Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ April 22, 2011

Abbey Jones

Parental Attitudes and Beliefs Associated with Internet Use as a Source of Vaccine Information

By

Abbey M. Jones
Master of Public Health

Global Epidemiology

_____

Saad B. Omer, MBBS MPH PhD
Committee Chair

Parental Attitudes and Beliefs Associated with Internet Use as a Source of Vaccine Information

By

Abbey M. Jones

Bachelor of Arts
College of the Holy Cross
2007

Thesis Committee Chair: Saad B. Omer, MBBS MPH PhD

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Epidemiology
2011

Abstract

Parental Attitudes and Beliefs Associated with Internet Use as a Source of Vaccine Information

By Abbey M. Jones

Background: School immunization requirements have led to high immunization coverage rates among school-aged children and contributed to the success of vaccination as a public health intervention in the United States. However, vaccine refusal rates have increased in recent years, leading to the potential for outbreaks of vaccine-preventable diseases. Additionally, the internet has rapidly become a widely used source of information, including information on vaccines, but research has not been conducted to examine the factors associated with the use of the internet for vaccine information among parents. The objective of this study was to determine the attitudes and beliefs associated with the use of the internet as a source of vaccine information among parents of school-aged children.

Methods: Surveys were mailed to 1630 parent of fully vaccinated children and 815 parents of children with exemptions to one or more vaccine, and were returned by 56.1% of parents. Surveys asked respondents to identify information sources used for vaccine information. Respondents were asked about their perceptions of the accuracy of vaccine information sources and their beliefs on key issues related to vaccination.

Results: Internet use as a source of vaccine information was significantly higher among parents who did not view their child's healthcare provider as a reliable source of information on vaccines. Younger parents and parents with higher education levels were significantly more likely to use the internet for vaccine information, as were parents who were opposed to school immunization requirements. Parents who used the internet as a source of vaccine information were also significantly more likely to have lower perceptions of vaccine safety (OR, 1.66; 95% CI, 1.18-2.35) and vaccine effectiveness (OR, 1.83; 95% CI, 1.32-2.53) and lower perceptions of disease susceptibility (OR, 2.08; 95% CI, 1.49-2.90).

Discussion: Parents who used the internet were more likely to view vaccines as harmful or unsafe, and they were less likely to view vaccines as effective. Internet users were also less likely to believe that their child would benefit from vaccination. These findings indicate the need to reach internet users with accurate information regarding vaccines and vaccine-preventable diseases.

Parental Attitudes and Beliefs Associated with Internet Use as a Source of Vaccine Information

By

Abbey M. Jones

Bachelor of Arts
College of the Holy Cross
2007

Thesis Committee Chair: Saad B. Omer, MBBS MPH PhD

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Epidemiology
2011

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my family for their unconditional love and support of all of my academic pursuits.

I would like to thank my thesis advisor, Dr. Saad B. Omer, for providing me with both a project that I found truly interesting and the guidance needed to see this project to completion.

I would like to thank Jena Black for providing support and advice during the most hectic and stressful times of the past two year.

Finally, I would like to thank my friends, especially those who shared many long nights at school over the past semester.

Table of Contents

BACKGROUND

Vaccination

Vaccination has been one of the greatest achievements of public health, contributing to the reduction of infectious diseases globally and the prevention of over 2.5 million deaths worldwide each year [1, 2]. In the United States, vaccination has contributed to a 99% reduction in the number of deaths due to many vaccine-preventable diseases [3].

Nonmedical exemption claims, an indicator of vaccine refusal rates, have increased in recent years. This raises concern, as increases in exemption rates indicate an increase in the potential for outbreaks of vaccine-preventable diseases [4].

Vaccine Information Sources

The most frequently used source of vaccine information among parents is their child's primary healthcare provider, but many parents distrust their healthcare providers' advice or are not satisfied with the information they provide [5]. Research has shown that in addition to parental distrust, healthcare providers experience additional barriers to providing vaccine information, the most frequently reported of which was time constraints during primary care appointments [6].

For each vaccine that a healthcare provider administers, they must provide a vaccine information statement that contains information specific to that vaccine. These vaccine information statements have been shown to assist parents in vaccine decision making [7].

The Centers for Disease Control and Prevention, state and local health departments, and professional organizations are all sources that actively produce information on vaccines. These sources are commonly used by parents, and the content of the information from these sources can be assumed to be accurate, as they are all health based organizations and the content they produce is regulated. However, research has shown that parents also use a variety of sources for vaccine information from which the content is not regulated or monitored, such as other parents, religious organizations, media, and the internet [5].

The media has been shown to be an influential source of information in many studies, although the content of vaccine information in the media often not regulated for accuracy, and instead information presented by the media focuses mainly on getting and holding the attention of the intended audience [8, 9].

Internet Use

The internet has greatly altered the way that information is acquired and used. In the past decade, the internet has transitioned from functioning primarily as a source of static information through published websites to an interactive interface of user-based content. This transition, frequently referred to as the rise of “Web 2.0”, allows all internet users to contribute to the information base. Additionally, the rise of social networking sites has revolutionized the way that people interact, and enables people around the world to instantly share information.

However, this shift in the way that the internet is used has led to an increased ability for people to contribute to the information base on the internet without any

regulation of the content. This has major implications in the way that people are influenced by internet content, particularly when the accuracy and reliability of the information being accessed is unclear.

Internet as a Source of Vaccine Information

Internet use for health information has been increasing; a 2009 study by the National Center for Health Statistics found that 51% of adults had used the internet to search for health information within the previous year [10]. Vaccine information on the internet is greatly varied, and can range from highly regulated information from official sources to unregulated information published by unaffiliated organizations or individuals.

