DEMOGRAPHIC CHARACTERISTICS RELATED TO VACCINATION STATUS IN CHILDREN AGED 19 TO 35 MONTHS

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DEDICATION

To my ever-loving, ever-supportive husband, who has never stopped encouraging me to go confidently in the direction of my dreams and to believe in myself. I could not have done this without you.
I shall endeavor still further to prosecute the inquiry, an inquiry I trust not merely speculative, but of sufficient moment to inspire the pleasing hope of its becoming essentially beneficial to mankind.

-Edward Jenner
ABSTRACT OF THE THESIS

Demographic Characteristics Related to Vaccination Status in Children Aged 19 to 35 Months
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Master of Public Health
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The purpose of this study was to show a relationship between maternal and household demographic characteristics and refusal of some or all vaccines recommended for children under 35 months of age according to the Centers for Disease Control and Prevention Recommended Childhood Immunization Schedule. More specifically, this study aimed to demonstrate a significant relationship between vaccine refusal and a high level of maternal education (some college or more), higher than the median household income ($35,001-$50,000), and non-Hispanic white ethnicity.

Data from the 2002 National Immunization Survey (NIS) were used, which implemented household telephone surveys and healthcare provider questionnaires to collect demographic information and vaccination statuses on 19- to 35-month-old children in the United States. Pearson chi-square and logistic regression analysis were performed to test the relationships between child, mother, and household demographic variables and 3 vaccination status categories: fully vaccinated, undervaccinated, and selectively unvaccinated.

Selectively unvaccinated children were more likely to be female, to be in the 30-35 month age category, to be of Hispanic or non-Hispanic black ethnicity, to have a mother 30 years of age or older, to have a mother who was either widowed, divorced or separated, to have a mother who had 12 years of education, to live in a household with an annual income of $20,001-$35,000, to live in a single-child household, and to live in a state that does not allow philosophical exemptions to school-entry immunization requirements. Whereas, undervaccinated children tended to be male, to be younger than 30 months, to be non-Hispanic white, to have a mother who was younger than 30 years and married, to have a mother who had 12 years of education or had graduated college, to live in a household whose income was not the median level, to live in a household with at least one other child, and to live in a state allowing philosophical exemptions to immunization requirements.

Although other studies have shown that parents who refuse all vaccines for their children tend to be white, more highly educated, and live in higher-income communities, the results of this study suggest that there may not be clear-cut demographic characteristics that define parents who selectively refuse vaccines. Consequently, there may not be specific populations for health promotion campaigns and healthcare providers to target in an effort to increase vaccine uptake. While it is important for the good of the society that herd immunity is maintained in communities, it is essential that parents retain the autonomy to choose what they believe is best for their child's health. Thus, healthcare providers have a responsibility to ensure parents are educated on the risks and benefits of vaccination so they can make informed immunization decisions for their children.
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CHAPTER 1

INTRODUCTION

BACKGROUND

Vaccines are arguably one of the most important scientific developments of the past century. Since the introduction of the smallpox vaccine in 1796, the prevalence of vaccine-preventable diseases has decreased dramatically. In fact, smallpox was declared eradicated by the World Health Organization in 1979 (Centers for Disease Control and Prevention [CDC], 1999).

Today, 11 different vaccines are recommended for children age 0 to 6 years to guard against some of the most highly infectious and prevalent childhood diseases (CDC, 2002b). Thanks to these medical advances, the incidence of vaccine-preventable diseases in the United States has dropped significantly compared to the pre-vaccine era. A 2007 study found that the annual number of cases of measles had decreased from more than 530,000 before measles-containing vaccines were introduced to just 55 in 2006. Cases of invasive Haemophilus influenzae type b decreased from 20,000 in the 1980s to an estimated 50 in 2006. And incidences of polio and diphtheria have both dropped from 36,000 and 21,000, respectively, to zero (Roush & Murphy, 2007).

Despite the significant decreases in disease incidence that vaccine implementation has created overall, there has been an increasing number of outbreaks of vaccine-preventable diseases as more parents are refusing certain vaccines for their children. In fact, some say vaccines are victims of their own success, as the fear that was once associated with contracting diseases like polio and pertussis is now being projected onto the safety and efficacy of vaccines themselves. In 1998, an article was published erroneously linking the measles-mumps-rubella (MMR) triple shot to autism (Murch et al., 2004). As a result, immunization rates for MMR have declined steadily in certain communities. The article has since been retracted, but the negative effect it has had on the public trust in the safety of the MMR vaccine will be difficult to reverse.
As the threat of disease has decreased, the fear of vaccine-related adverse events is causing increasing numbers of parents to forego some or all recommended vaccines for their children. Some commonly stated fears about vaccines are that they may cause autism or other neurological disorders, which they may weaken or overwhelm the infant immune system, or that illness may interfere with the child's immune response to a vaccine (Offit et al., 2002). Studies have shown these fears to be unfounded. In fact, while infants today receive a greater number of vaccines than they did 40 or 100 years ago, they receive a much smaller number of total antigens. It is also much smaller than the number to which the infant immune system is capable of generating a response (Offit et al., 2002).

The media and anti-vaccine activist groups have also had a detrimental effect on immunization rates in the United States. In an age where information is readily available via television and the Internet, many parents have the ability to seek answers to their questions about vaccine safety at any time. However, an alarming number of websites with information on childhood immunization are dedicated to warning parents about potential risks associated with vaccines, despite the fact that these risks are scientifically unjustified. Some researchers theorize that the increase in vaccine refusal among more highly educated and affluent communities is a result of this population having better access to information sources, such as the Internet.

Immunization rates in many European countries have decreased dramatically over the past couple of decades due to concerns about vaccine safety fueled, in large part, by negative messages from the media and anti-vaccine advocacy groups. As a result, many vaccine-preventable diseases are making a resurgence (Jansen et al., 2003). In this day and age where travel to any part of the world is possible, including countries where diseases like polio are still prevalent, parents need to be vigilant about protecting their children from such exposures. Though diseases like pertussis and measles are no longer common in the United States, they are endemic to some countries and causing an increasing number of outbreaks in undervaccinated U.S. populations (Gangarosa et al., 1998).

Since the introduction of vaccines, drops in immunization rates have been associated with outbreaks of vaccine-preventable diseases. Although the United States has maintained an overall high rate of immunization coverage, certain communities within some states report higher than average rates of vaccine refusal (Smith, Chu, & Barker, 2004). In studying these
communities, researchers have found that the unvaccinated children in these areas are at a much higher risk of contracting vaccine-preventable diseases and that the distribution of disease outbreak cases is significantly more likely to overlap the geographic area where vaccine refusal rates are high (Omer et al., 2008). Vaccine refusal rates are also more likely to be higher than the national average in states which allow philosophical or personal belief exemptions from immunizations required for school entry (Omer et al., 2006).

States permitting nonmedical exemptions from mandated vaccinations for school entry have also been found to have a higher incidence of measles, especially in areas where schools were lenient about enforcement of state immunization laws (Robbins, Brandling-Bennett, & Hinman, 1981). In fact, 16 states allow school officials to be the sole authority for granting exemptions, and only 9 states inform parents seeking exemptions of the risks of underimmunization. Additionally, 15 states make obtaining a nonmedical exemption easier than fulfilling school-entry immunization requirements (Rota et al., 2001). Consequently, these states also have the highest rates of nonmedical exemptions.

There is an ethical dilemma for state governments related to protecting the health of the community as a whole while still allowing parents autonomy to choose what is best for their child. One could argue that parents have a responsibility to vaccinate their child for the good of society, which would benefit both. However, the risk is borne only by the child. Some children and adults are not able to be vaccinated because they are immunocompromised or because they are too young to receive certain vaccines. As the rates of vaccine refusal increase, so does the risk of contracting disease by those more likely to suffer adverse effects.

Studies have shown that there are statistically significant differences in the socioeconomic and demographic characteristics between parents whose children are undervaccinated and parents who refuse some or all vaccines for their children. Undervaccinated children and those with delayed vaccination tend to have single mothers, live in urban areas, live closer to the poverty level, have more children living in the household, and have mothers with lower education levels (Smith et al., 2004). Whereas, parents who refuse vaccines for their children tend to be white, married, live in middle- to upper-income level communities, and have attended at least some college (Smith et al., 2004). Some commonly hypothesized reasons for delays in immunization include barriers to
medical care, such as lack of insurance or funding for immunizations, conflicts in scheduling, and not understanding the importance of immunization for overall child health. Whereas, vaccine refusal tends to be related to parents' attitudes and beliefs about vaccine safety and efficacy and their trust in medical professionals.

**STATEMENT OF THE PROBLEM**

As the number of parents refusing to have their children vaccinated grows, herd immunity in certain communities is decreasing, and the risk of an outbreak of vaccine-preventable disease is rising. Although there has been some risk associated with vaccination, such as infection at the injection site and febrile seizures, many parents who refuse vaccines for their children do not realize that their risk of contracting and spreading vaccine-preventable diseases is considerably greater. And while these diseases have the potential to be serious for otherwise healthy children and may require hospitalization, they pose the greatest threat to those who are medically unable to receive vaccinations, immunocompromised populations, the elderly, and children who are yet too young to be vaccinated.

