaccination coverage and measles incidence. The full table of Pearson product-moment correlations by state can be found in Appendix XV.

TABLE 4: MMR VACCINATION COVERAGE VS. MEASLES INCIDENCE 1996–2012

State	Correlation	95% CI	P-value
US National	-0.45	-0.76, 0.04	0.070
Alaska	-0.54	-0.81, -0.08	0.025
Colorado	-0.54	-0.81, -0.08	0.026
Nevada	-0.54	-0.81, -0.08	0.025
North Dakota	0.64	0.24, 0.86	0.005
Oregon	-0.53	-0.81, -0.06	0.029

Figure 7 is a scatter plot of MMR vaccination coverage vs. measles incidence for 2011. This year was chosen to give a better picture of what current MMR vaccination coverage and measles incidence looks like in the US. During 2011, the average measles incidence was 91.6% and 220 cases of measles were reported. Each circle depicts a specific states MMR vaccination coverage compared to its measles incidence. The figure shows a high incidence of measles when MMR vaccination rates hovered around 91% with 8 states having 8 or more cases of measles during 2011.

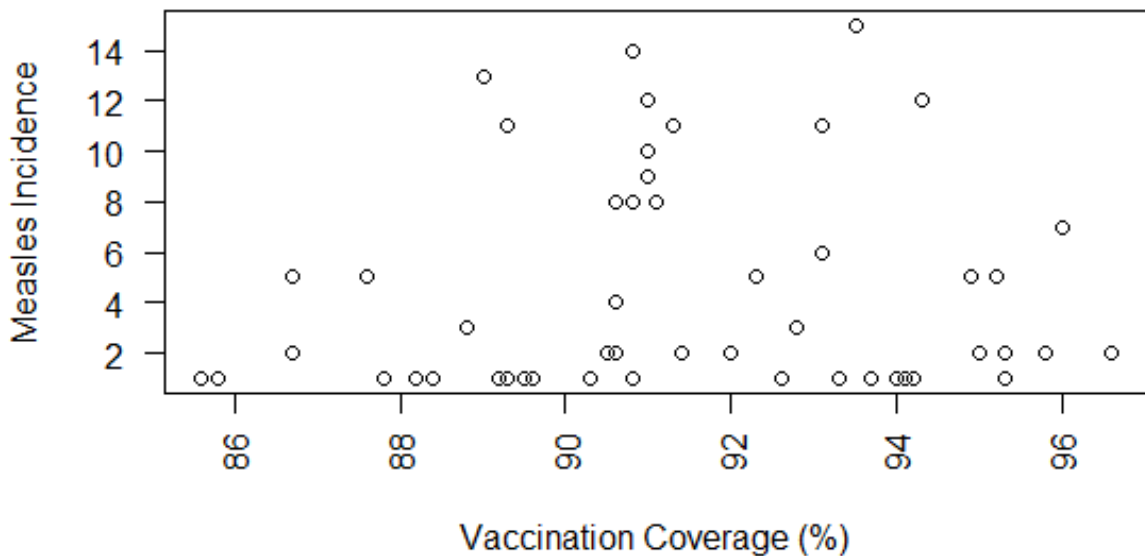
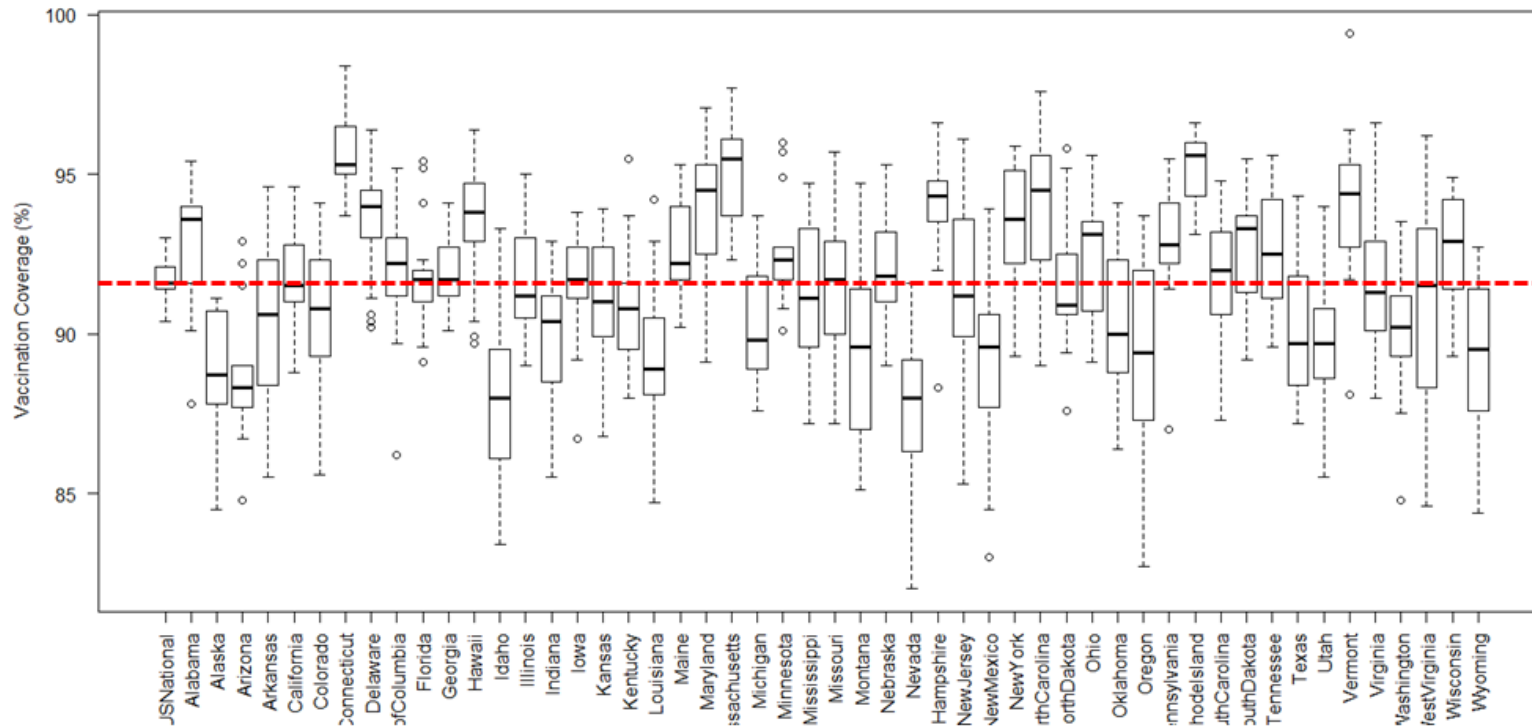


FIGURE 7: MMR VACCINATION COVERAGE VS. MEASLES INCIDENCE IN 2011

Secondary Analysis

A secondary analysis was performed to determine if there was a specific sub-population of people who were less likely to receive the MMR vaccine. Boxplots were generated to show the difference in vaccination coverage across different locations for each sub-population. A one-way ANOVA test was then conducted on all variables; location, poverty status, participation in VFC, urbanicity, and race/ethnicity. Subsequently, if the p-values from the one-way ANOVA tests were statistically significant, the Tukey HSD test was performed to narrow down which populations had MMR vaccination coverage that was different from the national averages. The MMR vaccination coverage values in Table 2 were used as US national values and compared to every sub-population to look for differences in vaccination coverage. Because the goal was to determine if specific populations had different values from the national averages, the use of overall national MMR vaccination coverage values instead of each sub-populations' national MMR vaccination coverage values was warranted for this analysis.

MMR vaccination coverage vs. Location



42

FIGURE 8: MMR VACCINATION COVERAGE BY LOCATION FROM 1996–2012¹

¹ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

Figure 8 depicts MMR vaccination coverage by state; the national MMR vaccination coverage ranged from about 90–93%. The red dashed line depicts the true average national MMR coverage (92%). The state which fell fully below this line was Nevada, indicating that there might be an issue with MMR vaccination coverage. Conversely, states, which were fully above this line included Connecticut, Massachusetts, and Rhode Island. The state with the lowest MMR vaccination coverage was Nevada, whose coverage ranged from 82–92%. The state with the highest MMR vaccination coverage was Vermont, whose coverage ranged from 92–98%.

TABLE 5: STATE MMR VACCINATION COVERAGE COMPARED TO NATIONAL COVERAGE BETWEEN 1996 AND 2012

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alaska	-2.96	-5.94	0.01	0.05
Connecticut	3.99	1.02	6.97	0.0001
Idaho	-3.54	-6.51	-0.56	0.002
Massachusetts	3.38	0.41	6.35	0.006
Nevada	-3.98	-6.50	-1.00	0.0001
Rhode Island	3.48	0.51	6.45	0.003

Since the one-way ANOVA resulted in a p-value much lower than 0.05, the Tukey HSD was run to determine exactly where the statistically significant differences were occurring in the US. Alaska, Idaho, and Nevada all had significantly lower vaccination coverage compared to the average MMR vaccination coverage, nationally. Conversely, Connecticut, Massachusetts, and Rhode Island had significantly higher

MMR vaccination coverage compared to the national average. The full table of Tukey

HSD correlations by state can be found in Appendix XVI.

Figure 8 displays the MMR vaccination coverage of states from highest coverage to lowest coverage from left to right.

The red dashed line depicts the true average of national MMR coverage. As mentioned above, Connecticut, Rhode Island, and

Massachusetts have the highest MMR vaccination coverage while Alaska, Idaho, and Nevada have the lowest MMR

vaccination coverage.

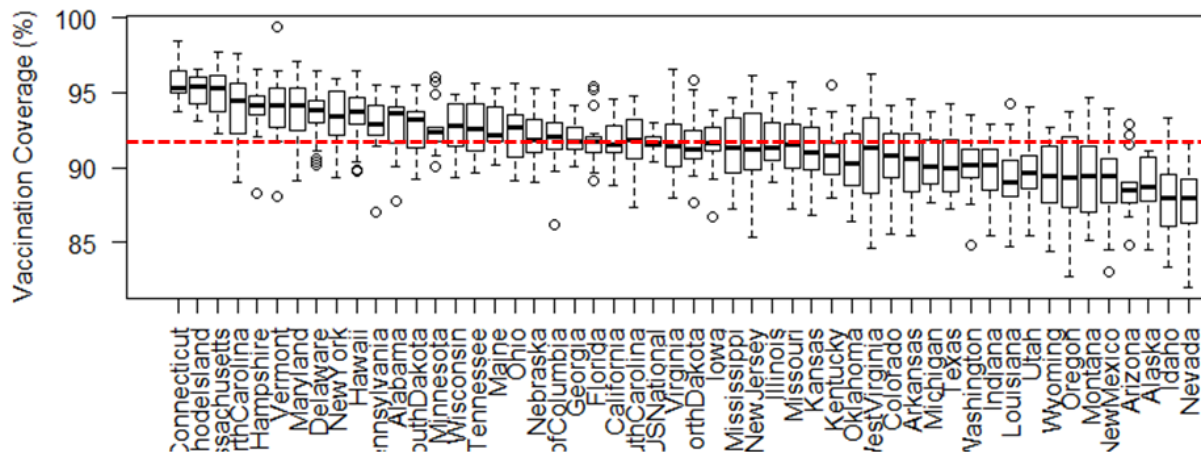


FIGURE 9: MMR VACCINATION COVERAGE IN ORDER OF MOST VACCINATED STATES²

² Each box represents one state's MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

MMR vaccination coverage vs. Poverty Status

People who lived at or Above the Poverty Line

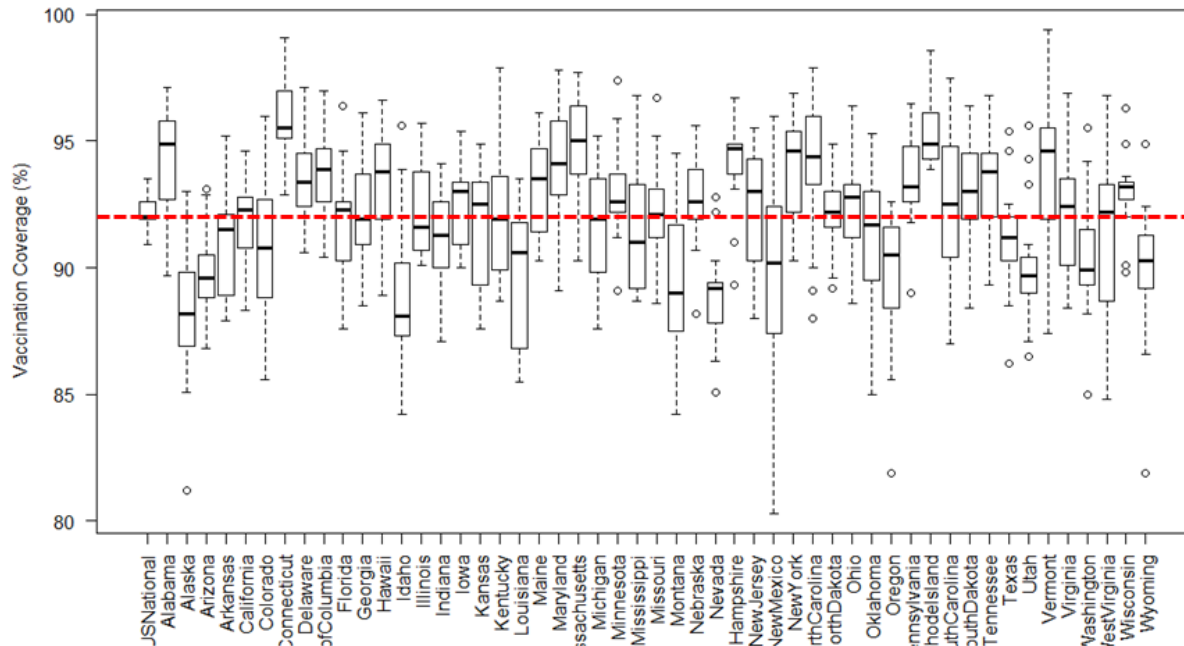


FIGURE 10: MMR VACCINATION COVERAGE FOR PEOPLE WHO LIVED AT OR ABOVE THE POVERTY LINE BY STATE FROM 1996–2012³

³ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

MMR vaccination coverage for people who lived at or above the poverty line is depicted in Figure 10. The national MMR vaccination coverage ranged from about 91–93%. The red dashed line depicts the true average national MMR coverage (92%). States which were fully above this line include Connecticut and Rhode Island. The state with the lowest range of MMR vaccination coverage was New Mexico, whose coverage ranged from 80–95%. The state with the highest MMR vaccination coverage was Vermont, whose coverage ranged from 87–98%.

TABLE 6: STATE MMR VACCINATION COVERAGE VS. NATIONAL COVERAGE FOR PEOPLE WHO LIVED AT OR ABOVE THE POVERTY LEVEL FROM 1996–2012

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alaska	-3.55	-6.76	-0.34	0.01
Connecticut	4.15	0.94	7.36	0.0003
Massachusetts	3.37	0.16	6.58	0.02
Rhode Island	3.53	0.32	6.73	0.01

When comparing the MMR vaccination coverage of people who lived at or above the poverty line from 1996 to 2012 to the national MMR vaccination coverage, Alaska had MMR vaccination coverage that was significantly lower than the national average, whereas Connecticut, Massachusetts, and Rhode Island had MMR vaccination coverage that was significantly higher than the national average (Table 6). The full table of Tukey HSD correlations for people who live at or above the poverty line can be found in Appendix XVII.

People who lived Below the Poverty Line

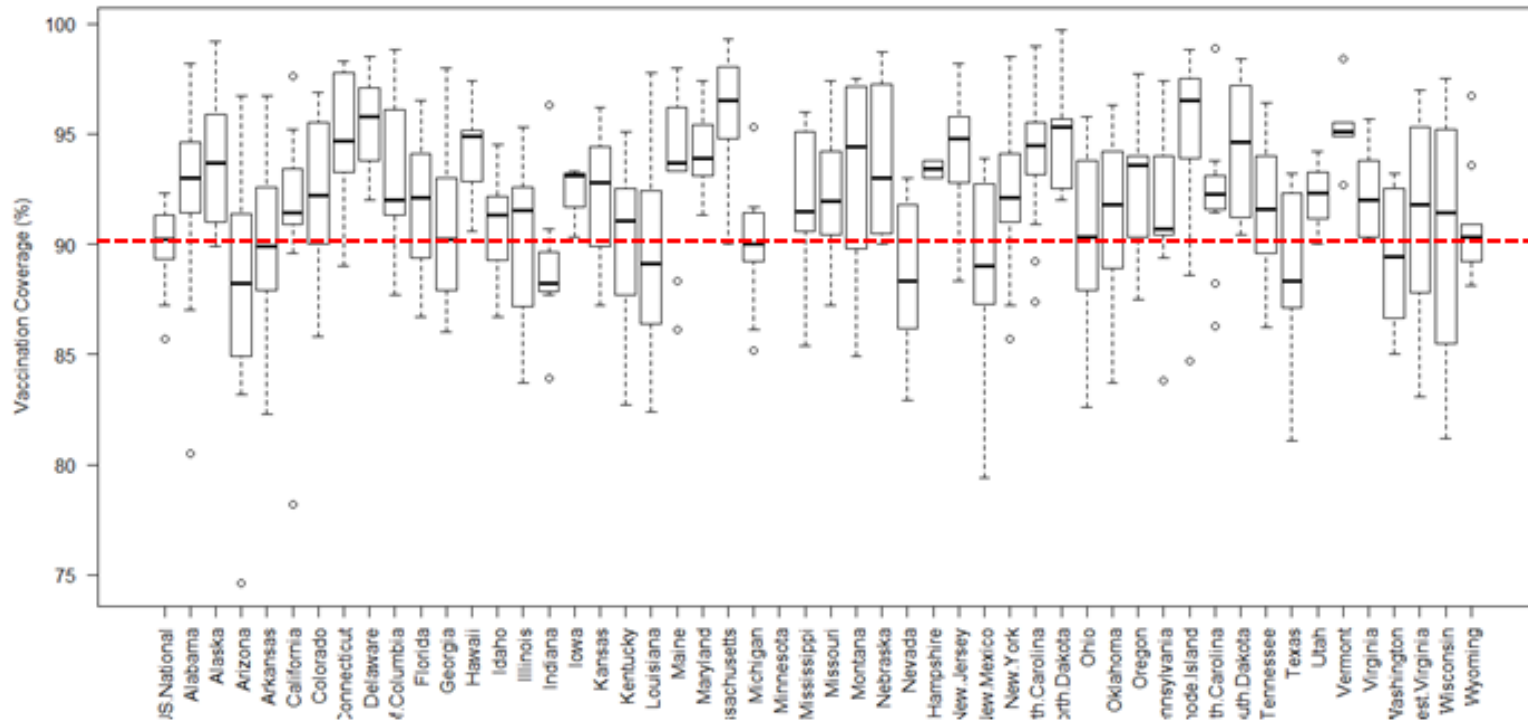


FIGURE 11: MMR VACCINATION COVERAGE FOR PEOPLE WHO LIVED BELOW THE POVERTY LINE BY STATE FROM 1996–2012⁴

⁴ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

MMR vaccination coverage for people who lived below the poverty line is depicted in Figure 11, with the national MMR vaccination coverage ranging from about 87–93%. The red dashed line depicts the true average national MMR coverage (90%). No states were fully below this line, but states, which were fully above this line included Alaska, Delaware, Hawaii, Iowa, Maryland, Massachusetts, New Hampshire, North Dakota, South Dakota, Utah, Vermont, and Virginia. The state with the lowest MMR vaccination coverage was New Mexico, whose coverage ranged from 79–94%. The state with the highest MMR vaccination coverage was South Dakota, whose coverage ranged from 83–98%.

No individual differences were found between MMR vaccination coverage for any particular state compared to the national coverage. The full table of Tukey HSD correlations for people who live below the poverty line can be found in Appendix XVII.

MMR vaccination coverage by Participation in the Vaccines for Children Program

Children whose provider participated in VFC

50

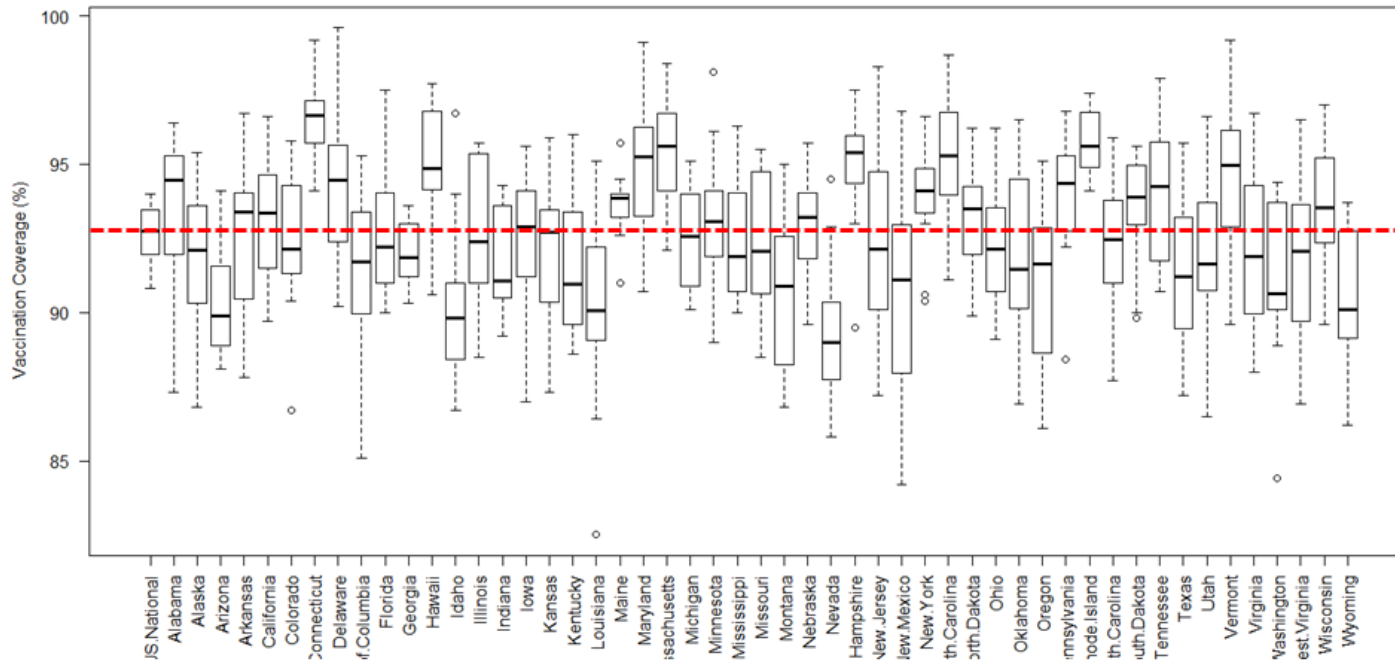


FIGURE 12: MMR VACCINATION COVERAGE FOR CHILDREN WHOSE PROVIDERS PARTICIPATED IN THE VFC PROGRAM FROM 1997–2012⁵

⁵ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

Data on the VFC program was available from 1997 to 2012. National MMR vaccination coverage for children whose healthcare providers participated in the VFC program (Figure 12) ranged from about 91–94%. The red dashed line depicts the true average national MMR coverage (93%). No states were fully below this line, but states, which were fully above this line included Connecticut and Rhode Island. The state with the lowest MMR vaccination coverage was New Mexico, whose coverage ranged from 84–96%. The state with the highest MMR vaccination coverage was Delaware, whose coverage ranged from 94–98%.

TABLE 7: STATE MMR VACCINATION COVERAGE VS. NATIONAL COVERAGE FOR CHILDREN WHOSE PROVIDERS PARTICIPATED IN THE VFC PROGRAM FROM 1997–2012

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Connecticut	4.79	1.56	8.02	0.000005
Hawaii	3.27	0.04	6.50	0.04
Massachusetts	3.69	0.46	6.92	0.005
New Hampshire	3.23	-0.01	6.46	0.05
North Carolina	3.63	0.39	6.86	0.007
Rhode Island	3.96	0.73	7.19	0.001

When MMR vaccination coverage for children whose healthcare providers participated in the VFC program was compared to the national MMR vaccination coverage, Connecticut, Hawaii, Massachusetts, New Hampshire, North Carolina, and Rhode Island all had MMR vaccination coverage that was significantly higher than the

national average. The full table of Tukey HSD correlations for children whose providers participated in the VFC program can be found in Appendix XVIII.