There are many reputable websites that provide vaccine information. The official website of the Centers for Disease Control and Prevention provides parents with accurate vaccine information and immunization statistics, as well as information about common vaccine misconceptions [11]. Many state and local health departments also have websites that contain accurate vaccine information [12]. The World Health Organization maintains a list of vaccine safety websites that meet credibility and content good information practices criteria; this list includes websites of both governmental and nonprofit organizations [13].

Analyses of vaccine information content have shown that information from the internet is more likely to contain anti-vaccine content than messages conveyed by other forms of media [14]. A study conducted in 2003 determined that a basic search on vaccinations was more likely to find anti-vaccination websites than websites that promote vaccination [15]. Research on the content of anti-vaccination websites found several

themes prevalent in many of these sites, including the dispute of vaccine safety and vaccine effectiveness, the discussion of vaccination and immunization requirements violating an individual's civil liberties, and a distrust of pharmaceutical companies, healthcare professionals, and government organizations [16].

INTRODUCTION

Vaccines are one of the most important public health interventions in reducing the burden of infectious disease [1, 2]. In the United States, the incidence of many vaccine-preventable diseases has been reduced by over 99% [3]. School immunization requirements have contributed to high immunization coverage rates among school-aged children, which has been an important factor in reducing disease transmission [17].

However, vaccine refusal rates have increased in recent years, as parents have chosen to claim nonmedical exemptions to school immunization requirements. Decreased immunization coverage leads to the potential for outbreaks of vaccine-preventable diseases, causing increasing exemption rates to be an issue of major concern [4].

Increasing exemption rates and the potential for reemergence of vaccine-preventable diseases in the United States highlight the need to effectively communicate accurate information on vaccination to parents. The most common source of vaccine information is primary healthcare providers, but research has shown that parents obtain vaccine information from a multitude of other sources as well [5].

The internet has rapidly become a widely used source of information, including information on vaccines. In the past decade, the rise of interactive content on the internet, frequently referred to as “Web 2.0”, has changed the way that people use the internet to access information. This has not only increased the potential audience base for internet based information, it has made it impossible to regulate the information that reaches parents searching for vaccine information. Much of the internet-based vaccine

information that reaches parents contains anti-vaccine content, which indicates a need to further identify parents that are using the internet and improve the content that they are receiving, both through the internet and through other information sources [14-16].

Although studies have been conducted to examine the use of health information sources for vaccine information and the content of vaccine information on the internet, there is little data on the characteristics of parents who use the internet for vaccine information. This study examines the parental attitudes and beliefs associated with internet use as a source of vaccine information.

METHODS

Target Population and Sample Participants

Participants were recruited from 112 private and public elementary schools, grades kindergarten through 5, that participated in a previous survey. Schools with 5 or more students with exemptions were chosen in four states, Colorado (n=25), Massachusetts (n=23), Missouri (n=34), and Washington (n=30). An earlier study had sampled 1,000 schools, including the 150 schools with the highest exemption rates per state, 50 schools with the lowest exemption rates per state, and 50 schools randomly selected from the remaining schools in each state. States were selected on their proportion of exemptions compared to other states (high, medium, and low) [18].

Up to thirteen children with exemptions were randomly selected from each of the 112 schools, resulting in a total of 815 children selected as cases. For each case, two fully vaccinated children were randomly selected from the same school and grade to be controls.

This study was approved by the Committee on Human Research at Johns Hopkins Bloomberg School of Public Health.

Survey Procedure

School nurses and personnel were trained by the study team through random selection procedures; school personnel were responsible for mailing survey packets to the

parents of selected children. An enclosed postcard was mailed to the school by the parents to indicate willingness to participate, and an enclosed disclosure letter was used to indicate consent to participate. Schools followed up with parents by mail and telephone calls. Parents mailed completed surveys directly to Johns Hopkins. Surveys sent to parents in Massachusetts were mailed in February 2002, and surveys sent to parents in Colorado, Missouri, and Washington were mailed in February 2003.

Surveys mailed to the parents of exempt children contained exemption specific questions to distinguish surveys completed by parents of children with exemptions from those completed by parents of fully vaccinated children; this allowed the researchers to identify students with exemptions without collecting any identifying information.

Survey Content

Surveys sent to the parents of children identified as having exemptions by the school included exemption specific questions; this allowed researchers to identify these students without collecting any identifying information. Parents of exempt children were asked to confirm that their child was missing at least one vaccine required by their school. They were also asked whether their child had received the complete number of doses for each vaccine. Parents were asked about the reasons for claiming exemptions, and those claiming medical exemptions were asked to provide the medical condition that prevented vaccination. Parents were asked to identify the type of medical professional (doctor/physician, physician's assistant, nurse, nurse practitioner, chiropractor, homeopathic doctor, or other) that served as their child's primary healthcare provider.

Parents were asked to identify which of 16 sources (healthcare provider's advice; Vaccine Information Statements; professional organizations; alternative healthcare providers; parents and friends; religious leaders and organizations; media; internet; local or state health departments; US Centers for Disease Control and Prevention; US Food and Drug Administration; vaccine companies; pharmacists; National Vaccine Information Center; Dissatisfied Parents Together; National Academy of Sciences, Institute of Medicine) they had used in the past to obtain information about vaccines. For each of these 16 vaccine information sources, respondents were also asked to use a 5-point Likert scale to indicate the quality of each as a source of accurate information about vaccines.

