Distribution Agreement

Signature:

____________________________ __________________

Chimora Ngozi Amobi Date

A Correlation Analysis between the Parent Attitudes about Childhood Vaccines Short Scale and the Vaccination Confidence Scale

By

Chimora Ngozi Amobi
Master of Public Health

Hubert Department of Global Health

____
Saad B. Omer, MBBS MPH PhD
Committee Chair

A Correlation Analysis between the Parent Attitudes about Childhood Vaccines Short Scale and the Vaccination Confidence Scale

By

Chimora Ngozi Amobi

MD
Windsor University School of Medicine
2013

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 the Hubert Department of Global Health
2018

Abstract

A Correlation Analysis between the Parent Attitudes about Childhood Vaccines Short Scale and the Vaccination Confidence Scale

By Chimora Ngozi Amobi

Background

Although vaccine-preventable diseases have been effectively controlled in the United States, vaccine refusal has caused recent outbreaks. Identifying vaccine-hesitant parents is important to deliver interventions that will boost vaccine acceptance and prevent progression to complete vaccine refusal. There is a need to identify an effective survey tool that can aid in classification of vaccine hesitancy among both parents of young children and parents of adolescents. The Parental Attitudes about Childhood Vaccines (PACV) survey has not performed well in the adolescent population but the Vaccination Confidence Scale (VCS) was developed for this population. This analysis assessed the correlation between both surveys.

Methods

By conducting a secondary analysis of baseline data collected for a Human Papillomavirus (HPV) vaccine uptake intervention trial, we assessed correlation using the Spearman correlation coefficient, the Cochran-Mantel-Haenszel statistic, and the Kappa coefficient. Logistic regression models were then developed to assess the associations between the PACV categories, the VCS categories and an outcome of the respondent's intent to vaccinate their daughter against HPV.

Results

1421 participants were included in the analysis. The PACV and VCS categories were strongly correlated with each other (Spearman correlation coefficient = 0.69, $p < .0001$), and the Cochran-Mantel-Haenszel test of association showed a significant relationship (CMH statistic = 797.81, df = 4, $p < .0001$). Both tools were also found to have similar associations with an intent to vaccinate against HPV, indicating similar abilities in classifying vaccine confidence.

Conclusion

The PACV short scale and VCS tools showed similar abilities in identifying and classifying vaccine-hesitant parents, as well as estimating intent to vaccinate against HPV among parents of female young children and adolescents. The PACV short scale is an effective tool. The VCS may be used effectively to assess vaccine confidence among parents of young children as well as parents of adolescents.

A Correlation Analysis between the Parent Attitudes about Childhood Vaccines Short Scale and the Vaccination Confidence Scale

By

Chimora Ngozi Amobi

MD
Windsor University School of Medicine
2013

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 the Hubert Department of Global Health
2018

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Dr. Saad Omer, my thesis advisor, for his invaluable guidance, support and constructive suggestions throughout the development of this research. I would also like to thank Ms. Avnika Amin for her enthusiastic encouragement and patient guidance at every stage of this research. This research would not have been possible without their support, sacrifice, and generosity. I also extend my profound gratitude to Dr. Robert Bednarczyk and Ms. Rachael Porter for their valuable insight and useful critiques of this work.

Finally, I wish to thank my family and friends for their unconditional love, immense support, consistent encouragement and constant sacrifice. I will be forever grateful.

TABLE OF CONTENTS

CHAPTER 1: REVIEW OF THE LITERATURE

Importance of Vaccination

It is widely known that vaccination has greatly reduced the burden of infectious diseases [1-5]. Few combinations of scientific development and large-scale delivery rival the impact that vaccines and associated immunization programs have had on human health and wellbeing [4]. Some claim that the only public health intervention that has a greater contribution to global health than vaccination, is the introduction of clean water and sanitation [1, 5]. The development of vaccination as a public health tool is attributed to Edward Jenner and his experiments with cowpox in 1796 [5, 6]. Vaccination was rapidly adopted as a public health tool in Europe and the United States, and was eventually made compulsory in the UK following the introduction of the Vaccination Act in 1871 [5]. Before the development and wide use of human vaccines, few people survived childhood without experiencing a litany of diseases, with thousands of children each year suffering or succumbing to life-threatening episodes of paralytic poliomyelitis, diphtheria, or bacterial meningitis caused by *Haemophilus influenzae* type b (Hib) or *Streptococcus pneumoniae* [4, 7]. In addition to the morbidity and mortality, the economic and social costs resulting from these diseases cannot be overemphasized. However, with the introduction of multiple vaccines in the 20th century and widespread use of vaccines, rates of vaccine-preventable diseases have declined globally; with the most extraordinary accomplishment related to vaccines and immunization programs being the global eradication of smallpox in 1980 [2-4, 8]. Currently, the WHO estimates that vaccination averts an estimated 2 to 3 million deaths every year [2, 7].

These successes are not just a result of the protection conferred on the vaccine recipient but is also due to the disruption of infection transmission. Vaccines do not only protect the vaccinated individual, but also protects the wider community [2]. This is the concept of herd immunity. Vaccine-preventable diseases are usually spread from person to person therefore, if an individual gets an infectious disease, he can spread it to other susceptible individuals in the community [3]. An individual who is immune to a disease can act as a barrier to stop or reduce the transmission of disease to other individuals [2]. This phenomenon is especially important for vulnerable groups who cannot be vaccinated including babies too young to be vaccinated, immune-compromised children, or individuals too old to have been vaccinated [2]. This shows that there is a collective social benefit of increased vaccination coverage.

In the United States, vaccine-preventable diseases, like pertussis, polio, measles, rubella and *Haemophilus influenzae*, were a major cause of death decades ago [3], but with widespread use of vaccines, most of these diseases have been effectively controlled [2, 3, 9, 10]. For example, an epidemic of Rubella in 1964-65 infected 12½ million Americans, killed 2,000 babies, and caused 11,000 miscarriages but since 2012, only 15 cases of rubella were reported to Centers for Disease Control and Prevention (CDC) [3]. For each U.S. birth cohort that receives a series of seven vaccines that protect against ten different diseases (diphtheria, pertussis, tetanus, measles, mumps, rubella, polio, Hib, hepatitis B, and varicella), an estimated 14 million disease episodes and 33,000 premature deaths are prevented [4, 11]. These vaccinations lead to an estimated $43 billion saved, including $9.9 billion in direct savings from medical costs and $33 billion saved indirectly through reduction in societal costs (e.g., from missed work) [4].

Vaccination Recommendations and Coverage in the United States

The Advisory Committee on Immunization Practices (ACIP) of the CDC, established in 1964, develops the U.S. immunization policy by reviewing relevant scientific information and developing evidence-based recommendations for the use of licensed vaccines for infants, children, adolescents, and adults [7, 12]. Some health professional organizations, including the American Academy of Pediatrics and American Academy of Family Physicians, also provide vaccination recommendations, which are usually incorporated into the Advisory Committee on Immunization Practices recommendations [4, 7, 12, 13]. The U.S. immunization system has evolved and expanded substantially since the 20th century. In 1985, the U.S. immunization system only covered seven childhood diseases: diphtheria, pertussis, tetanus, measles, mumps, rubella, and poliomyelitis [4]. Currently, sixteen vaccine-preventable diseases are targeted by pediatric vaccination and all adults are now recommended to receive influenza vaccination, with additional vaccines recommended for people with specific medical conditions, occupational, behavioral, or travel exposures [4]. Appendix 1 shows the current U.S. immunization recommendations for children and adolescents.