Children whose provider did not participate in VFC

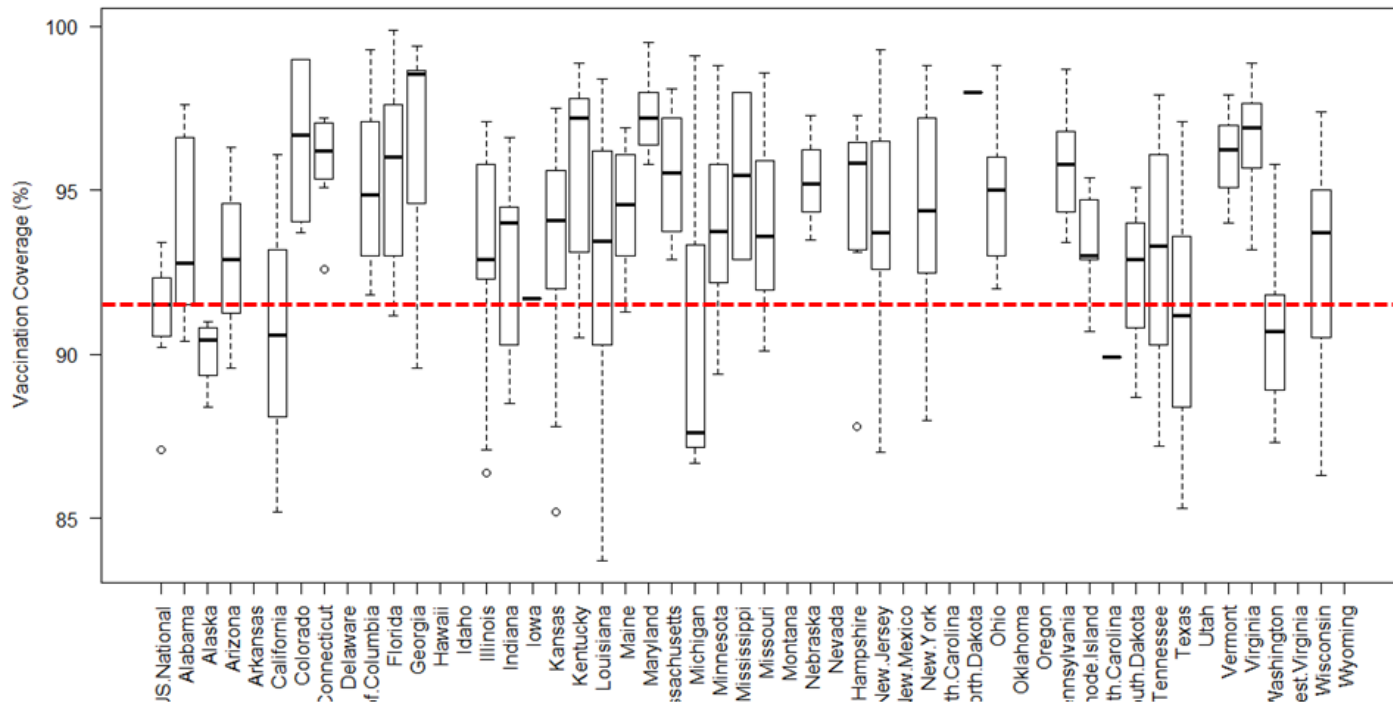


FIGURE 13: MMR VACCINATION COVERAGE FOR CHILDREN WHOSE PROVIDERS DID NOT PARTICIPATE IN THE VFC PROGRAM FROM 1997–2012⁶

⁶ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

MMR vaccination coverage for children whose provider did not participate in the VFC program, depicted in Figure 13, ranged from about 90–93%. The red dashed line depicts the true average national MMR coverage (92%). Alaska and South Carolina were fully below the national MMR vaccination coverage line whereas Colorado, Connecticut, DC, Maryland, Massachusetts, Mississippi, Nebraska, Ohio, Pennsylvania, Vermont and Virginia were fully above this line. The state with the lowest MMR vaccination coverage was Louisiana, whose coverage ranged from 83–97%. The state with the highest MMR vaccination coverage was Florida, whose coverage ranged from 91–98%.

TABLE 8: STATE MMR VACCINATION COVERAGE VS. NATIONAL COVERAGE FROM 1997–2012 FOR CHILDREN WHOSE PROVIDERS DID NOT PARTICIPATE IN THE VFC PROGRAM

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Georgia	4.93	0.55	9.30	0.008
Maryland	5.59	0.81	10.36	0.004
Virginia	-4.88	-9.36	-0.39	0.015

When MMR vaccination coverage for children whose providers did not participate in the VFC program was compared to the national MMR vaccination coverage, Georgia and Maryland had MMR vaccination coverage that was significantly higher the national coverage, while Virginia had MMR vaccination coverage that was significantly lower than the national average. The full table of Tukey HSD correlations for children whose providers did not participate in the VFC program can be found in Appendix XVIII.

MMR vaccination coverage vs. Urbanicity

MSA Central City

55

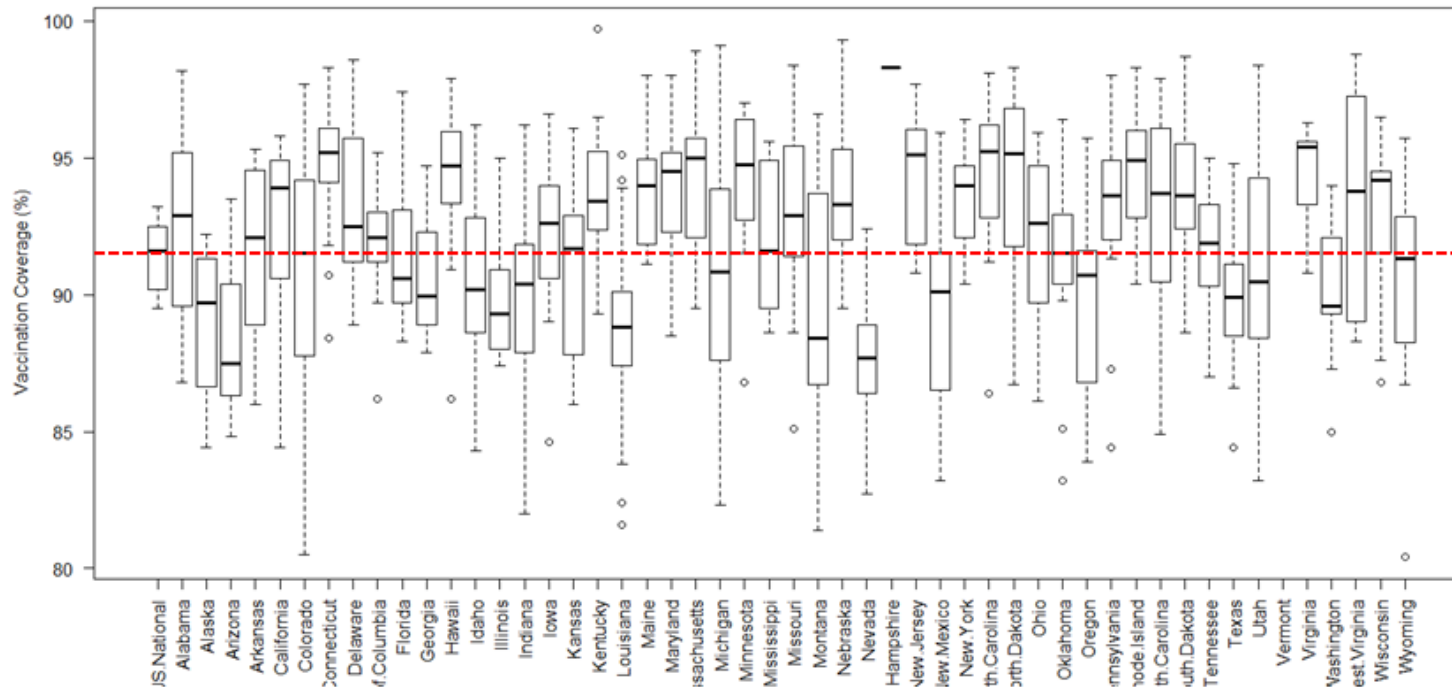


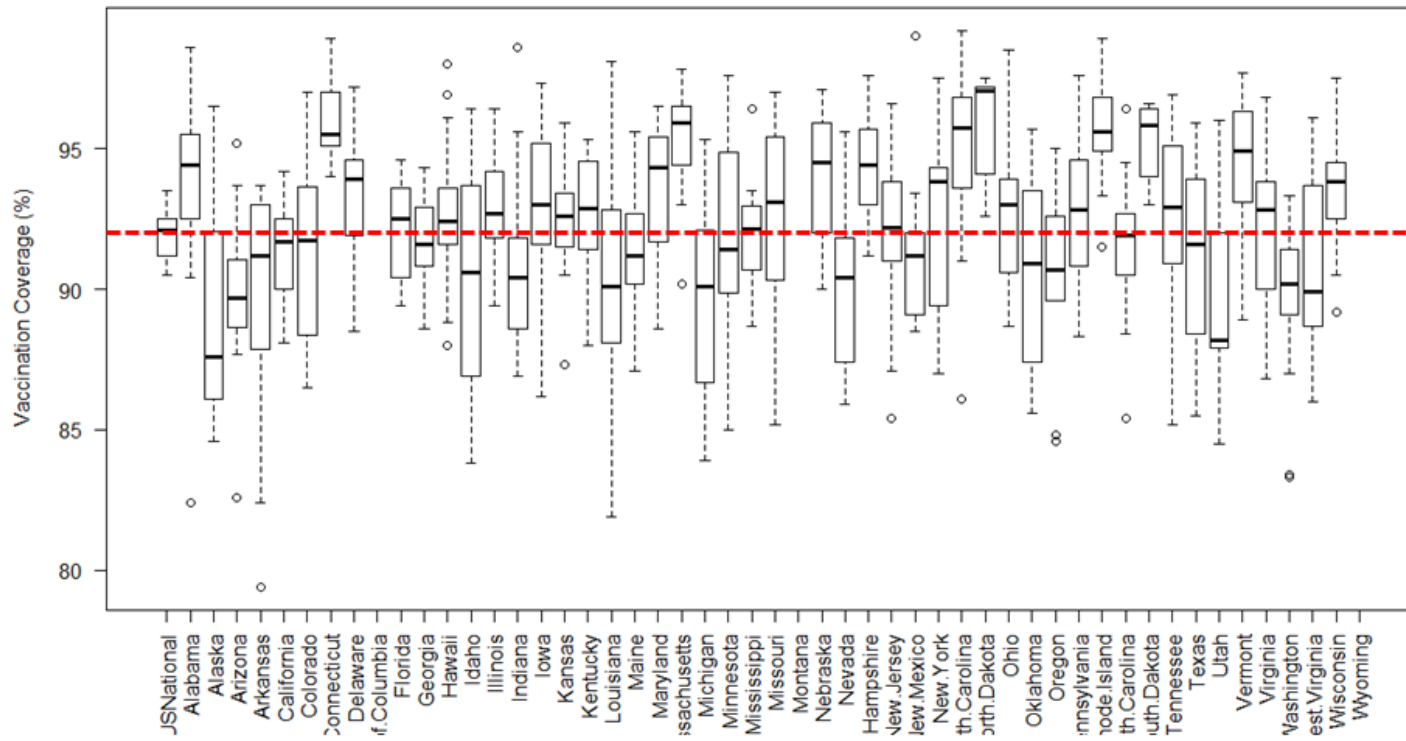
FIGURE 14: MMR VACCINATION COVERAGE FOR PEOPLE WHO LIVED IN A MSA CENTRAL CITY FROM 1996–2012⁷

⁷ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

For people who lived in a MSA central city, the MMR vaccination coverage ranged from 89–93%. The red dashed line depicts the true average national MMR coverage (91%). The state with the lowest MMR vaccination coverage was Colorado, whose coverage ranged from 81–97%. The state with the highest MMR vaccination coverage was Nebraska, whose coverage ranged from 90–98%.

No statistically significant differences were found when comparing MMR vaccination coverage for people who lived in a MSA central city in each individual state to the national MMR vaccination coverage. The full table of Tukey HSD correlations for people who lived in a MSA central city can be found in Appendix XIX.

MSA Non-Central City



57

FIGURE 15: MMR VACCINATION COVERAGE FOR PEOPLE WHO LIVED IN A MSA NON-CENTRAL CITY FROM 1996–2012⁸

⁸ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

MMR vaccination coverage for people who lived in a MSA non-central city ranged from 91–93% (Figure 15). The red dashed line depicts the true average national MMR coverage (92%). Connecticut, North Dakota, and South Dakota were fully above this line. The state with the lowest MMR vaccination coverage was Louisiana, whose coverage ranged from 83–98%. The state with the highest MMR vaccination coverage was South Carolina, with MMR vaccination coverage from 91–99%.

TABLE 9: STATE MMR VACCINATION COVERAGE VS. NATIONAL COVERAGE FROM 1996–2012 FOR PEOPLE WHO LIVE IN A MSA NON-CENTRAL CITY

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Connecticut	4.29	0.38	8.20	0.01
Rhode Island	3.97	0.06	7.88	0.04

When comparing MMR vaccination coverage in individual states to the national MMR vaccination coverage, Connecticut and Rhode Island had MMR vaccination coverage that was significantly higher than the national average. The full table of Tukey HSD correlations for people who lived in a MSA non-central city can be found in Appendix XIX.

Non-MSA Central City

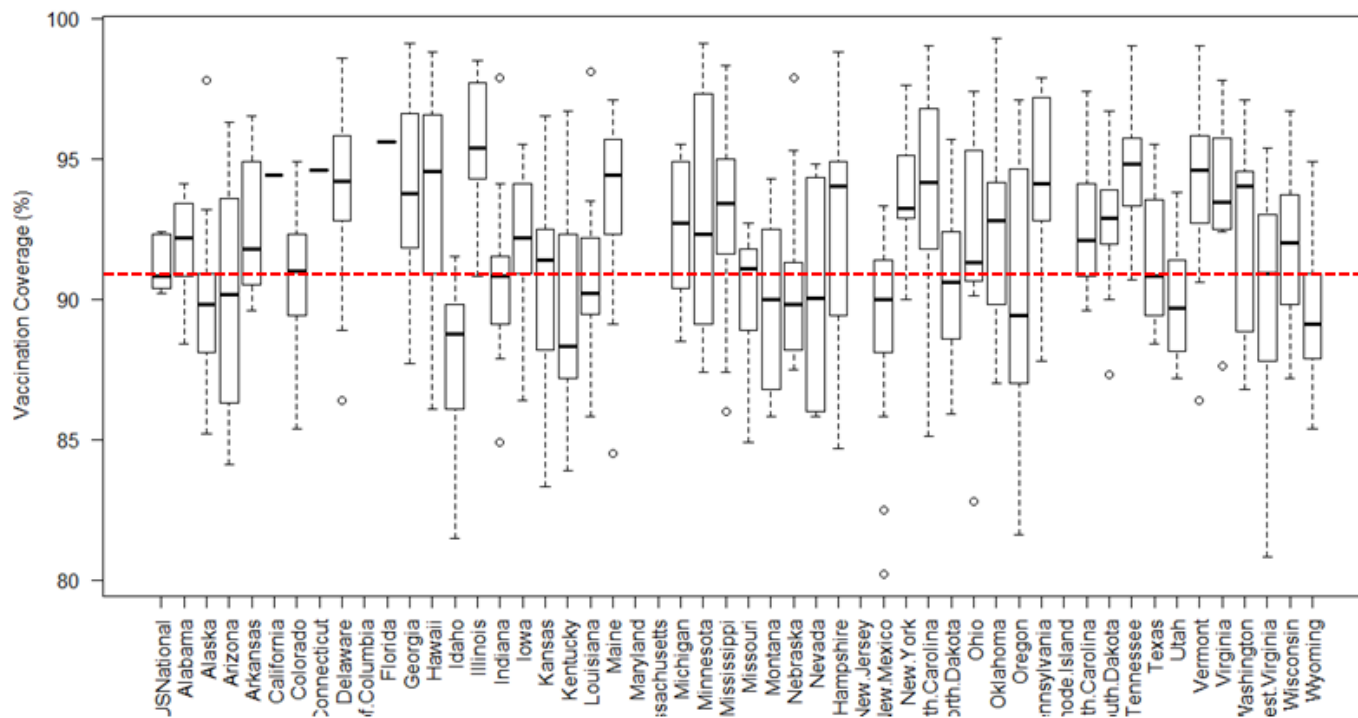


FIGURE 16: MMR VACCINATION COVERAGE FOR PEOPLE WHO LIVED IN A NON-MSA CENTRAL CITY FROM 1996–2012⁹

⁹ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

The national MMR vaccination coverage for people who lived in a non-MSA central city ranged from 90–93%. The red dashed line depicts the true average national MMR coverage which is 91%. Illinois and Tennessee were the only states, which had MMR vaccination coverage where the full range was higher than the national average. West Virginia had one of the lowest MMR vaccination coverages ranging from 82–95%. Conversely, Oklahoma had one of the highest MMR vaccination coverages ranging from 85–98%.

When comparing MMR vaccination coverage in individual states to the national MMR vaccination coverage, no statistically significant differences were found. The full table of Tukey HSD correlations for people who lived in a non-MSA central city can be found in Appendix XIX.

MMR vaccination coverage vs. Race

White

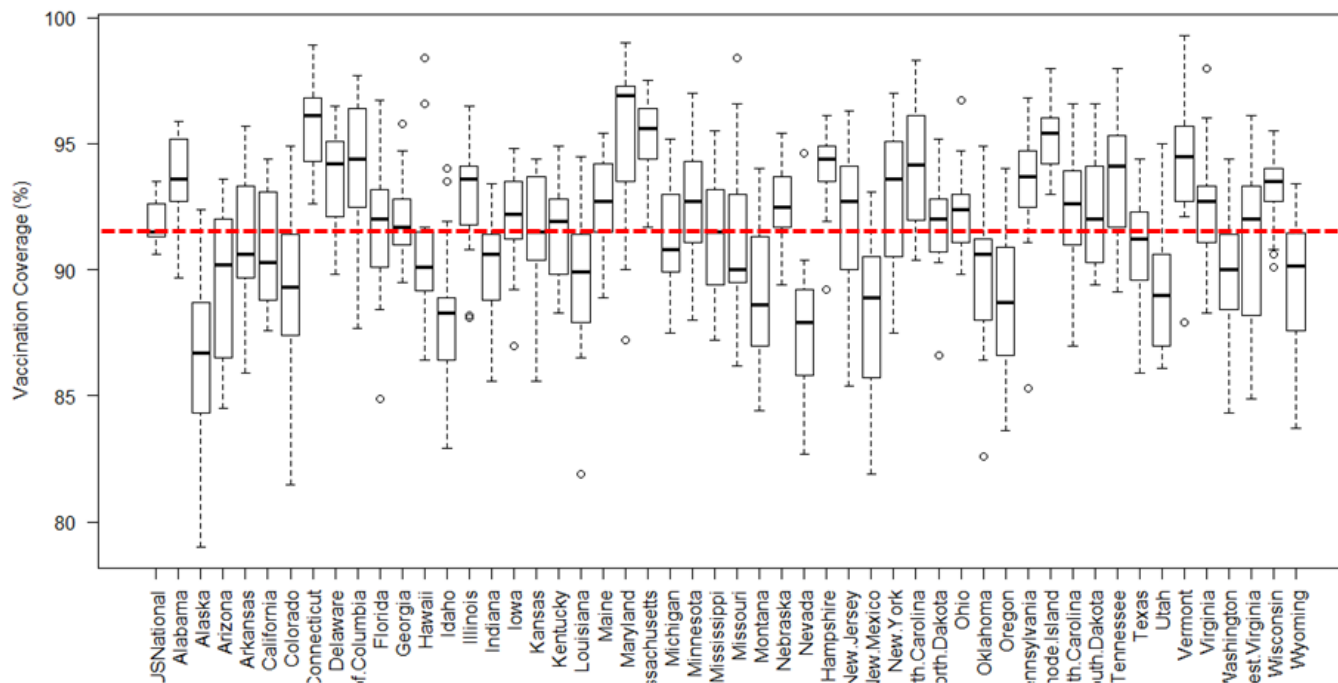


FIGURE 17: MMR VACCINATION COVERAGE FOR PEOPLE WHO IDENTIFIED AS WHITE FROM 1996–2012¹⁰

¹⁰ Each box represents one state's MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

National MMR vaccination coverage for people who identified as white in the US from 1996–2012 ranged from 91–93%. The red dashed line depicts the true average national MMR coverage, 92%. Connecticut, Massachusetts, and Rhode Island had MMR vaccination coverage where the full range was higher than the national average for people who identified as white. Alaska had one of the lowest MMR vaccination coverages ranging from 79–93%, while Vermont had one of the highest MMR vaccination coverages ranging from 93–99%, with an outlier at 88%.

TABLE 10: STATE MMR VACCINATION COVERAGE VS. NATIONAL COVERAGE FROM 1996–2012 FOR PEOPLE WHO IDENTIFIED AS WHITE

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alaska	-5.54	-9.09	-1.99	0.0000007
Connecticut	4.18	0.63	7.73	0.003
Maryland	3.59	0.04	7.14	0.043
Nevada	-4.20	-7.74	-0.65	0.003
Rhode Island	3.69	0.14	7.24	0.028

When comparing the MMR vaccination coverage for people who identified as white in individual states to the national MMR vaccination coverage, Connecticut, Maryland, and Rhode Island had MMR vaccination coverage that was significantly higher than the national average, whereas Alaska and Nevada had MMR vaccination coverage that was significantly lower than the national average. The full table of Tukey HSD correlations for people who identified as white can be found in Appendix XX.

Black

63

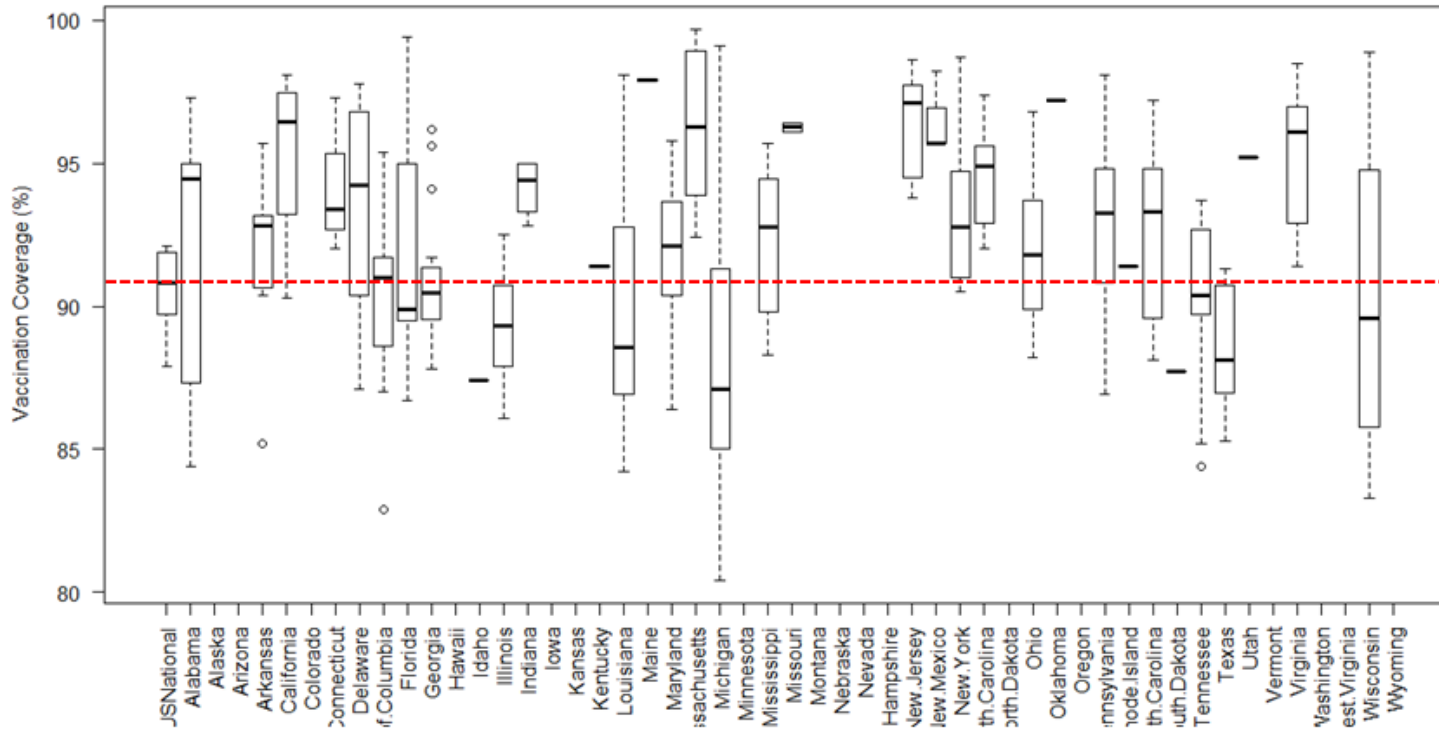


FIGURE 18: MMR VACCINATION COVERAGE FOR PEOPLE WHO IDENTIFIED AS BLACK FROM 1996–2012¹¹

¹¹ Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

Figure 18 shows the MMR vaccination coverage for people who identified as black in the US from 1996–2012. The national MMR vaccination coverage ranged from 88–93%. The red dashed line depicts the true average national MMR vaccination coverage, which was 91%. Some data were missing for people who identified as black, however, California, Connecticut, Indiana, Massachusetts, New Jersey, New Mexico, North Carolina, and Virginia had MMR vaccination coverage where the full range was higher than the national average for people who identified as black. Michigan had one of the lowest MMR vaccination coverages ranging from 80–98%, while Massachusetts had one of the highest MMR vaccination coverages ranging from 93–99%.