There is also a potential financial burden placed on the community by vaccine refusers. The cost of an outbreak is significantly higher than the cost of vaccination. For example, the 2008 measles outbreak in a San Diego community with a higher than average MMR vaccine refusal rate cost the public sector $10,376 per case. Whereas, an MMR vaccination for the children who spread the disease would only have cost about $100 per dose. Incidentally, while this outbreak caused only 12 children to become infected with the measles virus, all of whom were unvaccinated, 839 people were exposed and an infant who was too young to be vaccinated had to be hospitalized (Sugerman et al., 2010).

The four most commonly refused vaccines among parents of children 6 years or younger are the varicella vaccine, the hepatitis B vaccine, the diphtheria-tetanus-acellular pertussis (DTaP) vaccine, and the measles-mumps-rubella (MMR) vaccine (Frederickson et al., 2004; Salmon et al., 2005). It is not likely a coincidence that diseases such as measles and pertussis are the most frequent outbreaks among children in the United States and other developed nations (Roush & Murphy, 2007).
PURPOSE OF THE STUDY

The purpose of this study is to show a relationship between maternal and household demographic characteristics and refusal of some or all vaccines recommended for children under 35 months of age according to the Centers for Disease Control and Prevention Recommended Childhood Immunization Schedule (see Figure 1). More specifically, this study aims to demonstrate a significant relationship between vaccine refusal and a high level of maternal education (some college or more), higher than the median household income ($35,001-$50,000), and non-Hispanic white ethnicity.


In order to fulfill this purpose, healthcare provider data on vaccination rates and demographic characteristics of 19- to 35-month-old children collected for the 2002 National Immunization Survey (NIS) was obtained from the Inter-university Consortium for Political
and Social Research (ICPSR) website. The data set includes information on vaccination rates for each vaccine recommended by the CDC for children under 18 months of age (DTaP, polio, MCV, Hib, Hep B, varicella) and the number of doses each study subject has received, as well as child, maternal, and household demographic variables.

**GOALS AND HYPOTHESES**

The goal of this study is to support and expand on the previously established body of knowledge on childhood vaccination rates in the U.S. and the differences between populations who refuse vaccines for their children, those who delay vaccination, and those whose children are fully vaccinated. It is hoped that the findings of this study will guide healthcare providers and health promotion campaigns in knowing which populations to target with additional information on the benefits versus risks of vaccination. With a better understanding of the demographic characteristics related to childhood vaccine refusal, health promoters may be able to adapt vaccination campaigns to influence these groups and perhaps increase the rate of vaccine uptake within communities of parents more likely to refuse them.

Based on previous literature relating family demographics to childhood vaccination status, this study hypothesizes that mothers who selectively refuse some or all CDC-recommended vaccines for their children are significantly more likely than mothers of fully vaccinated or partially vaccinated children to have attended at least some college, to live in a household whose income is greater than $50,000, and to be of non-Hispanic white ethnicity.

Previous studies have also shown that a child's age, the number of children under 18 years living in a household, mother's age and marital status, and living in a state which allows philosophical exemptions from school-entry immunization requirements to be related to a child's vaccination status. Therefore, these variables will also be included in the analysis.

**BASIC ASSUMPTIONS**

This study assumes that if a child in a particular household has not received a single dose of one or more CDC recommended vaccines for children between birth and 35 months of age, but has received all recommended doses for some vaccines, that child's parents refused the vaccine that was not received. Likewise, if a child has received some but not all
doses of any or all of the recommended vaccines, that child's parents have either deliberately or unconsciously delayed vaccination.

**DEFINITIONS**

For the purpose of this study, fully vaccinated children are defined as having received all 16 recommended vaccine doses at the time the data for this study was collected. According to the 2000 CDC recommended immunization schedule, children should receive all recommended vaccines by 18 months of age (4 DTP or DTaP doses, 3 polio vaccine doses, 1 measles-containing vaccine [MCV] dose, 4 *Haemophilus influenzae* type b [Hib] vaccine doses, 3 hepatitis B [hep B] vaccine doses, and 1 varicella zoster vaccine dose). Therefore, children are considered undervaccinated if they have received some but not all doses of any of the recommended vaccines, but have not been fully vaccinated at the time of the study. Whereas, the selectively unvaccinated group is defined as having received either no doses of any vaccine or have received all recommended doses of some vaccines but no doses of one or more specific vaccine (Smith et al., 2004).

For maternal characteristics hypothesized to be related to selectively unvaccinated children, higher education level is defined as having attended at least some college, while not having graduated high school is considered lower education level. A household is considered to have a higher income level if its annual income is greater than $50,000, to have a lower income level if it is between $20,001 and $35,000 (DeNavas-Walt, Cleveland, & Webster, 2003), and poverty level if income is $20,000 or less (Thompson, 2002).
CHAPTER 2

LITERATURE REVIEW

Studies have shown there is a difference between mothers whose children are undervaccinated or have delayed vaccination and mothers who selectively refuse vaccination. While undervaccination in children has been linked to low maternal education levels and household income at or near the poverty level, a number of other studies have shown a relationship between high maternal education and selective vaccine refusal. The theory behind these findings is that mothers from higher income households and with more education and household income levels have greater access to vaccine safety information that may dissuade them from having their child/children immunized. While mothers with lower education and income levels are more likely to encounter barriers to healthcare.

BACKGROUND

In the United States, overall childhood vaccination rates have continued to rise for most CDC recommended vaccines. Since 2000, rates of DTaP vaccine (4 doses) coverage in children have increased from 81.7 to 83.9%; polio vaccine (3 doses), from 89.5 to 92.8%; hep B (3 doses), from 90.3 to 92.4%; and varicella vaccine (1 dose), from 67.8 to 89.6% (CDC, 2002a, 2010b). These increases are due in large part to the implementation of goals set forth in Healthy People 2010, which called for 90% coverage for each of the recommended vaccines nationwide in children aged 19 to 35 months (CDC, 2010a). The only decreases observed were in uptake of MCV (1 dose), which dropped from 90.5 to 90.0%, and in Hib vaccine (3 doses), decreasing significantly from 93.4 to 83.6%. The decrease in MCV uptake may be related to a 1998 study by Wakefield et al., erroneously linking the MMR vaccine to the development of autism in children. Though the results of this study were disproved by subsequent research and the study retracted, it continues to fuel anti-vaccine activism worldwide.

Few parents today have first-hand experience with vaccine-preventable diseases, such as polio and pertussis, or understand the health risks associated with such diseases. As a
result, parents are ever more increasingly turning their attention and concern toward vaccine safety, concerns that are largely unfounded by scientific evidence (Murch et al., 2004). An article by Chen and DeStefano (1998) states:

Vaccine-safety concerns gain prominence whenever the incidence of vaccine-preventable disease falls to negligible levels and when the number of vaccine adverse events, whether true reactions or those coincidental to the vaccination but falsely attributed to it, rises as a consequence of high vaccine coverage. (p. 612)

Moreover, a 2006 study, in which parents of 19 to 35 month old children were given the National Immunization Survey Parental Knowledge Module, found that as many as 5.7% of parents believed that vaccines were not safe (Smith, Kennedy, Wooten, Gust, & Pickering, 2006). And, a study by Shui et al. reported that 21% of respondents to a nationwide survey of U.S. adults have the highest level of concern about vaccine safety (5 on a 1-to-5 point scale) (Shui, Weintraub, & Gust, 2006).

In an effort to assess vaccine risk perception among parents, a study by Raithatha et al. found that “Parents felt the immunization process was akin to a conveyor belt. They were pressurized to get on it, immunize their children and not ask too many questions.” Parents in this study also stated a feeling of “dread” about the risk of vaccine side effects, regardless of how small the risk may be (Raithatha, Holland, Gerrard, & Harvey, 2003, p. 162).

Although most parents continue to have their children immunized despite their vaccine safety concerns, researchers are attributing these concerns to steadily increasing numbers of underimmunized and unimmunized children. For example, a study by Allred et al. found that children whose parents believed vaccines are safe were 2.9 times more likely (95% CI: 1.4, 6.0) to be up-to-date on vaccinations as children whose parents view vaccines as unsafe (Allred, Shaw, Santibanez, Rickert, & Santoli, 2005). Additionally, a study by Gust et al. (2004) comparing underimmunized children to those fully immunized with all recommended vaccines demonstrated that “14.8% of underimmunization was attributable to parental attitudes, beliefs, and behaviors,” (p. e16) and that parents of underimmunized children were twice as likely as parents of fully immunized children to rate a vaccine as unsafe or only somewhat safe (95% CI: 1.2, 2.4).

Some supporting studies have analyzed the association between parents who refuse or delay vaccination for their children due to vaccine safety concerns and the specific vaccines about which they are concerned. A 1992 study by Bennett and Smith found that parents who refuse all vaccines for their children are significantly more likely to have concerns about the
long-term health effects of the pertussis and MMR vaccines than parents who partially vaccinate or fully vaccinate their children. Another study found that parents who refuse vaccines were more likely than fully- or partially-vaccinating parents to have doubts about the varicella vaccine and were also the most likely group to state vaccine safety as the primary reason for their doubts (Gust, Darling, Kennedy, & Schwartz, 2008).