The CDC, U.S. Food and Drug Administration, other federal agencies, and vaccine resources in the public and private sectors, share the responsibility of ensuring vaccine safety [7]. The Vaccine Adverse Events Reporting System and post-licensure monitoring is used to detect previously unrecognized or rare adverse events, and to ensure that the safety profiles established in pre-licensing studies are reflected during use in the general population [7]. In 1986, the U.S. Congress passed a bill called the National Childhood Vaccine Injury Act to allow children to be compensated for vaccine damages without suing in state courts; to protect pharmaceutical companies from litigation; and to encourage vaccine makers to produce new vaccines [14]. Compensation for individuals who may have been injured by recommended vaccination is now provided through the National Vaccine Injury Compensation Program [15].

The National Immunization Survey (NIS) primarily provides estimates of vaccination coverage rates for U.S. children and adolescents at the national, state, and territorial levels [4, 7]. The NIS uses a random digit-dialing sample of landline and cellular telephone numbers to contact parents or guardians of children and adolescents for an interview [16, 17]. A survey is then mailed to all vaccination providers identified by the parent/guardian to collect dates and types of all vaccinations administered [16]. However, vaccination coverage estimates only represent vaccination data reported by the provider [17]. 2016 NIS data shows that for children aged 19–35 months, coverage with recommended vaccines continues to be high but remains below 90% for vaccines that require booster doses during the second year of life, and for some recommended vaccines like HepB birth dose, rotavirus, and HepA [17]. Coverage in 2016 was approximately 1–2 percentage points lower than in 2015, although this difference may be due to chance [17]. Kindergarten vaccination coverage for MMR, DTaP, and varicella vaccine, in the 2016-17 school year, each approached 95% [18]. The median non-medical exemption rate among kindergarteners was 2%; this rate has been relatively consistent since the 2011–12 school year [18]. Despite high overall vaccination rates, four states have reported coverage <90% for at least one vaccine, for 6 consecutive years [18]. It is also important to note that coverage within states can vary, with clusters of under-vaccinated kindergartners existing in states with high overall rates, serving as opportunities for outbreaks [18]. 2016 NIS data for adolescent vaccination coverage shows a sustained and continuous improvement in several areas [16]. For Human papillomavirus (HPV), however, ≥1-dose vaccination coverage among teens was just 60.4%, 22–28 percentage points lower than those for Tdap and ≥1-dose MenACWY, and only 43.4% were up to date with the recommended HPV vaccination series [16]. HPV vaccine coverage is also increasing more rapidly among males, with an increase of 3.4 to 6.2 percentage points during 2015 – 2016, compared to only a 2.8 percentage point increase in females [16]. There is a need to better understand the variations in HPV vaccine coverage and explore opportunities to improve HPV vaccination practices.

Vaccine Acceptance

Although vaccination has been shown to undoubtably reduce the burden of infectious diseases globally, a clamorous anti-vaccine lobby still thrives today, adversely affecting vaccine acceptance [1]. In 1866, the original anti-vaccination organization, Anti-compulsory Vaccination League, was established in the UK protesting mandatory smallpox vaccination [2]. In the U.S., opposition to vaccination was organized through the Anti-Vaccination League of America and the American Medical Liberty League between 1880 - 1900s because smallpox mandates were perceived as a violation of liberty [2, 8, 19]. Opposition to the smallpox vaccine in the 19th century, was due to concerns about its safety and efficacy [2]. This was not completely unfounded as the vaccine industry was largely unregulated at the time. In the 20th and 21st century, vaccine resistance has been attributed to reasons including safety concerns and suspicion of the government [2]. Anti-vaccination movements can now be found worldwide [20]. In lower income countries, mistrust of government powers is the prevalent reason for vaccine resistance [21]. However, safety concern is the major reason in high income countries. This fear about adverse effects of vaccines was fueled by questions arising about the connection between the DPT vaccine and permanent brain injury, and between the MMR vaccine and bowel symptoms and autism [2]. Subsequently, studies showed no connection between DPT vaccine and permanent brain injury, and the erroneous publication by Andrew Wakefield connecting MMR vaccine to autism was found to be fraudulent [2, 22]. Despite the fact that a panel at the Institute of Medicine unanimously determined, through a review of more than 200 epidemiological and biological studies, that there was no evidence of a causal relationship between MMR vaccine and autism, this belief is consistently one of the most important reasons for vaccine refusal [14, 23].

Although many childhood vaccine-preventable diseases have been effectively controlled in the U.S. [9, 10], public concerns about the safety of vaccines as well as public complacency regarding the need for vaccinations have been linked to recent outbreaks of vaccine-preventable diseases like measles [4, 24]. An example is the outbreak of measles originating from Disneyland in Anaheim, California in 2014, which was associated with 111 cases in seven US states, Canada, and Mexico [9, 25, 26]. Approximately half of the cases were among unvaccinated persons, and most of them were eligible for vaccination but intentionally remained unvaccinated [9, 25]. A 2013 study showed that approximately 1 in 8 children <2 years old in the U.S. were under-vaccinated due to parental choice and a majority of pediatricians report at least one vaccine refusal per month [8, 27].

Among adolescent vaccines, coverage for HPV vaccines is lower as more than one-third (36%) of parents, in a national survey, report declining HPV vaccination for their children, and in clinical practices, healthcare providers regularly encounter parents who are hesitant to accept HPV vaccines [28-30]. This prevalence is much higher than declination of other routinely recommended adolescent vaccines [29]. Findings from a 2016 study by Gilkey *et al*. suggests that HPV vaccine refusal may have become more common in recent years. This could be because providers are recommending HPV vaccination more often, thereby giving parents more opportunities to refuse, or it could actually reflect an increase in parents' concerns about the HPV vaccine [30]. Perceived susceptibility as well as concern about lasting health problems are prevalent reasons behind HPV vaccine refusal [30].

Importance of Identifying Vaccine Hesitancy

Vaccine-hesitant individuals are defined as a heterogeneous group in the middle of a continuum ranging from total acceptors to complete refusers [20]. The Strategic Advisory Group of Experts (SAGE) on Immunization working group, established in 2012, first defined “vaccine hesitancy” as: “a behavior, influenced by a number of factors including issues of confidence (do not trust vaccine or provider), complacency (do not perceive a need for a vaccine, do not value the vaccine), and convenience (access)” [20]. Depending on various factors, these individuals may refuse some but not all vaccines, delay vaccination, or even accept vaccines but still have concerns about the decision [20, 31]. The behavior of vaccine-hesitant individuals is complex, and the factors affecting vaccine hesitancy are highly variable [20]. Although many parents overwhelmingly accept vaccines, and a small number of parents unequivocally refuse all vaccines, many families fall between these extremes, expressing some level of vaccine hesitancy [8, 27]. Research, therefore, should not solely focus on individuals who refuse or delay vaccination but should also explore the large group who accept vaccines with hesitancy as they are vulnerable to misinformation and can easily be swayed to refuse vaccines [32]. Reasons for vaccine hesitancy differs depending on the vaccine or vaccines in question, the hesitant individuals or groups, and the context [33].