When comparing the MMR vaccination coverage, for people who identified as black, in individual states to the national MMR vaccination coverage, no statistically significant differences were found. The full table of Tukey HSD correlations for people who identified as black can be found in Appendix XX.

Hispanic

69

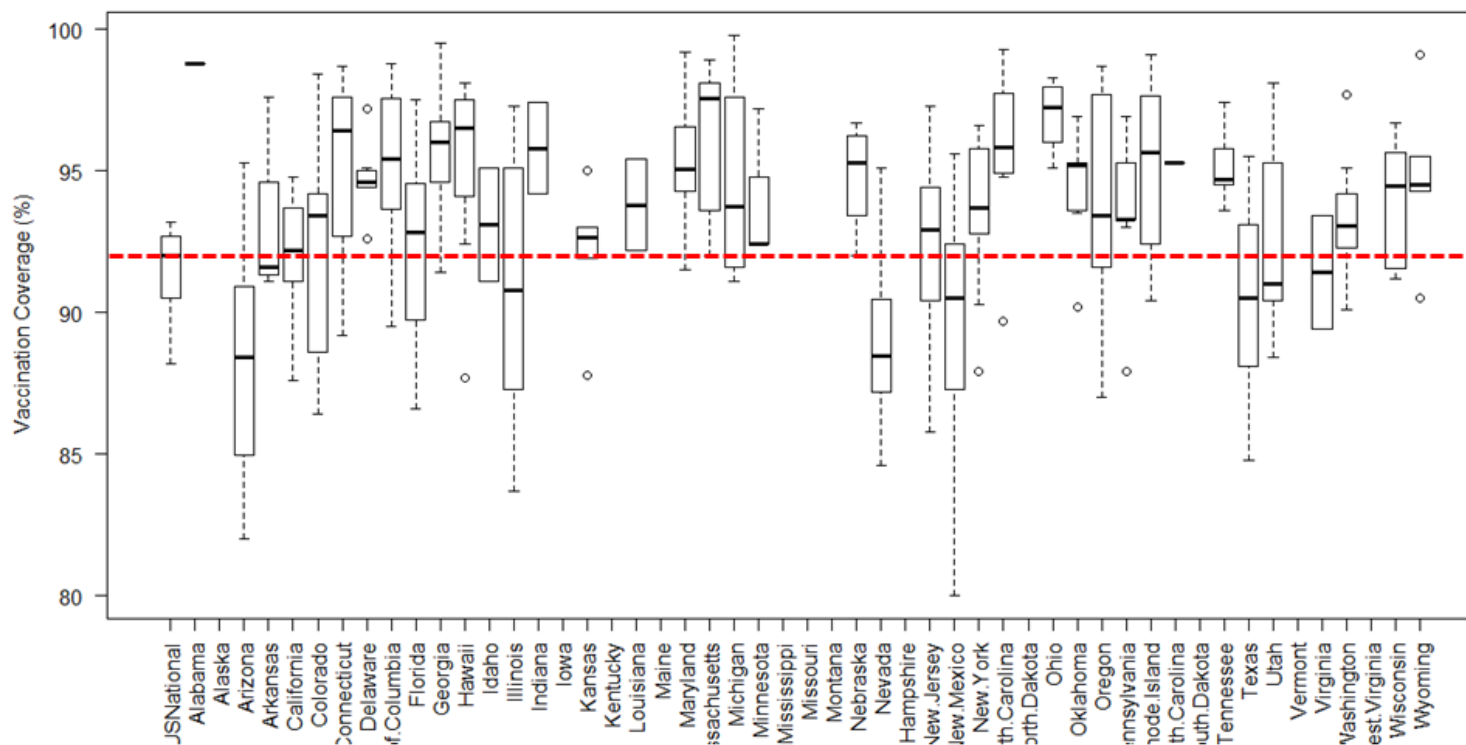


FIGURE 19: MMR VACCINATION COVERAGE FOR PEOPLE WHO IDENTIFIED AS HISPANIC FROM 1996–2012¹²

¹² Each box represents one state’s MMR vaccination coverage with the vertical lines indicating the 95% CI associated with the data. Half of the data fall inside the box and the other half fall either above or below the box. The open circles indicate outliers that fell more than 1.5 interquartile ranges below or above the 25th or 75th percentile, respectively.

MMR vaccination coverage for people who identified as Hispanic in the US from 1996–2012 (Figure 19) ranged from 88–94%. The red dashed line depicts the true average national MMR vaccination coverage, which was 93%. Some data were missing for people who identified as Hispanic, however, Delaware, Indiana, Louisiana, Massachusetts, Minnesota, Nebraska, Ohio, and Tennessee had MMR vaccination coverage where the full range was higher than the national average for people who identified as Hispanic. New Mexico had one of the lowest MMR vaccination coverages ranging from 80–95%, while Michigan had one of the highest MMR vaccination coverages ranging from 92–99%.

TABLE 11: STATE MMR VACCINATION COVERAGE VS. NATIONAL COVERAGE FROM 1996–2012 FOR PEOPLE WHO IDENTIFIED AS HISPANIC

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Massachusetts	4.77	0.13	9.40	0.034

When comparing the MMR vaccination coverage, for people who identified as Hispanic, in individual states to the national MMR vaccination coverage, Massachusetts had MMR vaccination coverage that was significantly higher than the national average. The full table of Tukey HSD correlations for people who identified as Hispanic can be found in Appendix XX.

American Indian/Alaska Native

National MMR vaccination coverage for people who identified as American Indian or Alaska Native ranged from 84–97%. Data were only available for Alaska, Montana, New Mexico, Oregon, and South Dakota.

When comparing the MMR vaccination coverage, for people who identified as American Indian or Alaska Native, in individual states to the national MMR vaccination coverage, Alaska and Montana both had MMR vaccination coverage that was significantly higher than the national average. Only 5 states had reported data for this race/ethnicity to the NIS. The full table of Tukey HSD correlations for people who identified as American Indian or Alaska Native can be found in Appendix XX

Pacific Islander

National MMR vaccination coverage for people who identified as Pacific Islander ranged from 87–99%. Only 6 states reported data to the National Immunization Survey for people identifying as Pacific Islander in the US. The full table of Tukey HSD correlations for people who identified as Pacific Islander can be found in Appendix XX.

DISCUSSION

This retrospective cohort study was designed to investigate the relationship between MMR vaccination coverage and incidence of measles in the US, and to assess whether demographic characteristics and socio-economic status had any correlation to MMR vaccination coverage. For this reason, data for MMR vaccination coverage in the US from 1996–2012 were obtained from the NIS, while data pertaining to the incidence of measles (in the US from 1996–2012) were obtained from the CDC-WONDER database.²⁶

Primary Analysis

On a national level, there was a medium negative correlation between MMR vaccination coverage and measles incidence. As the vaccination coverage increased, the measles rate decreased, and vice versa. MMR vaccination coverage was close to the standard vaccination coverage of 93% (needed to keep the population protected); but with coverage ranging from 90–93%, there is still room for improvement.

At the state level, Alaska, Colorado, Idaho, Nevada, and Oregon exhibited similar negative correlations between MMR vaccination coverage and measles incidence at the national level. Conversely, a medium positive correlation between MMR vaccination coverage and measles incidence was observed in North Dakota, indicating that although the MMR vaccination coverage was low, so was the state's incidence of measles. The raw data shows that North Dakota's vaccination coverage ranged from 87.6–95.8% with an average coverage of 91.5%. Although the average MMR vaccination coverage does not seem especially low, a 2% difference from 93%, can significantly affect a

population's risk of a measles outbreak.⁴ Even with low vaccination coverage, North Dakota only had 1 case of measles in the 17 years that data were collected for this analysis (APPENDIX I). The one measles case was reported in 2011 when vaccination coverage in North Dakota was at 95.8%, explaining how the measles did not spread. Travel into and out of North Dakota as well immigration rates in North Dakota will need to be investigated to determine why only one case of measles was reported in 17 years. Theoretically, if only a limited number of people were traveling into or out of North Dakota during this time, there would be a minimal chance that measles would have been brought into this population, explaining their very low incidence of measles despite low MMR vaccination coverage.

Secondary Analysis

Location

On a state level, Alaska had MMR vaccination coverage that was lower than national MMR vaccination coverage where Connecticut, Massachusetts, and Rhode Island had MMR vaccination coverage that was higher than the national averages. States in the Pacific Northwest have a higher rate of vaccine exemption than states in the Northeast³⁴ which could explain why vaccination rates are lower in Alaska than they are in Connecticut, Massachusetts, and Rhode Island. Furthermore, a report was published recently by the state of Alaska department of epidemiology stating that Alaska has consistently lower vaccination rates, across the board, compared to other states. The article mentions how Alaska needs to work harder at increasing vaccination coverage in their state.³⁵

Poverty Status

MMR vaccination coverage for people who lived at or above the poverty line was compared to national MMR vaccination coverage (Table 6). People who lived at or above the poverty line in Alaska had MMR vaccination coverage lower than the national average, whereas people who lived at or above the poverty line in Connecticut, Massachusetts, and Rhode Island had MMR vaccination coverage that was above the national average.

While the one-way ANOVA test comparing the MMR vaccination coverage for people who lived below the poverty line to the national MMR vaccination coverage resulted in a p-value <0.05 , there were no statistically significant differences between the MMR vaccination coverages for each state compared to the national averages. Differences in MMR vaccination coverage were found between individual states but for the purposes of this analysis, only the comparison of state MMR vaccination coverage to national MMR vaccination coverage is valid. The reason for this comparison is to determine which states are statistically different from the national averages. Data which conclude that two individual states have statistically different MMR vaccination coverages do not show the full picture of which states are truly at risk.

The results summarized above were expected because it was hypothesized that people living below the poverty line would have a lower MMR vaccination coverage. Previous studies have reported that people of lower poverty level would have less access to and less education about the importance of vaccines in general. Specifically, Pruitt et al. investigated the effect that poverty status had on HPV vaccination in 2010. It was

discovered that higher state-level poverty is associated with lower vaccination coverage.³⁶

Participation in Vaccine for Children

Data for MMR vaccination coverage for children whose providers participated in VFC was available from 1997 until 2012. Connecticut, Hawaii, Massachusetts, New Hampshire, North Carolina, and Rhode Island all had MMR vaccination coverage that was higher than the national average. This result was expected because the VFC program was put in place to give underinsured and uninsured children access to childhood vaccines. It would be interesting to see the ratio of underinsured children to number of providers who participated in the VFC program in the above-mentioned states. Since the VFC program is clearly working well in these states, the ratio of underinsured children to participating providers might need to be applied to other states.

For children whose providers did not participate in VFC, Georgia, Maryland, and Virginia had MMR vaccination coverage that was higher than the national average. It would be interesting to determine the number of underinsured children in these states. If this number is low, maybe other programs are in place in these states to increase MMR vaccination coverage.

Urbanicity

While the p-value from the one-way ANOVA was <0.05 for people who lived in a MSA central city, MSA non-central city, and non-MSA central city, there was no statistically significant difference between the MMR vaccination coverage for MSA

central cities or non-MSA central cities compared to the national MMR vaccination coverage. For people who lived in a MSA non-central city in Connecticut and Rhode Island, MMR vaccination coverage was higher than the national MMR vaccination coverage (Table 9). This is not surprising because Connecticut and Rhode Island have the highest overall MMR vaccination coverage. The differences in urbanicity could be due to the fact that vaccination rates among children who live in areas similar to a MSA-central city as well as a non-MSA central city historically have lower vaccination rates than those who live in a MSA non-central city.³⁷

Race/Ethnicity

MMR vaccination coverage for people who identified as white was higher in Connecticut, Maryland, and Rhode Island when compared to the national MMR vaccination coverage. While in Alaska and Nevada, MMR vaccination coverage was lower than national coverage. These results are also not surprising because, overall, Connecticut, Maryland, and Rhode Island had higher vaccination coverage than Alaska and Nevada. This could be due to the increased vaccine exemptions in the latter two states.³⁴ Studies comparing MMR vaccination coverage to race, independent of other factors, need to be completed to determine the true effect of race on MMR vaccination coverage.

While the p-value was <0.05 for the comparison of MMR vaccination coverage for people who identified as black to the national MMR vaccination coverage, there was no statistically significant difference in state level MMR vaccination coverage and national level MMR vaccination coverage. These findings were consistent with previous

studies looking at factors associated with un-vaccination in different communities. While people who identify as black were commonly under-vaccinated, they were not usually un-vaccinated.³⁸

For people who identified as Hispanic, the MMR vaccination coverage in Massachusetts was higher than the national MMR vaccination coverage (Table 11). Massachusetts' state-wide high MMR vaccination coverage could be why this group has higher coverage than national averages for people who identify as Hispanic but there have not been any studies looking directly at the correlation between race and vaccination coverage without taking many other factors into account. More research needs to be done on why people who identify as Hispanic in Massachusetts have a higher MMR vaccination coverage than national MMR vaccination coverage for people who identify as Hispanic across the US.

Since the dataset for populations of people who identified as American Indian or Alaska Native as well as Pacific Islander were very limited, it was hard to make comparisons to national MMR vaccination coverage. Additional data are needed on these sub-populations to further analyze if a correlation exists.

Potential Bias & Limitations

There was no bias in this study because the nature of the data affected all groups equally. The nature of the aggregate data primarily resulted in limitations to the analysis. Since the data were not collected solely for the purposes of this analysis, there were some inconsistencies among different variables and how the data were collected from year to

year. These limitations were accounted for by selecting the years with the majority of data available for all categories. If the data were collected consistently throughout all of the years, the data set would be much larger and there would be a greater likelihood of seeing more robust results. For example, data have not yet been published from the NIS or the MMWR: Summary of Notifiable Diseases for the full years of 2013 and 2014. Anecdotal data has been published on recent outbreaks in the US. A report published in the MMWR investigated the measles outbreak in California which began at Disneyland in December 2014 and continues to spread as of February 2015. It was reported that a total of 110 cases have been reported in CA as well as 15 additional cases in surrounding states, 1 case in Mexico, and 10 cases reported in Canada.³⁹ While it has been reported that the incidence of measles in these two years has been astronomically high,⁴ it would have been of benefit to compare MMR vaccination coverage for these two years to the large increase in measles incidence in 2013 and 2014.

Similarly, the two populations that were compared in this analysis were not necessarily the same. The NIS data were obtained from a very specific population; parents of children who were randomly selected to fill out the NIS and who actually completed it. In contrast, the data on measles incidence were broader, encompassing all individuals in the US who had contracted measles. Most importantly, age was not accounted for in the analysis. Comparisons were made between children who were vaccinated in a specific year to people who contracted measles in that same year. While this provided some insight into how easily measles can be spread and how well the MMR vaccine prevents it, it did not account for an individual's vaccination status and their

incidence of measles. More precise data needs to be collected so that an analysis can be performed on the individuals who refused vaccination and those people who contracted measles. This analysis would allow for a more in-depth discussion of where the measles outbreak occurred, what the MMR vaccination coverage was in that location, as well as a multitude of other potentially contributing factors.

Lastly, there were data that were missing from the NIS data-set. Missing data could have led to an under-estimation of the trends that were seen in the different sub-populations. With a more precise data-set, it would be more likely to see trends in different sub-populations such as individuals who identify as American Indian or Alaska Native as well as Pacific Islander, where minimal data was available.

Other limitations to this study include confounders that were not considered for the purposes of this analysis. The increase in travel into and out of the US as well as immigration into the US have a large impact on the potential cases of measles that are reported. If vaccination rates are already low and travelers/immigrants bring measles into the US, a higher number of measles cases are likely to be reported. This would not change the fact that MMR vaccination coverage is low, but it does add to the need for universal vaccination coverage. This confounder was not investigated due to the limited nature of the data and should be considered in future investigations.

Future Directions

Future studies should be performed in order to mitigate the limitations mentioned above. In this analysis, significant correlations were found between MMR vaccination

coverage and measles incidence in some states as well as certain sub-populations. An analysis should be conducted using individual data to determine the accuracy of the results presented here. Data collected on an individual level would allow researchers to clearly see correlations between MMR vaccination coverage and measles incidence in the US. Having access to the actual number of people vaccinated in a certain location and for different confounders would allow for a more accurate analysis of MMR vaccination coverage data. A case-control study could then be used to compare individual level data on people who contracted measles and look back to determine the MMR vaccination coverage for that specific location and year when they contracted measles. Correlating individuals who contracted measles with specific MMR vaccination coverage data will more precisely determine correlations between the two factors.

Another potential study to expand upon the analysis presented here would be to choose a specific sub-population that was shown as having statistically significant MMR vaccination coverage that was lower than the national averages and determine why this occurs. In a similar retrospective cohort study, subjects would be chosen based on their MMR vaccination coverage with measles incidence as the outcome variable. Looking deeper into a specific populations and determining risk factors for lower MMR vaccination coverage would help healthcare workers and policymakers implement programs that would specifically target at-risk populations and increase MMR vaccination coverage on a national level.

Once the data in this study are corroborated with individual level data, policymakers would need to work with healthcare providers to implement specific

programs tailored to each sub-population that is at risk for not receiving the MMR vaccine. One example would be to include better education for parents who are faced with the decision to vaccinate their children. Parents need to be aware of not only the risks of receiving the MMR vaccine but more importantly, the severe risks and complications of their child contracting the measles virus. A hand-out, similar to the one given with facts about the MMR vaccine, should be given with each vaccine with the facts about the disease it will be preventing. This would allow parents to make a truly informed decision about vaccinating their children with the MMR as well as all vaccines for highly communicable diseases.

A second example of changes that can be made as a result of this study and further studies would be for policymakers to institute stricter policies with respect to vaccine exemptions. There needs to be a middle-ground where medical and religious exemptions can be considered but any other exemption would need strong support to be accepted. A policy similar to how colleges require proof of immunization in order for students to enroll would be a beneficial policy to add to public schools. For example, “the Commonwealth of Massachusetts requires that all full-time students submit proof of immunization”.⁴⁰ Specifically, Boston University requires 6 different immunizations be completed before a student can come to campus. This policy only allows for medical exemptions signed by a physician and religious exemptions put in writing and signed by the student. Students with exemptions will be required to leave campus in the event of any outbreak.⁴¹ State-mandated policies such as the one mentioned above could be one way to initiate higher vaccination coverage nationwide.

CONCLUSIONS

The objective of this study was to investigate the relationship between MMR vaccination coverage and incidence of measles in the US, and to assess whether demographic characteristics and socio-economic status had any correlation with MMR vaccination coverage. Results from this study suggest that regional differences in MMR vaccination rates spanning across multiple sub-populations are associated with the increasing measles incidence in the US. These correlations need to be investigated further to determine what specific programs can be put in place to increase MMR vaccination rates state-wide and among high risk sub-populations.

APPENDIX I

Measles Incidence by State

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	508	138	100	100	86	116	44	56	37	66	55	43	140	71	63	220	55
AL	0	1	1	0	0	0	12	0	0	0	0	0	0	0	0	0	0
AK	63	0	33	0	1	0	0	0	0	0	0	0	0	0	0	0	0
AZ	8	5	11	1	0	1	0	1	0	1	0	0	14	0	1	2	2
AR	0	0	0	5	1	0	0	0	0	0	0	0	2	0	0	0	4
CA	46	24	9	17	19	40	5	5	6	4	6	4	17	9	27	31	8
CO	7	0	0	0	2	0	0	0	1	0	1	0	0	0	0	0	0
CT	2	1	0	2	0	1	0	0	0	0	0	0	0	0	1	1	1
DE	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1
DC	0	2	0	0	0	0	0	0	0	0	0	0	1	2	0	N	1
FL	1	8	2	2	2	0	2	0	1	0	4	5	1	5	1	8	0
GA	3	1	2	0	0	1	3	1	1	0	0	0	1	1	1	0	2
HA	49	4	0	3	3	7	1	19	3	1	0	2	4	0	4	0	0
ID	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
IL	3	7	1	2	3	3	1	1	1	2	0	1	32	0	0	3	0
IN	0	0	3	2	0	4	2	0	0	33	1	0	0	0	0	14	15
IA	1	0	0	0	0	0	0	0	3	0	0	0	0	1	0	1	0
KS	1	0	0	0	2	0	0	0	0	0	1	0	0	0	0	6	6
KY	0	0	0	2	0	2	0	0	0	0	0	0	0	0	1	1	0
LA	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
ME	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MD	2	2	1	0	0	3	0	1	1	0	2	0	0	4	0	2	0
MA	12	16	2	8	0	3	0	0	2	0	19	1	2	2	3	24	0

MI	3	2	10	6	3	0	0	2	0	1	1	3	4	0	0	2	1
MN	19	8	0	1	1	4	2	0	0	0	1	1	0	1	3	26	0
MS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MO	3	1	0	0	0	2	2	0	2	0	1	0	1	6	3	0	0
MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NV	5	2	0	1	7	0	1	0	0	0	0	0	0	0	1	1	0
NH	0	1	0	1	3	0	0	1	0	1	1	0	0	0	0	1	0
NJ	3	3	8	0	0	1	1	2	2	2	1	1	1	2	0	4	2
NM	17	0	0	0	0	0	0	0	0	0	0	1	1	0	0	4	2
NY	23	16	4	5	23	11	7	7	5	7	10	7	30	18	8	32	5
NC	2	2	1	0	0	0	0	1	2	0	0	3	0	0	0	2	0
ND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
OH	6	0	1	0	3	3	1	2	0	3	0	0	0	1	2	0	1
OK	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OR	14	0	0	12	0	3	0	3	0	2	2	1	1	0	0	3	1
PA	12	8	4	0	1	8	1	9	0	0	2	3	1	14	2	13	2
RI	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SC	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SD	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TN	2	0	1	0	0	0	0	0	0	1	0	0	0	1	0	3	0
TX	26	7	0	7	0	1	1	0	0	3	0	7	0	1	0	6	0
UT	118	1	0	0	3	0	0	0	0	0	0	0	0	0	0	13	1
VT	2	0	1	0	3	1	0	0	0	0	0	0	0	0	0	1	0
VA	3	1	2	18	2	1	0	0	0	0	0	0	1	1	3	7	0
WA	38	2	1	5	3	15	1	0	7	2	2	3	19	1	1	4	0

WV	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
WI	9	1	1	0	1	0	1	1	0	2	0	0	6	0	0	2	0
WY	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