Because many parental fears related to vaccine safety are scientifically unfounded, researchers have conducted surveys to discover where parents are getting their information and their reasons for vaccine refusal. Studies by Fredrickson and Lyren found that, among parents who refuse vaccines, side effects reported by the media play a significant role in their decision-making process (Frederickson et al., 2004; Lyren & Leonard, 2006). A policy statement by the Committee on Practice and Ambulatory Medicine & Council on Community Pediatrics (2010) states that:

...the rise of a public antivaccination movement that uses the Internet as well as standard media outlets to advance a positions, wholly unsupported by any scientific evidence, linking vaccines with various childhood conditions, particularly autism...provide flawed or biased information that serves to fuel public concern regarding the safety of childhood immunizations, which leads to increased rates of immunization refusal or delays in on-time immunization (p. 1295).

This finding supports a previous study conducted by Gangarosa et al. (1998), which compared pertussis incidence between countries where high DTaP vaccination was maintained and countries where anti-vaccine movements had disrupted immunization rates. They found that “Pertussis incidence was 10 to 100 times lower in countries where high vaccine coverage was maintained than in countries where immunization programs were compromised by anti-vaccine movements” (p. 356). However, a 2007 study on the effects of media coverage of the autism controversy surrounding the MMR vaccine failed to find a significant temporal association between media coverage and MMR immunization rates (Smith, Ellenburg, Bell, & Rubin, 2008). A possible limitation of this study could be that researchers did not qualify the content of the news stories before including them in the analysis.

Further studies indicate that while most parents agree that vaccines are important for their child's overall health and well-being, they continue to have concerns about the safety and efficacy of those vaccines. Of note are the demographic variables these studies have associated with parental vaccine safety concerns.
**MATERNAL EDUCATION**

In an attempt to better understand the differences between parents who fully immunize their children, parents who delay immunization, and those who selectively refuse vaccines, researchers have conducted studies on parent and child demographics, and most have found significant relationships between maternal education level and childhood vaccination status. A study by Luman et al., which compared children who had been fully vaccinated (4 DTaP doses, 3 polio doses, 1 MCV dose, 3 Hib doses, and 3 hep B doses) to children who were undervaccinated, found in multiple logistic regression that undervaccination was significantly related to mothers having less than a high school education (OR=.6, 95% CI: .5, .8) (Luman, McCauley, Shefer, & Chu, 2003). A 2007 study, on the other hand, found that children of less educated mothers were more likely to be up-to-date on the 4:3:1:3 vaccine series (4 DTaP doses, 3 polio doses, 1 MMR dose, and 3 Hib doses) than children of college graduates (OR=1.16, 95% CI: 1.01, 1.33) (Kim, Frimpong, Rivers, & Kronenfeld, 2007). Although both studies used NIS data, their results differ likely because, (1) the 2007 study did not include the Hep B vaccine up-to-date status in their analysis, which may have affected the significance of demographic characteristics of the sample, and (2) many of the participants in the up-to-date sample of the 2007 study were also Women, Infants, and Children (WIC) program participants, which requires compliance with the program's immunization requirements. Whereas, the 2003 study related undervaccination to eligibility for, but non-participation in, the WIC program.

A retrospective cohort study on children born between January 1, 2002, and December 31, 2004, in Philadelphia, Pennsylvania, found that mothers who had less than a high school education were 1.23 times more likely than mothers who had been to college to have an infant who was a late vaccination starter (95% CI: 1.08, 1.38) (Feemster, Spain, Eberhart, Pati, & Watson, 2009). Being late to initiate immunization puts children at greater risk of having continued delays throughout their childhood.

While child safety is a concern for all parents, doubts over vaccine safety have been shown to be a strong predictor of vaccine refusal among certain groups of parents. In an effort to expound on parents' misconceptions about vaccine safety, Gellin et al. conducted a telephone survey with a nationally representative sample of parents with children 6 years old or younger and expectant parents. The results indicate that, while 86.9% of respondents rated

...
immunization as extremely important for their child's health, those with a high school diploma or less were more likely than other groups to hold this belief (91.3%) when compared to parents who were college graduates (83.3%). Moreover, a greater proportion of college graduates (16.9%) were more likely to report that they “would choose to opt out of any immunization” than were respondents with a high school degree or less (10.7%) (Gellin, Maibach, & Marcuse, 2000).

Likewise, a study by Gust et al. (2005) using 2003-2004 NIS data found that a greater proportion of college-educated parents refused vaccines for their children and did so out of doubt regarding vaccine safety and efficacy. This study also found that a greater proportion of parents who chose to delay vaccination for their children had a high school education or less. These delays were most often due to their child being ill at the time the vaccination was recommended.

In an effort to better understand why parents choose not to vaccinate their children, Gullion et al. conducted a survey on 25 parents of unvaccinated children, which contained open-ended questions on parents' beliefs and attitudes about vaccines. They found that, overall, the sample was well-educated, with all 25 participants having attended at least some college, and that this group has “...high levels of skepticism of the medical community running concurrent with a high value on scientific knowledge” (Gullion, Henry, & Gullion, 2008, p. 405).

Conversely, a study on childhood vaccines and parental attitudes, beliefs, and behaviors, which divided the study population into 5 clusters according to their level of vaccine safety concern, found that the highest percentage of college graduates belonged to the “Immunization Advocate” cluster (42.2%). This group was defined by their strong belief that vaccines are necessary and safe for their children. However, the second highest percentage of college graduates were in the “Worried” cluster (33.3%), which was the group most concerned with the necessity and safety of childhood vaccines (Gust et al., 2005).

In a case-control study by Salmon et al. (2005), a survey was conducted to discover the differences in vaccine safety perceptions among parents with fully vaccinated children and parents who claim non-medical exemptions to school-entry immunization requirements for their children. They found that parents who claim exemptions were significantly more likely than parents of vaccinated children “...to report low perceived vaccine safety and
efficacy, a low level of trust in the government, and low perceived susceptibility to and severity of vaccine-preventable disease” (p. 438). Parents of exempt children were also more likely to have higher than the median education level (some college) than parents of fully vaccinated children ($p<.02$).

Some studies on specific disease outbreaks, like measles and pertussis, have shown that these outbreaks have been caused by children whose parents have refused to vaccinate them against these diseases, that these children are clustered geographically, and that the vaccines were refused due to doubts of their safety. A study on the 2008 measles outbreak in San Diego, California, also found that all 12 children who had been infected with the virus were unvaccinated and all had parents who were college-educated (Sugerman et al., 2010). While another study found that unvaccinated children are clustered geographically and are more likely to have a mother who has a college degree compared to children who were undervaccinated (OR=2.4, 95% CI: 1.0, 6.1) (Smith et al., 2004). These results are further supported by review of medical records of 0 to 6 year-old patients within two HMOs, which found that, among the age 6 chart review sample, parents who refuse vaccines for their children are more likely to live in well-educated communities ($p=.01$) (Wei et al., 2009).

Although many studies examining parents' sources for vaccine information have found that the media plays a significant role in spreading negative messages about vaccine safety, a 2007 study on the impact of media coverage of the MMR-autism controversy on MMR uptake looked at the demographic characteristics related to MMR non-receipt. Investigators found overall MMR non-receipt to be significantly related to lower maternal education levels ($p<.001$), but no significant association between selective MMR non-receipt and maternal education (Smith et al., 2007). However, this finding refers only to the MMR vaccine, and not selective non-receipt of CDC-recommended childhood vaccines, as a whole.

**HOUSEHOLD INCOME**

Despite an upward trend overall in most childhood vaccination rates, studies have shown changes in demographic characteristics in children who have not received the recommended number of vaccine doses. Historically, unvaccinated children were more likely to live in a household whose income was at or near the poverty level because their families could not afford to have them vaccinated. However, more recent studies show that, due in
large part to programs like the WIC Immunization Action Plan, lower income families have had increasing rates of childhood vaccinations. This upward trend has had a positive effect on vaccination rates in the U.S. overall, despite the decreases in childhood vaccination rates in more affluent communities.

Many studies relating maternal education level to childhood vaccination status have also found a significant association to household income. For example, studies by Wei et al. (2009), Smith et al. (2004), and Sugerman et al. (2010), which each looked at demographic characteristics related to parents refusing vaccines for their children, each found that unvaccinated children were significantly more likely than undervaccinated children to live in households with higher than average incomes. Smith et al. (2004) also found that undervaccinated children were significantly more likely than fully vaccinated children to live near the poverty level (OR=1.7, 95% CI: 1.5, 2.0).

Smith's results are supported by two additional studies by Gust et al. on parental vaccine safety concerns, which used NIS data from different years. Both the 2004 and 2007 study found that parents of children who are undervaccinated report the highest level of safety concern, and that these children are significantly more likely than fully vaccinated children to live in a household with an income level between $0 and $30,000 (AOR=2.7, 95% CI: 1.5, 4.6, and p<.01, respectively) (Gust et al., 2004, 2007).

Furthermore, a study by Bennett and Smith (1992), which also focused on parental perceptions of vaccine safety and ranked their level of concern on a scale of 1 (lowest) to 5 (greatest), found that parents with a household income below $30,000 were 2.1 times more likely than parents with a household income greater than $75,000 to report their level of concern as a 5 (95% CI: 1.5, 3.2).