Theory can help explain actual practices relating to health behaviors and can also assist with behavior change [34, 35]. The Theory of Planned Behavior (TPB) is a popular model that has been shown to highly predict human action [34, 36] and has the ability to explain variance in intentions, behavior, and behavior change [37]. The Theory of Planned Behavior proposes that "attitudes, normative beliefs, and perceived behavioral control directly influence an individual's intentions to participate in a behavior" [34, 37]. Therefore, intention is the direct predictor of behavioral action while attitudes, normative beliefs, and perceived behavioral control are direct predictors of intention [37]. Attitude refers to the general feeling that the behavior is either favorable or unfavorable; normative belief is an estimate of the social pressure to either perform or not perform a behavior; perceived behavioral control is the belief in one's ability to perform the behavior [34]. According to this behavioral model, one must first produce changes in attitudes, normative beliefs, and perceived behavioral control, before changes in intentions can be produced [37]. This model, in the context of vaccine acceptance, shows that identifying and addressing an individual's attitudes, beliefs, and perceived behavioral control towards vaccination, may be more effective at predicting vaccine hesitancy and improving vaccine acceptance.

Currently, there is more research aimed at identifying strategies to effectively address vaccine hesitancy, in order to improve vaccine acceptance and consequently, vaccine coverage [8, 31]. Vaccine hesitancy is receiving increasing public health attention in countries around the world and public health authorities are looking for effective strategies to address it [38]. However, this cannot be achieved without first developing strategies to identify vaccine-hesitant parents because they comprise a much larger group than the complete refusers [39], and are potentially more amenable to behavior change because they are more likely to seek information from their child's provider about vaccines [31, 40]. Current efforts to change negative vaccination beliefs in order to prevent vaccine refusal, are hindered by a dearth of valid and reliable measures for identifying populations most at risk for these behaviors [41]. Therefore, the first step in tackling the issue of vaccine hesitancy in parents of children and adolescents is to identify parents in this group, and then measure their level of vaccine hesitancy before targeted intervention can be applied to improve their vaccination beliefs.

Existing Strategies to Classify Vaccine Hesitancy

As previously stated, vaccine hesitancy is on a continuum ranging from total acceptors to complete refusers. Some factors identified as determinants include attitudes and beliefs towards infectious diseases and vaccines, as well as others like accessibility, competing priorities, social norms, trust in health care providers and government, and compliance with provider recommendations and vaccination requirements for school or work [32]. Currently, strategies aimed at identifying individuals on this continuum and measuring vaccine hesitancy, focus on assessing attitudes and beliefs toward infectious diseases and towards vaccines used to prevent these diseases [32].

The ideal classification tool is one that is very brief so as to minimize participant burden and the considerable expense [41], easy to use in both research and clinical settings, easily understood by individuals with various educational backgrounds, widely validated in diverse demographic populations, effective across vaccine types [41], and can be used globally to allow comparability across countries [33].

Several cross-sectional surveys and studies examining determinants of vaccination decision-making have been used to measure vaccine hesitancy using a variety of methods [42]. These have resulted in a few proposed models of vaccine acceptance and resistance. One of these models is that developed by Gust *et al*. By analyzing 44 questions on the HealthStyles survey which assess attitudes and beliefs about immunization and health, Gust *et al*. identified five categories of parental attitudes regarding vaccination: the ”Immunization Advocates,” the “Go Along to Get Alongs,” the “Health Advocates,” the “Fencesitters” and the “Worrieds” [39]. Keane *et al*. classified parents into four distinct groups by using a survey with 56 attitude and belief statements. These groups are the “Vaccine Believer” parents who were convinced of the benefit of vaccination; the “Cautious” parents with high emotional investment in their child; the “Relaxed” parents with a less involved parenting style and some skepticism about vaccines; and the “Unconvinced” parents who distrust vaccinations and vaccination policy [43]. Also, using qualitative, open-ended interviews, Benin *et al*. categorized mothers into four categories: the “Accepters” who completely agreed with vaccination, the “Vaccine-hesitant” who accepted vaccination but still had significant concerns about them, the “Late Vaccinators” who either delayed vaccinating on purpose or only chose some vaccines and the “Rejecters” who entirely rejected vaccination [42, 44]. Differences between these models are evident showing that due to the complexity of this group, it is difficult to clearly picture the range of possible attitudes about vaccination [42].

Currently, there is no widely used, standardized tool to measure vaccine hesitancy but newer tools have been developed which show great promise. Among these tools are the Parent Attitudes about Childhood Vaccines survey developed by Opel *et al*., and the Vaccination Confidence Scale developed by Gilkey *et al*.

Parent Attitudes About Childhood Vaccines (PACV)

Developed in 2010, this survey tool aims to identify vaccine-hesitant parents and accurately assess parental vaccine hesitancy in research settings [31]. The PACV is a combination of de novo items and items borrowed or modified from existing surveys. The 15-item survey was developed using an iterative, qualitative approach, by conducting focus groups involving parents and pediatricians, and reads at a sixth grade level [31]. Four content domains are represented in the PACV questions: immunization behavior, beliefs about vaccine safety and efficacy, attitudes about vaccine mandates, and trust. Three groups of parents were identified by the PACV survey based on their summary scores: high hesitancy, medium hesitancy, and low hesitancy. The survey has been tested among parents of 19 – 35 month old children in a closed model HMO and was found to be valid and reliable instrument to identify vaccine-hesitant parents, although more research is needed to test the predictive validity of the PACV survey [45].

The PACV survey has not shown much success in the adolescent setting. A study conducted in Oklahoma and South Carolina among parents of adolescents aged 11 – 17 years failed to predict adolescent vaccine uptake at an office visit [46]. A five-item PACV short scale has been developed by Opel *et al*. as a more convenient tool. This condensed version of the PACV survey is easier to administer, can be integrated into the clinical setting, and can be used for national surveillance but requires further testing [47, 48].

Vaccination Confidence Scale (VCS)

The VCS was developed in 2014 as a composite measure to characterize vaccination beliefs particularly in parents of adolescents [49]. Data from an annual, population-based telephone survey, the National Immunization Survey-Teen, was used to develop an eight-item survey tool using exploratory and confirmatory factor analysis. These questions are divided into three factors assessing benefits of vaccination, harms of vaccination, and trust in healthcare providers, corresponding to some constructs of the Health Belief Model [49]. The response format for each of the VCS questions is an 11-point Likert scale (0 - "strongly disagree" to 10 - "strongly agree"), with summary scores ranging from 0 – 10. Using this scale, parents are classified into three categories: high confidence, medium confidence, and low confidence.

The VCS has been tested and validated among parents of adolescents and was found to be an efficient way to measure confidence in adolescent vaccination across demographic subgroups [41, 49]. It also shows promise as a tool for identifying parents at risk for refusing adolescent vaccines [41]. However, more research is needed to test the VCS in other populations, including parents of young children and younger adolescents.