APPENDIX II

MMR vaccination coverage by Location

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	90.6	90.4	92.0	91.5	90.5	91.4	91.6	93.0	93.0	91.5	92.3	92.3	92.1	92.1	91.5	91.6	90.8
AL	90.6	93.8	95.0	90.1	87.8	94.0	91.6	91.2	91.8	94.1	94.0	95.0	93.6	93.6	95.4	94.0	93.1
AK	84.5	87.4	91.1	90.7	88.8	87.8	88.7	90.7	89.7	90.8	85.7	89.7	88.4	88.4	88.4	90.8	86.2
AZ	84.8	88.0	88.0	87.4	87.7	88.7	88.9	91.5	92.9	88.8	87.7	89.0	92.2	92.2	87.7	86.7	88.3
AR	85.5	92.3	87.9	86.9	88.4	90.3	92.8	90.6	94.6	89.0	85.8	92.5	92.2	92.2	90.5	93.7	92.3
CA	90.7	88.8	91.2	92.8	90.8	91.3	90.4	92.8	93.1	91.6	92.8	94.6	92.7	92.7	91.4	91.0	91.5
CO	89.4	94.1	92.9	90.4	87.2	92.1	90.7	85.6	90.8	93.2	88.3	91.2	92.3	92.3	89.3	88.4	91.5
CT	96.7	93.7	96.6	95.4	95.9	93.9	95.3	98.4	95.0	95.2	96.5	95.3	95.3	95.3	97.8	95.0	94.8
DE	90.4	91.1	94.1	94.2	90.2	93.6	95.2	93.0	94.5	95.2	96.4	94.8	93.1	93.1	94.0	90.6	94.4
DC	92.9	89.7	92.7	91.2	86.2	91.9	91.2	92.8	94.6	91.6	92.2	95.2	89.7	89.7	94.7	93.5	93.0
FL	89.6	90.1	92.0	91.7	89.1	91.4	91.1	95.2	95.4	92.0	91.2	92.3	91.7	91.7	94.1	90.8	91.0
GA	91.9	91.2	91.7	91.5	91.1	90.1	93.0	90.7	91.9	92.9	91.0	91.4	92.7	92.7	91.5	94.1	91.9
HA	92.9	90.4	94.4	94.1	93.7	90.6	96.4	93.6	94.7	89.7	89.9	93.8	94.8	94.8	93.2	94.2	95.0
ID	83.4	88.0	89.7	86.1	88.0	88.6	86.9	92.9	91.7	86.5	88.0	86.1	86.1	86.1	87.2	89.5	93.3
IL	89.5	89.0	91.2	91.4	91.5	89.0	94.4	93.6	95.0	93.0	89.2	93.1	91.0	91.0	90.5	90.8	91.6
IN	85.5	88.5	92.9	89.1	87.7	91.1	91.1	92.5	91.5	91.2	89.6	90.4	88.0	88.0	92.3	90.6	90.0
IA	92.4	89.8	92.1	91.1	92.7	89.2	92.3	91.1	92.9	91.7	90.3	93.0	91.4	91.4	93.8	86.7	93.3
KS	86.8	93.7	90.8	89.9	87.1	90.4	93.9	89.4	92.3	92.7	92.7	93.1	91.9	91.9	90.0	91.0	88.5
KY	91.6	89.5	91.6	93.7	88.6	91.6	88.0	95.5	91.0	90.2	92.5	90.8	90.2	90.2	89.5	91.4	89.2
LA	88.0	88.1	88.3	89.8	87.7	84.7	87.4	88.4	88.7	89.2	88.9	92.9	94.2	94.2	89.7	92.6	90.5
ME	95.3	95.3	93.6	92.0	94.0	94.2	92.3	94.1	91.7	92.2	92.2	90.2	91.8	91.8	90.9	90.3	91.2
MD	91.7	95.3	89.1	95.8	90.9	92.9	95.4	93.7	94.8	93.6	96.3	97.1	94.5	94.5	90.5	95.2	92.5
MA	97.2	95.6	96.0	94.0	96.1	92.8	95.5	97.7	96.0	97.0	96.6	93.3	94.4	94.4	92.3	93.1	93.7
MI	89.7	89.2	90.4	89.8	88.9	88.6	93.3	92.5	91.8	93.7	92.2	89.5	88.1	88.1	91.1	87.6	91.4
MN	95.7	91.7	92.4	95.7	92.5	90.8	92.2	92.6	91.7	91.4	92.3	94.9	91.8	91.8	92.7	96.0	90.1

MS	93.1	90.7	93.0	92.3	90.3	93.3	91.1	94.7	94.4	91.0	88.5	87.2	89.3	89.3	93.8	89.6	93.4
MO	87.2	90.1	92.8	88.1	92.9	90.0	94.8	94.5	93.8	90.3	95.7	89.0	91.7	91.7	90.4	88.2	92.7
MT	87.6	87.0	91.4	93.1	89.9	94.7	85.3	90.7	91.2	93.6	87.3	89.6	85.9	85.9	85.1	87.8	91.5
NE	91.2	89.4	90.2	91.8	91.5	90.9	93.2	91.0	92.7	94.8	91.4	94.0	91.9	91.9	94.2	95.3	89.0
NV	82.0	87.9	91.6	88.7	88.0	86.0	89.4	89.2	87.4	85.7	85.1	86.3	88.0	88.0	87.0	90.5	89.8
NH	94.0	95.5	94.8	93.3	94.9	94.3	93.9	94.6	93.5	88.3	92.9	96.6	94.8	94.8	95.8	92.0	93.7
NJ	90.9	93.6	96.1	94.1	88.5	91.1	92.8	93.5	94.6	85.3	91.2	91.2	89.9	89.9	86.1	91.3	94.8
NM	89.6	84.5	85.5	87.5	83.0	87.7	92.5	93.9	89.9	91.2	89.1	90.6	90.6	90.6	88.8	93.1	88.8
NY	95.1	92.5	95.1	94.9	94.1	92.5	94.4	95.1	95.5	92.9	95.9	93.6	92.2	92.2	89.3	91.0	90.2
NC	89.7	94.4	95.6	92.5	94.8	96.4	94.9	95.7	95.6	94.4	97.6	96.9	92.2	92.2	94.5	92.3	89.0
ND	89.4	90.6	87.6	90.8	91.6	92.5	90.7	90.9	92.6	92.3	91.7	95.2	90.6	90.6	92.6	95.8	90.6
OH	93.2	89.2	91.4	90.3	89.1	91.8	91.3	95.6	93.1	93.1	93.5	90.7	93.9	93.9	93.6	93.3	90.3
OK	88.4	87.1	94.1	88.8	89.6	93.8	86.4	88.0	90.6	89.8	94.1	89.9	92.3	92.3	91.0	94.0	90.0
OR	86.2	88.4	89.8	86.1	91.1	89.4	86.6	92.4	93.7	82.7	88.7	88.9	92.0	92.0	92.8	90.6	87.3
PA	91.4	92.1	94.4	94.3	92.0	95.5	92.2	94.1	95.0	93.6	94.0	93.8	92.2	92.2	92.3	92.8	87.0
RI	96.1	95.8	96.5	95.8	93.1	94.8	96.0	93.6	95.6	95.2	96.1	94.7	93.7	93.7	95.8	96.6	94.3
SC	94.8	90.6	94.4	90.9	92.1	94.7	92.6	91.6	92.0	87.3	93.9	92.5	88.5	88.5	91.7	89.3	93.2
SD	93.2	89.9	89.8	93.0	91.3	93.7	95.5	91.3	93.7	94.4	94.3	95.0	93.7	93.7	92.1	89.2	93.3
TN	89.7	90.4	93.2	89.6	90.6	94.2	92.5	94.6	91.3	92.0	93.0	94.5	95.6	95.6	93.9	91.1	92.2
TX	88.4	87.6	89.6	87.9	87.2	90.4	87.7	91.4	89.2	89.1	92.1	90.4	93.7	93.7	91.8	94.3	89.7
UT	87.4	86.1	90.4	92.3	89.7	89.1	94.0	88.6	89.8	89.0	92.4	90.9	90.8	90.8	85.5	88.8	87.3
VT	93.7	95.3	96.4	99.4	93.1	95.6	94.7	96.4	94.4	92.6	95.1	93.6	88.1	88.1	92.7	95.3	91.7
VA	88.0	89.5	90.1	89.4	91.3	91.0	90.3	92.9	96.6	93.3	93.6	90.9	92.3	92.3	92.3	89.0	94.3
WA	91.7	91.1	90.0	89.3	90.2	89.3	89.6	93.5	92.3	90.6	87.5	90.5	91.2	91.2	89.8	89.3	84.8
WV	87.6	91.5	92.5	93.3	92.4	93.8	93.6	88.7	94.6	85.7	91.1	96.2	88.3	88.3	92.0	85.8	84.6
WI	90.2	91.3	92.0	94.2	91.0	92.3	92.9	94.2	93.6	91.6	94.0	91.4	94.3	94.3	93.2	94.9	89.3
WY	87.6	84.4	89.5	92.6	91.4	91.6	89.7	90.8	92.7	89.4	87.7	87.5	87.6	87.6	92.5	85.6	91.2

APPENDIX III

MMR vaccination coverage for people who lived at or above the poverty line

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	90.3	90.4	92.0	91.5	90.5	91.4	91.6	93.0	93.0	91.5	92.3	92.3	92.1	92.1	91.5	91.6	90.8
AL	92.8	93.9	96.1	89.8	89.7	92.1	92.7	92.1	95.6	96.8	97.1	95.0	95.8	95.8	95.3	94.9	93.5
AK	81.2	88.5	91.1	93.0	86.9	89.3	88.8	91.5	88.1	90.2	86.0	88.2	87.3	87.3	85.3	89.8	85.1
AZ	88.3	89.1	90.5	88.8	86.8	89.3	89.3	92.9	93.1	88.5	90.2	87.4	92.9	92.9	89.6	90.4	89.8
AR	87.9	91.4	92.1	88.9	88.5	91.1	93.0	91.0	91.7	88.9	88.2	91.9	95.2	95.2	92.1	94.0	91.5
CA	92.3	91.5	94.6	94.1	90.3	91.1	89.0	92.6	93.7	90.8	93.3	92.8	92.8	92.8	90.9	88.3	90.0
CO	88.9	96.0	91.4	92.8	88.4	93.1	91.6	87.3	90.8	92.0	88.4	89.7	92.7	92.7	89.4	85.6	88.8
CT	95.1	92.9	97.0	95.8	97.3	95.2	96.6	99.1	95.3	95.5	95.9	95.1	94.3	94.3	97.2	97.0	94.9
DE	92.6	93.0	92.4	93.4	91.9	91.8	94.5	93.7	94.6	95.8	97.1	94.6	90.6	90.6	93.7	93.4	93.5
DC	95.5	94.7	93.9	95.1	94.4	93.9	92.9	92.0	94.2	90.4	92.0	92.7	92.6	92.6	97.0	93.5	94.7
FL	90.9	92.6	91.4	92.5	87.6	91.7	90.1	96.4	94.6	92.4	92.3	93.7	90.0	90.0	92.9	90.3	92.6
GA	93.7	90.9	92.8	91.9	90.6	90.5	94.7	90.1	88.5	94.1	92.0	93.1	91.3	91.3	91.2	96.1	94.8
HA	90.8	91.9	94.9	93.2	92.7	89.7	96.6	94.0	95.6	88.9	91.9	94.5	95.0	95.0	93.5	93.8	94.5
ID	84.2	91.3	89.1	88.4	86.1	88.9	86.5	93.9	93.4	87.3	90.2	87.3	87.4	87.4	88.1	87.8	95.6
IL	90.1	90.7	92.9	91.6	92.1	90.1	94.3	95.7	95.4	95.2	90.2	93.8	91.5	91.5	91.1	90.5	91.8
IN	88.5	90.6	94.1	90.0	89.9	91.8	93.1	93.3	91.4	92.6	92.0	92.6	87.1	87.1	90.0	91.3	91.2
IA	93.4	90.0	93.0	90.7	93.2	90.9	92.4	91.7	95.4	91.4	90.5	93.4	93.9	93.9	93.0	90.8	94.2
KS	89.3	94.9	93.4	90.0	87.6	93.5	93.5	88.5	90.2	92.7	92.5	93.6	93.2	93.2	88.6	90.2	88.8
KY	93.6	92.5	94.1	93.8	88.7	91.6	93.3	95.2	91.5	90.4	93.2	91.9	89.5	89.5	89.9	97.9	89.8
LA	91.4	90.6	92.4	90.4	85.5	86.1	85.5	86.2	89.0	90.7	91.7	93.5	91.8	91.8	86.8	92.1	89.6
ME	95.5	96.0	96.1	94.2	94.7	93.5	94.5	95.0	91.7	91.4	91.5	94.3	91.1	91.1	90.3	90.7	92.6
MD	93.4	96.3	89.1	97.2	91.8	92.5	97.8	95.7	93.4	92.9	95.8	97.0	94.1	94.1	92.0	95.7	94.9
MA	96.3	96.4	97.3	94.4	96.7	92.9	94.9	97.0	95.0	97.7	96.4	93.7	93.1	93.1	90.3	96.2	93.8
MI	89.7	91.7	92.2	91.9	88.5	91.6	93.5	93.7	95.2	94.6	93.4	91.4	87.6	87.6	89.8	95.2	92.7

MN	95.1	92.0	93.3	95.9	92.2	89.1	93.3	93.0	92.2	92.4	91.2	95.0	92.5	92.5	93.7	97.4	92.6
MS	90.3	91.0	92.0	93.7	88.7	94.4	91.0	92.9	96.8	89.2	89.8	88.8	89.1	89.1	92.5	93.3	93.9
MO	92.9	91.8	92.4	92.1	92.4	91.2	95.2	95.2	94.6	90.8	96.7	91.1	91.2	91.2	90.8	88.6	93.1
MT	88.5	87.5	89.0	92.9	89.4	94.5	84.9	93.1	91.6	91.7	88.3	88.7	84.9	84.9	84.2	90.7	93.9
NE	93.1	91.3	90.9	93.4	93.9	91.9	94.5	93.4	92.5	94.1	90.7	92.1	92.6	92.6	94.9	95.6	88.2
NV	86.6	89.2	92.2	90.3	89.4	85.1	89.1	92.8	86.3	87.9	85.1	88.0	89.2	89.2	87.8	90.2	89.2
NH	93.7	96.1	94.7	94.3	94.7	94.8	94.6	95.4	93.3	89.3	93.1	96.7	94.9	94.9	95.8	91.0	94.2
NJ	92.9	95.1	95.5	93.8	89.3	93.0	93.2	93.8	94.9	89.0	92.0	94.3	90.3	90.3	88.0	91.6	94.3
NM	88.6	80.3	91.4	90.2	85.1	86.1	96.0	95.7	92.7	94.4	91.6	91.5	87.4	87.4	87.1	92.4	88.3
NY	95.0	95.4	96.0	95.2	96.4	92.6	95.0	93.3	95.4	93.0	96.9	94.6	91.7	91.7	90.3	90.7	92.2
NC	89.1	96.6	93.8	93.9	94.5	96.2	95.5	96.2	95.6	94.4	97.9	96.0	90.0	90.0	94.4	93.3	88.0
ND	90.6	91.2	89.2	89.6	92.1	92.3	91.8	93.2	93.0	92.2	93.6	94.9	92.4	92.4	91.6	94.8	91.9
OH	95.7	88.7	92.2	92.2	91.2	92.8	92.2	96.4	93.9	93.0	93.3	89.5	93.0	93.0	95.4	91.2	88.6
OK	92.0	89.8	95.1	87.9	91.3	95.3	85.0	89.5	88.3	91.7	93.0	90.2	93.2	93.2	92.5	92.5	89.0
OR	90.4	91.7	88.4	86.3	90.3	91.6	89.9	91.7	92.6	81.9	90.5	85.6	91.1	91.1	91.8	90.5	85.8
PA	94.8	92.6	92.6	93.2	92.8	96.2	93.2	96.5	96.5	95.8	94.7	94.0	92.3	92.3	93.4	91.8	89.0
RI	96.1	95.0	98.6	94.9	94.4	96.4	96.5	94.6	93.9	94.3	96.6	94.4	93.9	93.9	94.9	95.4	94.1
SC	94.4	91.6	97.5	90.4	90.3	93.2	95.3	90.1	95.1	87.0	96.5	91.8	92.5	92.5	91.2	87.0	94.8
SD	93.8	91.9	88.5	93.0	90.6	94.8	95.7	88.4	95.4	96.4	94.5	93.6	92.5	92.5	93.3	90.3	92.2
TN	91.5	92.0	94.0	89.3	91.5	94.5	92.4	93.8	92.0	93.0	94.2	96.8	95.7	95.7	95.0	89.9	94.1
TX	89.7	90.2	92.0	91.2	88.5	90.5	86.2	90.6	91.3	90.4	92.5	91.7	94.6	94.6	90.3	95.4	91.3
UT	87.1	86.5	90.4	94.3	89.4	89.0	95.6	90.9	90.1	89.7	93.3	90.1	89.6	89.6	88.5	88.0	90.4
VT	94.6	95.7	96.0	99.4	91.7	95.2	95.5	96.2	95.0	91.9	94.6	94.1	87.4	87.4	92.3	95.4	90.8
VA	88.4	90.5	90.5	89.1	90.1	91.9	89.2	94.4	96.9	93.2	94.2	92.4	92.5	92.5	93.5	89.0	95.3
WA	94.2	92.2	90.1	89.1	89.9	91.5	90.6	95.5	93.3	89.3	88.2	89.6	89.5	89.5	88.3	90.4	85.0
WV	87.5	89.0	94.3	92.8	94.8	92.6	91.7	90.8	93.3	88.0	88.7	96.8	92.2	92.2	93.3	87.6	84.8
WI	90.1	92.4	93.4	94.9	92.0	93.3	93.4	93.1	93.0	93.6	93.1	89.8	96.3	96.3	93.3	93.2	92.7
WY	90.3	81.9	89.7	94.9	91.2	92.2	87.5	91.3	92.0	89.1	92.4	86.6	89.2	89.2	91.2	90.0	90.9

APPENDIX IV

MMR vaccination coverage for people who lived below the poverty line

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	87.2	85.7	90.1	90.0	88.9	89.1	90.2	92.0	91.3	89.3	91.1	91.3	92.3	92.3	91.3	91.3	89.9
AL	91.8	93.2	89.8	93.0	80.5	98.2	NA	87.0	NA	NA	NA	94.7	91.4	91.4	94.8	93.6	94.6
AK	89.9	NA	NA	NA	93.5	NA	NA	NA	95.0	NA	NA	93.9	91.0	91.0	99.2	96.8	NA
AZ	74.6	83.2	84.4	85.4	88.2	88.3	89.3	90.6	92.1	88.2	83.6	96.7	93.6	93.6	87.1	NA	87.3
AR	NA	91.6	82.3	NA	90.0	86.5	89.9	89.5	96.7	NA	NA	94.9	87.9	87.9	86.9	93.3	92.6
CA	89.6	78.2	90.9	93.1	92.0	90.1	90.3	95.2	92.0	91.4	93.9	97.6	91.4	91.4	91.0	93.4	94.4
CO	NA	NA	95.5	NA	NA	85.8	NA	NA	88.2	96.9	NA	NA	92.2	92.2	90.0	93.6	95.7
CT	NA	NA	92.4	97.3	94.7	NA	NA	NA	NA	NA	NA	NA	98.3	98.3	NA	89.0	94.1
DE	92.4	NA	96.2	93.8	NA	97.3	95.8	NA	92.0	NA	NA	98.5	NA	NA	97.1	NA	95.2
DC	NA	87.7	92.0	89.0	NA	91.8	NA	98.4	96.1	NA	91.3	98.8	NA	NA	NA	93.7	92.0
FL	86.7	89.3	94.1	92.1	90.9	93.9	93.0	92.0	96.5	89.4	89.3	91.4	94.6	94.6	94.4	92.6	87.4
GA	86.0	88.4	90.2	89.6	90.0	87.9	87.4	93.0	98.0	95.7	87.7	90.6	97.1	97.1	92.8	91.0	87.6
HA	95.1	94.9	95.1	95.0	95.2	90.6	93.2	NA	97.4	93.5	NA	96.8	92.5	92.5	90.9	94.2	96.0
ID	NA	NA	91.3	NA	91.0	NA	87.5	92.1	NA	86.7	NA	NA	NA	NA	NA	92.2	94.5
IL	87.8	NA	83.7	95.3	89.5	84.8	93.0	92.7	92.0	86.5	86.3	90.5	92.6	92.6	92.3	92.5	91.1
IN	NA	NA	88.0	NA	NA	88.2	90.7	NA	NA	NA	NA	83.9	NA	NA	96.3	88.6	87.7
IA	NA	NA	NA	93.1	93.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	90.3
KS	NA	NA	NA	NA	NA	NA	94.4	89.9	NA	NA	92.8	NA	NA	NA	NA	96.2	87.2
KY	NA	NA	82.7	92.5	NA	90.7	NA	95.1	NA	NA	94.5	87.2	91.4	91.4	88.8	NA	87.7
LA	85.0	83.2	84.6	92.2	88.6	82.4	88.7	89.8	87.0	86.4	89.1	91.3	97.8	97.8	92.5	95.1	92.4
ME	97.0	98.0	NA	86.1	93.3	96.2	NA	94.1	NA	NA	NA	NA	93.7	93.7	93.6	88.3	NA
MD	NA	93.1	NA	91.3	NA	93.4	91.9	NA	97.4	95.4	97.4	NA	93.9	93.9	NA	94.1	NA
MA	98.7	96.3	91.4	95.2	97.5	90.0	97.7	99.3	98.4	NA	96.5	NA	NA	NA	NA	NA	94.4
MI	NA	90.0	91.4	86.1	85.2	NA	91.7	88.4	NA	90.4	NA	NA	90.0	90.0	95.3	NA	91.4

MN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MS	95.3	90.5	91.4	91.7	91.4	91.6	90.9	95.6	95.2	96.0	86.1	NA	90.6	90.6	95.0	85.4	92.3
MO	NA	91.0	97.4	NA	96.2	NA	NA	90.4	NA	87.6	NA	NA	94.2	94.2	92.0	87.2	91.9
MT	NA	89.6	96.9	92.9	97.5	97.4	NA	84.9	90.0	NA	NA	95.9	NA	NA	NA	NA	NA
NE	NA	NA	NA	NA	NA	NA	95.8	NA	90.3	98.7	93.0	98.7	NA	NA	90.7	NA	90.0
NV	NA	NA	NA	NA	NA	88.3	NA	84.5	92.0	NA	NA	82.9	NA	NA	87.8	93.0	91.6
NH	NA	NA	93.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	93.8	NA
NJ	NA	NA	96.1	98.2	NA	NA	95.8	93.8	92.0	NA	92.8	NA	94.8	94.8	NA	88.3	94.8
NM	92.5	93.0	80.1	NA	79.4	88.6	NA	87.6	85.4	88.3	89.3	87.0	93.6	93.6	90.6	93.9	89.0
NY	91.7	93.4	91.9	96.2	91.0	92.3	96.3	98.5	94.1	92.9	96.9	90.7	92.1	92.1	85.7	90.1	87.2
NC	NA	89.2	99.0	87.4	92.9	94.4	95.9	93.4	98.3	94.7	94.5	97.8	95.1	95.1	94.1	93.4	90.9
ND	92.0	NA	NA	95.3	NA	92.4	NA	NA	92.6	NA	NA	95.8	NA	NA	95.5	99.7	NA
OH	87.6	88.7	88.0	82.6	83.6	85.9	90.6	90.3	88.1	91.5	94.0	93.8	95.2	95.2	87.9	95.8	91.5
OK	NA	NA	NA	90.7	87.7	94.2	NA	NA	92.9	83.7	96.2	88.9	NA	NA	NA	96.3	91.8
OR	NA	87.5	93.3	NA	92.9	NA	NA	94.4	97.7	NA	NA	NA	93.8	93.8	94.0	90.3	89.6
PA	NA	83.8	96.6	97.4	89.4	90.4	NA	NA	93.3	NA	94.0	93.0	90.4	90.4	90.7	94.6	83.8
RI	98.8	96.9	91.1	NA	88.6	84.7	93.9	NA	98.4	97.3	96.5	95.0	NA	NA	97.5	98.1	94.8
SC	NA	88.2	92.4	92.1	93.8	98.9	NA	91.8	NA	86.3	93.1	92.8	NA	NA	93.1	91.4	91.8
SD	NA	NA	90.7	91.2	90.4	NA	NA	97.1	NA	NA	93.5	98.4	97.2	97.2	NA	NA	94.6
TN	86.2	89.6	87.6	90.1	92.2	93.8	94.0	96.4	89.5	91.8	89.0	91.6	94.5	94.5	90.5	95.1	91.1
TX	88.0	81.1	89.0	82.5	83.5	89.8	88.3	92.3	86.4	87.2	90.4	87.1	92.9	92.9	93.2	92.9	87.1
UT	NA	NA	94.2	NA	NA	NA	NA	NA	90.0	NA	NA	92.3	NA	NA	NA	NA	NA
VT	NA	95.1	98.4	NA	NA	NA	NA	NA	95.5	NA	NA	NA	NA	NA	NA	94.9	92.7
VA	NA	91.8	NA	92.2	95.7	NA	93.8	NA	NA	NA	90.2	NA	NA	NA	90.3	NA	NA
WA	88.8	91.4	87.4	88.6	93.1	85.0	85.0	89.3	89.6	92.2	85.9	92.1	93.2	93.2	92.8	85.8	NA
WV	87.8	91.8	87.8	92.6	87.4	95.3	96.8	NA	95.4	NA	97.0	94.7	NA	NA	88.4	83.3	83.1
WI	91.4	81.2	82.7	88.6	84.0	87.0	93.1	96.8	93.6	NA	97.5	NA	NA	NA	NA	97.5	NA
WY	NA	90.8	88.1	88.6	89.2	89.6	96.7	NA	93.6	NA	NA	90.9	NA	NA	NA	NA	90.3