**CHILD ETHNICITY**

Many of the studies which found a child's vaccination status to be related to maternal education and household income levels also found it to be related a child's ethnicity. The 2004 study by Smith et al. found that undervaccinated children were 4.0 times more likely than unvaccinated children (95% CI: 1.2, 1.5) and 1.3 time more likely than fully vaccinated children to be black (95% CI: 1.3, 12.3). Whereas, unvaccinated children tended to be white. These results are supported by studies by Gullion et al. (2008) and Gust et al. (2007) on
vaccine refusers, which reported that the majority of study participants who had refused vaccines for their children were non-Hispanic white (88% and 83.9%, respectively). And, in a study on a 2005 measles outbreak in Indiana, researchers found that 33 of the 34 case patients (97%) were non-Hispanic white, and 32 of these 33 had not been immunized against measles due to vaccine refusal by their parents (Parker et al., 2006).

Additionally, a study by Gellin et al. (2000) found that, although white parents were more likely than black parents to rate child immunizations as “extremely important” (90.8% vs. 76.1%), they were also more likely than black parents to choose to opt out of any immunization for their child (15.8% vs. 7.1%).

A study on inner-city Latino and African-American preschoolers revealed that, among Latino children, 70% were up-to-date on vaccinations at 3 months of age and only 42% were up-to-date at 24 months. Among African-American children, 53% were up-to-date at 3 months, and only 26% were up-to-date at 24 months, while being up-to-date at 24 months was strongly related to receiving care from public health clinics versus private providers among Latino children (Wood et al., 1995). Two supporting studies found a child's up-to-date vaccination status to be strongly related to ethnicity, as well. In bivariate analysis, Luman et al. (2003) found that “...children were less likely to be fully vaccinated if their mothers were black or Hispanic” (p. 1216). Ethnicity was not found to be significant in the multivariate analysis, however. Similar findings were reported in a study by Smith et al. (2007), which found that non-Hispanic black children were more likely than children of other ethnicities to not have received the MMR vaccine (p<.001). These findings may be explained by results from a study by Shui et al. (2006), which found that black parents were more likely to have negative attitudes about immunizations than white parents. This study also found that Hispanic parents were twice as likely (95% CI: 1.5, 2.8) and black parents were 2.6 times more likely (95% CI: 1.8, 3.6) to report the highest level of vaccine safety concern than white parents.

Two separate studies found that Hispanic parents were more likely than those of other ethnicities to have concerns about serious adverse effects related to vaccines, such as autism (Freed, Clark, Butchart, Singer, & Davis, 2010; Shui et al., 2006). However, Freed's study indicates that Hispanic parents were more likely to take their pediatrician's advice to immunize their child and were “...less likely to have ever refused a vaccine” (p. 654).
Whereas, a 2005 study by Allred et al. (2005) found that non-Hispanic white parents were more likely to communicate the most concern over vaccine safety. However, this study also reported that only 1% of participants regarded vaccines as unsafe, which is a much lower estimate than other studies have suggested (Shui et al., 2006; Smith et al., 2006).

**AGE OF CHILD**

As the majority of CDC-recommended childhood vaccines are due by the time a child reaches 18 months of age, child age can be a significant variable in determining a child's risk of being undervaccinated or selectively unvaccinated. Three separate studies using NIS data from different years each found child age categories to be significantly related to immunization status in multivariate analysis. In a 2007 study, Gust et al. found that children in the 19-24 month age category were 2.04 times more likely than children in the 25-29 month category to have parents who delayed vaccination (95% CI: 1.10, 3.85). Whereas, children in the 25-29 month category were 2.76 times more likely (95% CI: 1.30, 5.88), and children in the 30-35 month category were 2.60 times more likely (95% CI: 1.30, 5.19), than children in the 19-24 month category to have parents who had refused vaccines.

Similarly, another 2007 study found that children in both the 24-29 month and 30-35 month categories were more likely to have received the MMR vaccine than children in the 19-24 month category (OR=1.45, 95% CI: 1.35, 1.54; and OR=1.72, 95% CI: 1.61, 1.85, respectively) (Smith et al., 2007). These findings support results from a 2004 study, which found that 19- to 24-month-old children were 1.5 times more likely than 30- to 35-month-old children to be undervaccinated (95% CI: 1.3, 1.6) (Smith et al., 2004).

**AGE OF MOTHER**

Maternal age has also been found by a number of studies to be a significant predictor of a child's vaccination status, with younger mothers being the most likely to have undervaccinated children and older mothers more likely to have selectively unvaccinated children. A study by Salmon et al. (2005) on childhood vaccine refusal in states which allow non-medical exemptions from immunization requirements for school-entry found that, compared to parents of fully vaccinated children, the highest proportion of parents of exempt children (and thus, parents who had refused certain vaccines) were older than the median age.
(36-40 years) (35.9% vs. 40.0%, \( p=.02 \)). Whereas, studies by Smith et al. (2007) and Gust et al. (2007) have shown that children of mothers younger than the median age (30 years) are significantly more likely to be undervaccinated or have immunization delays when compared to fully vaccinated children (OR=1.3, 95% CI: 1.2, 1.4; and \( p<.01 \), respectively).

These results are further supported by findings of Feemster et al. (2009), which reported that infants of mothers younger than 30 years were significantly more likely than infants of mothers over 30 to be late to initiate immunizations (AOR\(_{25-29\text{ years}}\)=1.26, 95% CI: 1.07, 1.50; AOR\(_{18-24\text{ years}}\)=1.54, 95% CI: 1.31, 1.81; and AOR\(_{<17\text{ years}}\)=1.79, 95% CI: 1.46, 2.20), putting the child at greater risk for immunization delays throughout childhood.

**Marital Status of Mother**

In addition to many other demographic characteristics, a mother's marital status has been shown to be significantly related to a child's up-to-date vaccination status. Although no studies have found a significant relationship between mother's marital status and vaccine refusal, many have found an association between marital status and undervaccination in children. Studies by Kim et al. (2007) and Smith et al. (2007) both found that children of unmarried mothers were significantly more likely than those of married mothers to not be up-to-date for the MMR vaccine and the 4:3:1:3 vaccine series, respectively (AOR=1.10, 95% CI: 1.03, 1.18; and HR=.86, 95% CI: .59, .78, respectively).

Three additional studies support these results. Luman et al. (2003) reported that children of mothers who were divorced, widowed, or separated were 1.25 times more likely (95% CI: 1.11, 1.43) than children of married mothers to be undervaccinated with respect to the 4:3:1:3:3 vaccine series (4:3:1:3 series plus 3 Hep B doses). While Gust et al. (2007) and Smith et al. (2004) both found that children of unmarried mothers were significantly more likely to be undervaccinated or have immunization delays (OR=2.14, 95% CI: 1.08, 4.26; and OR=1.3, 95% CI: 1.1, 1.5, respectively).

A possible explanation for these results is that single mothers are often the sole provider for the family, and work schedules may conflict with healthcare providers' office hours, which can make it especially difficult to keep children up-to-date on all recommended immunizations.
Another demographic characteristic related to childhood vaccination status is family size or, more specifically, number of children under 18 years of age living in the household. In fact, studies assessing this relationship have found that the more children there are living in a household, the lower the likelihood that any of those children is up-to-date for any vaccine.

In a study by Wood et al. (1995) on immunization status of inner-city Latino and African-American 3- and 24-month-old children, it was revealed that the likelihood that a 3-month-old African-American infant is up-to-date on all recommended vaccines decreases by a magnitude of 1.67 for every preschool-aged sibling in the household (95% CI: 1.20, 2.27). However, there was no significant relationship between family size and Latino ethnicity or in the 24-month age category.

Further studies by Luman et al. (2003) and Kim et al. (2007) have found that children living in households with 2 to 3 children are significantly more likely to be undervaccinated than children living in households with only 1 child (OR=1.25, 95% CI: 1.11, 1.43; and OR=1.18, 95% CI: 1.10, 1.27, respectively). Likewise, both of these studies found that the odds of children living in households with 4 or more children being undervaccinated were even greater (OR=1.67, 95% CI: 1.43, 2.0; and OR=1.47, 95% CI: 1.28, 1.69, respectively).

A study by Lieu et al. (1994) found that, among 13-month-old children in a Kaiser Permanente HMO, children were significantly less likely to be up-to-date if they lived in a household with 3 or more children than in a household of only 1 child (RR=2.2, 95% CI: 1.3, 3.7). While Gust et al. (2004) found that only children in households with 4 or more children were more likely to be undervaccinated than children in single-child households (OR=3.1, 95% CI: 1.5, 6.3).

A supporting study on infants born in Philadelphia between 2002 and 2004 also found that fewer prenatal care visits and birth order were related to delayed infant vaccination, stating that, when compared to first-born children, second-born children are 1.57 times more likely, and third-born and greater children are 2.08 times more likely to be late to start immunizations (95% CI: 1.43, 1.72, and 1.90, 2.28, respectively), and therefore, at higher risk for future vaccination delays (Feemster et al., 2009). And, Smith et al. (2007) found that
children with older siblings were 1.41 times more likely than first-born children to have not received the MMR vaccine (95% CI: 1.33, 1.51).