All parents were asked about ten diseases that had corresponding elementary school vaccination requirements (diphtheria, pertussis, tetanus, measles, mumps, rubella, polio, *Haemophilus influenzae* type b, varicella, and hepatitis B). All respondents were asked to use a 5-point Likert scale to identify the likelihood that an unimmunized child in the United States would get one of these diseases within the next ten years, the severity if an 8 year old were to get one of these diseases, the effectiveness of vaccines in protecting against these diseases, and the safety of the vaccines against these diseases.

All parents were asked to use 5-point Likert scales ("strongly disagree" to "strongly agree") to indicate their agreement with 11 questions measuring trust in healthcare professionals and 6 questions measuring trust in government. Parents were asked to use 5-point Likert scales ("strongly disagree" to "strongly agree") to respond to 14 questions on key immunization beliefs. Parents were also asked to use 5-point Likert scales ("not at all" to a "great deal") to respond to 5 questions on who benefits from

vaccination (the child, the community, doctors, the government, companies that make vaccines).

Respondents were asked to report their age (9 categories starting with “18-20 years”, continuing in five year intervals up to “61 or older”), highest level of education completed (4^{th} grade, 8^{th} grade, 12^{th} grade or GED certificate, some college, college graduate, or post-graduate), gross household income (7 categories starting with “under $20,000”, continuing in $10,000 intervals up to “over $70,000”), and race or ethnicity (white non-Hispanic, black non-Hispanic, Hispanic, Asian/Pacific Islander, Native American, and other). Respondents were also asked about their relationship to the child (mother, father, or other), the age of the child, and whether or not they had other children.

Surveys took approximately 30 minutes to complete.

Data Analysis

Parents were excluded from data analysis if their child was listed by the school as exempt but they indicated that their child was fully vaccinated. Parents were also excluded if their child had a valid, medical exemption.

Age, education, and income were dichotomized by their medians, as determined by combining cases and controls. Age was dichotomized into the median of “36-40 years” and younger compared to “41-45 years” and older. Education was dichotomized into the median of “some college” or less compared to “college graduate” and more.

Income was dichotomized into the median of “$60,000 - $69,999” or lower compared to “$70,000 and higher”. Race was dichotomized into white compared to all other races.

Perceptions of vaccine information sources were dichotomized into “good source” or “excellent source” compared to all other answers.

Constructs were created for disease susceptibility, disease severity, vaccine protectiveness, and vaccine safety by taking the mean score of the respondents assessments of each of the ten diseases or antigens mentioned. A construct score was created to assess the respondents’ trust in health care professionals by using the mean of eleven questions, and a construct score was created to assess the respondents’ trust in government by using the mean of six questions. All construct scores were dichotomized by comparing the lowest quartile of scores among all respondents to all higher scores.

Answers to question about key immunization beliefs were dichotomized into “strongly agree” or “agree” compared with all other responses. Answers to questions about vaccine benefits were dichotomized into “moderate amount” or “great deal” of benefit compared to all other responses.

Logistic regression models were used to compare differences in the independent variables between respondents who used the internet as a source of vaccine information and respondents who did not use the internet as a source of vaccine information, when controlling for exemption status. Stratified logistic regression models were created by stratifying on exemption status. Data was analyzed using SAS version 9.2 (SAS Institute Inc, Cary, NC).

RESULTS

Surveys were returned by 1367 (56.1%) of the 2435 parents of selected children, including 391 (48.6%) of 805 parents of children with exemptions and 976 (59.9%) of 1630 parents of fully vaccinated children.

Of the 391 parents of children that were identified by their school as having an exemption to one or more vaccines, 86 indicated that their child was fully vaccinated and these respondents were excluded from analysis. An additional 28 respondents that provided valid medical contraindications to vaccination were excluded; the remaining 277 parents of children with nonmedical exemptions were included in the analysis.

Among all respondents, 345 (27.5%) reported living in Colorado, 350 (27.9%) lived in Massachusetts, 249 (19.9%) lived in Missouri, 291 (23.2%) lived in Washington, and 6 (0.5%) reported living in a state other than these four. The majority of parents were between the ages of 31 and 45 (n=910, 72.6%). The majority of respondents reported their race as white (n=1094, 87.3%). Most respondents (n=1109, 88.5%) reported that their child saw a doctor as their primary healthcare provider.

The majority of respondents (n=997, 79.6%) reported using between 2 and 6 sources for information on vaccines, and only 4.4% (n=55) reported using a single information source. No respondents reported using the internet as their only information source. Among respondents who used the internet as a source of vaccine information, 83.1% (n=207) reported using five or more information sources; 29.7% (n=298) of respondents who did not use the internet reported using five or more information sources.

Among all respondents, the most commonly used source of vaccine information was the child's healthcare provider (n=1149, 91.7%), followed by Vaccine Information Statements (printed materials from healthcare providers) (n=1052, 84.0%) and parents/friends (n=674, 53.8%). The internet was reported as a source used for vaccine information by 19.9% (n=249) of all respondents.

Six vaccine information sources were identified by approximately three-quarters or more of respondents as good or excellent sources of information, including healthcare provider's advice (n=1004, 81.8%) and the US Centers for Disease Control and Prevention and the National Immunization Program (n=911, 81.6%). Among all respondents, 39.9% (n=425) reported that they view the internet as a good or excellent source of vaccine information.