APPENDIX V

MMR vaccination coverage for children whose providers participated in the VFC program

	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	90.8	92.3	92.0±	91.1	91.8	91.9	93.9	93.8	92.1	93.2	94.0	93.4	93.4	93.1	93.5	92.4
AL	94.5	95.3	90.9	87.3	94.4	91.6	90.6	92.3	93.9	93.5	95.1	96.4	96.4	95.5	95.2	95.3
AK	86.8	92.4	94.2	93.1	92.2	90.3	95.4	90.3	94.6	89.0	92.0	90.6	90.6	93.2	94.0	89.1
AZ	89.1	88.2	89.2	90.1	90.1	89.1	92.9	94.1	89.7	88.1	90.2	93.3	93.3	90.1	88.7	88.6
AR	93.7	88.2	87.8	89.9	90.3	93.9	90.6	94.6	93.1	91.1	93.9	94.1	94.1	92.2	96.7	94.0
CA	89.7	91.0	94.4	90.4	92.0	90.7	94.5	93.3	93.4	92.8	96.6	94.8	94.8	95.7	93.5	93.0
CO	95.2	95.2	91.7	90.4	92.6	92.0	86.7	91.8	95.8	93.6	94.5	91.3	91.3	91.0	94.1	92.3
CT	94.3	97.4	96.8	96.8	96.4	96.5	99.2	94.1	96.9	96.7	97.5	95.5	95.5	98.1	95.9	96.6
DE	90.2	94.4	94.4	93.1	94.5	96.0	92.5	96.1	96.3	99.6	94.7	92.2	92.2	94.8	92.3	95.3
DC	88.9	92.3	91.1	85.1	90.8	90.2	93.3	94.2	90.5	92.6	94.9	89.7	89.7	93.1	93.5	95.3
FL	90.5	92.7	92.0	90.0	91.7	91.2	95.1	97.5	90.8	90.6	95.7	92.2	92.2	95.3	93.0	92.2
GA	91.1	91.5	91.9	91.1	90.3	93.2	91.3	91.8	92.8	91.9	91.1	93.3	93.3	91.6	93.6	92.0
HA	91.8	94.5	94.8	93.8	91.7	97.3	95.8	96.3	90.6	94.9	94.8	97.7	97.7	94.6	95.9	97.7
ID	88.8	89.9	86.7	89.0	89.7	87.3	93.6	94.0	86.8	90.9	91.1	88.4	88.4	90.7	90.3	96.7
IL	88.5	92.7	91.3	90.9	90.3	95.5	95.7	95.2	92.3	90.0	95.5	92.4	92.4	91.1	95.5	95.2
IN	89.2	92.2	89.4	90.6	89.8	90.9	93.2	91.2	90.7	94.0	94.0	90.5	90.5	94.1	91.8	94.3
IA	90.6	92.0	91.2	92.7	89.2	93.3	91.2	93.6	93.3	92.5	94.6	95.6	95.6	95.3	87.0	93.1
KS	93.5	90.1	92.9	87.3	90.4	94.0	90.7	95.1	92.5	90.3	95.9	93.4	93.4	93.3	89.1	91.7
KY	89.1	90.8	94.4	90.2	92.4	88.6	96.0	91.4	91.1	93.6	93.2	89.6	89.6	88.9	94.3	90.2
LA	90.2	88.5	89.7	86.4	82.5	87.8	89.6	90.9	89.9	91.8	93.1	95.1	95.1	89.7	92.4	92.0
ME	95.7	93.1	93.4	94.2	94.0	92.6	94.0	93.8	91.0	93.3	94.0	93.9	93.9	94.5	92.9	93.8
MD	94.9	91.4	96.6	91.9	93.2	95.8	94.0	95.2	93.3	95.9	99.1	97.6	97.6	90.7	95.4	95.3
MA	95.1	95.7	96.6	96.1	92.7	96.0	98.4	98.0	97.2	96.8	93.0	94.1	94.1	92.1	95.2	95.5
MI	92.7	92.4	91.4	90.9	90.6	94.7	93.7	94.1	93.9	93.7	91.5	90.1	90.1	95.1	90.9	95.0

MN	91.5	92.0	96.1	93.4	92.3	94.3	93.3	91.8	93.5	91.7	98.1	92.8	92.8	93.9	98.1	89.0
MS	92.6	92.9	91.2	90.5	94.7	90.9	96.3	95.4	92.7	90.4	90.3	90.9	90.9	94.9	90.0	93.4
MO	89.9	93.9	88.5	92.4	89.7	94.8	95.0	94.7	91.2	95.3	91.4	91.7	91.7	93.5	90.1	95.5
MT	86.8	91.2	92.9	88.8	94.7	89.7	91.2	92.2	94.1	88.4	91.0	88.1	88.1	88.1	90.8	95.0
NE	89.6	91.7	93.4	91.4	93.4	93.0	91.9	93.8	95.2	93.8	94.3	93.0	93.0	95.7	95.7	91.7
NV	88.4	94.5	89.6	88.0	87.5	91.6	90.1	88.8	86.7	85.8	87.2	89.2	89.2	88.2	92.9	90.6
NH	94.6	94.7	94.2	96.3	94.5	93.0	95.2	96.6	89.5	96.2	97.5	95.7	95.7	95.7	95.6	94.2
NJ	94.8	97.0	92.8	87.2	91.9	92.3	94.8	93.5	87.4	92.0	91.3	90.1	90.1	89.3	94.7	98.3
NM	87.3	85.0	87.4	84.2	88.5	96.8	95.8	89.6	90.6	91.6	93.8	92.1	92.1	91.7	94.5	90.4
NY	93.3	94.9	94.3	95.8	93.4	94.2	96.6	96.1	93.0	94.7	94.8	93.8	93.8	90.4	94.0	90.6
NC	94.5	96.1	93.4	95.3	97.0	94.5	96.5	97.9	95.0	98.7	97.6	93.2	93.2	96.3	95.3	91.1
ND	92.1	89.9	91.6	91.9	93.7	90.8	92.0	93.8	94.7	93.4	95.5	93.6	93.6	92.6	96.2	94.9
OH	90.0	90.9	89.4	89.1	91.1	91.7	96.2	93.8	93.3	92.1	90.5	93.3	93.3	94.7	94.7	92.2
OK	86.9	94.9	90.6	90.6	94.1	87.5	88.0	91.5	90.3	93.4	90.0	95.9	95.9	91.4	96.5	92.3
OR	88.5	88.8	86.1	92.0	90.8	87.6	92.6	95.1	89.3	92.0	92.8	92.9	92.9	94.7	91.3	88.2
PA	92.5	95.1	96.2	93.0	95.5	92.4	94.8	94.7	94.2	96.8	96.0	93.1	93.1	92.2	94.5	88.4
RI	97.4	97.0	97.0	94.3	94.9	95.4	95.8	96.3	94.9	95.9	94.1	94.9	94.9	96.7	96.8	94.7
SC	92.4	95.6	89.8	93.7	95.9	92.8	92.0	92.2	87.7	93.8	94.7	91.0	91.0	92.5	90.5	93.8
SD	89.8	90.0	93.4	92.5	93.1	94.1	93.1	93.7	95.5	94.9	95.6	95.0	95.0	94.4	92.8	94.9
TN	91.5	93.3	90.7	90.9	94.2	93.7	95.3	92.0	94.3	95.0	97.9	97.6	97.6	96.2	91.4	94.6
TX	87.4	90.6	87.4	89.7	90.5	87.2	92.2	90.6	89.2	93.7	91.9	94.2	94.2	92.7	95.7	91.8
UT	86.8	91.5	96.6	90.4	91.6	95.2	92.8	92.3	91.1	94.6	96.1	91.7	91.7	88.9	91.4	86.5
VT	95.6	95.3	99.2	92.8	95.8	93.4	97.1	96.1	93.0	96.2	93.7	89.6	89.6	94.6	96.5	92.3
VA	89.0	89.6	91.8	91.1	90.3	88.9	91.8	96.7	93.0	93.8	92.3	95.5	95.5	92.0	88.0	94.8
WA	90.4	90.1	90.7	91.4	90.1	90.6	93.7	94.4	89.6	88.9	94.0	93.7	93.7	91.7	90.3	84.4
WV	91.0	93.2	93.0	91.8	94.1	94.5	89.9	94.7	86.9	92.5	96.5	89.7	89.7	92.3	87.5	88.1
WI	91.9	92.7	93.7	89.6	92.0	93.3	95.0	93.4	92.9	94.5	93.9	97.0	97.0	95.4	96.2	90.5
WY	86.2	89.2	93.2	92.5	92.1	90.1	91.0	93.7	90.1	89.6	89.8	89.1	89.1	93.1	87.4	93.0

APPENDIX VI

MMR vaccination coverage for children whose providers did not participate in the VFC program

	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	92.4	92.3	91.5	90.6	90.4	92.2	91.5	92.7	90.5	92.4	93.4	90.6	90.6	90.2	87.1	91.8
AL	92.4	93.7	90.8	92.6	91.5	91.2	94.8	NA	92.8	NA	96.6	97.2	97.2	97.6	90.4	NA
AK	90.6	91.0	NA	NA	NA	88.4	NA	90.3	NA	NA	NA	NA	NA	NA	NA	NA
AZ	89.6	NA	NA	NA	NA	NA	96.3	NA	NA	92.9	NA	NA	NA	NA	NA	NA
AR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CA	92.5	93.2	88.1	91.0	89.2	90.2	88.3	93.1	87.8	94.5	93.4	85.2	85.2	NA	NA	96.1
CO	NA	NA	NA	NA	94.4	NA	NA	93.7	NA	NA	NA	99.0	99.0	NA	NA	NA
CT	92.6	97.2	95.6	95.1	97.1	97.0	96.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
DE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DC	94.3	NA	96.8	NA	94.8	97.1	91.8	94.5	94.9	93.0	92.2	98.0	98.0	99.3	95.0	92.2
FL	96.6	91.2	95.7	NA	96.1	93.4	98.6	NA	99.9	96.0	99.3	92.6	92.6	NA	NA	NA
GA	93.3	98.5	95.9	98.7	NA	93.1	NA	99.4	98.6	NA	99.3	98.6	98.6	89.6	96.2	NA
HA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IL	92.9	NA	96.1	96.9	87.1	95.2	88.5	97.1	95.7	NA	95.8	92.9	92.9	92.3	NA	86.4
IN	90.3	94.0	96.6	NA	94.5	90.3	NA	94.4	NA	88.5	92.4	NA	NA	96.6	NA	NA
IA	91.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
KS	95.3	92.0	85.2	87.8	95.6	93.7	NA	NA	94.1	97.5	90.7	96.3	96.3	NA	94.1	92.7
KY	93.1	98.8	93.6	NA	90.5	NA	97.2	NA	NA	93.1	NA	97.8	97.8	97.2	NA	98.9
LA	83.7	94.2	90.5	96.2	94.3	96.6	NA	NA	90.3	86.6	92.7	NA	NA	NA	98.4	NA
ME	93.4	95.7	91.3	93.0	96.1	NA	96.9	NA	NA	NA	NA	NA	NA	NA	NA	NA
MD	96.4	NA	96.1	NA	99.5	NA	97.6	98.0	NA	98.3	97.2	NA	NA	95.8	NA	96.9
MA	98.1	95.9	94.3	95.2	92.9	93.2	97.4	97.0	NA	NA	NA	NA	NA	NA	NA	NA
MI	NA	86.7	87.6	NA	NA	NA	NA	NA	NA	99.1	NA	NA	NA	NA	NA	NA

APPENDIX VII

MMR vaccination coverage for people who lived in a MSA central city

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	89.5	89.8	91.3	91.3	89.7	90.9	90.2	93.2	92.8	91.6	92.5	91.8	92.6	92.6	92.4	92.0	90.1
AL	88.5	96.1	94.9	89.6	87.7	95.4	92.9	86.8	89.3	95.2	98.2	93.1	92.9	92.9	96.9	93.8	92.7
AK	84.4	86.4	91.4	90.8	92.0	92.2	86.9	90.9	91.5	89.7	87.2	91.2	NA	NA	84.8	87.9	85.1
AZ	84.8	86.6	86.2	84.9	86.3	88.1	88.4	90.4	91.8	87.1	87.1	87.5	93.5	93.5	85.3	88.3	92.1
AR	NA	87.7	86.0	NA	92.9	95.3	NA	95.1	94.8	NA	NA	94.3	91.3	91.3	88.6	94.1	89.2
CA	91.7	90.5	89.3	94.9	87.9	93.9	84.4	95.1	95.1	94.1	95.8	95.5	94.1	94.1	93.6	91.7	90.6
CO	87.0	94.6	94.5	92.2	87.3	88.6	93.9	80.5	87.7	95.2	87.8	97.7	NA	NA	91.5	89.9	91.9
CT	94.7	91.8	94.1	95.2	95.3	88.4	90.7	97.0	96.1	98.3	98.0	94.5	95.4	95.4	98.3	94.1	92.9
DE	89.8	90.3	95.0	95.7	89.9	92.5	93.9	88.9	92.3	95.2	96.0	98.6	91.2	91.2	96.7	91.3	98.0
DC	92.9	89.7	92.7	91.2	86.2	91.9	91.2	92.8	94.6	91.6	92.1	95.2	89.7	89.7	94.7	93.5	93.0
FL	88.6	88.3	92.3	94.9	88.6	90.6	90.4	97.4	95.6	91.2	91.2	93.1	90.5	90.5	95.2	89.7	88.4
GA	87.9	91.0	93.6	NA	88.0	89.0	NA	90.4	89.1	94.7	88.8	NA	NA	NA	94.1	90.5	89.5
HA	97.6	90.9	94.8	93.2	96.3	93.7	95.6	95.4	93.5	NA	86.2	97.9	94.7	94.7	91.4	94.5	96.9
ID	NA	90.1	NA	93.1	91.3	NA	NA	96.2	90.2	87.1	87.9	84.3	90.2	90.2	92.8	88.6	95.4
IL	87.9	87.4	88.0	87.7	88.2	87.8	91.0	92.4	95.0	90.9	88.1	91.8	90.4	90.4	89.1	89.3	89.9
IN	82.0	87.2	91.8	87.3	87.0	93.0	91.8	93.5	91.4	NA	88.5	91.9	88.5	88.5	96.2	90.6	90.2
IA	90.0	93.2	93.3	84.6	91.9	93.2	91.2	94.7	95.6	95.5	NA	96.6	89.0	89.0	92.6	NA	91.3
KS	86.6	91.2	87.5	89.6	86.4	93.2	96.1	86.0	94.0	92.2	93.6	89.7	92.4	92.4	92.6	NA	88.1
KY	NA	89.3	93.8	94.8	92.1	92.6	NA	95.7	NA	92.9	96.5	91.2	NA	NA	NA	99.7	93.4
LA	81.6	83.8	90.1	90.1	88.3	82.4	86.2	87.4	89.5	88.8	93.9	88.3	94.2	94.2	89.8	95.1	87.5
ME	NA	91.6	98.0	91.1	94.0	NA	95.2	NA	NA	NA	NA	NA	NA	NA	94.7	92.1	NA
MD	94.5	95.7	91.3	93.1	91.3	92.0	96.1	94.5	95.2	95.0	97.5	98.0	92.3	92.3	88.5	93.5	94.8
MA	NA	95.1	95.2	95.7	91.9	90.3	89.5	97.2	95.0	97.8	98.9	NA	94.3	94.3	NA	NA	92.1
MI	87.5	82.3	85.8	86.8	88.9	92.2	95.3	92.7	89.4	95.0	87.7	NA	91.7	91.7	95.7	90.0	99.1

MN	96.7	93.3	96.6	96.4	96.4	91.8	93.1	97.0	91.5	86.8	92.4	95.7	94.0	94.0	95.9	95.5	NA
MS	NA	88.6	88.8	NA	NA	95.4	NA	94.9	95.6	91.4	94.0	NA	89.5	89.5	91.8	NA	NA
MO	NA	94.9	93.0	91.5	92.9	85.1	98.3	91.3	93.2	91.9	98.4	NA	96.0	96.0	92.3	88.6	89.4
MT	81.4	88.3	94.7	93.7	88.7	96.2	84.7	86.1	86.7	96.6	88.5	87.2	NA	NA	NA	87.3	92.7
NE	95.3	90.0	90.1	92.8	93.5	91.3	92.2	92.0	96.1	97.6	96.1	99.3	93.3	93.3	92.2	94.8	89.5
NV	82.7	87.9	90.4	87.9	87.7	84.2	87.2	88.1	88.9	84.1	85.7	86.4	87.5	87.5	89.2	89.4	92.4
NH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	98.3	NA
NJ	NA	92.1	90.8	NA	NA	NA	95.1	95.7	97.7	NA	NA	NA	NA	NA	NA	91.6	96.4
NM	86.9	86.6	83.2	86.0	85.7	87.7	91.3	95.9	90.1	91.3	90.3	92.4	91.5	91.5	86.3	94.8	86.5
NY	94.2	93.1	95.3	95.6	93.6	91.3	94.7	96.4	94.2	91.7	95.9	93.1	94.0	94.0	90.4	92.1	91.3
NC	NA	96.0	96.4	91.6	95.4	93.6	97.1	92.2	94.0	93.4	98.1	96.9	95.5	95.5	91.2	95.1	86.4
ND	86.7	92.6	91.7	89.4	90.5	95.9	NA	91.8	96.9	92.0	96.0	97.5	96.8	96.8	95.4	98.3	94.9
OH	91.6	87.1	89.7	92.1	86.1	93.6	89.5	95.5	91.2	92.9	92.6	93.0	95.9	95.9	94.9	94.7	88.5
OK	90.9	83.2	91.5	89.8	90.5	92.6	94.9	NA	92.8	85.1	96.4	NA	90.4	90.4	93.1	96.3	92.6
OR	91.6	89.3	91.3	87.9	94.3	84.3	85.1	93.7	94.2	83.9	86.8	86.9	91.5	91.5	90.7	95.7	85.4
PA	87.3	93.0	95.7	97.4	93.6	92.0	94.4	91.3	98.0	95.4	94.9	91.3	93.7	93.7	93.2	93.2	84.4
RI	94.1	97.2	92.8	96.0	92.7	90.8	95.0	96.5	95.2	94.8	98.1	94.9	90.4	90.4	95.4	98.3	94.6
SC	96.1	90.1	93.7	91.3	96.1	97.9	90.8	94.6	NA	NA	97.9	94.5	84.9	84.9	91.6	89.0	97.2
SD	91.8	88.6	96.7	93.8	93.6	93.6	93.5	91.5	94.8	94.9	92.7	98.7	96.1	96.1	NA	92.1	93.0
TN	87.0	89.1	90.5	87.4	88.9	93.4	91.2	94.3	91.9	92.0	93.3	92.6	95.0	95.0	90.3	93.2	91.3
TX	90.3	88.0	89.9	86.6	88.5	89.5	84.4	91.1	89.8	90.8	90.9	88.2	92.8	92.8	92.8	94.8	89.3
UT	87.2	83.2	89.0	88.9	91.4	89.5	98.4	92.6	92.6	87.9	95.9	91.7	96.1	96.1	85.2	89.3	NA
VT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VA	NA	NA	90.8	95.4	NA	NA	NA	NA	95.8	95.1	95.7	92.6	95.5	95.5	94.0	91.9	96.3
WA	92.1	92.8	89.3	87.3	89.5	89.6	89.4	93.2	92.0	89.5	88.1	94.0	90.4	90.4	92.4	87.3	85.0
WV	NA	92.4	NA	96.7	95.7	97.8	94.8	NA	98.8	89.6	92.8	98.8	88.4	88.4	88.3	NA	NA
WI	91.5	94.5	89.8	94.2	86.8	91.2	93.0	93.6	95.0	91.7	95.2	96.5	94.3	94.3	94.3	96.2	87.6
WY	86.7	80.4	95.7	91.3	93.8	92.8	89.9	92.9	89.4	89.8	91.8	NA	87.1	87.1	91.7	NA	93.6

APPENDIX VIII

MMR vaccination coverage for people who lived in a MSA non-central city

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	91.4	90.8	92.4	92.1	91.0	92.0	93.3	93.1	93.5	91.8	92.5	92.8	92.3	92.3	90.5	91.2	91.0
AL	94.6	94.2	96.6	91.1	82.4	92.5	90.4	98.6	96.3	94.4	90.9	98.0	95.5	95.5	95.4	94.4	93.1
AK	NA	NA	NA	NA	NA	NA	NA	NA	NA	96.5	NA	84.6	NA	NA	87.6	NA	NA
AZ	87.7	92.2	89.2	89.2	91.3	88.0	90.7	93.7	95.2	89.7	88.1	90.7	89.7	89.7	90.8	NA	82.6
AR	90.9	91.2	86.1	88.5	79.4	82.4	92.8	89.3	93.2	92.6	NA	93.5	93.7	93.7	92.1	87.2	91.2
CA	90.0	88.1	92.2	91.6	92.1	91.2	94.1	91.7	92.4	88.9	90.4	94.2	92.5	92.5	88.4	89.7	92.5
CO	92.4	94.1	92.6	89.1	88.1	93.6	89.6	86.5	93.7	91.1	NA	87.0	97.0	97.0	86.9	88.6	93.1
CT	97.5	94.5	98.0	95.5	96.1	95.9	97.0	98.9	94.0	95.4	95.4	95.1	94.4	94.4	97.6	95.7	95.5
DE	91.9	93.9	93.8	90.4	88.5	92.6	95.1	96.9	97.2	93.8	95.3	94.0	93.9	93.9	94.6	88.7	91.3
DC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FL	89.4	92.7	92.4	89.6	89.8	93.6	93.0	92.5	94.6	93.8	91.8	90.4	93.9	93.9	90.0	91.2	93.3
GA	90.8	90.9	89.8	90.0	92.9	91.6	93.8	88.6	94.0	91.6	92.0	93.5	91.9	91.9	90.1	94.3	91.2
HA	91.6	89.7	91.7	96.1	91.2	88.0	98.0	91.9	93.5	88.8	92.9	93.2	92.4	92.4	93.8	96.9	93.6
ID	91.1	91.9	95.5	83.8	NA	86.1	85.5	94.4	96.4	90.6	NA	87.7	89.4	89.4	83.9	94.2	93.2
IL	93.0	89.4	92.6	94.0	92.1	90.5	96.4	94.2	94.8	96.2	94.1	95.4	90.2	90.2	91.8	92.7	92.1
IN	89.8	88.3	90.4	91.8	86.9	88.8	92.3	95.1	95.6	98.6	88.4	89.7	90.7	90.7	88.5	90.9	88.6
IA	NA	91.6	93.0	91.9	97.3	86.2	93.5	NA	NA	96.0	88.1	91.5	93.0	93.0	95.2	NA	95.3
KS	93.4	92.6	92.6	92.3	90.5	92.3	94.6	NA	90.7	94.7	93.4	95.9	92.8	92.8	87.3	91.7	91.3
KY	93.2	92.4	93.6	94.5	88.0	88.9	93.3	92.0	92.5	NA	90.5	95.1	94.6	94.6	91.5	95.3	91.3
LA	94.0	91.7	87.4	88.1	84.3	81.9	90.1	90.5	86.9	89.5	92.8	98.1	96.2	96.2	89.0	91.9	89.6
ME	94.2	94.6	95.6	90.3	92.7	92.2	91.3	90.1	91.7	89.1	90.2	87.1	90.9	90.9	89.9	95.1	91.2
MD	91.7	95.5	88.6	96.2	91.2	92.8	95.4	92.9	94.3	93.5	94.9	96.5	94.9	94.9	90.9	95.5	91.1
MA	97.5	95.6	96.2	93.8	96.5	93.0	96.0	97.8	96.4	96.9	95.9	96.8	94.4	94.4	90.2	95.0	94.3
MI	90.9	90.9	92.7	90.1	88.3	86.7	92.6	91.8	92.1	94.4	95.3	89.0	83.9	83.9	86.5	85.5	87.5