Problem Statement

Vaccine hesitancy has become a significant issue in both developed and developing countries worldwide. In the United States, many vaccine-preventable diseases have been effectively controlled but, due to the potential for vaccine refusal and delay in vaccine-hesitant parents, the issue of vaccine hesitancy is a threat to current successes. Researchers are developing a variety of interventions to improve vaccine acceptance in vaccine-hesitant parents. However, the first step in this process is identifying individuals in this group and measuring their level of vaccine hesitancy in order to target interventions effectively. Although various tools show promise in measuring vaccine hesitancy in limited populations, there is no extensively validated tool that is widely used among both parents of young children and parents of adolescents. Therefore, there is a need to identify a tool that can be used to effectively measure vaccine hesitancy among both parents of young children and parents of adolescents.

Purpose

This analysis aims to assess the correlation between two existing vaccine acceptance surveys, the PACV short scale and the VCS, and to further validate these tools by assessing their association with an intent to vaccinate, in a more diverse population within the U.S.

Significance

If the PACV short scale is found to perform well, this will provide evidence for improving its utilization. Additionally, if both survey tools are found to be highly correlated, this will provide evidence for use of the VCS tool in parents of younger children as well as parents of adolescents.

CHAPTER 2: MANUSCRIPT

A Correlation Analysis between the Parent Attitudes about Childhood Vaccines Short Scale and the Vaccination Confidence Scale

Contribution of the student

For this manuscript, the student conducted all statistical analyses presented with guidance from Ms. Avnika Amin, created all figures and tables and wrote the manuscript with editorial assistance from Dr. Saad Omer, Ms. Avnika Amin, Dr. Robert Bednarczyk, and Ms. Rachael Porter. This manuscript is primarily intended for submission to the Vaccine journal.

Abstract

Background

Identifying vaccine-hesitant parents is important to deliver interventions that will boost vaccine acceptance and prevent progression to complete vaccine refusal. There is a need to identify an effective survey tool that can aid in classification of vaccine hesitancy among both parents of young children and parents of adolescents. The five-item Parental Attitudes about Childhood Vaccines (PACV) short scale is easier to administer, can be integrated into the clinical setting, and can be used for national surveillance but requires further testing and validation This analysis assessed the correlation between the PACV short scale and the Vaccination Confidence Scale.

Methods

By conducting a secondary analysis of baseline data collected for a Human Papillomavirus (HPV) vaccine uptake intervention trial, we assessed correlation using the Spearman correlation coefficient, the Cochran-Mantel-Haenszel statistic, and the Kappa coefficient. Logistic

regression models were then developed to assess the associations between the PACV categories, the VCS categories and an outcome of the respondent's intent to vaccinate their daughter against HPV.

Results

1421 participants were included in the analysis. The PACV and VCS categories were strongly correlated with each other (Spearman correlation coefficient = 0.69, $p < .0001$), and the Cochran-Mantel-Haenszel test of association showed a significant relationship (CMH statistic = 797.81, df = 4, $p < .0001$). Both tools were also found to have similar associations with an intent to vaccinate against HPV, indicating similar abilities in classifying vaccine confidence.

Conclusion

The PACV short scale and VCS tools showed similar abilities in identifying and classifying vaccine-hesitant parents, as well as estimating intent to vaccinate against HPV among parents of female young children and adolescents. The PACV short scale is an effective tool. The VCS may be used effectively to assess vaccine confidence among parents of young children as well as parents of adolescents.

Introduction

Vaccine-preventable diseases, like pertussis, polio, measles, rubella and *Haemophilus influenzae*, were a major cause of morbidity and mortality in the United States decades ago [3]. With the introduction of multiple vaccines to combat these diseases in the 20th century and with widespread use of vaccines, rates of vaccine-preventable diseases have declined [2, 3, 8]. In the U.S., most of these diseases have been effectively controlled [2, 3, 9, 10]. However, outbreaks of vaccine-preventable diseases have been reported in the U.S. in recent years [9]. This is largely due to vaccine refusal [9, 14]. Correct identification of vaccine-hesitant parents is an essential step in delivering interventions to promote immunization, thereby combatting vaccine refusal and its resultant effect on vaccine-preventable diseases [8, 38].

There is a need to identify an effective, standardized survey tool that can aid in classification of vaccine hesitancy among both parents of young children and parents of adolescents [33, 38, 47, 50]. When hesitant parents can be identified and classified, tailored intervention can then be delivered effectively to address their concerns and improve vaccine acceptance. This is crucial for the successful implementation of immunization programs around the world [8].

In recent years, several tools have been developed to measure vaccine hesitancy and acceptance [38, 50]. These tools include the Parental Attitudes about Childhood Vaccines (PACV) survey developed by Opel *et al*., and the Vaccination Confidence Scale (VCS) developed by Gilkey *et al*., which have shown promise among parents of young children and parents of adolescents, respectively [41, 48]. However, they have not been widely validated in diverse populations and thus, their utility is limited to the populations in which they have been tested [48]. The 15-item PACV survey has been tested in a limited population and shown to be predictive of under-immunization in young children [45, 48]. The condensed, five-item version of this survey (the PACV short scale) is easier to administer, can be integrated into the clinical setting, and can be used for national surveillance but requires further testing and validation [47, 48]. The eight-item VCS is a newer tool that shows promise in identifying parents at risk for refusing adolescent vaccines [41]. This tool, however, needs to be tested in parents of younger children and compared with the more established PACV survey.

This analysis aimed to assess the correlation between the PACV short scale and the VCS. We also sought to further validate these tools by assessing their association with intention to vaccinate, in a diverse population within the U.S. This will provide evidence for improving the utilization of the PACV short scale as a more concise but similarly effective tool. Additionally, this analysis assessed the validity of the VCS tool in parents of younger children, with a goal of improving its utilization in this population.

Methods

1. Study Population and Data Collection

This paper was based on secondary analysis of baseline data collected for a Human Papillomavirus (HPV) vaccine uptake intervention trial. Recruitment was conducted through Amazon Mechanical Turk web services, and screening and survey administration were conducted using SurveyMonkey. The sample selection and data collection methods are outlined in Porter *et al*.[51]. All data cleaning and analyses were conducted using SAS 9.4 (Cary, NC).

2. Survey Instrument

The relevant items from the survey instrument (Appendix 2) included questions from the Parent Attitudes about Childhood Vaccines (PACV) short scale survey, the Vaccination

Confidence Scale (VCS) survey, and demographic questions. The PACV questions on the survey instrument were adopted from the five-item PACV short scale survey developed by Opel *et al*. as a more concise version of the full 15-item PACV survey [31]. The VCS questions were adopted from the eight-item VCS survey developed by Gilkey *et al*. as an efficient measure of adolescent vaccination beliefs [49]. The additional demographic section included questions on respondent's age, gender, race, marital status, education level, household income, number of children, and age of oldest daughter under 18 years.

Each of the eight VCS questions received a score between 0 – 10. Two questions representing negative attitudes in the "Harms" factor ("Teenagers receive too many vaccines." and "If I vaccinate my teenager, he/she may have serious side effects.") were reverse coded according to methods used in the Gilkey *et al*. paper [41]. A summary score for each respondent was calculated by taking an average of all eight response scores. These summary scores were categorized into three ordinal categories: low confidence (≤6), medium confidence (>6 to 8), and high confidence (>8) [41].