**PHILOSOPHICAL EXEMPTION STATUS OF STATE OF RESIDENCE**

Another factor that plays an important part in immunization refusal rates among children is state-mandated immunization requirements for school entry. While all states allow medical exemptions from school vaccination requirements, 48 states offer religious exemptions, and 20 also permit philosophical or personal belief exemptions (“States with religious and philosophical exemptions,” 2010). Parents who believe that immunization for school entry should not be compulsory were 1.7 times more likely to live in a state that allows philosophical exemptions than parents who support compulsory vaccination (95% CI: 1.2, 2.4), as well as stating “…that they did not plan to have their youngest child receive all recommended vaccines” (OR=4.3, 95% CI: 1.8, 10.3) (Kennedy, Brown, & Gust, 2005, p. 256).

A study by Omer et al. (2006) determined that states allowing personal belief exemptions had significantly “higher non-medical exemption rates than states that offered only religious exemptions…” (p. 1757) and that the mean exemption rate among these states increased 6% per year, on average. This study also agrees with findings by Rota et al. (2001) and Salmon et al. (2005), which show that the difficulty of the exemption process is inversely proportional to the number of nonmedical exemptions claimed, meaning the easier the process, the higher the number of non-medical exemptions claimed in that state.

Additionally, a much earlier study by Robbins et al. (1981) reported a significant association between low measles incidence and strictly enforced school immunization laws, reporting that, among the low measles incidence group, 77% of the schools enforced exclusion for immunization non-compliance, while none of the schools enforced exclusion among the high incidence group ($p<.001$). This supports further findings of Omer et al. (2006) that easily granting nonmedical exemptions is significantly related to higher pertussis incidence in children (incidence rate ratio=1.48, 95% CI: 1.03, 2.13).

A study by Smith et al. (2004) also found that states allowing philosophical exemptions from school vaccination requirements had significantly higher numbers of
unvaccinated children ($p < .05$), and that those children were clustered within counties. Geographic clustering of unvaccinated children has been attributed to outbreaks of both measles and pertussis in the United States. Studies on measles outbreaks in California and Indiana reported that nearly all of the cases were intentionally unvaccinated children (Parker et al., 2006; Sugerman et al., 2010). The index cases in both outbreaks were unvaccinated individuals returning from a trip to a foreign country where vaccine refusal rates were unusually high.

A similar study was performed for a measles outbreak in a military community in Wiesbaden, Germany. All 5 cases were young children whose parents had either refused or chosen to delay vaccination for measles and that “...only 71% of 19- to 35-month-olds in the community had been vaccinated with measles-containing vaccine before the outbreak, creating a 'pocket of susceptibility'” (Mancuso, 2008, p. 776). Additionally, multivariate analysis of data gathered by Omer et al. (2008) showed that geographic clustering of nonmedical vaccine exemptors significantly overlapped pertussis outbreak clusters in Michigan (OR=2.7, 95% CI: 2.2, 3.3), demonstrating that vaccine exemptors pose a risk to the whole community.

These findings are further supported by studies on the relative risk of contracting measles and pertussis among vaccinated and selectively unvaccinated children. A study of outbreaks in Colorado counties demonstrated that, not only is the measles incidence in a county significantly associated with the number of vaccine exemptors, but selectively unvaccinated children were 22.2 times more likely (95% CI: 15.9, 31.1) to contract measles and 5.9 times more likely (95% CI: 4.2, 8.2) to become infected with pertussis than vaccinated children (Feikin et al., 2000). While a nationwide study of similar populations found that exemptors were 35 times more likely (95% CI: 34, 37) than vaccinated children to become infected with measles. This study also shows vaccine exemptors are geographically clustered within states (Salmon et al., 1999). Another Colorado case-control study of children enrolled in a Kaiser Permanente health plan found that children for whom DTP or DTaP vaccines were refused were 22.8 times more likely (95% CI: 6.7, 77.5) to be diagnosed with pertussis than children who were partially or fully vaccinated against pertussis (Glanz et al., 2009).
A case-control study by Salmon et al. (2005) examined the characteristics and 
perceptions of parents who claim nonmedical exemptions to state-mandated immunizations 
for their children. Parents of exempt children were more likely to be older than 40 years (p = 
0.02), to have more education than the median (some college) (p < 0.02) compared to parents 
of vaccinated children, but were similar in terms of income (p = 0.90) and race (p = 0.14). 
Parents of exempt children were also 41.8 times more likely (95% CI: 12.7, 137.8) than 
parents of vaccinated children to report that their child's primary care provider was a 
complimentary or alternative medical practitioner, 14.3 times more likely (95% CI: 8.7, 23.6) 
to report that they believe healthy children do not need immunizations, and 12.9 times more 
likely (95% CI: 8.4, 19.8) to report they believe immunizations do more harm than good.

**What This Study Adds**

Although many studies have been published on sociodemographic characteristics 
related to childhood vaccination status, only a few have compared simultaneously both 
children who are undervaccinated and those who are selectively unvaccinated to fully 
vaccinated children. Most studies group both the unvaccinated and undervaccinated into a 
single category of “not up-to-date” vaccination status.

This study differs from previous work in that it separated the three vaccination status 
categories (fully-, under-, and unvaccinated) for analysis. And, it included selective vaccine 
refusers in the unvaccinated category, whereas previous studies that have analyzed all three 
vaccination status separately have only included children for whom all recommended 
vaccines have been refused.
CHAPTER 3

METHODS

STUDY OVERVIEW

The data for this study were collected for the 2002 National Immunization Survey (NIS), a random-digit-dialing telephone survey designed to identify households with children aged 19 to 35 months and to track the immunization status of children in the United States. An adult in the household with knowledge about the child's vaccination history was asked a series of questions pertaining to the child's up-to-date vaccination status, sociodemographic characteristics about the child's mother and household, and the child's healthcare provider. A mailed questionnaire was then sent to the child's healthcare provider to obtain vaccination information from the child's medical record.

STUDY POPULATION

The survey was given to a nationally representative sample of parents of 19- to 35-month-old children living in one of 78 Immunization Action Plan (IAP) areas in the United States. Twenty-eight of these areas are urban, while the remaining areas represent either an entire state or a “rest of state” area. Respondents were included in the analysis if there was adequate provider data of the vaccination record.

As data collected from household interviews were subject to recall bias and did not allow for unvaccinated cases to be differentiated from those who were undervaccinated, only vaccination data collected from provider questionnaires were analyzed. Subjects who did not have adequate provider data or who did not consent to have NIS investigators contact their vaccination provider were removed.

DATA COLLECTION PROCEDURES

For each child in the household within the specified age range, respondents were asked to give information about the child (date of birth, gender, whether the child's immunization records were available), which vaccinations had been received and how many
of each (DTP or DTaP, polio, MCV, Hib, varicella, RV, pneumococcal, and hep B), information on the mother (age, ethnic origin/race, marital status, and education level) and household (number of adults and children living in the household, place of residence, income level, and whether benefits were received from the nutrition and health program for Women, Infants, and Children). The questionnaire to the healthcare provider requested information on the age and up-to-date immunization status of the child according to the child's medical record, the type of facility, and the provider's position within the facility.

Although data on rotavirus vaccine and pneumococcal vaccine doses were collected for the NIS, these variables were excluded from this study's analysis because pneumococcal vaccine was not recommended by the CDC until 2001, and rotavirus vaccine was not recommended until 2002. Whereas, the children represented in the study were born and vaccinated between 1998 and 2001. To include these vaccines in the analysis would have caused the fully vaccinated sample to be significantly smaller and would have skewed the results.

This data set was obtained from the ICPSR website, for which all personal subject identifiers had been removed, and a unique household and child study number was assigned. The data were cleaned and edited prior to this data set being made publicly available.

**OUTCOMES OF INTEREST**

The outcome of interest in this study was a child's vaccination status, which was divided into 3 categories: fully vaccinated, undervaccinated, and selectively unvaccinated. There were 6 vaccines recommended by the CDC for children between birth and 18 months of age (a total of 16 shots): 4 DTaP vaccine doses, 3 polio vaccine doses, 1 MCV dose, 4 Hib vaccine doses, 3 hep B vaccine doses, and 1 varicella zoster vaccine dose. A child was defined as fully vaccinated if he/she had received all 16 recommended vaccine doses at the time data was collected for the 2002 NIS. If a child had received some but not all doses of the DTaP, polio, Hib, and/or hep B vaccines, and had or had not received the MCV and varicella doses, he/she was considered undervaccinated. And, a child who had either received no vaccine doses or had received all doses of some vaccines but zero doses of one or more specific vaccines, he/she was defined as selectively unvaccinated.
The primary variables of interest were maternal education level (median = high school graduate), household income (median = $35,001-$50,000), and the child's race/ethnicity (reference = non-Hispanic white). Based on results from previous literature, other variables that will be included in the univariate analysis are the child's age category, mother's age and marital status, number of children living in the household, and whether the family lives in a state that allows philosophical exemptions from school-entry immunization requirements.

**STATISTICAL ANALYSIS**

The data set, as it was obtained from the ICPSR website, had been cleaned and edited for public use. To test for outliers and missing variables, frequencies of each variable in the model were calculated, as well as minimum and maximum values for each. The data were also checked by NIS investigators for normal frequency distribution of all variables. The one variable that was manipulated and recoded for this study's purposes, vaccination status, was also checked for frequency distribution through skewness and kurtosis tests, and fell within the normal range (.68 and -.58, respectively).