Parents of children with non-medical exemptions for one or more vaccine were significantly more likely to use the internet as a source of vaccine information than parents of fully vaccinated children (37.9% vs 14.8%, respectively; $p<0.0001$). Parents of children with non-medical exemptions for one or more vaccine did not differ significantly from parents of fully vaccinated children in reporting the internet as an accurate source of vaccine information (42.1% vs 39.3%, respectively; $p=0.4389$). [This replicates a previous analysis of this data [19] .]

Respondents who used the internet as a source of vaccine information were significantly more likely to believe that the National Vaccine Information Center, previously known as Dissatisfied Parents Together, (odds ratio [OR], 1.69; 95% confidence interval [CI], 1.12-2.55) and alternative health care providers (OR, 1.55; 95%

CI, 1.12-2.14) were good or excellent sources of information. Internet users were less likely to report that healthcare providers (OR, 0.59; 95% CI, 0.42-0.85), Vaccine Information Statements (OR, 0.49; 95% CI, 0.35-0.69), professional organizations (OR, 0.56; 95% CI, 0.39-0.80), local or state health departments (OR, 0.60; 95% CI, 0.43-0.84), and the CDC (OR, 0.57; 95% CI, 0.39-0.83) were good or excellent sources of information on vaccination.

Respondents who reported that they were older than the median age (all respondents age 41 years or older) were significantly less likely to use the internet than the respondents who reported being 40 years or younger (OR, 0.72; 95% CI, 0.53-0.97). Respondents who reported their highest education level as above the median (college graduate or higher) were significantly more likely to use the internet as a source of vaccine information (OR, 1.49; 95% CI, 1.12-2.00). Higher household income ($70,000 or higher) was also significantly associated with internet use (OR, 1.41; 95% CI, 1.04-1.91). Parent's race and child's primary healthcare provider were not significantly associated with the use of internet as a source of vaccine information. In stratified analysis, higher parent education was found to be significantly associated with internet use among parents of fully vaccinated children (OR, 1.82; 95% CI, 1.27-2.60), as was higher household income (OR, 1.68; 95% CI, 1.16-2.44). Older parental age was negatively associated with internet use among parents of children with exemptions (OR, 0.59; 95% CI, 0.35-0.98).

Respondents that used the internet for vaccine information were significantly less likely to believe that vaccines strengthen the immune system (OR, 0.65; 95% CI, 0.46-0.92) or that immunization requirements protect children from getting diseases from

unimmunized children (OR, 0.44; 95% CI, 0.32-0.60), when compared to respondents who did not use the internet as a source of vaccine information. Respondents that used the internet were significantly more likely to believe that children get more immunizations than are good for them (OR, 2.88; 95% CI, 2.03-4.10), healthy children do not need immunizations (OR, 2.06; 95% CI, 1.28-3.31), immunizations do more harm than good (OR, 2.47; 95% CI, 1.60-3.81), parents should be allowed to send their children to school even if not vaccinated (OR, 2.21; 95% CI, 1.59-3.07), and be concerned that a child's immune system could be weakened by too many immunizations (OR, 1.74; 95% CI, 1.25-2.43) . Respondents who used the internet as a source of vaccine information were also significantly more likely to be opposed to immunization requirements because immunization requirements go against the freedom of choice (OR, 2.36; 95% CI, 1.64-3.39) and because parents know what is best for their children (OR, 2.68; 95% CI, 1.75-4.09). Respondents who used the internet as a source of vaccine information were significantly less likely to think that a child benefits from vaccination (OR, 0.39; 95% CI, 0.25-0.59). They were also significantly less likely to believe that the community, including the child's family, playmates, and neighbors, benefits from vaccination (OR, 0.53; 95% CI, 0.36-0.76).

Respondents who used the internet for vaccine information were significantly more likely to report low perceptions of disease susceptibility than respondents who did not use the internet as a source of vaccine information (OR, 2.08; 95% CI, 1.49-2.90). Low perceptions of vaccine protectiveness (OR, 1.83; 95% CI, 1.32-2.53) and vaccine safety (OR, 1.66; 95% CI, 1.18-2.35) were found to be associated with internet use for vaccine information. Low perceptions of disease severity, low trust in healthcare

provider, and low trust in government were not significantly associated with the use of the internet for vaccine information.

In stratified analysis, low perceptions of disease susceptibility was significantly associated with internet use among parents of fully vaccinated children (OR, 2.10; 95% CI, 1.37-3.24) and parents of children with nonmedical exemptions (OR, 2.04; 95% CI, 1.21-3.42). Low perceptions of vaccine protectiveness was also found to be significantly associated with internet use among parents of fully vaccinated children (OR, 1.71; 95% CI, 1.12-2.62) and among children with nonmedical exemptions (OR, 2.02; 95% CI, 1.21-3.37). Low perceptions of vaccine safety was significantly associated with internet use among parents of children with exemptions (OR, 1.86; 95% CI, 1.10-3.16), but not among parents of fully vaccinated children. Low trust in government was significantly associated with internet use among parents of children with nonmedical exemptions for one or more vaccine (OR, 1.91; 95% CI, 1.11-3.29), but not among parents of fully vaccinated children. Low perceptions of disease severity and low trust in healthcare were not significantly associated with internet use in stratified analysis.

DISCUSSION

The use of the internet as a source of vaccine information is significantly higher among parents of children with nonmedical exemptions than among children who have been fully vaccinated, but parents of fully vaccinated children are just as likely to report that the internet is a good or excellent source of information.