Each of the five PACV questions received a score between 0 – 2. For question 1, a "Yes" response received a score of 0, "Don't know" received a score of 1 and "No" received a score of 2. For questions 2 – 4, a "Yes" response received a score of 2, "Don't know" received a score of 1 and "No" received a score of 0, since they represent negative attitudes. Summary scores for each respondent was calculated as the aggregate of all five individual scores, ranging between 0 – 10. These PACV summary scores were categorized as low hesitancy (0 – 4), medium hesitancy (5 – 6), and high hesitancy (7 – 10) [45]. For easier interpretation when assessing the correlation between the PACV and VCS categories, the PACV categories were then reversed to reflect vaccine confidence. Hence, the PACV categories used in this study were low acceptance (corresponds with high hesitancy), medium acceptance (corresponds with medium hesitancy), and high acceptance (corresponds with low hesitancy).

3. Statistical Analyses

Data collected from the survey were cleaned and analyzed using SAS 9.4. All demographic variables assessed on the survey instrument were included in the analysis. Respondent's age was dichotomized into 18 – 39 years and 40 years and above. Gender was reported as male, female, or undisclosed. Race was dichotomized into white and other race, which includes Hispanic, Latino or Spanish, Black or African American, Asian, American Indian or Alaska Native, and Native Hawaiian or Other Pacific Islander. Marital status was categorized as single, married, or other status, where "other status" includes widowed, divorced, and separated. Highest level of education was dichotomized as below college graduate, and college graduate and above. Age of oldest daughter under 18 years was categorized as 0 – 4, 5 – 8, and 9 – 18. The intent to vaccinate against HPV variable was categorized as yes, no, and don't know. The "yes" category included respondents who intended to have their daughters start the HPV vaccine, those who intended to have their daughters complete the HPV vaccine, and those whose daughters had received all three doses of the HPV vaccine. The "no" response included respondents who did not intend to have their daughters start or complete the HPV vaccine.

Descriptive statistics were calculated for all the variables to examine the characteristics of the sample population (Table 1). We used several parameters to assess the correlation and association between the PACV and VCS categories (Table 2). The Spearman correlation coefficient was used to assess correlation, the Cochran-Mantel-Haenszel statistic was used to assess association, and the Kappa coefficient was computed to assess the level of agreement. Descriptive statistics were then used to assess the characteristics of respondents whose scores matched in the Kappa test versus those who did not match (Supplement table). We created four separate logistic regression models, two multinomial (Models 1 and 2) and two binary models (Models 3 and 4), using the stepwise approach. This approach involved automatic addition or removal of variables in each step based on the prespecified criterion. The dependent variable for all the models was intent to vaccinate against HPV. In the multinomial models, the dependent variable had three levels (yes, no, and don't know) while the binary models had two levels (yes and no) with "don't know" level included in "no" (Tables 3 and 4). We included all the demographic variables as covariates in the model building process and those at significance of $p < 0.05$ were retained in the final models (Tables 3 and 4).

4. Ethics and Financial Disclosures

The Institutional Review Board of Emory University in the United States approved the study. There are no financial interests or conflict of interests to declare.

Results

Of the 16,474 individuals who were assessed for eligibility using Amazon Mechanical Turk, 1479 were eligible for participation and were invited to complete the survey. Of those, 58 participants were excluded due to incomplete survey responses. The final sample size used for analysis in this study was 1,421 participants. For model building, the sample size was 1,384 as 37 respondents were excluded due to incomplete data. Most respondents were female (n = 1,018, 71.6%), white (n = 1,129, 79.5%) and married or in a domestic partnership (n = 1,067, 75.1%). There was an even distribution of respondent's age in the two categories: 18 to 39 years (n = 765, 53.8%) and 40 years and above (n = 656, 46.2%). Highest level of education was also evenly distributed between the two categories with 53.3% (n = 757) of respondents having a college degree or higher and 46.7% (n = 664) having less than a college degree. 12.1% (n = 172) of respondents reported a household income of less than $25,000 per year while 19.1% (n = 271) earned above $100,000 per year. Most respondents reported the age of their oldest daughter under 18 years to be between 0 and 8 years old, with 44.1% (n =626) between ages 0 to 4, and 43.3% (n = 615) between ages 5 to 8 (Table 1).

A larger proportion of respondents were found to have high vaccine acceptance (n = 913, 64.3%), indicated by the PACV summary scores, compared to 22.0% (n = 312) with low vaccine acceptance. The VCS categories had a more even distribution with 41.6% (n = 591) showing high vaccine confidence and 25.8% (n = 367) showing low vaccine confidence. The majority of respondents indicated an intent to vaccinate their daughters against HPV (n = 834, 60.3%). Table 1 shows the demographic characteristics of the study sample and frequency distributions of all the variables used in the analysis.

The PACV and VCS categories corresponded well (Figure 1). 96.8% of respondents in the VCS-based high confidence category, were also in the PACV-based high acceptance category. 65.0% of respondents who were in the VCS-based low confidence category were also in the PACV-based low acceptance category (Figure 1).

The PACV and VCS categories were strongly congruent with each other (Spearman correlation coefficient = 0.69, $p < .0001$). A stronger correlation was observed when the analysis was performed with the continuous form of the PACV and VCS summary scores (Spearman correlation coefficient = -0.76, Pearson correlation coefficient = -0.79) compared to analysis using the categories. The Cochran-Mantel-Haenszel test of association showed a significant relationship between the PACV and VCS categories (CMH statistic = 797.81, df = 4, $p < .0001$). The Kappa test of agreement showed moderate agreement between the PACV and VCS categories (Simple Kappa coefficient = 0.45, $p < .0001$) (Table 2).

75% of parents in the PACV-based high acceptance category indicated an intent to vaccinate their daughters compared to 83% of parents in the VCS-based high confidence category (Table 3). Similarly, 78% of parents in the PACV-based low acceptance category did not intend to vaccinate or were unsure compared to 72% in the VCS-based low confidence category.

Model 1 adjusts for respondent's gender, race and number of children and Model 2 adjusts for respondent's gender, race, number of children and household income, according to the stepwise regression method. In Model 1, the odds of not intending to vaccinate against HPV were 28.5 times higher in those with PACV-based low vaccine acceptance compared to those with high vaccine acceptance (95% CI = 18.84, 43.22; p <.0001). The odds of not intending to vaccinate against HPV were 6.5 times higher in those with PACV-based medium vaccine acceptance compared to those with high vaccine acceptance (95% CI = 4.13,10.12; p <.0001). In Model 2, the odds of not intending to vaccinate against HPV were 39 times higher in respondents with VCS-based low vaccine confidence compared to those with high vaccine confidence (95% CI = 24.04, 63.39; p <.0001). The odds of not intending to vaccinate against HPV were 5.6 times higher in respondents with VCS-based medium vaccine confidence compared to those with high vaccine confidence (95% CI = 3.46, 9.00, p <.0001) (Table 3). Pseudo R^2 was used to assess goodness of fit: Model 1 R^2 = 0.2501 and Model 2 R^2 = 0.2761.