A Pearson chi-square analysis was performed to test for significant relationships between a child's vaccination status and demographic characteristics between the three groups at a significance level of $\alpha = 0.05$. Additionally, frequencies of vaccine refusal for each of the CDC-recommended vaccines were calculated among the selectively unvaccinated group, as were frequencies of delayed vaccines among the undervaccinated sample.

In the multivariate logistic regression, selectively unvaccinated children were compared to fully vaccinated and undervaccinated children, which together were used as the reference category, and odds ratios and 95% confidence intervals were calculated. The same methods were used to compare undervaccinated children to fully vaccinated and selectively unvaccinated children. To test for confounding variables, the multivariate model was built by adding one variable at a time, beginning with the primary variable of interest, maternal education level. If the coefficient changed by the addition of a particular variable, that variable was removed from the model. To ensure model fit, $R^2$ and residual statistics were analyzed.
The study sample was weighted at the child level to account for the complex sample design of the NIS and was used to estimate vaccination coverage rates. All data were recoded using Microsoft Excel 2007 and analyzed using SPSS version 19.
CHAPTER 4

RESULTS

CHILDHOOD VACCINATION RATES

In 2002, an estimated 50.8% of 19- to 35-month-old children were fully vaccinated with all CDC-recommended childhood vaccines (4 DTaP doses, 3 polio doses, 1 MCV dose, 3 Hib doses, 3 hep B doses, and 1 varicella dose) in the United States. Undervaccinated children comprised 40.2% of the population. And, 9.0% of children were selectively unvaccinated and had either received no doses of any vaccine or had received all doses of some vaccines but no doses of one or more other vaccines.

The most commonly refused vaccines were the varicella zoster vaccine by a large margin, which was refused by 83.5% among the selectively unvaccinated sample (see Table 1). Rates of varicella vaccine refusal were distantly followed by measles-containing vaccines (18.0%) and hepatitis B vaccines (11.4%). While the least commonly refused vaccines was the DTaP vaccine, which was only refused by 7.0% of the selectively unvaccinated group.

Among the undervaccinated sample, children were most likely to be not up-to-date on the Hib vaccines (83.5%), followed by DTaP vaccines (40.9%), but were most commonly up-to-date on measles-containing vaccines (see Table 2).

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Refusals n (%)</th>
<th>Vaccine</th>
<th>Delays n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTaP</td>
<td>135 (7.0)</td>
<td>DTaP</td>
<td>3522 (40.9)</td>
</tr>
<tr>
<td>Polio</td>
<td>180 (9.4)</td>
<td>Polio</td>
<td>1772 (20.6)</td>
</tr>
<tr>
<td>Measles-containing</td>
<td>346 (18.0)</td>
<td>Measles-containing</td>
<td>1257 (14.6)</td>
</tr>
<tr>
<td>Hib</td>
<td>139 (7.2)</td>
<td>Hib</td>
<td>7192 (83.5)</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>219 (11.4)</td>
<td>Hepatitis B</td>
<td>1765 (20.5)</td>
</tr>
<tr>
<td>Varicella zoster</td>
<td>1604 (83.5)</td>
<td>Varicella zoster</td>
<td>2177 (25.3)</td>
</tr>
</tbody>
</table>
In the total study population and among each vaccination status sample, the highest proportion of study participants fell into the following categories: children with non-Hispanic white ethnicity, mothers who were married and were 30 years of age or older, mothers who had graduated high school but had not attended college, had annual household incomes greater than $50,000, and had 2 to 3 children under 18 years of age. Proportions of study participants differed among the three vaccination status samples for child gender, child age, and state of residence allowing philosophical exemptions from school-entry immunization requirements variables.

In chi-squared analysis of demographic differences among all vaccination status categories combined, each variable was found to be significantly related to vaccination status ($p<.0001$), which is also shown in Table 3. Therefore, each of these variables was included in the multivariate logistic regression model.

**Table 3. Weighted Percentages and $\chi^2$ Analysis of Demographic Characteristics by Up-to-Date Vaccination Status of Children Aged 19-35 Months Among Families With Adequate Provider Data**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total Population $n = 21,410$</th>
<th>Fully Vaccinated $n = 10,871$</th>
<th>Undervaccinated $n = 8617$</th>
<th>Selectively Unvaccinated $n = 1922$</th>
<th>$p$-value$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (SE)</td>
<td>% (SE)</td>
<td>% (SE)</td>
<td>% (SE)</td>
<td></td>
</tr>
<tr>
<td>Child Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>51.5 (0.6)</td>
<td>51.5 (0.8)</td>
<td>52.1 (0.9)</td>
<td>48.7 (1.9)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Female</td>
<td>48.5 (0.6)</td>
<td>48.5 (0.8)</td>
<td>47.9 (0.9)</td>
<td>51.3 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Child Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-23 Months</td>
<td>29.9 (0.5)</td>
<td>30.1 (0.7)</td>
<td>29.5 (0.8)</td>
<td>30.3 (1.8)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>24-29 Months</td>
<td>35.5 (0.5)</td>
<td>35.0 (0.8)</td>
<td>36.3 (0.8)</td>
<td>34.7 (1.7)</td>
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</tr>
<tr>
<td>30-35 Months</td>
<td>34.6 (0.5)</td>
<td>34.9 (0.8)</td>
<td>34.2 (0.8)</td>
<td>35.1 (1.8)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity of Child</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hispanic</td>
<td>24.4 (0.5)</td>
<td>24.8 (0.8)</td>
<td>23.4 (0.8)</td>
<td>25.9 (1.9)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>53.8 (0.6)</td>
<td>52.9 (0.8)</td>
<td>55.0 (0.9)</td>
<td>52.8 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>13.6 (0.4)</td>
<td>13.9 (0.6)</td>
<td>13.3 (0.6)</td>
<td>13.5 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic Other or Multiple Race</td>
<td>8.3 (0.3)</td>
<td>8.4 (0.4)</td>
<td>8.3 (0.5)</td>
<td>7.8 (0.9)</td>
<td></td>
</tr>
</tbody>
</table>

*(table continues)*
Table 3. (continued)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total Population $n = 21,410$</th>
<th>Fully Vaccinated $n = 10,871$</th>
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<th>Selectively Unvaccinated $n = 1922$</th>
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<tr>
<td></td>
<td>% (SE)</td>
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<td>% (SE)</td>
<td>% (SE)</td>
<td></td>
</tr>
<tr>
<td><strong>Age of Mother</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 19 Years</td>
<td>3.3 (0.2)</td>
<td>3.4 (0.3)</td>
<td>3.3 (0.4)</td>
<td>3.3 (0.7)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>20-29 Years</td>
<td>44.8 (0.6)</td>
<td>44.8 (0.8)</td>
<td>44.9 (0.9)</td>
<td>44.2 (1.9)</td>
<td></td>
</tr>
<tr>
<td>≥ 30 Years</td>
<td>51.8 (0.6)</td>
<td>51.8 (0.8)</td>
<td>51.8 (0.9)</td>
<td>52.5 (1.9)</td>
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</tr>
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<td><strong>Marital Status of Mother</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Married</td>
<td>70.6 (0.5)</td>
<td>70.1 (0.8)</td>
<td>71.0 (0.8)</td>
<td>71.5 (1.7)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Never Married</td>
<td>21.7 (0.5)</td>
<td>22.0 (0.7)</td>
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<td>Widowed/Divorced/ Separated</td>
<td>7.7 (0.3)</td>
<td>7.8 (0.5)</td>
<td>7.4 (0.5)</td>
<td>7.9 (1.0)</td>
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</tr>
<tr>
<td><strong>Education Level of Mother</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 12 Years</td>
<td>17.4 (0.5)</td>
<td>17.7 (0.7)</td>
<td>16.8 (0.7)</td>
<td>18.1 (1.6)</td>
<td>&lt;.0001</td>
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<td>12 Years</td>
<td>35.3 (0.6)</td>
<td>34.4 (0.8)</td>
<td>36.2 (0.9)</td>
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<tr>
<td>&gt; 12 Years, Not College Graduate</td>
<td>15.5 (0.4)</td>
<td>16.1 (0.5)</td>
<td>15.1 (0.6)</td>
<td>15.1 (1.4)</td>
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</tr>
<tr>
<td>College Graduate</td>
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<td>31.8 (0.7)</td>
<td>30.2 (0.7)</td>
<td>31.7 (1.5)</td>
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</tr>
<tr>
<td><strong>Household Income Category</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ $20,000</td>
<td>27.1 (0.6)</td>
<td>27.6 (0.8)</td>
<td>26.9 (0.9)</td>
<td>24.8 (1.7)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>$20,001-$35,000</td>
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<td>19.7 (0.7)</td>
<td>20.4 (0.8)</td>
<td>23.9 (1.9)</td>
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<tr>
<td>$35,001-$50,000</td>
<td>16.0 (0.4)</td>
<td>16.2 (0.6)</td>
<td>15.7 (0.6)</td>
<td>16.0 (1.3)</td>
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<tr>
<td>≥ $50,001</td>
<td>36.5 (0.5)</td>
<td>36.4 (0.8)</td>
<td>37.0 (0.8)</td>
<td>35.2 (1.7)</td>
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<tr>
<td><strong>Number of Children Living in Household</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Child</td>
<td>27.2 (0.5)</td>
<td>28.2 (0.7)</td>
<td>25.9 (0.7)</td>
<td>27.1 (1.6)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>2-3 Children</td>
<td>59.7 (0.6)</td>
<td>58.3 (0.8)</td>
<td>61.5 (0.8)</td>
<td>59.3 (1.8)</td>
<td></td>
</tr>
<tr>
<td>4+ Children</td>
<td>13.1 (0.4)</td>
<td>13.5 (0.6)</td>
<td>13.6 (0.6)</td>
<td>13.6 (1.3)</td>
<td></td>
</tr>
<tr>
<td><strong>State of Residency Allows Philosophical Exemptions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>50.3 (0.6)</td>
<td>50.7 (0.8)</td>
<td>50.9 (0.9)</td>
<td>45.1 (1.9)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>No</td>
<td>49.7 (0.6)</td>
<td>49.3 (0.8)</td>
<td>49.1 (0.9)</td>
<td>54.9 (1.9)</td>
<td></td>
</tr>
</tbody>
</table>