APPENDIX IX

MMR vaccination coverage for people who lived in a non-MSA central city

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	90.5	90.6	92.4	90.4	90.8	90.8	90.2	92.3	92.4	90.4	91.5	92.3	90.4	90.4	91.4	91.5	92.4
AL	89.6	90.8	93.4	89.4	93.6	94.1	91.5	88.4	89.6	91.6	91.6	93.4	92.2	92.2	92.9	93.7	93.7
AK	88.1	87.9	91.5	90.4	88.6	85.2	89.2	89.8	88.7	88.0	88.0	92.1	90.6	90.6	90.9	97.8	93.2
AZ	NA	84.1	90.5	94.0	84.5	93.6	86.3	89.7	90.0	96.3	90.3	NA	NA	NA	NA	NA	NA
AR	90.4	94.6	89.7	90.4	91.1	92.5	95.8	89.6	95.2	94.9	93.1	90.7	91.8	91.8	90.5	96.5	95.9
CA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	94.4	NA	NA	NA	NA	NA	NA
CO	NA	93.5	90.3	88.8	85.4	94.4	NA	94.9	90.0	91.1	NA	NA	91.0	91.0	88.2	NA	NA
CT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	94.6	NA
DE	88.9	NA	92.5	98.6	94.6	97.8	NA	95.8	94.2	97.7	NA	92.8	93.2	93.2	86.4	94.5	NA
DC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FL	95.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GA	96.5	91.6	93.6	94.5	90.9	87.7	92.9	93.9	NA	93.6	91.5	96.1	99.1	99.1	92.1	98.3	96.7
HA	90.1	90.9	98.8	90.9	96.0	91.2	94.6	94.9	97.1	86.1	NA	91.6	97.3	97.3	94.5	90.2	95.8
ID	81.5	86.5	88.8	85.8	88.7	89.8	88.8	91.0	90.0	82.5	89.4	86.6	NA	NA	NA	86.1	91.5
IL	NA	93.6	94.3	90.8	98.5	NA	95.0	94.6	95.8	NA	NA	NA	97.7	97.7	NA	NA	96.1
IN	84.9	91.0	97.9	87.9	89.8	91.1	88.4	NA	NA	NA	94.1	NA	NA	NA	90.8	90.0	91.9
IA	95.5	87.1	91.0	95.0	90.9	88.0	92.5	89.8	94.6	86.4	94.6	91.6	92.2	92.2	93.7	91.5	94.1
KS	83.3	96.5	91.6	88.2	85.0	87.1	91.6	96.3	92.5	91.6	91.4	93.6	90.5	90.5	90.0	93.3	86.7
KY	92.6	88.3	89.0	92.8	87.3	92.3	87.2	96.7	93.0	90.2	90.3	87.8	83.9	83.9	87.7	85.5	84.8
LA	89.1	88.4	86.3	92.7	92.2	90.0	85.8	NA	90.1	89.8	NA	93.5	92.2	92.2	90.5	90.2	98.1
ME	95.1	97.1	89.1	94.5	95.7	94.6	92.3	96.4	90.1	96.2	96.1	93.1	94.4	94.4	90.1	84.5	92.3
MD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MI	90.5	94.9	94.0	95.5	90.3	88.5	92.7	95.1	94.9	90.4	92.8	NA	NA	NA	91.0	NA	89.0

MN	94.5	90.6	88.0	91.3	97.9	88.9	96.8	87.4	89.3	NA	88.3	98.0	92.3	92.3	NA	97.8	99.1
MS	95.5	91.5	93.5	92.9	91.4	93.8	92.4	96.7	95.9	94.5	87.4	86.0	91.6	91.6	95.0	93.4	98.3
MO	92.3	85.8	91.8	88.9	91.2	91.1	89.2	92.7	91.4	84.9	NA	NA	NA	NA	90.0	85.5	92.4
MT	91.0	86.4	89.7	94.0	90.0	94.3	86.5	92.5	93.1	92.9	85.9	90.2	86.8	86.8	85.8	89.5	90.5
NE	87.7	88.0	90.4	89.8	89.0	89.9	94.8	90.3	91.3	93.3	87.8	88.2	88.3	88.3	95.3	97.9	87.5
NV	NA	NA	93.9	85.8	NA	86.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	94.8	NA
NH	98.8	94.8	88.7	94.1	94.9	92.2	89.4	91.6	94.3	84.7	89.5	94.0	96.4	96.4	97.0	87.7	87.3
NJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NM	91.5	80.2	85.8	89.0	82.5	87.3	90.8	88.5	88.6	92.4	88.1	91.4	90.1	90.1	90.0	93.3	91.5
NY	93.2	93.3	NA	95.1	NA	NA	NA	91.5	96.4	NA	97.6	NA	92.9	92.9	90.0	NA	93.5
NC	93.5	89.8	93.7	94.0	94.3	96.5	90.9	94.4	95.0	92.7	98.8	97.1	85.1	85.1	97.9	NA	99.0
ND	91.4	88.6	89.4	93.6	92.4	91.6	91.3	88.6	88.4	93.6	89.4	94.4	86.4	86.4	90.6	95.7	85.9
OH	97.0	91.5	96.2	82.8	95.0	90.1	90.2	NA	95.5	90.4	95.1	91.3	90.9	90.9	NA	97.4	91.1
OK	87.0	87.6	95.1	89.4	91.9	92.7	NA	90.2	90.6	92.9	94.7	93.6	93.3	93.3	96.3	99.3	87.8
OR	81.6	92.3	87.1	NA	83.5	88.7	82.8	88.5	94.8	90.1	94.5	93.6	95.3	95.3	97.1	88.2	86.9
PA	95.0	93.2	97.2	NA	92.5	97.2	93.1	NA	NA	94.9	NA	93.3	97.9	97.9	88.4	87.8	NA
RI	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SC	94.9	91.2	97.4	90.6	89.6	94.1	NA	90.8	94.1	NA	89.7	91.3	92.5	92.5	91.7	96.1	NA
SD	92.9	90.0	87.3	92.2	90.2	93.5	96.7	91.9	93.3	94.1	93.7	94.1	92.0	92.0	95.8	NA	92.9
TN	90.7	94.2	95.4	96.7	92.5	94.2	95.3	94.1	90.8	91.2	NA	99.0	95.9	95.9	94.8	NA	95.6
TX	NA	90.7	89.3	NA	NA	89.5	NA	92.4	90.9	NA	92.7	94.4	95.5	95.5	88.6	88.4	89.8
UT	91.3	90.4	88.0	93.8	89.0	88.3	NA	NA	87.2	NA	NA	NA	NA	NA	NA	91.5	NA
VT	93.0	95.2	97.1	99.0	92.7	95.8	94.6	95.5	92.2	95.9	94.4	95.9	86.4	86.4	93.7	95.3	90.6
VA	87.6	94.2	NA	NA	92.4	92.6	96.5	95.0	97.8	NA	92.7	NA	NA	NA	NA	NA	NA
WA	88.4	88.9	90.6	94.6	94.5	91.2	88.1	94.5	94.7	NA	86.8	97.1	94.0	94.0	88.8	95.5	NA
WV	88.4	90.9	89.8	94.8	92.6	92.0	95.4	87.8	93.0	80.8	92.2	95.3	87.2	87.2	94.6	87.1	88.4
WI	89.1	87.2	94.5	94.2	93.2	92.5	92.0	96.7	91.5	88.0	93.7	NA	NA	NA	89.9	92.0	89.8
WY	87.9	86.4	86.4	93.1	90.9	91.3	89.7	90.0	94.9	89.1	85.4	88.2	87.9	87.9	92.8	87.1	90.4

APPENDIX X

MMR vaccination coverage for people who identified as white

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	91.4	91.4	93.1	92.4	91.5	91.7	92.6	93.2	93.5	91.4	92.8	92.1	91.3	91.3	90.6	91.1	90.9
AL	92.3	93.6	95.9	92.0	89.7	93.2	93.4	92.7	95.8	94.6	93.0	95.2	95.5	95.5	94.5	94.8	92.3
AK	87.1	84.3	91.3	92.4	88.7	87.9	89.2	86.7	85.7	88.7	80.9	89.5	79.0	79.0	85.9	85.4	82.1
AZ	86.5	91.6	92.3	89.6	85.3	90.9	90.2	92.4	92.8	87.5	88.0	93.6	92.0	92.0	86.1	86.4	84.5
AR	89.1	91.3	90.0	89.7	87.6	90.1	90.6	92.8	94.2	85.9	87.2	93.3	94.6	94.6	90.2	95.7	91.4
CA	93.7	90.3	92.7	92.9	93.7	88.5	90.7	89.6	93.1	88.8	94.2	94.4	88.2	88.2	87.6	89.3	89.7
CO	89.3	94.9	94.6	90.8	88.8	90.9	93.6	86.1	89.2	92.7	81.5	87.0	91.4	91.4	87.4	85.2	88.7
CT	98.3	93.3	97.9	96.8	96.8	96.5	96.6	98.9	94.7	93.8	95.1	96.1	94.3	94.3	97.2	95.8	92.6
DE	94.2	91.9	96.3	96.4	92.1	94.3	95.1	94.9	93.4	95.1	96.5	93.3	91.1	91.1	89.8	92.4	95.4
DC	NA	NA	NA	97.7	97.7	94.2	96.2	95.4	97.5	94.3	92.5	92.1	92.5	92.5	96.4	87.7	94.5
FL	91.1	93.3	93.2	89.8	88.4	90.3	90.1	96.7	95.8	84.9	90.6	92.4	92.0	92.0	92.4	88.4	96.1
GA	92.8	92.6	92.0	91.1	91.5	90.9	93.6	90.0	91.5	94.7	90.5	91.0	91.7	91.7	94.1	95.8	89.5
HA	91.7	89.9	90.1	88.0	NA	86.4	98.4	88.6	96.6	NA	NA	90.9	NA	NA	91.3	NA	89.7
ID	82.9	88.9	88.3	87.8	88.8	88.9	88.0	93.5	91.9	86.4	90.8	86.0	85.2	85.2	88.3	88.4	94.0
IL	88.2	91.5	96.5	93.9	93.9	91.9	95.6	93.9	96.2	95.4	91.8	93.5	93.6	93.6	88.1	90.8	94.1
IN	85.6	90.0	93.4	91.4	87.5	90.9	91.4	91.9	93.1	91.9	88.8	89.7	87.1	87.1	90.6	91.3	90.3
IA	93.5	90.0	93.8	92.2	91.2	89.2	93.6	92.1	91.7	90.5	92.0	94.3	92.4	92.4	92.5	87.0	94.8
KS	88.1	93.7	94.0	89.6	88.8	91.5	93.2	91.1	90.4	92.9	92.2	94.4	93.7	93.7	91.0	91.2	85.6
KY	94.2	89.6	92.0	94.3	88.3	91.9	90.5	94.9	93.8	89.8	92.3	92.8	89.1	89.1	90.5	91.9	90.5
LA	92.1	86.5	91.4	89.6	88.2	81.9	86.5	87.2	89.9	89.5	91.0	94.5	92.8	92.8	87.9	91.3	90.4
ME	95.2	95.4	94.1	92.3	94.2	93.7	91.5	94.2	90.7	91.9	94.2	90.4	92.7	92.7	90.0	88.9	91.6
MD	93.5	97.2	90.0	97.8	93.7	93.5	97.0	94.9	94.8	91.7	99.0	97.3	96.9	96.9	87.2	98.6	98.9
MA	97.2	96.2	95.6	95.7	97.4	94.5	95.5	97.5	94.7	96.5	95.7	94.4	93.0	93.0	91.7	96.4	92.9
MI	92.2	90.8	95.2	90.7	90.1	90.2	93.8	93.0	90.8	93.5	94.8	90.8	87.5	87.5	88.6	89.9	89.2

MN	96.6	92.7	92.9	94.9	93.6	90.9	91.7	90.9	91.4	88.0	94.3	93.5	91.1	91.1	95.2	97.0	92.6
MS	93.2	91.5	91.8	94.2	90.8	91.8	89.9	94.3	95.5	89.4	89.4	87.2	89.0	89.0	93.4	91.8	90.0
MO	88.1	90.7	92.9	88.3	91.8	89.7	96.6	96.0	93.0	90.0	98.4	89.5	89.9	89.9	88.9	86.2	95.2
MT	87.4	87.1	90.8	93.4	91.3	94.0	87.0	90.0	93.5	91.7	85.3	88.6	85.1	85.1	88.2	84.4	90.8
NE	92.2	89.4	89.7	91.4	92.4	93.6	94.5	93.7	91.7	94.7	93.2	92.7	92.5	92.5	93.8	95.4	90.4
NV	87.9	89.8	94.6	88.4	89.2	86.5	88.5	90.4	89.2	88.6	84.7	82.7	85.8	85.8	84.8	85.8	83.9
NH	93.9	95.7	94.7	93.5	94.4	93.9	93.9	95.3	93.2	89.2	91.9	96.1	94.9	94.9	95.5	93.0	94.8
NJ	89.1	93.7	96.3	95.2	91.6	92.7	92.8	92.7	94.4	85.4	92.0	93.7	90.0	90.0	86.0	94.1	95.2
NM	85.7	90.2	86.4	90.6	83.6	87.8	89.4	93.1	88.4	90.5	90.8	81.9	NA	NA	83.0	NA	89.9
NY	94.2	92.8	94.3	95.9	97.0	94.2	93.6	95.1	96.8	92.3	96.6	91.0	90.5	90.5	88.9	87.5	89.8
NC	90.4	93.8	95.9	92.8	95.3	96.8	94.5	98.3	NA	96.8	96.3	95.0	91.0	91.0	93.3	92.5	91.4
ND	90.3	91.7	86.6	90.8	90.7	92.3	93.1	92.6	91.1	92.8	92.7	94.6	90.3	90.3	92.0	95.2	93.3
OH	94.1	89.8	91.3	89.9	91.1	92.4	90.6	96.7	93.0	92.1	93.9	89.8	92.6	92.6	92.8	94.7	91.6
OK	86.4	90.3	94.9	88.6	90.6	93.9	87.7	82.6	91.2	90.7	93.3	88.9	90.9	90.9	87.4	92.6	88.0
OR	87.4	86.4	89.8	87.2	90.1	88.7	85.7	90.6	93.4	83.6	90.9	85.2	91.2	91.2	94.0	87.5	86.6
PA	92.5	93.3	94.5	94.1	91.1	96.0	94.7	95.8	96.8	96.1	93.7	93.7	92.6	92.6	92.1	92.3	85.3
RI	96.0	96.0	97.7	96.9	94.0	96.2	98.0	94.1	95.1	94.7	94.2	95.5	93.0	93.0	95.2	95.6	95.4
SC	96.6	91.0	93.1	91.1	92.6	94.7	93.9	88.4	93.4	90.4	94.8	93.1	91.0	91.0	91.5	87.0	95.4
SD	91.6	90.3	89.4	92.0	91.4	93.1	96.6	89.4	94.7	95.5	94.5	94.1	94.0	94.0	89.9	89.7	91.8
TN	91.7	92.1	93.9	89.1	91.6	95.2	94.2	95.8	90.8	92.5	94.3	98.0	95.3	95.3	95.9	91.4	94.1
TX	88.0	85.9	89.6	93.8	86.3	90.0	92.1	91.0	91.3	91.7	92.3	89.5	92.5	92.5	90.5	94.4	91.2
UT	86.1	86.8	90.2	92.5	89.3	87.8	95.0	88.0	89.0	87.0	91.3	91.1	90.6	90.6	87.0	87.4	86.1
VT	93.7	95.9	97.0	99.3	93.0	95.7	95.4	96.8	94.7	92.1	94.5	93.0	87.9	87.9	92.4	95.2	92.7
VA	89.2	90.3	91.8	91.1	92.7	92.9	93.1	93.2	96.0	91.3	98.0	92.0	93.3	93.3	88.3	89.6	94.5
WA	91.3	91.3	89.9	90.0	91.4	88.2	88.6	94.4	90.2	91.4	84.3	88.4	92.6	92.6	89.8	86.8	85.0
WV	86.7	92.1	92.6	93.4	92.0	94.2	93.3	89.1	94.4	86.6	90.7	96.1	88.2	88.2	92.0	85.1	84.9
WI	90.8	90.6	92.7	94.7	93.0	92.8	94.1	93.5	93.8	93.7	94.0	90.8	94.0	94.0	93.3	95.5	90.1
WY	86.7	83.7	89.9	93.4	92.2	91.0	90.6	91.4	91.5	88.8	90.4	86.4	87.6	87.6	93.1	NA	89.7

APPENDIX XI

MMR vaccination coverage for people who identified as black

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	89.7	89.0	88.8	89.8	87.9	89.1	90.3	92.1	90.7	91.9	90.9	91.5	92.0	92.0	92.1	90.8	90.9
AL	86.6	97.3	92.6	87.3	84.4	95.5	86.9	93.7	NA	94.7	94.4	95.0	NA	NA	94.8	94.5	96.4
AK	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AZ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AR	NA	93.2	85.2	NA	92.8	90.4	95.7	NA	93.1	NA	NA	90.9	NA	NA	NA	NA	NA
CA	NA	NA	NA	NA	NA	NA	NA	96.8	NA	90.3	98.1	96.1	NA	NA	NA	NA	NA
CO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CT	NA	92.0	93.4	NA	97.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DE	NA	NA	89.5	93.7	87.1	93.8	97.8	NA	94.7	NA	96.9	NA	96.8	96.8	NA	NA	90.4
DC	91.3	87.2	91.7	88.6	82.9	91.0	89.3	91.3	94.0	90.3	91.6	95.4	87.0	87.0	92.7	93.4	89.7
FL	89.5	89.5	89.9	94.3	89.6	89.8	95.4	90.2	94.6	99.4	86.7	95.6	89.1	89.1	99.1	NA	NA
GA	91.0	91.7	90.3	94.1	88.3	90.6	90.3	95.6	NA	89.7	87.8	89.0	90.7	90.7	89.6	89.5	96.2
HA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	87.4	NA	NA	NA	NA	NA
IL	92.2	NA	NA	88.8	86.1	86.8	87.3	NA	88.5	89.5	NA	92.5	89.3	89.3	90.4	91.1	NA
IN	NA	NA	95.0	NA	NA	93.8	92.8	NA	NA	NA	95.0	NA	NA	NA	NA	NA	NA
IA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
KS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
KY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	91.4	NA	NA	NA	NA	NA
LA	84.2	88.8	85.7	93.0	88.3	86.4	87.5	92.4	87.4	87.9	85.4	NA	98.1	98.1	92.1	96.6	92.5
ME	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	97.9	NA	NA	NA	NA	NA
MD	91.8	90.8	87.4	94.2	86.4	90.0	95.8	NA	94.3	95.5	92.1	NA	93.1	93.1	91.0	89.9	93.1
MA	96.1	NA	99.7	93.0	92.4	98.2	NA	99.7	94.8	NA	96.4	NA	NA	NA	NA	NA	NA
MI	80.4	86.9	NA	85.0	87.1	81.5	91.3	88.7	NA	95.3	NA	NA	NA	NA	NA	99.1	NA

APPENDIX XII

MMR vaccination coverage for people who identified as Hispanic

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	88.2	88.4	91.0	90.2	90.0	92.1	90.5	92.7	93.2	91.1	92.0	92.6	92.8	92.8	92.9	92.4	90.7
AL	NA	NA	NA	NA	NA	NA	98.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AK	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AZ	82.1	82.9	82.0	83.0	88.8	86.9	87.0	89.9	92.8	90.4	88.0	87.9	95.3	95.3	89.1	NA	91.4
AR	NA	NA	NA	NA	NA	91.6	NA	NA	NA	NA	NA	91.1	NA	NA	NA	NA	97.6
CA	88.2	87.6	91.7	93.4	90.9	93.7	90.8	92.9	93.1	92.1	91.1	94.8	94.0	94.0	94.3	92.2	91.3
CO	88.0	93.5	94.0	93.2	88.2	94.5	86.4	86.6	93.4	93.9	98.4	97.6	93.1	93.1	88.6	94.3	94.2
CT	93.0	NA	92.7	90.1	97.8	89.2	94.2	96.3	96.8	97.6	NA	97.7	96.5	96.5	NA	92.6	98.7
DE	NA	NA	NA	NA	NA	92.6	94.4	94.4	97.2	95.0	94.8	NA	NA	NA	92.6	94.6	95.1
DC	94.8	NA	NA	NA	NA	95.3	92.3	97.5	94.4	89.5	92.9	97.9	95.5	95.5	97.6	NA	98.8
FL	NA	86.6	94.3	92.6	90.3	94.8	87.0	96.0	94.4	97.5	94.7	89.2	91.1	91.1	93.3	93.1	87.2
GA	NA	NA	97.4	NA	95.6	NA	96.1	NA	99.5	92.6	94.7	94.5	96.0	96.0	91.4	98.1	NA
HA	NA	NA	NA	97.5	NA	NA	98.1	97.8	94.6	NA	87.7	NA	96.5	96.5	92.4	94.1	97.0
ID	NA	NA	95.1	NA	NA	NA	NA	NA	91.1	NA	NA	NA	NA	NA	NA	NA	NA
IL	89.1	91.2	87.3	87.2	89.2	83.7	96.5	96.3	97.3	88.8	92.6	95.1	87.1	87.1	95.1	90.9	90.8
IN	NA	NA	NA	NA	NA	NA	NA	97.4	NA	NA	NA	94.2	NA	NA	NA	NA	NA
IA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
KS	NA	NA	NA	92.5	91.9	NA	95.0	87.8	NA	NA	93.0	NA	NA	NA	NA	NA	92.8
KY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LA	NA	NA	NA	NA	NA	NA	92.2	NA	NA	95.4	NA	NA	NA	NA	NA	NA	NA
ME	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MD	NA	NA	NA	NA	NA	95.7	NA	99.2	NA	91.5	94.5	97.4	94.3	94.3	NA	95.6	NA
MA	97.9	93.3	93.6	NA	96.7	NA	98.9	97.7	98.5	98.1	97.4	NA	NA	NA	NA	92.0	NA
MI	NA	NA	NA	91.1	NA	NA	95.4	NA	99.8	NA	92.1	NA	NA	NA	NA	NA	NA

APPENDIX XIII

MMR vaccination coverage for people who identified as American Indian or Alaska Native

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	88.9	92.3	91.4	91.7	86.9	94.2	84.3	91.8	88.8	89.7	89.3	96.2	95.8	95.8	93.4	94.8	92.0
AL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AK	NA	NA	91.2	93.5	91.1	95.8	90.5	97.0	95.4	NA	94.7	96.1	98.3	98.3	98.7	98.6	99.2
AZ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
KS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
KY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ME	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MI	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX XIV

MMR vaccination coverage for people who identified as Pacific Islander

	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
US	93.3	89.9	92.2	92.7	89.6	90.2	94.3	NA	NA	90.3	94.3	87.6	97.0	97.0	96.9	98.7	NA
AL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AK	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AZ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CA	95.2	88.6	93.5	94.9	NA	89.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	97.6	97.6	NA	NA	NA
DE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HA	98.2	91.0	95.0	95.3	96.0	92.3	97.5	88.1	95.3	95.4	NA	NA	NA	NA	92.8	96.7	96.4
ID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
KS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
KY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ME	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MA	98.3	99.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MI	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

MN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NV	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NY	NA	NA	NA	NA	90.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OK	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RI	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TX	NA	95.4	NA	95.9	97.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
UT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WA	96.6	96.5	NA	NA	NA	91.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WV	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WI	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX XV