Model 3 adjusts for respondent's race and number of children and Model 4 adjusts for respondent's gender, race, number of children and household income. In Model 3, the odds of not intending to vaccinate against HPV were 12 times higher in respondents with PACV-based low vaccine acceptance compared to those with high vaccine acceptance (95% CI = 8.65, 16.70; p <.0001). The odds of not intending to vaccinate against HPV were 3.6 times higher in respondents with PACV-based medium vaccine acceptance compared to those with high vaccine acceptance (95% CI = 2.60, 5.05; p <.0001). In Model 4, the odds of not intending to vaccinate against HPV were 15.9 times higher in respondents with VCS-based low vaccine confidence compared to those with high vaccine confidence (95% CI = 11.33, 22.43; p <.0001). Respondents with VCS-based medium vaccine confidence had 4.8 times higher odds of not intending to vaccinate against HPV compared to those with high vaccine confidence (95% CI =

3.55, 6.44; $p <.0001$) (Table 4). The Area Under the Curve (AUC) and Hosmer-Lemeshow (HL) test were used to assess goodness of fit: Model 3 AUC = 0.7502; Model 4 AUC = 0.7827; Model 3 HL = 6.5558, p-value <.0001; Model 4 HL = 3.1999, p-value <.0001).

Discussion

The PACV and VCS scales were strongly correlated with each other. The categories from the two scales corresponded well with each other, particularly the high and low categories (Figure 1). They were also found to have similar associations with an intent to vaccinate against HPV, indicating similar abilities in classifying vaccine confidence. The Kappa statistic indicated moderate agreement and on further exploration, there was a significant difference in parent's gender, race and number of children for the respondents whose confidence categories matched compared to those who did not (Supplement table). This finding, in addition to gender, race and number of children being significant predictors in the models, indicates that these demographic variables are important in explaining intent to vaccinate against HPV in parents of girls, and provides evidence for more research in this area.

It is important to note that a stronger correlation was observed when the PACV and VCS scores were in the continuous form compared to the categorical form (Table 2). This may indicate that the categories may show better agreement if the thresholds for high, medium and low are adjusted. In the models, both tools seemed to explain intent to vaccinate against HPV similarly (Tables 3 and 4). Both models also fit the data to a similar degree, shown by their similar goodness of fit statistics. This means that both tools are comparable in their ability to estimate intent to vaccinate against HPV in parents of female young children and adolescents. However, the PACV models were more parsimonious and may therefore be better. On exploration of the intent to vaccinate responses of “I don’t know” and “No”, the results from the binary models were quite different from the multinomial models where all the levels of the outcome were accounted for. This shows that respondents who are unsure of intending to vaccinate their daughters against HPV are different from those who do not intend to vaccinate and should be treated as a separate group. This is not surprising as parents in the “unsure” group are on varying levels of the vaccine hesitancy continuum. In this study, an appreciable number of respondents were unsure of their intent to vaccinate (21.5%). This is consistent with other studies like Gust *et al*. where 13.2% of respondents were “Fencesitters” [39]. This may be an important population to focus on, to ensure they don’t become vaccine refusers.

Strengths of this study include the online mode of data collection, which helped reduce information bias that may have otherwise occurred due to social desirability. Additionally, our study is generalizable to U.S. parents with daughters under 18 years old, as studies have found that populations accessed through Amazon Mechanical Turk are at least as representative to the U.S. population as traditional subject pools.[51-54] A limitation of this study is that we assessed intent to vaccinate, which may not always correlate with actual vaccination practices. Also, with the self-report design, there is a chance for information bias but as earlier stated, we expect this to be minimal due to the online mode of data collection. Another limitation is the inclusion of parents of young children in a study assessing intent to vaccinate against HPV. Since these parents are not making the decision at this time, their present intent may not reflect future intent or practice. However, since this limitation is non-differential for both tools, we do not expect this limitation to affect our findings.

Conclusion

The PACV short scale and VCS tools showed similar abilities in identifying and classifying vaccine-hesitant parents, as well as estimating intent to vaccinate against HPV among parents of female young children and adolescents. Although the PACV did not perform well in the adolescent population in a previous study [46], these results lend credence to the utility of the PACV short scale as an effective tool to classify vaccine hesitancy, even when assessing adolescent vaccinations. It also shows that the VCS can be used effectively to assess vaccine confidence among parents of young children as well as parents of adolescents. More research is needed in exploring how parent's gender, race and number of children are associated with vaccine hesitancy, and to explore the needs of parents who are unsure of their intent to vaccinate. Research should also focus on validating these tools against actual vaccination events.

Tables and Figures

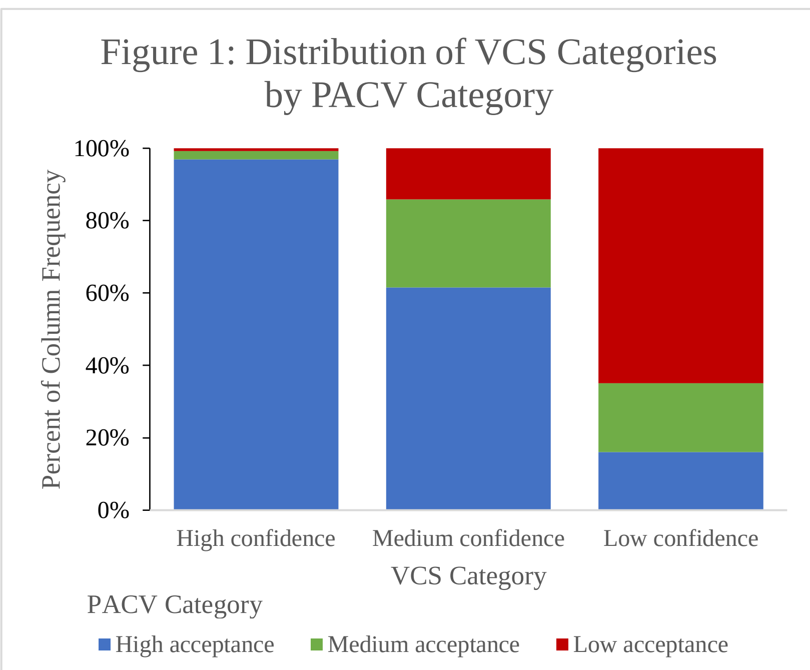
Table 1: Demographic Characteristics of Study Sample (N = 1421)

Characteristics	n	(%)
Respondent’s age (years)		
18 – 39	765	(53.8)
≥ 40	656	(46.2)
Respondent’s gender		
Male	390	(27.4)
Female	1018	(71.6)
Undisclosed	13	(0.9)
Race		
White	1129	(79.5)
Other*	292	(20.6)
Marital Status		
Married/Domestic partnership	1067	(75.1)
Single, never married	128	(9.0)
Other†	226	(15.9)
Education Level		
Less than college graduate	664	(46.7)
College graduate and above	757	(53.3)
Household Income (USD)		
<25,000	172	(12.1)
25,000 – 49,999	407	(28.6)
50,000 – 74,999	309	(21.8)
75,000 – 99,999	262	(18.4)
≥100,000	271	(19.1)
Number of Children		
1	222	(15.6)
2	562	(39.6)
3	327	(23.0)
≥4	310	(21.8)
Age of oldest daughter <18 (years)	626	(44.1)
0 – 4	615	(43.3)
5 – 8	180	(12.7)
9 – 18		
PACV Score		
Low	312	(22.0)
Medium	196	(13.8)
High	913	(64.3)

VCS Score		
Low	367	(25.8)
Medium	463	(32.6)
High	591	(41.6)
Intent to Vaccinate‡		
Yes	834	(60.3)
No	253	(18.3)
I don't know	297	(21.5)

*Includes African American, Asian, Hispanic, American Indian, Hawaiian and Multi-race
† Includes widowed, divorced and separated
‡37 observations were missing
PACV – Parent Attitudes about Childhood Vaccines
VCS – Vaccination Confidence Scale

Figure 1: Distribution of VCS Categories by PACV Category



PACV – Parent Attitudes about Childhood Vaccines
VCS – Vaccination Confidence Scale

Table 2: Summary of Correlation Analysis between the Parent Attitudes about Childhood Vaccines Short Scale and the Vaccine Confidence Scale Categories

Statistic name	Statistic value	p-value
Spearman correlation coefficient		
With continuous form	-0.76	<.0001
With categorical form	0.69	<.0001
Pearson correlation coefficient	-0.79	<.0001
Cochran-Mantel-Haenszel statistic	797.81	<.0001
Simple Kappa coefficient	0.45	<.0001
Weighted Kappa coefficient	0.56	<.0001

Table 3: Multinomial regression: Associations between intention to vaccinate responses "No" and "Don't Know", as compared to "Yes", and respondent's PACV and VCS categories.