$^a$ Significance level set at $\alpha = .05$
FULLY VACCINATED VS. SELECTIVELY UNVACCINATED CHILDREN

When compared to fully vaccinated and undervaccinated 19- to 35-month-old children, selectively unvaccinated children were significantly more likely to be female than male (OR=1.12, 95% CI: 1.11, 1.13), to be in the 30-35 month age category than in the 19-23 month or 24-29 month categories, and more likely to be of Hispanic or non-Hispanic black ethnicity than to be non-Hispanic white (OR_{Hispanic}=1.29, 95% CI: 1.28, 1.30; OR_{black}=1.10, 95% CI: 1.09, 1.11) (Table 4).

Table 4. Logistic Regression of Demographic Characteristics by Vaccination Status Among Children Aged 19-35 Months With Adequate Provider Data

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Fully Vaccinated vs. Selectively Unvaccinated&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Undervaccinated vs. Selectively Unvaccinated&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Child Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
</tr>
<tr>
<td>Female</td>
<td>0.90 (0.89, 0.91)</td>
<td>0.88 (0.88, 0.89)</td>
</tr>
<tr>
<td><strong>Child Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-23 Months</td>
<td>1.00 (0.99, 1.01)</td>
<td>1.02 (1.01, 1.03)</td>
</tr>
<tr>
<td>24-29 Months</td>
<td>1.04 (1.03, 1.05)</td>
<td>1.08 (1.07, 1.09)</td>
</tr>
<tr>
<td>30-35 Months&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
</tr>
<tr>
<td><strong>Ethnicity of Child</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.80 (0.79, 0.80)</td>
<td>0.74 (0.73, 0.75)</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>0.93 (0.92, 0.94)</td>
<td>0.88 (0.87, 0.89)</td>
</tr>
<tr>
<td>Non-Hispanic Other or Multiple Race</td>
<td>1.04 (1.03, 1.05)</td>
<td>1.04 (1.03, 1.05)</td>
</tr>
<tr>
<td><strong>Age of Mother</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 19 Years</td>
<td>1.08 (1.06, 1.10)</td>
<td>1.23 (1.20, 1.26)</td>
</tr>
<tr>
<td>20-29 Years</td>
<td>1.02 (1.01, 1.03)</td>
<td>1.06 (1.05, 1.07)</td>
</tr>
<tr>
<td>≥ 30 Years&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
</tr>
<tr>
<td><strong>Marital Status of Mother</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
</tr>
<tr>
<td>Never Married</td>
<td>1.04 (1.03, 1.05)</td>
<td>1.02 (1.01, 1.03)</td>
</tr>
<tr>
<td>Widowed/Divorced/Separated</td>
<td>0.96 (0.95, 0.97)</td>
<td>0.90 (0.89, 0.91)</td>
</tr>
</tbody>
</table>

(table continues)
### Table 4. (continued)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>OR (95% CI)</th>
<th>Fully Vaccinated vs. Selectively Unvaccinated</th>
<th>Undervaccinated vs. Selectively Unvaccinated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Level of Mother</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 12 Years</td>
<td>0.98 (0.97, 0.99)</td>
<td>0.93 (0.92, 0.94)</td>
<td></td>
</tr>
<tr>
<td>12 Years</td>
<td>0.88 (0.87, 0.88)</td>
<td>0.95 (0.94, 0.96)</td>
<td></td>
</tr>
<tr>
<td>&gt; 12 Years, Not College Graduate</td>
<td>0.98 (0.97, 0.99)</td>
<td>0.96 (0.95, 0.97)</td>
<td></td>
</tr>
<tr>
<td>College Graduatea</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
<td></td>
</tr>
<tr>
<td>Annual Household Income</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ $20,000</td>
<td>1.13 (1.12, 1.15)</td>
<td>1.20 (1.19, 1.21)</td>
<td></td>
</tr>
<tr>
<td>$20,001-35,000</td>
<td>0.83 (0.82, 0.84)</td>
<td>0.90 (0.89, 0.91)</td>
<td></td>
</tr>
<tr>
<td>$35,001-50,000a</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
<td></td>
</tr>
<tr>
<td>≥ $50,001</td>
<td>0.99 (0.98, 1.00)</td>
<td>1.05 (1.04, 1.06)</td>
<td></td>
</tr>
<tr>
<td>Number of Children Living in Household</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Childa</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
<td></td>
</tr>
<tr>
<td>2-3 Children</td>
<td>0.96 (0.96, 0.97)</td>
<td>1.11 (1.11, 1.12)</td>
<td></td>
</tr>
<tr>
<td>4+ Children</td>
<td>1.14 (1.13, 1.15)</td>
<td>1.19 (1.18, 1.21)</td>
<td></td>
</tr>
<tr>
<td>State of Residency Allows Philosophical Exemptions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1.22 (1.21, 1.23)</td>
<td>1.22 (1.21, 1.23)</td>
<td></td>
</tr>
<tr>
<td>Noa</td>
<td>1.00 (1.00, 1.00)</td>
<td>1.00 (1.00, 1.00)</td>
<td></td>
</tr>
</tbody>
</table>

*Reference category

Of the maternal characteristics, selectively unvaccinated children were significantly more likely to have mothers who were 30 years or older than to have a mother younger than 30 years. They were 1.07 times more likely to have a mother who had been widowed, divorced, or separated than to have a married mother (95% CI: 1.06, 1.09). And, selectively unvaccinated children were most likely to have a mother who had 12 years of education (OR=1.10, 95% CI: 1.09, 1.11), but were also slightly more likely to have a mother who had attended some college (OR=1.03, 95% CI: 1.02, 1.04) or had less than 12 years of education (OR=1.04, 95% CI: 1.03, 1.06) than to have a mother who was a college graduate.

Selectively unvaccinated children were 1.16 times more likely to live in a household with an annual income between $20,001 and $35,000 (95% CI: 1.15, 1.17), but less likely to live in a household whose income was $20,000 or less (OR=0.86, 95% CI: 0.85, 0.87) or
greater than $50,000 per year (OR=0.98, 95% CI: 0.98, 0.99) than a household at the median income level ($35,001-$50,000). They were also significantly less likely to live in a household with more than one child under 18 years old than in a single-child household. Additionally, selectively unvaccinated children were less likely to live in state permitting philosophical exemptions from immunization requirements for school entry (OR=0.82, 95% CI: 0.81, 0.82).

**Undervaccinated vs. Selectively Unvaccinated Children**

Compared to fully vaccinated and selectively unvaccinated children, undervaccinated children were more likely to be male than female (OR$_{female}=0.96$, 95% CI: 0.96, 0.97). They were slightly more likely to be in the 19-23 month category (OR=1.02, 95% CI: 1.01, 1.02) and in the 24-29 month age category (OR=1.05, 95% CI: 1.04, 1.05) than in the 30-35 month category. And, they were less likely to be of Hispanic or non-Hispanic black ethnicity than to be of non-Hispanic white ethnicity (OR$_{Hispanic}=0.89$, 95% CI: 0.88, 0.89; OR$_{black}=0.93$, 95% CI: 0.93, 0.94).

Undervaccinated children were also 1.15 times more likely to have a mother who was 19 years or younger (95% CI: 1.14, 1.16) and 1.04 times more likely to have a mother between 20 and 29 years old (95% CI: 1.04, 1.05) than to have a mother 30 years or older. They were more likely to have a mother who was married than a mother who had never been married or was widowed, divorced or separated. And, undervaccinated children were significantly more likely to have a mother who had 12 years of education (OR=1.06, 95% CI: 1.05, 1.07) or who was a college graduate than to have a mother who had less than 12 years of education or had attended some college but did not graduate.