MMR vs. Measles Correlation

State	T-value	DF	P-value	95% CI	Correlation
US National	-1.9518	15	0.06989	-0.76517174, 0.03905054	-0.4500412
Alabama	-0.7806	15	0.4472	-0.6194037, 0.3127655	-0.1975816
Alaska	-2.4854	15	0.02522	-0.81036896, -0.08028484	-0.5400884
Arizona	-0.8191	15	0.4255	-0.6253699, 0.3039528	-0.2069219
Arkansas	0.0345	15	0.9729	-0.4737574, 0.4874734	0.00891812
California	-1.7159	15	0.1068	-0.74136970, 0.09385397	-0.4050634
Colorado	-2.4731	15	0.02584	-0.80944443, -0.07761439	-0.5381823
Connecticut	-1.3594	15	0.1941	-0.7003543, 0.1777411	-0.331198
Delaware	-0.0535	15	0.9581	-0.4911909, 0.4699577	-0.01380545
District of Columbia	-0.1911	15	0.851	-0.5176732, 0.4418191	-0.04929354
Florida	-0.0268	15	0.979	-0.4859434, 0.4753108	-0.006913323
Georgia	-1.1059	15	0.2862	-0.6671613, 0.2374170	-0.2745585
Hawaii	-1.5182	15	0.1497	-0.7194136, 0.1402851	-0.3649685
Idaho	-1.9332	15	0.07231	-0.76338805, 0.04333226	-0.4466143
Illinois	-0.256	15	0.8014	-0.5298089, 0.4282612	-0.06596108
Indiana	1.3019	15	0.2126	-0.1913036, 0.6931299	0.3186398
Iowa	0.1072	15	0.9161	-0.4590857, 0.5016381	0.02766315
Kansas	0.6703	15	0.5129	-0.3378071, 0.6018416	0.170525
Kentucky	0.4565	15	0.6546	-0.3852717, 0.5658583	0.1170478
Louisiana	0.1164	15	0.9088	-0.4571962, 0.5034256	0.03005265
Maine	-0.4914	15	0.6303	-0.5719151, 0.3776197	-0.1258707
Maryland	-0.1272	15	0.9005	-0.5054861, 0.4550073	-0.03281367
Massachusetts	-0.6297	15	0.5384	-0.5952156, 0.3469217	-0.160483
Michigan	-1.2342	15	0.2361	-0.6843941, 0.2072645	-0.3036279
Minnesota	0.7953	15	0.4389	-0.3094155, 0.6216844	0.2011431
Mississippi	N/A	0	N/A	N/A	N/A
Missouri	1.1838	15	0.2549	-0.2191361, 0.6777261	0.2922951

Montana	-1.716	15	0.1067	-0.74138068, 0.09382979	-0.4050838
Nebraska	N/A	0	N/A	N/A	N/A
Nevada	-2.4966	15	0.02467	-0.81120205, -0.08270017	-0.5418084
New Hampshire	-1.1382	15	0.2729	-0.6715861, 0.2298376	-0.2819548
New Jersey	0.8695	15	0.3983	-0.2923868, 0.6330387	0.2190407
New Mexico	-0.4474	15	0.661	-0.5642810, 0.3872431	-0.1147618
New York	-0.9199	14	0.3732	-0.6567243, 0.2914596	-0.2387382
North Carolina	-0.6331	15	0.5362	-0.5957798, 0.3461525	-0.1613345
North Dakota	3.2535	15	0.005344	0.2353280, 0.8584618	0.6432188
Ohio	-0.1587	15	0.876	-0.5115208, 0.4485291	-0.04094209
Oklahoma	-1.681	15	0.1134	-0.7376415, 0.1020028	-0.3981627
Oregon	-2.415	15	0.02897	-0.80502408, -0.06499003	-0.529107
Pennsylvania	-0.5731	15	0.575	-0.585814, 0.359556	-0.1463873
Rhode Island	-0.2965	15	0.7709	-0.5372660, 0.4197106	-0.07633298
South Carolina	-1.7247	15	0.1051	-0.74230546, 0.09179094	-0.4068014
South Dakota	1.8219	15	0.08848	-0.75237483, 0.06912888	-0.425659
Tennessee	-0.1186	15	0.9072	-0.5038346, 0.4567626	-0.03060017
Texas	-1.6296	15	0.124	-0.7320168, 0.1140871	-0.3878242
Utah	-1.7065	15	0.1085	-0.74037218, 0.09604529	-0.4032133
Vermont	-1.0144	15	0.3265	-0.6543332, 0.2587850	-0.2533755
Virginia	-1.1979	15	0.2495	-0.6796080, 0.2158123	-0.2954826
Washington	-0.9063	15	0.3791	-0.6385662, 0.2838789	-0.2278556
West Virginia	-0.1595	15	0.8754	-0.5116731, 0.4483643	-0.04114801
Wisconsin	-1.1869	15	0.2537	-0.6781439, 0.2183999	-0.2930021
Wyoming	0.4852	15	0.6346	-0.3789902, 0.5708379	0.1242963

APPENDIX XVI

Correlation between MMR vaccination coverage and location

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-1.205882353	-4.178516241	1.76675154	0.999997
Alaska	2.964705882	-0.007928006	5.93733977	0.0519207
Arizona	2.805882353	-0.166751536	5.77851624	0.1059206
Arkansas	1.217647059	-1.75498683	4.19028095	0.999996
California	-0.117647059	-3.090280947	2.85498683	1
Colorado	1.088235294	-1.884398594	4.06086918	0.9999999
Connecticut	-3.994117647	-6.966751536	-1.02148376	0.0001023
Delaware	-1.747058824	-4.719692712	1.22557506	0.9788613
District of Columbia	-0.270588235	-3.243222124	2.70204565	1
Florida	-0.129411765	-3.102045653	2.84322212	1
Georgia	-0.182352941	-3.15498683	2.79028095	1
Hawaii	-1.647058824	-4.619692712	1.32557506	0.9926111
Idaho	3.535294118	0.562660229	6.50792801	0.0022207
Illinois	0.2	-2.772633888	3.17263389	1
Indiana	1.658823529	-1.313810359	4.63145742	0.9915472
Iowa	0.176470588	-2.7961633	3.14910448	1
Kansas	0.711764706	-2.260869183	3.68439859	1
Kentucky	0.770588235	-2.202045653	3.74322212	1
Louisiana	2.052941176	-0.919692712	5.02557506	0.8185683
Maine	-0.876470588	-3.849104477	2.0961633	1
Maryland	-2.094117647	-5.066751536	0.87851624	0.779896
Massachusetts	-3.382352941	-6.35498683	-0.40971905	0.0056029
Michigan	1.311764706	-1.660869183	4.28439859	0.9999652
Minnesota	-1.064705882	-4.037339771	1.90792801	0.9999999
Mississippi	0.188235294	-2.784398594	3.16086918	1
Missouri	0.252941176	-2.719692712	3.22557506	1
Montana	2.388235294	-0.584398594	5.36086918	0.444583

Nebraska	-0.364705882	-3.337339771	2.60792801	1
Nevada	3.976470588	1.0038367	6.94910448	0.0001161
New Hampshire	-2.323529412	-5.2961633	0.64910448	0.5201741
New Jersey	0.194117647	-2.778516241	3.16675154	1
New Mexico	2.429411765	-0.543222124	5.40204565	0.3984257
New York	-1.664705882	-4.637339771	1.30792801	0.9909694
North Carolina	-2.382352941	-5.35498683	0.59028095	0.4513238
North Dakota	0.123529412	-2.849104477	3.0961633	1
Ohio	-0.535294118	-3.507928006	2.43733977	1
Oklahoma	1.058823529	-1.913810359	4.03145742	1
Oregon	2.323529412	-0.649104477	5.2961633	0.5201741
Pennsylvania	-1.217647059	-4.190280947	1.75498683	0.999996
Rhode Island	-3.482352941	-6.45498683	-0.50971905	0.0030779
South Carolina	-0.023529412	-2.9961633	2.94910448	1
South Dakota	-1.111764706	-4.084398594	1.86086918	0.9999998
Tennessee	-0.929411765	-3.902045653	2.04322212	1
Texas	1.411764706	-1.560869183	4.38439859	0.9997563
Utah	2.076470588	-0.8961633	5.049104477	0.7969219
Vermont	-2.235294118	-5.20792801	0.737339771	0.6250628
Virginia	0.064705882	-2.90792801	3.037339771	1
Washington	1.547058824	-1.42557506	4.519692712	0.9979302
West Virginia	1.070588235	-1.90204565	4.043222124	0.9999999
Wisconsin	-0.970588235	-3.94322212	2.002045653	1
Wyoming	2.282352941	-0.69028095	5.25498683	0.569224

APPENDIX XVII

Correlation between MMR vaccination coverage and poverty status
People who lived at or above the poverty line

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-2.415882353	-5.622623821	0.790859115	0.6200966
Alaska	3.548823529	0.342082061	6.755564998	0.0095514
Arizona	1.654705882	-1.552035586	4.86144735	0.998281
Arkansas	0.313529412	-2.893212056	3.52027088	1
California	-0.174705882	-3.38144735	3.032035586	1
Colorado	1.078235294	-2.128506174	4.284976762	1
Connecticut	-4.151176471	-7.357917939	-0.944435003	0.0002853
Delaware	-1.721764706	-4.928506174	1.484976762	0.9960215
District of Columbia	-2.01	-5.216741468	1.196741468	0.9434134
Florida	-0.239411765	-3.446153233	2.967329703	1
Georgia	-0.568823529	-3.775564997	2.637917939	1
Hawaii	-1.680588235	-4.887329703	1.526153233	0.997596
Idaho	2.648823529	-0.557917939	5.855564998	0.3703274
Illinois	-0.621764706	-3.828506174	2.584976762	1
Indiana	0.666470588	-2.54027088	3.873212056	1
Iowa	-0.815882353	-4.022623821	2.390859115	1
Kansas	0.248823529	-2.957917939	3.455564998	1
Kentucky	-0.498235294	-3.704976762	2.708506174	1
Louisiana	1.931176471	-1.275564997	5.137917939	0.9686839
Maine	-1.545294118	-4.752035586	1.66144735	0.9996499
Maryland	-2.692352941	-5.899094409	0.514388527	0.3287428
Massachusetts	-3.368823529	-6.575564997	-0.162082061	0.0236277
Michigan	-0.139411765	-3.346153233	3.067329703	1
Minnesota	-1.498235294	-4.704976762	1.708506174	0.9998393
Mississippi	0.084117647	-3.122623821	3.290859115	1
Missouri	-0.786470588	-3.993212056	2.42027088	1
Montana	2.307647059	-0.899094409	5.514388527	0.7336503
Nebraska	-1.045294118	-4.252035586	2.16144735	1
Nevada	2.960588235	-0.246153233	6.167329703	0.1364184
New Hampshire	-2.562941176	-5.769682645	0.643800292	0.4588309
New Jersey	-0.786470588	-3.993212056	2.42027088	1
New Mexico	1.866470588	-1.34027088	5.073212056	0.9820406
New York	-2.204117647	-5.410859115	1.002623821	0.8271541
North Carolina	-2.204117647	-5.410859115	1.002623821	0.8271541
North Dakota	-0.521764706	-3.728506174	2.684976762	1

Ohio	-0.845294118	-4.052035586	2.36144735	1
Oklahoma	0.495882353	-2.710859115	3.702623821	1
Oregon	2.160588235	-1.046153233	5.367329703	0.8603114
Pennsylvania	-1.986470588	-5.193212056	1.22027088	0.9521317
Rhode Island	-3.527647059	-6.734388527	-0.320905591	0.0106655
South Carolina	-0.780588235	-3.987329703	2.426153233	1
South Dakota	-1.145294118	-4.352035586	2.06144735	1
Tennessee	-1.615882353	-4.822623821	1.590859115	0.9989898
Texas	0.407647059	-2.799094409	3.614388527	1
Utah	1.495882353	-1.710859115	4.702623821	0.9998457
Vermont	-2.074705882	-5.28144735	1.132035586	0.9136914
Virginia	-0.333529412	-3.54027088	2.873212056	1
Washington	1.278235294	-1.928506174	4.484976762	0.9999983
West Virginia	0.442941176	-2.763800292	3.649682645	1
Wisconsin	-1.527647059	-4.734388527	1.679094409	0.9997367
Wyoming	1.666470588	-1.54027088	4.873212056	0.9979942

People who lived below the poverty line

State	Difference	Lower CI	Upper CI	Adjusted P- Value
Alabama	-0.20321267	-5.5229706	5.11654526	1
Alaska	-2.144558824	-8.33509021	4.04597257	1
Arizona	3.755441176	-1.2737703	8.78465265	0.6332147
Arkansas	1.642941176	-3.67681675	6.9626991	1
California	0.119411765	-4.83301335	5.07183688	1
Colorado	-0.590392157	-6.54246638	5.36168207	1
Connecticut	-3.228487395	-9.71273395	3.25575916	0.9990312
Delaware	-3.72372549	-9.67579972	2.22834874	0.9396614
District of Columbia	-1.437058824	-7.19125682	4.31713917	1
Florida	-0.251176471	-5.20360158	4.70124864	1
Georgia	0.460588235	-4.49183688	5.41301335	1
Hawaii	-2.550392157	-7.66523482	2.5644505	0.9989988
Idaho	0.885798319	-5.59844824	7.37004488	1
Illinois	1.442941176	-3.5862703	6.47215265	1
Indiana	2.585798319	-3.89844824	9.07004488	0.9999973
Iowa	-0.590392157	-9.63224198	8.45145767	1
Kansas	-0.457058824	-7.80269235	6.8885747	1
Kentucky	1.442941176	-4.31125682	7.19713917	1
Louisiana	2.001764706	-2.95066041	6.95418982	0.999996
Maine	-1.757058824	-7.51125682	3.99713917	1

Maryland	-2.537058824	-8.29125682	3.21713917	0.9999525
Massachusetts	-4.302513369	-9.8896024	1.28457567	0.5517034
Michigan	1.652032086	-3.93505695	7.23912112	1
Minnesota	NA	NA	NA	NA
Mississippi	-0.207058824	-5.2362703	4.82215265	1
Missouri	-0.567058824	-6.32125682	5.18713917	1
Montana	-1.494558824	-7.68509021	4.69597257	1
Nebraska	-2.242773109	-8.72701967	4.24147345	1
Nevada	3.057226891	-3.42701967	9.54147345	0.9997321
New Hampshire	-1.757058824	-12.55061912	9.03650147	1
New Jersey	-2.497058824	-8.25125682	3.25713917	0.9999692
New Mexico	2.849607843	-2.26523482	7.9644505	0.9904202
New York	-0.892352941	-5.84477805	4.06007217	1
North Carolina	-2.488308824	-7.5175203	2.54090265	0.9991602
North Dakota	-3.114201681	-9.59844824	3.37004488	0.9995807
Ohio	1.625294118	-3.32713099	6.57771923	1
Oklahoma	0.265163399	-5.68691083	6.21723762	1
Oregon	-1.087058824	-6.84125682	4.66713917	1
Pennsylvania	0.273710407	-5.04604752	5.59346833	1
Rhode Island	-3.095520362	-8.41527829	2.22423757	0.979656
South Carolina	-0.49872549	-5.94263998	4.945189	1
South Dakota	-2.834836601	-8.78691083	3.11723762	0.9996571
Tennessee	0.025294118	-4.92713099	4.97771923	1
Texas	3.137058824	-1.81536629	8.08948393	0.9288021
Utah	-0.52372549	-9.56557532	8.51812434	1
Vermont	-3.677058824	-11.02269235	3.6685747	0.9989071
Virginia	-0.690392157	-7.54671426	6.16592994	1
Washington	2.055441176	-2.9737703	7.08465265	0.9999944
West Virginia	0.7660181	-4.55373983	6.08577603	1
Wisconsin	1.333850267	-4.25323877	6.9209393	1
Wyoming	0.77627451	-5.17579972	6.72834874	1

APPENDIX XVIII

Correlation between MMR vaccination coverage and participation in VFC

Children whose provider participated in the VFC program

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-1.912500	-5.143551	1.318551459	0.9760364
Alaska	-0.012500	-3.243551	3.218551459	1
Arizona	1.425000	-1.806051	4.656051459	0.999965
Arkansas	-0.662500	-3.893551	2.568551459	1
California	-1.437500	-4.668551	1.793551459	0.9999555
Colorado	-0.743750	-3.974801	2.487301459	1
Connecticut	-4.787500	-8.018551	-1.556448541	0.0000047
Delaware	-2.562500	-5.793551	0.668551459	0.4794652
District of Columbia	0.150000	-3.081051	3.381051459	1
Florida	-0.943750	-4.174801	2.287301459	1
Georgia	-0.262500	-3.493551	2.968551459	1
Hawaii	-3.268750	-6.499801	-0.037698541	0.0423104
Idaho	1.581250	-1.649801	4.812301459	0.9994823
Illinois	-1.056250	-4.287301	2.174801459	1
Indiana	0.075000	-3.156051	3.306051459	1
Iowa	-0.825000	-4.056051	2.406051459	1
Kansas	-0.375000	-3.606051	2.856051459	1
Kentucky	0.262500	-2.968551	3.493551459	1
Louisiana	1.431250	-1.799801	4.662301459	0.9999605
Maine	-1.906250	-5.137301	1.324801459	0.9772856
Maryland	-3.143750	-6.374801	0.087301459	0.072566
Massachusetts	-3.687500	-6.918551	-0.456448541	0.0052896
Michigan	-0.825000	-4.056051	2.406051459	1
Minnesota	-1.687500	-4.918551	1.543551459	0.9977372
Mississippi	-0.650000	-3.881051	2.581051459	1
Missouri	-0.731250	-3.962301	2.499801459	1
Montana	1.031250	-2.199801	4.262301459	1
Nebraska	-1.437500	-4.668551	1.793551459	0.9999555
Nevada	2.456250	-0.774802	5.687301459	0.5953784
New Hampshire	-3.225000	-6.456051	0.006051459	0.051341
New Jersey	-0.618750	-3.849801	2.612301459	1
New Mexico	1.012500	-2.218551	4.243551459	1
New York	-2.256250	-5.487301	0.974801459	0.7968857
North Carolina	-3.625000	-6.856051	-0.393948541	0.007392

North Dakota	-1.418750	-4.649801	1.812301459	0.9999691
Ohio	-0.543750	-3.774801	2.687301459	1
Oklahoma	-0.137500	-3.368551	3.093551459	1
Oregon	0.750000	-2.481051	3.981051459	1
Pennsylvania	-2.181250	-5.412301	1.049801459	0.8566602
Rhode Island	-3.962500	-7.193551	-0.731448541	0.0011082
South Carolina	-0.737500	-3.968551	2.493551459	1
South Dakota	-1.887500	-5.118551	1.343551459	0.9807282
Tennessee	-2.412500	-5.643551	0.818551459	0.6427811
Texas	0.537500	-2.693551	3.768551459	1
Utah	-0.100000	-3.331051459	3.131051	1
Vermont	-2.700000	-5.931051459	0.531052	0.340152
Virginia	-0.406250	-3.637301459	2.824801	1
Washington	0.618750	-2.612301459	3.849801	1
West Virginia	0.137500	-3.093551459	3.368551	1
Wisconsin	-1.962500	-5.193551459	1.268551	0.9640117
Wyoming	1.150000	-2.081051459	4.381051	1

Children whose provider did not participate in the VFC program

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-2.028846154	-6.30467367	2.2469814	0.9983443
Alaska	1.65	-4.75144263	8.0514426	1
Arizona	-1.208333333	-8.41291931	5.9962526	1
Arkansas	NA	NA	NA	NA
California	1.167857143	-3.02287077	5.3585851	1
Colorado	-4.8	-11.20144263	1.6014426	0.5628395
Connecticut	-4.103571429	-9.29285918	1.0857163	0.4314318
Delaware	NA	NA	NA	NA
District of Columbia	-3.410714286	-7.6014422	0.7800136	0.3623334
Florida	-3.911363636	-8.39652833	0.5738011	0.216559
Georgia	-4.925	-9.29801783	-0.5519822	0.0081361
Hawaii	NA	NA	NA	NA
Idaho	NA	NA	NA	NA
Illinois	-1.336538462	-5.61236598	2.9392891	0.9999999
Indiana	-1.341666667	-6.11302029	3.429687	1
Iowa	0.025	-11.77867698	11.828677	1
Kansas	-1.451923077	-5.7277506	2.8239044	0.9999993
Kentucky	-4.075	-8.69114593	0.5411459	0.1948199
Louisiana	-0.625	-5.24114593	3.9911459	1

Maine	-2.675	-8.15686796	2.806868	0.9972215
Maryland	-5.586111111	-10.35746473	-0.8147575	0.0039862
Massachusetts	-3.775	-8.73353614	1.1835361	0.5253867
Michigan	0.591666667	-6.61291931	7.7962526	1
Minnesota	-2.225	-7.70686796	3.256868	0.9999369
Mississippi	-3.725	-12.31343652	4.8634365	0.9997273
Missouri	-2.293181818	-6.77834651	2.1919829	0.9937345
Montana	NA	NA	NA	NA
Nebraska	-3.608333333	-10.81291931	3.5962526	0.9955935
Nevada	NA	NA	NA	NA
New Hampshire	-2.7875	-7.74603614	2.1710361	0.9730787
New Jersey	-2.528846154	-6.80467367	1.7469814	0.9474123
New Mexico	NA	NA	NA	NA
New York	-2.583333333	-6.95635116	1.7896845	0.9481649
North Carolina	NA	NA	NA	NA
North Dakota	-6.275	-18.07867698	5.528677	0.988219
Ohio	-3.175	-7.36572791	1.0157279	0.5373992
Oklahoma	NA	NA	NA	NA
Oregon	NA	NA	NA	NA
Pennsylvania	-3.984090909	-8.4692556	0.5010738	0.1842555
Rhode Island	-1.615	-7.48201908	4.2520191	1
South Carolina	1.825	-9.97867698	13.628677	1
South Dakota	-0.508333333	-7.71291931	6.6962526	1
Tennessee	-1.059615385	-5.3354429	3.2162121	1
Texas	0.353571429	-3.83715649	4.5442993	1
Utah	NA	NA	NA	NA
Vermont	-4.35	-9.3085361	0.60853614	0.2057799
Virginia	-4.875	-9.3601647	-0.38983531	0.0148206
Washington	0.691666667	-4.079687	5.46302029	1
West Virginia	NA	NA	NA	NA
Wisconsin	-1.375	-5.5657279	2.81572791	0.9999997
Wyoming	NA	NA	NA	NA

APPENDIX XIX

Correlation between MMR vaccination coverage and urbanicity

People who lived in a MSA central city

State	Difference	Upper CI	Lower CI	Adjusted P-Value
Alabama	-1.115882353	-5.38165555	3.14989084	1
Alaska	2.81627451	-1.5893971	7.22194612	0.9226848
Arizona	3.295882353	-0.96989084	7.56165555	0.5470272
Arkansas	-0.07372549	-4.76284324	4.61539226	1
California	-0.845294118	-5.11106731	3.42047908	1
Colorado	0.95627451	-3.4493971	5.36194612	1
Connecticut	-3.074705882	-7.34047908	1.19106731	0.7244096
Delaware	-1.680588235	-5.94636143	2.58518496	0.9999984
District of Columbia	-0.280588235	-4.54636143	3.98518496	1
Florida	0.084117647	-4.18165555	4.34989084	1
Georgia	1.092941176	-3.59617658	5.78205893	1
Hawaii	-2.563308824	-6.89522198	1.76860433	0.9746706
Idaho	1.073710407	-3.50846504	5.65588586	1
Illinois	1.919411765	-2.34636143	6.18518496	0.9999279
Indiana	1.680441176	-2.65147198	6.01235433	0.999999
Iowa	-0.470392157	-4.87606377	3.93527945	1
Kansas	0.917941176	-3.41397198	5.24985433	1
Kentucky	-2.175240642	-6.98768184	2.63720056	0.9999186
Louisiana	2.748823529	-1.51694967	7.01459672	0.9143553
Maine	-2.171344538	-7.7565527	3.41386362	0.999999
Maryland	-2.215882353	-6.48165555	2.04989084	0.9977587
Massachusetts	-2.764751131	-7.34692658	1.81742432	0.9656659
Michigan	0.905441176	-3.42647198	5.23735433	1
Minnesota	-2.550808824	-6.88272198	1.78110433	0.9765878
Mississippi	-0.307058824	-5.26343939	4.64932174	1
Missouri	-1.210392157	-5.61606377	3.19527945	1
Montana	2.157226891	-2.33125619	6.64570997	0.9996159
Nebraska	-1.851176471	-6.11694967	2.41459672	0.999973
Nevada	4.160588235	-0.10518496	8.42636143	0.0701744
New Hampshire	-6.657058824	-19.4543784	6.14026076	0.9976905
New Jersey	-2.557058824	-8.14226698	3.02814934	0.9998863
New Mexico	2.348823529	-1.91694967	6.61459672	0.9927903
New York	-1.939411765	-6.20518496	2.32636143	0.9999052
North Carolina	-2.632058824	-6.96397198	1.69985433	0.9618559