Model number	Effect	N = 1384*			No vs. Yes			Don't know vs. Yes		
		Yes	No	Don't know	Odds Ratio	95% Confidence Interval	p-value	Odds Ratio	95% Confidence Interval	p-value
Model 1	**PACV category†**									
	High acceptance	677	63	161	1.00	-	-	1.00	-	-
	Medium acceptance	92	48	50	6.46	4.13, 10.12	<.0001	2.56	1.73, 3.79	<.0001
	Low acceptance	65	142	86	28.54	18.84, 43.22	<.0001	6.44	4.40, 9.41	<.0001
Model 2	**VCS category‡**									
	High confidence	487	29	70	1.00	-	-	1.00	-	-
	Medium confidence	248	66	136	5.58	3.46, 9.00	<.0001	4.37	3.12, 6.13	<.0001
	Low confidence	99	158	91	39.04	24.04, 63.39	<.0001	7.91	5.30, 11.81	<.0001

*37 respondents with missing observations for intent to vaccinate were excluded

†Adjusting for respondent's gender, race and number of children

‡Adjusting for respondent's gender, race, number of children and household income

PACV – Parent Attitudes about Childhood Vaccines

VCS – Vaccination Confidence Scale

Table 4: Binary regression: Associations between no reported intention to vaccinate as compared to reported intent to vaccine and respondent's PACV and VCS categories.

Model number	Effect	N = 1384*		Odds Ratio	95% Confidence Interval	p-value
		Yes	No			
Model 3	**PACV category**†					
	High acceptance	677	224	1.00	-	-
	Medium acceptance	92	98	3.62	2.60, 5.05	<.0001
	Low acceptance	65	228	12.02	8.65, 16.70	<.0001
Model 4	**VCS category**‡					
	High confidence	487	99	1.00	-	-
	Medium confidence	248	202	4.78	3.55, 6.44	<.0001
	Low confidence	99	249	15.94	11.33, 22.43	<.0001

*37 respondents with missing observations for intent to vaccinate were excluded

†Adjusting for respondent's race and number of children

‡Adjusting for respondent's gender, race, number of children and household income

PACV – Parent Attitudes about Childhood Vaccines

VCS – Vaccination Confidence Scale

Supplement: Descriptive Statistics of Respondents with Matched vs. Unmatched Vaccine Confidence/Acceptance Categories

Characteristics	**Unmatched Scores (Total = 495) n (%)**	**Matched Scores (Total = 926) n (%)**	**p-value**
Respondent's age (years)			0.78
18 – 39	269 (54.3)	496 (53.6)	
≥ 40	226 (45.7)	430 (46.4)	
Respondent's gender			<.0001
Male	177 (35.8)	213 (23.0)	
Female	315 (63.6)	703 (75.9)	
Undisclosed	3 (0.6)	10 (1.1)	
Race			<.0001
White	364 (73.5)	765 (82.6)	
Other*	131 (26.5)	161 (17.4)	
Marital Status			0.76
Married/Domestic partnership	373 (75.4)	694 (75.0)	
Single, never married	41 (8.3)	87 (9.4)	
Other†	81 (16.4)	145 (15.7)	
Education Level			0.55
Less than college graduate	226 (45.7)	438 (47.3)	
College graduate and above	269 (54.3)	488 (52.7)	
Household Income (USD)			0.59
<25,000	66 (13.3)	106 (11.5)	
25,000 – 49,999	144 (29.1)	263 (28.4)	
50,000 – 74,999	109 (22.0)	200 (21.6)	
75,000 – 99,999	92 (18.6)	170 (18.4)	
≥100,000	84 (17.0)	187 (20.2)	
Number of Children			0.002
1	69 (13.9)	153 (16.5)	
2	226 (45.7)	336 (36.3)	
3	113 (22.8)	214 (23.1)	
≥4	87 (17.6)	223 (24.1)	
Age of oldest daughter <18			0.34
(years)	218 (44.0)	408 (44.1)	
0 – 4	206 (41.6)	409 (44.2)	
5 – 8	71 (14.3)	109 (11.8)	
9 - 18			

*Includes African American, Asian, Hispanic, American Indian, Hawaiian and Multi-race
† Includes widowed, divorced and separated

CHAPTER 3: CONCLUSION AND PUBLIC HEALTH IMPLICATIONS

The PACV short scale and VCS tools showed similar abilities in identifying and classifying vaccine-hesitant parents, as well as estimating intent to vaccinate against HPV among parents of female young children and adolescents. The PACV survey was developed primarily for use in parents of young children. A previous study tested a modified version of the PACV survey in the context of adolescent vaccinations and although the tool identified vaccine hesitancy, it failed to predict adolescent vaccine uptake [46]. Our analysis indicates that the PACV short scale is an effective tool to identify and classify vaccine hesitancy even in the context of adolescent vaccinations. The PACV categories were also associated with the intention to vaccinate against HPV. This finding is consistent with the research conducted by Oladejo *et al*., where the PACV short scale was also found to be effective. This further validates the short scale and provides evidence for its adoption as a more convenient tool for use in both clinical and research settings. However, more research is needed to ascertain how the tool predicts actual vaccination practice.

The VCS survey was originally developed for use in assessing parent's confidence in adolescent vaccinations. The strong correlation observed between the VCS and the PACV survey tools indicates that the VCS can be used effectively to assess vaccine confidence among parents of young children as well as parents of adolescents. Being an eight-item tool, it is also brief and can conveniently be used in various clinical and research settings. As with the PACV short scale, more research is also needed to assess its prediction of actual vaccination practice. These tools, if adopted in healthcare settings, can aid providers to quickly identify and classify vaccine-hesitant parents in the clinic using a single tool regardless of the vaccine type. Targeted interventions can then be delivered to this group of parents to help improve their acceptance of vaccination and prevent them from progressing to complete vaccine refusal. If widely implemented, this will have substantial implications as an increase in vaccine acceptance will cause vaccine uptake to improve, subsequently leading to an increase in vaccine coverage.

Further recommendations for research include exploring how parent’s gender, race and number of children are associated with vaccine hesitancy, testing these tools internationally in different geographical settings, and exploring the needs of parents who are unsure of their intent to vaccinate.

REFERENCES

1. Andre, F.E., et al., *Vaccination greatly reduces disease, disability, death and inequity worldwide.* Bulletin of the World Health Organization, 2008. **86**(2): p. 140-146.