This analysis indicates a relationship between internet use and an acceptance of alternative views to traditional medicine. Among respondents in this survey, parents who used the internet as a source of vaccine information were more likely to view the advice of an alternative healthcare provider, such as a chiropractor or acupuncturist, as an accurate source of vaccine information. They were also more likely to view the National Vaccine Information Center, a nonprofit organization that has historically questioned the safety of vaccination, as an accurate source. Internet users were significantly less likely to view healthcare providers, professional organizations, and governmental health departments as an accurate source of information. This suggests that the internet is used as a source of vaccine information by parents who seek alternative opinions to traditional medicine.

Both younger parents and parents with higher levels of education were more likely to use the internet for vaccine information. It is possible that this association can be explained by higher internet use among younger parents and among parents with higher levels of education. However, it is also possible that younger parents and parents with higher levels of education are more likely to seek additional sources of information beyond a healthcare provider’s advice.

Parents who use the internet as a source of vaccine information were more likely to believe that immunizations are harmful to the child and can damage the child's immune system. These parents are also more likely to have negative views of immunization requirements, and they are less likely to see the benefits if vaccination on the child or the community.

An important finding in this analysis is that parents who use the internet for vaccine information have lower perceptions of disease susceptibility. This reflects a general decrease in the public's concern over vaccine-preventable diseases as they have become less common in the United States[20, 21], but also suggests that a lack of concern over preventable childhood diseases has motivated parents to seek information from additional sources. Parents who used the internet for vaccine information were also significantly more likely to have low perceptions of vaccine safety and protectiveness. Interestingly, in stratified analysis, the association between internet use and low perception of vaccine safety were only associated in the exempt group. This suggests that parents with concerns over the safety and usefulness of vaccines may seek information from sources to supplement other sources of information, such as their child's healthcare provider.

While this analysis cannot provide any information on the causality of these associations, it does help describe the parents who may be using the internet for vaccine information, and provide opportunities for improving vaccine information content, particularly in the context of new media. Moreover, it could be that the association between parental attitudes and use of the internet as an information source is bidirectional. On the one hand, the information on the internet may influence parental

attitude and behavior towards vaccines. On the other hand, it is possible that distrust of vaccination and disapproval of immunization requirements influence parents to use the internet as an alternative source of information.

One limitation of this analysis is the potential for non-response bias. While there is no way to measure non-response bias in this study, it is likely that parents who felt strongly about immunization were more likely to return the survey than those with neutral opinions. Additionally, the response rate among parents of fully vaccinated children was higher than the response rate among parents of children with exemptions, which could affect the results if factors influencing internet use differ between these two groups.

Another limitation of this study is that, in order to maintain confidentiality, information on schools was not collected, meaning that similarities of respondents within schools cannot be accounted for in this analysis. While this would not be likely to influence the overall effect estimates, it could have implications when calculating the precision of these estimates.

Additional limitations arise when generalizing the results of this study to a broader population. Because the study was conducted in only four states, Colorado, Massachusetts, Missouri, and Washington, it may be difficult to generalize these results to other parts of the country.

These data were collected before the rise of interactive information sources and social networking sites. As information has become easier to find on the internet, it is likely that parents who use the internet frequently have encountered vaccine information on the internet, whether they intended to or not. Therefore, data collected now that asks

simply about the use of the internet as a source of vaccine information has the potential to miss parents who actively seek out information on the internet. On the other hand, it is important to find out the characteristics of parents who actively seek information on the internet, as these parents may have a higher likelihood of being influenced by internet messaging. The analysis of this data is important because it provides information on parental attitudes and beliefs associated with parents who likely sought out vaccine information on the internet, and provides a baseline on parental internet use for vaccine information before the expansion of new media, interactive information sources, and social networking sites.

The results of this analysis have implications on the role of the internet in vaccine communication. Because internet use and nonmedical exemptions are significantly related, it is necessary for the content of internet-based vaccine information to best target the appropriate audiences, and knowing factors that predict internet use could be helpful in creating and marketing this content.

REFERENCES

1. *Impact of vaccines universally recommended for children--United States, 1990-1998.* MMWR Morb Mortal Wkly Rep, 1999. **48**(12): p. 243-8.
2. *Ten great public health achievements--United States, 1900-1999.* MMWR Morb Mortal Wkly Rep, 1999. **48**(12): p. 241-3.
3. Roush, S.W. and T.V. Murphy, *Historical comparisons of morbidity and mortality for vaccine-preventable diseases in the United States.* JAMA, 2007. **298**(18): p. 2155-63.
4. Omer, S.B., et al., *Nonmedical exemptions to school immunization requirements: secular trends and association of state policies with pertussis incidence.* JAMA, 2006. **296**(14): p. 1757-63.
5. Kennedy, A., et al., *Development of vaccine risk communication messages using risk comparisons and mathematical modeling.* J Health Commun, 2008. **13**(8): p. 793-807.
6. Davis, T.C., et al., *Childhood vaccine risk/benefit communication in private practice office settings: a national survey.* Pediatrics, 2001. **107**(2): p. E17.
7. Clayton, E.W., G.B. Hickson, and C.S. Miller, *Parents' responses to vaccine information pamphlets.* Pediatrics, 1994. **93**(3): p. 369-72.
8. Offit, P.A. and S.E. Coffin, *Communicating science to the public: MMR vaccine and autism.* Vaccine, 2003. **22**(1): p. 1-6.
9. Brown, K.F., et al., *Factors underlying parental decisions about combination childhood vaccinations including MMR: a systematic review.* Vaccine, 2010. **28**(26): p. 4235-48.
10. Cohen, R. and B. Stussman, *Health information technology use among men and women aged 18-64: Early release of estimates from the National Health Interview Survey, January-June 2009*, in *Heath E-Stats*. 2010, National Center for Health Statistics.
11. *Centers for Disease Control and Prevention: Vaccines & Immunizations.* Available from: http://www.cdc.gov/vaccines/.
12. *Centers for Disease Control and Prevention: MMWR - Public Health Resources: State Health Departments.* Available from: http://www.cdc.gov/mmwr/international/relres.html.
13. *World Health Organization: Vaccine safety web sites meeting credibility and content good information practices criteria.* 2011.
14. Davies, P., S. Chapman, and J. Leask, *Antivaccination activists on the world wide web.* Arch Dis Child, 2002. **87**(1): p. 22-5.
15. Wolfe, R.M. and L.K. Sharp, *Vaccination or immunization? The impact of search terms on the internet.* J Health Commun, 2005. **10**(6): p. 537-51.
16. Bean, S.J., *Emerging and continuing trends in vaccine opposition website content.* Vaccine, 2011. **29**(10): p. 1874-80.
17. Orenstein, W.A. and A.R. Hinman, *The immunization system in the United States - the role of school immunization laws.* Vaccine, 1999. **17 Suppl 3**: p. S19-24.