North Dakota	-2.307058824	-6.63897198	2.02485433	0.9962433
Ohio	-0.404117647	-4.66989084	3.86165555	1
Oklahoma	0.27627451	-4.1293971	4.68194612	1
Oregon	1.99	-2.27577319	6.25577319	0.9998161
Pennsylvania	-1.445294118	-5.71106731	2.82047908	1
Rhode Island	-2.898235294	-7.16400849	1.3675379	0.8421413
South Carolina	-1.06372549	-5.4693971	3.34194612	1
South Dakota	-2.200808824	-6.53272198	2.13110433	0.9986137
Tennessee	0.09	-4.17577319	4.35577319	1
Texas	1.613529412	-2.65224378	5.87930261	0.9999996
Utah	0.705441176	-3.62647198	5.03735433	1
Virginia	-2.775240642	-7.58768184	2.03720056	0.9834493
Washington	1.507647059	-2.75812614	5.77342025	1
West Virginia	-1.89872549	-6.58784324	2.79039226	0.9999964
Wisconsin	-1.280588235	-5.54636143	2.98518496	1
Wyoming	1.37627451	-3.0293971	5.78194612	1

People who lived in a MSA non-central city

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-2.115882353	-6.027688	1.795923077	0.9940429
Alaska	2.07627451	-5.065672	9.218221425	1
Arizona	1.736691177	-2.235766	5.709148369	0.9999542
Arkansas	1.780441177	-2.192016	5.752898369	0.9999121
California	0.319411765	-3.592394	4.231217195	1
Colorado	0.367941177	-3.604516	4.340398369	1
Connecticut	-4.292352941	-8.204158	-0.380547511	0.0114354
Delaware	-1.639411765	-5.551217	2.272393665	0.9999855
District of Columbia	NA	NA	NA	NA
Florida	-0.468823529	-4.380629	3.442981901	1
Georgia	-0.057058824	-3.968864	3.854746606	1
Hawaii	-1.045294118	-4.9571	2.866511312	1
Idaho	1.43627451	-2.603821	5.476369785	0.9999999
Illinois	-1.280588235	-5.192394	2.631217195	1
Indiana	0.754705882	-3.1571	4.666511312	1
Iowa	-1.095520362	-5.297473	3.106432717	1
Kansas	-0.788308824	-4.760766	3.184148369	1
Kentucky	-0.938308824	-4.910766	3.034148369	1
Louisiana	1.160588235	-2.751217	5.072393665	1
Maine	0.048823529	-3.862982	3.960628959	1

Maryland	-1.933529412	-5.845335	1.978276018	0.9990739
Massachusetts	-3.692352941	-7.604158	0.219452489	0.1048342
Michigan	2.107647059	-1.804158	6.019452489	0.994469
Minnesota	-0.250808824	-4.223266	3.721648369	1
Mississippi	-0.444558824	-5.334316	4.445197964	1
Missouri	-0.874705882	-4.786511	3.037099548	1
Montana	NA	NA	NA	NA
Nebraska	-2.267058824	-6.812166	2.278048362	0.9988675
Nevada	1.781402715	-2.42055	5.983355794	0.9999801
New Hampshire	-2.751176471	-6.662982	1.160628959	0.7700664
New Jersey	-0.268823529	-4.180629	3.642981901	1
New Mexico	0.087385621	-4.614019	4.78879064	1
New York	-0.91	-4.821805	3.00180543	1
North Carolina	-3.307058824	-7.279516	0.665398369	0.3425469
North Dakota	-4.27372549	-9.689375	1.141923898	0.4827902
Ohio	-1.027647059	-4.939452	2.884158371	1
Oklahoma	1.007226891	-3.108808	5.123262056	1
Oregon	1.004479638	-3.197473	5.206432717	1
Pennsylvania	-1.145294118	-5.0571	2.766511312	1
Rhode Island	-3.968823529	-7.880629	-0.057018099	0.0406801
South Carolina	0.119411765	-3.792394	4.031217195	1
South Dakota	-3.528487395	-8.650243	1.593268173	0.8104369
Tennessee	-0.91	-4.821805	3.00180543	1
Texas	0.578235294	-3.33357	4.490040724	1
Utah	2.166470588	-1.745334842	6.078276	0.9907754
Vermont	-2.757058824	-6.873093988	1.358976	0.8578028
Virginia	-0.474705882	-4.386511312	3.4371	1
Washington	1.972352941	-1.939452489	5.884158	0.998567
West Virginia	0.81627451	-3.223820766	4.85637	1
Wisconsin	-1.868823529	-5.780628959	2.042982	0.9995758
Wyoming	NA	NA	NA	NA

People who lived in a non-MSA central city

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-0.647058824	-4.97476353	3.68064588	1
Alaska	1.182352941	-3.14535176	5.51005765	1
Arizona	1.287647059	-3.74069142	6.31598553	1
Arkansas	-1.4	-5.7277047	2.9277047	1
California	-3.182352941	-16.16546706	9.80076117	1
Colorado	0.435828877	-4.44648049	5.31813824	1
Connecticut	-3.382352941	-16.36546706	9.60076117	1
Delaware	-2.643891403	-7.29259197	2.00480916	0.9829969
District of Columbia	NA	NA	NA	NA
Florida	-4.382352941	-17.36546706	8.60076117	1
Georgia	-3.038602941	-7.43340784	1.35620196	0.7940035
Hawaii	-2.363602941	-6.75840784	2.03120196	0.9935707
Idaho	3.574789916	-0.97885803	8.12843786	0.4884783
Illinois	-4.192352941	-9.22069142	0.83598553	0.3332489
Indiana	0.50855615	-4.37375322	5.39086552	1
Iowa	-0.588235294	-4.91594	3.73946941	1
Kansas	0.647058824	-3.68064588	4.97476353	1
Kentucky	2.2	-2.1277047	6.5277047	0.9978494
Louisiana	0.477647059	-3.99198714	4.94728126	1
Maine	-2.076470588	-6.40417529	2.25123412	0.9993775
Maryland	NA	NA	NA	NA
Massachusetts	NA	NA	NA	NA
Michigan	-1.059276018	-5.70797658	3.58942455	
Minnesota	-1.615686275	-6.08532047	2.85394793	0.9999997
Mississippi	-1.805882353	-6.13358706	2.52182235	0.9999803
Missouri	1.433031674	-3.21566889	6.08173224	1
Montana	1.458823529	-2.86888118	5.78652823	1
Nebraska	0.758823529	-3.56888118	5.08652823	1
Nevada	1.042647059	-5.96903594	8.05433006	1
New Hampshire	-1.241176471	-5.56888118	3.08652823	1
New Jersey	NA	NA	NA	NA
New Mexico	2.329411765	-1.99829294	6.65711647	0.9934736
New York	-2.422352941	-7.45069142	2.60598553	0.9993189
North Carolina	-2.394852941	-6.78965784	1.99995196	0.9918366
North Dakota	0.764705882	-3.56299882	5.09241059	1
Ohio	-1.142352941	-5.61198714	3.32728126	1
Oklahoma	-1.013602941	-5.40840784	3.38120196	1
Oregon	1.198897059	-3.19590784	5.59370196	1

Pennsylvania	-2.815686275	-7.57288176	1.94150921	0.9682845
Rhode Island	NA	NA	NA	NA
South Carolina	-1.389495798	-5.94314374	3.16415214	1
South Dakota	-1.444852941	-5.83965784	2.94995196	1
Tennessee	-3.202352941	-7.67198714	1.26728126	0.7198145
Texas	-0.257352941	-5.01454842	4.49984254	1
Utah	1.280147059	-4.12948382	6.68977794	1
Vermont	-2.529411765	-6.85711647	1.79829294	0.9737869
Virginia	-2.382352941	-7.79198382	3.02727794	0.9999196
Washington	-0.895686275	-5.36532047	3.57394793	1
West Virginia	0.776470588	-3.55123412	5.10417529	1
Wisconsin	-0.518067227	-5.07171517	4.03558072	1
Wyoming	1.841176471	-2.48652823	6.16888118	0.999967

APPENDIX XX

Correlation between MMR vaccination coverage and race/ethnicity

White

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-2.121764706	-5.670674053	1.42714464	0.9720165
Alaska	5.537058824	1.988149476	9.08596817	0.0000007
Arizona	2.131176471	-1.417732877	5.68008582	0.969988
Arkansas	0.566470588	-2.982438759	4.11537994	1
California	0.725294118	-2.82361523	4.27420347	1
Colorado	2.025294118	-1.52361523	5.57420347	0.9872318
Connecticut	-4.180588235	-7.729497583	-0.6316789	0.0027356
Delaware	-2.080588235	-5.629497583	1.46832111	0.9796711
District of Columbia	-2.728487395	-6.462680195	1.0057054	0.697593
Florida	0.025294118	-3.52361523	3.57420347	1
Georgia	-0.415882353	-3.9647917	3.13302699	1
Hawaii	0.588395722	-3.415313987	4.59210543	1
Idaho	3.213529412	-0.335379936	6.76243876	0.1676568
Illinois	-1.445294118	-4.994203465	2.10361523	0.9999966
Indiana	1.525294118	-2.02361523	5.07420347	0.9999834
Iowa	-0.31	-3.858909347	3.23890935	1
Kansas	0.166470588	-3.382438759	3.71537994	1
Kentucky	0.142941176	-3.405968171	3.69185052	1
Louisiana	2.025294118	-1.52361523	5.57420347	0.9872318
Maine	-0.927647059	-4.476556406	2.62126229	1
Maryland	-3.586470588	-7.135379936	-0.0375612	0.0429736
Massachusetts	-3.527647059	-7.076556406	0.02126229	0.0544025
Michigan	0.548823529	-3.000085818	4.09773288	1
Minnesota	-1.204117647	-4.753026995	2.3447917	1
Mississippi	0.337058824	-3.211850524	3.88596817	1
Missouri	0.166470588	-3.382438759	3.71537994	1
Montana	2.601764706	-0.947144642	6.15067405	0.68947
Nebraska	-0.933529412	-4.482438759	2.61537994	1
Nevada	4.195882353	0.646973005	7.7447917	0.0025279
New Hampshire	-2.404117647	-5.953026995	1.1447917	0.8516116
New Jersey	-0.41	-3.958909347	3.13890935	1
New Mexico	3.692941176	-0.041251623	7.42713398	0.0583733
New York	-1.357058824	-4.905968171	2.19185052	0.9999995
North Carolina	-2.425808824	-6.029743303	1.17812566	0.8616812

North Dakota	-0.145294118	-3.694203465	3.40361523	1
Ohio	-0.651176471	-4.200085818	2.89773288	1
Oklahoma	1.707647059	-1.841262289	5.25655641	0.999661
Oregon	2.848823529	-0.700085818	6.39773288	0.4467325
Pennsylvania	-1.721764706	-5.270674053	1.82714464	0.9995853
Rhode Island	-3.686470588	-7.235379936	-0.1375612	0.0283077
South Carolina	-0.651176471	-4.200085818	2.89773288	1
South Dakota	-0.827647059	-4.376556406	2.72126229	1
Tennessee	-1.957058824	-5.505968171	1.59185052	0.9932331
Texas	0.901764706	-2.647144642	4.45067405	1
Utah	2.478235294	6.027144642	-1.07067405	0.7973669
Vermont	-2.31	1.238909347	-5.85890935	0.906763
Virginia	-0.745294118	2.80361523	-4.29420347	1
Washington	1.866470588	5.415379936	-1.68243876	0.9974009
West Virginia	1.078235294	4.627144642	-2.47067405	1
Wisconsin	-1.380588235	2.168321112	-4.92949758	0.9999992
Wyoming	2.017941176	5.621875656	-1.5859933	0.9909705

Black

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-0.792773109	-5.25362	3.668073	1
Alaska	NA	NA	NA	NA
Arizona	NA	NA	NA	NA
Arkansas	0.028655462	-5.52216	5.579474	1
California	-3.682058824	-10.5508	3.186729	0.9810114
Colorado	NA	NA	NA	NA
Connecticut	-2.590392157	-10.3306	5.149855	0.9999981
Delaware	-2.107058824	-7.03292	2.818804	0.9995738
District of Columbia	1.384117647	-2.85539	5.623626	0.999999
Florida	-0.477058824	-4.8556	3.901486	1
Georgia	0.699191176	-3.60605	5.004432	1
Hawaii	NA	NA	NA	NA
Idaho	4.242941176	-8.47558	16.96147	0.9999982
Illinois	2.32627451	-2.33397	6.98652	0.9934362
Indiana	-2.507058824	-9.37585	4.361729	0.9999852
Iowa	NA	NA	NA	NA
Kansas	NA	NA	NA	NA
Kentucky	0.242941176	-12.4756	12.96147	1
Louisiana	1.367941176	-2.9373	5.673182	0.9999995

Maine	-6.257058824	-18.9756	6.461465	0.9947997
Maryland	-0.257058824	-4.6356	4.121486	1
Massachusetts	-4.644558824	-9.94394	0.654826	0.2008211
Michigan	3.27627451	-1.81898	8.371529	0.845374
Minnesota	NA	NA	NA	NA
Mississippi	-0.450808824	-4.75605	3.854432	1
Missouri	-4.607058824	-13.8469	4.632735	0.9935526
Montana	NA	NA	NA	NA
Nebraska	NA	NA	NA	NA
Nevada	NA	NA	NA	NA
New Hampshire	NA	NA	NA	NA
New Jersey	-4.642773109	-10.1936	0.908046	0.2892878
New Mexico	-4.890392157	-12.6306	2.849855	0.8686923
New York	-1.707058824	-6.16791	2.753788	0.9999575
North Carolina	-2.934836601	-8.03009	2.160418	0.9516273
North Dakota	NA	NA	NA	NA
Ohio	-0.345947712	-5.4412	4.749307	1
Oklahoma	-5.557058824	-18.2756	7.161465	0.9993584
Oregon	NA	NA	NA	NA
Pennsylvania	-1.299915966	-5.76076	3.160931	0.9999999
Rhode Island	0.242941176	-8.99685	9.482735	1
South Carolina	-0.980135747	-5.5341	3.573826	1
South Dakota	3.942941176	-8.77558	16.66147	0.9999997
Tennessee	1.528655462	-2.93219	5.989502	0.9999966
Texas	3.015668449	-1.76714	7.798478	0.8712386
Utah	-3.557058824	-12.79685	5.68273	0.9999516
Vermont	NA	NA	NA	NA
Virginia	-3.537058824	-9.825265	2.75115	0.9639274
Washington	NA	NA	NA	NA
West Virginia	NA	NA	NA	NA
Wisconsin	1.342941176	-3.956444	6.64233	1
Wyoming	NA	NA	NA	NA

Hispanic

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	-7.15705882	-19.12800847	4.81389082	0.9441056
Alaska	NA	NA	NA	NA
Arizona	3.34294118	-0.70924443	7.39512679	0.3355748
Arkansas	-1.79039216	-9.07568011	5.49489579	1
California	-0.48058824	-4.47090478	3.50972831	1
Colorado	-0.76882353	-4.75914008	3.22149302	1
Connecticut	-3.33563025	-7.53427549	0.86301498	0.4258889
Delaware	-2.87928105	-7.67504469	1.91648259	0.9411289
District of Columbia	-3.52372549	-7.91004968	0.8625987	0.3985932
Florida	-0.43205882	-4.48424443	3.62012679	1
Georgia	-3.98433155	-8.48601574	0.51735264	0.1924181
Hawaii	-3.57705882	-8.21338768	1.05927004	0.4990327
Idaho	-1.45705882	-10.15375212	7.23963447	1
Illinois	0.74294118	-3.24737537	4.73325772	1
Indiana	-4.15705882	-12.85375212	4.53963447	0.998398
Iowa	NA	NA	NA	NA
Kansas	-0.52372549	-6.0480686	5.00061762	1
Kentucky	NA	NA	NA	NA
Louisiana	-2.15705882	-10.85375212	6.53963447	1
Maine	NA	NA	NA	NA
Maryland	-3.66955882	-8.65745451	1.31833686	0.6166326
Massachusetts	-4.76705882	-9.40338768	-0.13073	0.0341729
Michigan	-2.95705882	-9.42211054	3.50799289	0.9993315
Minnesota	-2.35705882	-9.64234677	4.92822913	0.9999999
Mississippi	NA	NA	NA	NA
Missouri	NA	NA	NA	NA
Montana	NA	NA	NA	NA
Nebraska	-3.18205882	-9.64711054	3.28299289	0.9972248
Nevada	2.54919118	-1.50299443	6.60137679	0.8988443
New Hampshire	NA	NA	NA	NA
New Jersey	-0.78782805	-5.0741156	3.49845949	1
New Mexico	2.29588235	-1.6944342	6.2861989	0.9661125
New York	-2.14529412	-6.13561067	1.84502243	0.9874886
North Carolina	-4.10705882	-9.09495451	0.88083686	0.3399607
North Dakota	NA	NA	NA	NA
Ohio	-5.33205882	-11.79711054	1.13299289	0.3361921
Oklahoma	-2.75705882	-7.55282246	2.03870482	0.9664875
Oregon	-2.32628959	-6.61257714	1.95999796	0.9855039

Pennsylvania	-2.11261438	-6.90837802	2.68314926	0.9996958
Rhode Island	-3.64455882	-7.69674443	0.40762679	0.1658416
South Carolina	-3.65705882	-15.62800847	8.31389082	1
South Dakota	NA	NA	NA	NA
Tennessee	-3.47372549	-8.9980686	2.05061762	0.8993449
Texas	1.27235294	-2.71796361	5.26266949	0.9999999
Utah	-0.99705882	4.92153709	-6.91565473	1
Vermont	NA	NA	NA	NA
Virginia	0.24294118	8.93963447	-8.45375212	1
Washington	-1.59991597	2.59872927	-5.7985612	0.9999896
West Virginia	NA	NA	NA	NA
Wisconsin	-2.25705882	2.73083686	-7.24495451	0.999464
Wyoming	-3.13705882	2.78153709	-9.05565473	0.9900268

American Indian or Alaska Native

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	NA	NA	NA	NA
Alaska	-3.9570588	-6.134624	-1.7794932	0.0000558
Arizona	NA	NA	NA	NA
Arkansas	NA	NA	NA	NA
California	NA	NA	NA	NA
Colorado	NA	NA	NA	NA
Connecticut	NA	NA	NA	NA
Delaware	NA	NA	NA	NA
District of Columbia	NA	NA	NA	NA
Florida	NA	NA	NA	NA
Georgia	NA	NA	NA	NA
Hawaii	NA	NA	NA	NA
Idaho	NA	NA	NA	NA
Illinois	NA	NA	NA	NA
Indiana	NA	NA	NA	NA
Iowa	NA	NA	NA	NA
Kansas	NA	NA	NA	NA
Kentucky	NA	NA	NA	NA
Louisiana	NA	NA	NA	NA
Maine	NA	NA	NA	NA
Maryland	NA	NA	NA	NA
Massachusetts	NA	NA	NA	NA
Michigan	NA	NA	NA	NA
Minnesota	NA	NA	NA	NA
Mississippi	NA	NA	NA	NA
Missouri	NA	NA	NA	NA
Montana	-6.3570588	-10.867471	-1.8466467	0.0019938
Nebraska	NA	NA	NA	NA
Nevada	NA	NA	NA	NA
New Hampshire	NA	NA	NA	NA
New Jersey	NA	NA	NA	NA
New Mexico	NA	NA	NA	NA
New York	-0.9570588	-5.467471	3.5533533	0.9870031
North Carolina	NA	NA	NA	NA
North Dakota	-2.7070588	-6.060063	0.6459452	0.1723846
Ohio	NA	NA	NA	NA
Oklahoma	-3.3570588	-9.565616	2.8514983	0.5839743
Oregon	NA	NA	NA	NA

Pennsylvania	NA	NA	NA	NA
Rhode Island	NA	NA	NA	NA
South Carolina	NA	NA	NA	NA
South Dakota	NA	NA	NA	NA
Tennessee	NA	NA	NA	NA
Texas	NA	NA	NA	NA
Utah	NA	NA	NA	NA
Vermont	NA	NA	NA	NA
Virginia	NA	NA	NA	NA
Washington	NA	NA	NA	NA
West Virginia	NA	NA	NA	NA
Wisconsin	NA	NA	NA	NA
Wyoming	NA	NA	NA	NA

Pacific Islander

State	Difference	Lower CI	Upper CI	Adjusted P-Value
Alabama	NA	NA	NA	NA
Alaska	NA	NA	NA	NA
Arizona	NA	NA	NA	NA
Arkansas	NA	NA	NA	NA
California	NA	NA	NA	NA
Colorado	NA	NA	NA	NA
Connecticut	NA	NA	NA	NA
Delaware	NA	NA	NA	NA
District of Columbia	NA	NA	NA	NA
Florida	NA	NA	NA	NA
Georgia	NA	NA	NA	NA
Hawaii	NA	NA	NA	NA
Idaho	NA	NA	NA	NA
Illinois	NA	NA	NA	NA
Indiana	NA	NA	NA	NA
Iowa	NA	NA	NA	NA
Kansas	NA	NA	NA	NA
Kentucky	NA	NA	NA	NA
Louisiana	NA	NA	NA	NA
Maine	NA	NA	NA	NA
Maryland	NA	NA	NA	NA
Massachusetts	NA	NA	NA	NA

Michigan	NA	NA	NA	NA
Minnesota	NA	NA	NA	NA
Mississippi	NA	NA	NA	NA
Missouri	NA	NA	NA	NA
Montana	NA	NA	NA	NA
Nebraska	NA	NA	NA	NA
Nevada	NA	NA	NA	NA
New Hampshire	NA	NA	NA	NA
New Jersey	NA	NA	NA	NA
New Mexico	NA	NA	NA	NA
New York	NA	NA	NA	NA
North Carolina	NA	NA	NA	NA
North Dakota	NA	NA	NA	NA
Ohio	NA	NA	NA	NA
Oklahoma	NA	NA	NA	NA
Oregon	NA	NA	NA	NA
Pennsylvania	NA	NA	NA	NA
Rhode Island	NA	NA	NA	NA
South Carolina	NA	NA	NA	NA
South Dakota	NA	NA	NA	NA
Tennessee	NA	NA	NA	NA
Texas	NA	NA	NA	NA
Utah	NA	NA	NA	NA
Vermont	NA	NA	NA	NA
Virginia	NA	NA	NA	NA
Washington	NA	NA	NA	NA
West Virginia	NA	NA	NA	NA
Wisconsin	NA	NA	NA	NA
Wyoming	NA	NA	NA	NA

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VITA

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OBJECTIVE:

To obtain full-time employment in the field of clinical research.

EDUCATION:

Boston University School of Medicine: Division of Graduate Medical Sciences, Boston, MA
Master of Science: Clinical Investigation
05/2015

Worcester Polytechnic Institute (WPI), Worcester, MA

Bachelor of Science: Chemical Engineering concentration in Biochemistry
05/2013

SKILLS:

Microsoft Word, Excel, & Power-point, MathCad, AspenPlus, COMSOL, HENSED, Basic Lab Safety, Basic Lab Skills, R, R Studio, eCaselink, ClinPlus

RELEVANT COURSEWORK:

Designing Clinical Trials, Regulatory and Compliance Issues, Biostatistics with Computing, Organic Chemistry, Advanced Chemical Processes, Applied Chemical Engineering Thermodynamics, Elementary Chemical Processes, Chemical Engineering Fundamentals, Biochemistry 1 & 2, Management of Clinical Trials, Good Clinical Practices in Clinical Research

PROJECTS:

Protocol Design 12/2013
A Prospective Cohort Study: Does the use of aromatase inhibitors after early-stage positive-receptive breast cancer surgery, increase a postmenopausal woman's risk of cardiovascular events?

Activity of Tethered Antimicrobial Peptides 03/2013
Investigating the activity of tethered antimicrobial peptides and their effect on the killing percentage of bacteria using a QCM-D and live/dead assay.

Emotional Impact of Students in Distress 03/2012
Investigating how acute illness and/or injuries and limitations affect the emotional and physical health of students within the WPI community by researching prevalent illness on campus and informing the community of the resources available.

WORK EXPERIENCE:

Research Intern/Assistant, Children's Hospital Boston 07/2011 – 08/2011
Followed the development and progression of a Peanut Desensitization Study in the Clinical Research Department

Intern at Cell Signaling Technologies, Danvers, MA 05/2012 – 08/2012

Laboratory preparation, clean up and preparations of cells for antibody testing
Clinical Research Associate at Boston Biomedical Inc., Cambridge, MA 05/2014 – present
Work on the clinical team to begin clinical trials at various hospitals around the United States and ensure that the trials are run according to Good Clinical Practices and that all regulatory requirements are met.

ACTIVITIES AND COMMUNITY SERVICE:

Volunteer at Rosie's Place	11/2013–present
Graduate Medical Sciences Student Organization	11/2013–present
Alpha Xi Delta Women's Fraternity	02/2010–present
Big Brothers Big Sisters	03/2011–05/2013
American Institute of Chemical Engineers	08/2010–05/2013
Colleges against Cancer	09/2009–05/2013