For household demographic characteristics, undervaccinated children were 1.08 times more likely to live in a household with an annual income of $20,000 or less but also 1.05 times more likely to be from a household with an income between $20,001 and $35,000 or with an income of more than $50,000 than to be from a household with the median income. They are also 1.15 times more likely to live in a household with 2 to 3 children and 1.07 times more likely to live in a household with 4 or more children than in a single-child household.
household. Finally, undervaccinated children were slightly more likely to live in a state that allows philosophical exemptions from school-entry immunization requirements than to live in a state that only allows medical and/or religious exemptions.
CHAPTER 5

DISCUSSION

The purpose of this study was to determine if a relationship exists between child, maternal, and household demographic characteristics and childhood vaccination status in 19- to 35-month-old children of 2002 National Immunization Survey participants. Univariate analysis showed a statistically significant relationship between each demographic variable in the model and the three vaccination status categories—fully vaccinated, undervaccinated, and selectively unvaccinated. Significant associations were also found when vaccination statuses were compared in multivariate analysis.

DEMOGRAPHICS AND VACCINATION STATUS

Results from multivariate analysis showed that, when compared to selectively unvaccinated children, fully vaccinated children tended to be male, to be in the 24-29 month age category, to be of non-Hispanic white ethnicity or of other/multiple races, to have a mother who is younger than 30 years of age, to have a mother who is either married or has never been married, to have a mother who is a college graduate, to live in a household whose annual income is either at the median level ($35,001-$50,000) or is $20,000 or lower, to live in a household with at least one other child, and to live in a state which allows philosophical exemptions from school immunization requirements.

Children who were undervaccinated were demographically similar to fully vaccinated children in every respect, except that undervaccinated children also tended to be in the 19-23 month age category, to live in a household whose annual income was greater than $50,000, and to live in a household with 2-3 children.

These results differ considerably from similar studies that also used NIS data to compare demographic characteristics related to vaccination status in children. Based on the previous research, it was expected that selectively unvaccinated children would have been of non-Hispanic white ethnicity, have mothers who were 30 years or older, had attended at least some college, to live in a household with an annual income greater than the median level, and
to live in a state that allows philosophical immunization exemptions. The one variable that matched results found in other studies was number of children living in the household. When compared to undervaccinated children, selectively unvaccinated children were more likely to live in single-child households than in households with 2 or more children.

The difference between this study's findings and the results of earlier works may lie in the method used to define each outcome category. Although most studies agree on the definition of a fully vaccinated child, they often differ in their definition of undervaccinated and unvaccinated status. While studies most similar to this have defined unvaccinated children as those who have received no vaccines, most other studies group the undervaccinated and unvaccinated samples into a single “not up-to-date” category. This study was unique in that it attempted to include children who were selectively unvaccinated, or who had received no doses of specific vaccines, in the same sample as children who had received no doses of any vaccine. However, this may have contributed to this study's results being incongruent with previous works.

The results of this study may have benefited from implementing a method used by Smith et al. (2004), in which the undervaccinated sample was further broken down into three categories: not up-to-date on all 6 vaccines, not up-to-date on 2-5 vaccines, and not up-to-date on only 1 vaccine. While this break down could have made it easier to see subtle differences between the selectively unvaccinated sample and varying levels of undervaccination, it was decided against for the sake of simplicity.

**STRENGTHS**

A significant strength of this study lies in the large, nationally representative sample. Despite removing subjects who did not have adequate provider data from the study population, 21,410 subjects were still included in the analysis, which contributed to the power of the study. Also, study subject vaccination records were confirmed by a healthcare provider using the child's medical record.

**LIMITATIONS**

A limitation of this study was that only subjects with adequate healthcare provider data were included in the analysis. Subjects who answered the household questionnaire, but
did not have a healthcare provider or refused contact to their provider by the study investigators, were removed from the study sample. However, these subjects were removed in order to eliminate recall bias by those answering the household survey, since only subjects with adequate provider data had vaccination records that were confirmed using the child's medical chart. Because the data for the removed subjects was distributed similarly to that of the subjects with adequate provider data, it was assumed that this would not affect the results of the study.

This study was also limited by the assumption that parents are vaccine refusers if their child has received no doses of one or more vaccines. Because only a single dose is required for a measles-containing vaccine and for the varicella vaccine, it is possible that subjects who, according to the outcome definitions of this study, were defined as selective vaccine refusers, but had in actuality chosen to delay these vaccinations. Earlier studies have shown measles-containing vaccines and varicella vaccines to be two of the most commonly refused among parents of young children. Therefore, based on the results of previous literature and because data for this study did not specify the reason doses of certain vaccines were not received, measles-containing vaccines and varicella vaccines were included in the definition for selectively unvaccinated status.

Conversely, the number of unvaccinated subjects may be an underestimate and not a true representation of the distribution of this population in the United States. Discussions of results from previous studies have suggested that because parents of unvaccinated children tend to have negative attitudes about vaccines in general, they may also be more likely to have negative feelings about vaccine surveys, and thus, not participate.

**IMPLICATIONS**

Although significant relationships between demographic characteristics and each vaccination status were found, the hypotheses—that selectively unvaccinated children have more highly educated mothers, live in households with an annual income higher than $50,000, and are of non-Hispanic white ethnicity—could not be accepted by the results of this study.

The tendency of selectively unvaccinated children to be of Hispanic or non-Hispanic black ethnicity could be related to results of some earlier studies, which found that these
populations are more likely to have concerns or negative attitudes about vaccine safety and efficacy. For example, Shui et al. (2006) found that Hispanic parents were 2.0 times more likely (95% CI: 1.5, 2.8) and black parents were 2.6 times more likely (95% CI: 1.8, 3.6) to report the highest level of concern about vaccine safety than were white parents.

Additionally, a study by Freed et al. (2009) found that Hispanic parents were 1.68 times more likely than non-Hispanic white parents to report concern over vaccine-related adverse effects (95% CI: 1.01, 2.79). However, this study also found that Hispanic parents were also to trust their doctor regarding vaccine recommendations (OR=2.5, 95% CI: 1.13, 5.16) and less likely to have ever refused a vaccine for their child (OR=0.47, 95% CI: 0.24, 0.93).

Other studies have also found vaccine safety perceptions to be related to maternal education level among mothers who refuse vaccines for their children, which may help to explain why selectively unvaccinated children were less likely to have mothers who were college graduates. In a study on parental attitudes and beliefs on child immunizations, Gust et al. (2008) found that the highest proportion of parents who had attended at least some college were in the “Immunization Advocate” cluster (42.2%), which was defined by a strong belief that vaccines are safe and important for overall child health. Another study by Gust et al. (2005) found that parents with less than 12 years of education were 4.1 times more likely (95% CI: 1.2, 14.4) than parents who had attended graduate school to report that they had not received enough immunization information. Furthermore, Smith et al. (2006) found that a significantly greater percentage of mothers with only 12 years of education were not influenced by their healthcare provider's recommendations and did not believe vaccines to be safe for their children than mothers with a college degree. While in multivariate analysis, Shui et al. (2006) found that parents with less than a high school education were 2.2 times more likely than parents with a college degree to report the highest level of vaccine safety concern (95% CI: 1.8, 3.6).

Some studies have also found lower income level to be significantly related to vaccine safety concerns. A 2004 study by Gust et al. found that underimmunized children were 2.7 times more likely (95% CI: 1.5, 4.6) to live in a household with an annual income under $30,000 than in a household whose income was $75,000 or more, which helps to support this study's results.
Future Research

Ideas for future research in the area of childhood vaccination rates could include methods to verify parental vaccine refusal either via a child's medical record or through additional questions on the NIS household questionnaire regarding whether certain vaccines were refused and reasons why. As the results of this study differ from results of previous studies on vaccine refusers, a possible supplemental study might look at the differences between children for whom specific vaccines were selectively refused and those for whom all vaccines were refused.

It would also be useful to study effective methods of childhood vaccine education among parents who refuse vaccines. Previous studies have tested the use of educational brochures and pamphlets on parents who have concerns about vaccine safety. One such study, which used a new intervention pamphlet developed by the CDC to answer frequently asked immunization questions, found that, “Overall, mothers expressed increased confidence and fewer concerns regarding multiple injections after reviewing the pamphlet” (OR=2.22, 95% CI: 1.26, 3.93) (Klein et al., 2009, p. 323).

Conclusion

While other studies have shown that parents who refuse all vaccines for their children tend to be white, more highly educated, and live in higher-income communities, the results of this study suggest that there may not be clear-cut demographic characteristics that define parents who selectively refuse vaccines. Consequently, there may not be specific populations for health promotion campaigns and healthcare providers to target in an effort to increase vaccine uptake. One characteristic refusing parents do share in common, based on conclusions from other studies, is a concern for vaccine safety and efficacy. In order to increase herd immunity within communities, it will be important in the future for healthcare providers to identify parents with fears about vaccine-related adverse effects.

While it is important for the good of the society that herd immunity is maintained in communities, it is essential that parents retain the autonomy to choose what they believe is best for their child's health. Thus, healthcare providers have a responsibility to ensure parents are educated on the risks and benefits of vaccination so they can make informed immunization decisions for their children. A study by Taylor et al. (1997) on the
immunization status of children followed by private providers concluded that “Individual provider behavior may be the most important determinant of the immunization status of children followed by private pediatricians” (p. 209).
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community in Germany after vaccine refusal and other vaccination delays. *Military Medicine, 173*(8), 776-779.


**WORKS CONSULTED**