18. Salmon, D.A., et al., *Knowledge, attitudes, and beliefs of school nurses and personnel and associations with nonmedical immunization exemptions.* Pediatrics, 2004. **113**(6): p. e552-9.
19. Salmon, D.A., et al., *Factors associated with refusal of childhood vaccines among parents of school-aged children: a case-control study.* Arch Pediatr Adolesc Med, 2005. **159**(5): p. 470-6.
20. Chen, R.T. and B. Hibbs, *Vaccine safety: current and future challenges.* Pediatr Ann, 1998. **27**(7): p. 445-55.
21. Gellin, B.G., E.W. Maibach, and E.K. Marcuse, *Do parents understand immunizations? A national telephone survey.* Pediatrics, 2000. **106**(5): p. 1097-102.

TABLES

Table 1: Demographic Characteristics of Parents of School-Aged Children with and without Nonmedical Exemptions in a Four State Case-Control Study

Characteristics	n (%)
State	
Colorado	345 (27.53%)
Massachusetts	350 (27.93%)
Missouri	249 (19.87%)
Washington	291 (23.22%)
Other	6 (0.48%)
missing	*12 (0.96%)*
Parent's Age	
21-25	22 (1.76%)
26-30	127 (10.14%)
31-35	291 (23.22%)
36-40	334 (26.66%)
41-45	285 (22.75%)
46-50	119 (9.50%)
51-55	41 (3.27%)
56-60	8 (0.64%)
61 or older	5 (0.40%)
missing	*21 (1.68%)*
Parent's Highest Level of Education	
8^{th} grade	10 (0.80%)
High school graduate or GED certificate	216 (17.24%)
Some college (1-3 years)	396 (31.60%)
College graduate (4 years or more)	354 (28.25%)
Post-graduate	256 (20.43%)
missing	*21 (1.68%)*
Gross Household Income	
Under $20,000	65 (5.19%)
$20,000 - $29,999	86 (6.86%)
$30,000 - $39,999	128 (10.22%)
$40,000 - $49,999	138 (11.01%)
$50,000 - $59,999	123 (9.82%)
$60,000 - $69,999	106 (8.46%)
Over $70,000	451 (35.99%)
missing	*156 (12.45%)*
Parent's Race	
White, non-Hispanic	1094 (87.31%)
Hispanic	23 (1.84%)
Black, non-Hispanic	23 (1.84%)
Asian/Pacific Islander	16 (1.28%)
Native American	10 (0.80%)
Other	16 (1.28%)
missing	*71 (5.67%)*
Child's Primary Health Care Provider	
Doctor / Physician	1109 (88.51%)
Physician's Assistant	34 (2.71%)
Nurse or Nurse Practitioner	47 (3.75%)
Chiropractor	12 (0.96%)
Homeopathic Doctor	15 (1.20%)
Other	20 (1.60%)
missing	*16 (1.28%)*

Table 2: Perceptions of Vaccine Information Sources among Parents who did or did not use the Internet for Vaccine Information

	Good or Excellent Source n (%)			
Information Source	**Internet used as a source of vaccine information**	**Internet not used as a source of vaccine information**	**Unadjusted OR (95% CI)**	**Adjusted OR[a] (95% CI)**
Health-care provider's advice	170 (68.83%)	834 (85.10%)	**0.3865 (0.2802 – 0.5331)**	**0.593 (0.416 – 0.845)**
Printed materials from health-care provider (Vaccine Information Statements)	141 (58.02%)	785 (80.93%)	**0.3258 (0.2411 – 0.4402)**	**0.489 (0.348 – 0.687)**
Professional organizations, such as doctors/nurses' associations	130 (60.47%)	691 (79.98%)	**0.3829 (0.2780 – 0.5274)**	**0.560 (0.393 – 0.798)**
Alternative health care providers, such as chiropractors or acupuncturists	104 (50.00%)	271 (33.54%)	**1.9815 (1.4555 – 2.6978)**	**1.549 (1.119 – 2.144)**
Parents/Friends	82 (34.02%)	300 (32.29%)	1.0813 (0.8012 – 1.4594)	1.034 (0.758 – 1.409)
Religious leaders and organizations	13 (6.47%)	65 (8.02%)	0.7926 (0.4278 – 1.4683)	0.806 (0.428 – 1.517)
Media (TV, radio, newspapers, books, magazines)	77 (32.63%)	273 (29.55%)	1.1548 (0.8499 – 1.5692)	1.184 (0.864 – 1.624)
Local or state health departments	140 (59.57%)	729 (77.97%)	**0.4164 (0.3076 – 0.5638)**	**0.601 (0.431 – 0.837)**
US Centers for Disease Control and Prevention (CDC) and the National Immunization Program	154 (68.44%)	757 (84.96%)	**0.3839 (0.2744 – 0.5372)**	**0.571 (0.394 – 0.828)**
US Food and Drug Administration (FDA)	105 (50.24%)	526 (61.59%)	**0.6296 (0.4644 – 0.8534)**	0.831 (0.600 – 1.149)
Vaccine companies	54 (23.18%)	251 (28.75%)	0.7476 (0.5333 – 1.0480)	0.983 (0.690 – 1.401)
Pharmacists	107 (48.86%)	504 (56.76%)	**0.7279 (0.5412 – 0.9790)**	0.967 (0.705 – 1.327)
Internet	134 (56.30%)	291 (35.23%)	**2.3688 (1.7668 – 3.1760)**	**2.446 (1.803 – 3.317)**
National Vaccine Information Center	152 (77.95%)	600 (76.14%)	1.1076 (0.7604 – 1.6133)	**1.689 (1.120 – 2.547)**
Dissatisfied Parents Together (DPT)	46 (30.26%)	127 (19.66%)	**1.7734 (1.1927 – 2.6370)**	1.216 (0.791 – 1.869)
National Academy of Sciences, Institute of Medicine (IOM)	101 (66.01%)	432 (64.48%)	1.0701 (0.7391 – 1.5493)	1.223 (0.833 – 1.796)

a: Adjusted for exemption status

Odds Ratios in **Bold** p-value<0.05

Table 3: Demographic Characteristics as Predictors for Internet Use as a Source of Vaccine Information among Parents of School Aged Children

	n (%)					
	Internet used as a source of vaccine information	**Internet not used as a source of vaccine information**	**Unadjusted OR (95% CI)**	**Adjusted OR[a] (95% CI)**	**Stratified OR[b] (95% CI)**	**Stratified OR[c] (95% CI)**
Characteristics						
Older Parent Age[d]	80 (32.65%)	378 (38.30%)	0.7811 (0.5809 - 1.0505)	**0.717 (0.527 – 0.974)**	**0.587 (0.353 – 0.977)**	0.804 (0.549 – 1.177)
Higher Parent Education[e]	145 (58.23%)	465 (46.31%)	**1.6161 (1.2205 – 2.1399)**	**1.494 (1.119 – 1.995)**	1.031 (0.631 – 1.683)	**1.817 (1.268 – 2.602)**
Higher Household Income[f]	105 (47.51%)	346 (39.50%)	**1.3865 (1.0305 – 1.8655)**	**1.408 (1.038 – 1.910)**	0.986 (0.581 – 1.675)	**1.682 (1.157 – 2.444)**
Parent Race[g]	211 (92.14%)	883 (92.65%)	0.9293 (0.5419 – 1.5935)	0.784 (0.450 – 1.366)	0.708 (0.210 – 2.384)	0.806 (0.430 – 1.508)
Child's Primary Healthcare Provider[h]	39 (15.85%)	89 (8.98%)	**1.9095 (1.2729 – 2.8645)**	1.273 (0.825 – 1.963)	0.989 (0.560 – 1.750)	1.773 (0.949 – 3.313)
Child is exempt for one or more vaccines[i]	105 (42.17%)	172 (17.13%)	**3.5271 (2.6120 – 4.7628)**			

a: Adjusted for exemption status
b: Includes only parents of children with exemptions
c: Includes only parents of fully vaccinated children
d: Parent age is above the median (41 years or older) compared to younger
e: Parent's education level is above the median (college graduate or higher) compared to lower education levels
f: Total household income is above the median ($70,000 or higher) compared to lower household income
g: Parent's race is white compared to all other races/ethnicities
h: Child's primary healthcare provider is not a doctor (nurse, physician's assistant, chiropractor, homeopathic doctor, or other) compared to doctor/physician
i: Child has nonmedical exemption for one or more vaccine compared to fully vaccinated; odds ratios adjusted by exemption status or stratified on exemption status could not be calculated

Odds Ratios in **Bold** p-value<0.05

Table 4: Vaccination Beliefs as Predictors for Internet Use as a Source of Vaccine Information among Parents of School Aged Children

	n (%)[a]			
	Internet used as a source of vaccine information	**Internet not used as a source of vaccine information**	**Unadjusted OR (95% CI)**	**Adjusted OR[b] (95% CI)**
Key Beliefs (Agree or Strongly Agree)				
Children should only be immunized against serious diseases	152 (62.55%)	577 (60.36%)	1.0971 (0.8207 – 1.4667)	1.068 (0.792 – 1.439)
Children get more immunizations than are good for them	139 (59.91%)	246 (27.33%)	**3.9735 (2.9415 – 5.3675)**	**2.880 (2.026 – 4.095)**
I am concerned that children's immune system could be weakened by too many immunizations	140 (61.14%)	331 (38.67%)	**2.4950 (1.8498 – 3.3652)**	**1.744 (1.252 – 2.430)**
I am more likely to trust immunizations that have been around for awhile	180 (73.47%)	765 (78.62%)	0.7529 (0.5454 – 1.0394)	1.033 (0.732 – 1.458)
Immunizations are one of the safest forms of medicine ever developed	61 (26.29%)	350 (39.73%)	**0.5412 (0.3922 – 0.7468)**	0.733 (0.521 – 1.031)
Immunizations are getting better and safer all of the time, as a result of medical research	107 (46.52%)	526 (62.03%)	**0.5325 (0.3969 – 0.7145)**	0.745 (0.541 – 1.027)
Vaccines strengthen the immune system	65 (29.28%)	358 (45.96%)	**0.4869 (0.3530 – 0.6716)**	**0.651 (0.461 – 0.918)**
It is better for a child to develop immunity by getting sick than to get a vaccine	68 (29.82%)	150 (16.69%)	**2.1222 (1.5203 – 2.9623)**	1.310 (0.899 – 1.908)
Healthy children do not need immunizations	43 (17.55%)	52 (5.83%)	**3.7457 (2.4323 – 5.7683)**	**2.060 (1.281 – 3.312)**
Immunizations do more harm than good	56 (23.73%)	66 (6.95%)	**4.1623 (2.8167 – 6.1507)**	**2.468 (1.599 – 3.810)**
I am opposed to immunization requirements because they go against freedom of choice	90 (36.59%)	134 (13.79%)	**3.6079 (2.6275 – 4.9542)**	**2.359 (1.641 – 3.390)**
I am opposed to immunization requirements because parents know what is best for their children	56 (22.95%)	64 (6.54%)	**4.2586 (2.8791 – 6.2992)**	**2.675 (1.750 – 4.091)**
Immunization requirements protect children from getting diseases from unimmunized children	114 (48.51%)	690 (74.84%)	**0.3168 (0.2356 – 0.4259)**	**0.436 (0.317 – 0.601)**
Parents should be allowed to send their children to school even if not vaccinated	141 (58.26%)	286 (30.20%)	**3.2265 (2.4125 – 4.3151)**	**2.210 (1.589 – 3.073)**
Who Benefits from Vaccination (Moderate or Great Deal of Benefit)				
The Child	160 (68.38%)	849 (90.22%)	**0.2343 (0.1652 – 0.3323)**	**0.388 (0.254 – 0.593)**
The Community – family, child's playmates, people in the child's neighborhood	152 (64.96%)	792 (84.71%)	**0.3347 (0.2425 – 0.4619)**	**0.525 (0.364 – 0.757)**
The Doctor	120 (56.07%)	460 (55.96%)	1.0046 (0.7420 – 1.3602)	1.061 (0.776 – 1.451)
The Government	117 (58.79%)	448 (59.57%)	0.9682 (0.7047 – 1.3302)	0.975 (0.702 – 1.354)
The Companies that Make Vaccines	219 (92.41%)	807 (89.67%)	1.4021 (0.8283 – 2.3734)	1.172 (0.684 – 2.010)

a: Number and percent of respondents that "Agree or Strongly Agree" with key beliefs, or the number and percent of respondents that reported the child, community, doctor, government, or vaccine companies experience a "Moderate or Great Deal" of benefit from vaccination
b: Adjusted for exemption status

Odds Ratios in **Bold** p-value<0.05

Table 5: Disease, Vaccine, and Trust Constructs as Predictors for Internet Use as a Source of Vaccine Information among Parents of School Aged Children

	Lowest Quartile n (%)					
	Internet used as a source of vaccine information	**Internet not used as a source of vaccine information**	**Unadjusted OR (95% CI)**	**Adjusted OR[a] (95% CI)**	**Stratified OR[b] (95% CI)**	**Stratified OR[c] (95% CI)**
Diseases and Vaccines						
Disease Susceptibility[d]	108 (43.90%)	196 (20.40%)	**3.0546 (2.2704 – 4.1096)**	**2.076 (1.488 – 2.896)**	**2.037 (1.212 – 3.424)**	**2.103 (1.365 – 3.242)**
Disease Severity[e]	90 (36.73%)	227 (23.09%)	**1.9338 (1.4338 – 2.6080)**	1.349 (0.974 – 1.868)	1.215 (0.739 – 1.996)	1.457 (0.953 – 2.229)
Vaccine Protectiveness[f]	100 (40.98%)	203 (21.19%)	**2.5828 (1.9162 – 3.4812)**	**1.830 (1.323 – 2.532)**	**2.019 (1.211 – 3.367)**	**1.710 (1.117 – 2.617)**
Vaccine Safety[g]	98 (41.00%)	199 (21.24%)	**2.5776 (1.9065 – 3.4849)**	**1.664 (1.180 – 2.346)**	**1.861 (1.096 – 3.160)**	1.530 (0.965 – 2.425)
Trust in Healthcare	103 (41.87%)	348 (35.05%)	**1.3350 (1.0041 – 1.7750)**	1.251 (0.932 – 1.677)	1.457 (0.887 – 2.392)	1.151 (0.798 – 1.661)
Trust in Government	73 (29.55%)	236 (24.13%)	1.3191 (0.9674 – 1.7986)	1.296 (0.940 – 1.785)	**1.912 (1.112 – 3.287)**	1.044 (0.693 – 1.575)

a: Adjusted for exemption status
b: Includes only parents of children with exemptions
c: Includes only parents of fully vaccinated children
d: How likely an unimmunized child in the United States is to acquire vaccine-preventable diseases on a 5 point Likert scale (impossible to very likely) – mean for 10 diseases
e: How serious it would be if an 8-year old child acquired vaccine-preventable diseases on a 5 point Likert scale (not at all serious to very serious) – mean for 10 diseases
f: How protective vaccines are on a 5 point Likert scale (not protective at all to very protective) – mean for 10 vaccines
g: How safe children's vaccines are on a 5 point Likert scale (very unsafe to very safe) – mean for 10 vaccines

Odds Ratios in **Bold** p-value<0.05