2. Vanderslott, S. and M. Roser. *Vaccination*. 2018 [cited 2018 March 20]; Available from: https://ourworldindata.org/vaccination.

3. Centers for Disease Control and Prevention. *Reported Cases and Deaths from Vaccine Preventable Diseases, United States, 1950-2013*. Epidemiology and Prevention of Vaccine-Preventable Diseases 2015 [Accessed March 20 2018]; 13:[Available from: https://www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/E/reported-cases.pdf.

4. Schuchat, A., *Human Vaccines and Their Importance to Public Health.* Procedia in Vaccinology, 2011. **5**: p. 120-126.

5. Greenwood, B., *The contribution of vaccination to global health: past, present and future.* Philosophical Transactions of the Royal Society B: Biological Sciences, 2014. **369**(1645): p. 20130433.

6. Riedel, S. *Edward Jenner and the history of smallpox and vaccination*. in *Baylor University Medical Center Proceedings*. 2005. Taylor & Francis.

7. Roush, S.W., T.V. Murphy, and V.-P.D.T.W. Group, *Historical comparisons of morbidity and mortality for vaccine-preventable diseases in the United States.* Jama, 2007. **298**(18): p. 2155-2163.

8. Kestenbaum, L.A. and K.A. Feemster, *Identifying and Addressing Vaccine Hesitancy.* Pediatric annals, 2015. **44**(4): p. e71-e75.

9. Phadke, V.K., et al., *Association Between Vaccine Refusal and Vaccine-Preventable Diseases in the United States: A Review of Measles and Pertussis.* JAMA, 2016. **315**(11): p. 1149-1158.

10. Whitney, C.G., et al., *Benefits from Immunization During the Vaccines for Children Program Era — United States, 1994–2013.* MMWR. Morbidity and Mortality Weekly Report, 2014. **63**(16): p. 352-355.

11. Zhou, F., et al., *Economic evaluation of the 7-vaccine routine childhood immunization schedule in the United States, 2001.* Archives of pediatrics & adolescent medicine, 2005. **159**(12): p. 1136-1144.

12. Smith, J.C., D.E. Snider, and L.K. Pickering, *Immunization policy development in the United States: the role of the Advisory Committee on Immunization Practices.* Annals of Internal Medicine, 2009. **150**(1): p. 45-49.

13. American Academy of Pediatrics Committee on Infectious Diseases, *Recommended immunization schedules for children and adolescents--United States, 2007.* Pediatrics, 2007. **119**(1): p. 207.

14. Ołpiński, M., *Anti-Vaccination Movement and Parental Refusals of Immunization of Children in USA.* Pediatria Polska, 2012. **87**(4): p. 381-385.

15. Mariner, W.K., *I. Legislative Report: The National Vaccine Injury Compensation Program.* Health Affairs, 1992. **11**(1): p. 255-265.

16. Walker, T.Y., et al., *National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years—United States, 2016.* MMWR. Morbidity and mortality weekly report, 2017. **66**(33): p. 874.

17. Hill, H.A., et al., *Vaccination coverage among children aged 19–35 months—United States, 2016.* MMWR. Morbidity and mortality weekly report, 2017. **66**(43): p. 1171.

18. Seither, R., et al., *Vaccination Coverage for Selected Vaccines, Exemption Rates, and Provisional Enrollment Among Children in Kindergarten—United States, 2016–17 School Year.* MMWR. Morbidity and mortality weekly report, 2017. **66**(40): p. 1073.

19. Wolfe, R.M. and L.K. Sharp, *Anti-vaccinationists past and present.* BMJ, 2002. **325**(7361): p. 430-432.

20. Larson, H.J., et al., *Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007-2012.* Vaccine, 2014. **32**(19): p. 2150-9.

21. Lahariya, C., *A brief history of vaccines & vaccination in India.* The Indian Journal of Medical Research, 2014. **139**(4): p. 491-511.

22. Godlee, F., J. Smith, and H. Marcovitch, *Wakefield's article linking MMR vaccine and autism was fraudulent*. 2011, British Medical Journal Publishing Group.

23. Stratton, K., et al., *Immunization safety review: measles-mumps-rubella vaccine and autism.* 2001.

24. Sugerman, D.E., et al., *Measles outbreak in a highly vaccinated population, San Diego, 2008: role of the intentionally undervaccinated.* Pediatrics, 2010. **125**(4): p. 747-755.

25. Clemmons, N.S., et al., *Measles - United States, January 4-April 2, 2015.* MMWR Morb Mortal Wkly Rep, 2015. **64**(14): p. 373-6.

26. Majumder, M.S., et al., *Substandard vaccination compliance and the 2015 measles outbreak.* JAMA Pediatr, 2015. **169**(5): p. 494-5.

27. Gowda, C. and A.F. Dempsey, *The rise (and fall?) of parental vaccine hesitancy.* Hum Vaccin Immunother, 2013. **9**(8): p. 1755-62.

28. Kornides, M.L., et al., *Associations between parents' satisfaction with provider communication and HPV vaccination behaviors.* Vaccine.

29. Kornides, M.L., A.-L. McRee, and M.B. Gilkey, *Parents Who Decline HPV Vaccination: Who Later Accepts and Why?* Academic Pediatrics, 2018. **18**(2, Supplement): p. S37-S43.

30. Gilkey, M.B., et al., *Parents who refuse or delay HPV vaccine: Differences in vaccination behavior, beliefs, and clinical communication preferences.* Human vaccines & immunotherapeutics, 2017. **13**(3): p. 680-686.

31. Opel, D.J., et al., *Development of a survey to identify vaccine-hesitant parents: the parent attitudes about childhood vaccines survey.* Human vaccines, 2011. **7**(4): p. 419-425.

32. Salmon, D.A., et al., *Vaccine Hesitancy: Causes, Consequences, and a Call to Action.* American Journal of Preventive Medicine, 2015. **49**(6, Supplement 4): p. S391-S398.

33. Larson, H.J., et al., *Measuring vaccine hesitancy: The development of a survey tool.* Vaccine, 2015. **33**(34): p. 4165-4175.

34. Catalano, H.P., et al., *Using the Theory of Planned Behavior to predict HPV vaccination intentions of college men.* Journal of American College Health, 2017. **65**(3): p. 197-207.

35. Glanz, K., B.K. Rimer, and K. Viswanath, *Health behavior and health education: theory, research, and practice*. 2008: John Wiley & Sons.

36. Ajzen, I. and B.L. Driver, *Prediction of leisure participation from behavioral, normative, and control beliefs: An application of the theory of planned behavior.* Leisure Sciences, 1991. **13**(3): p. 185-204.

37. Montanaro, E.A., T.S. Kershaw, and A.D. Bryan, *Dismantling the theory of planned behavior: evaluating the relative effectiveness of attempts to uniquely change attitudes, norms, and perceived behavioral control.* Journal of Behavioral Medicine, 2018.

38. Dubé, E., D. Gagnon, and N.E. MacDonald, *Strategies intended to address vaccine hesitancy: Review of published reviews.* Vaccine, 2015. **33**(34): p. 4191-4203.

39. Gust, D., et al., *Immunization attitudes and beliefs among parents: beyond a dichotomous perspective.* American journal of health behavior, 2005. **29**(1): p. 81-92.

40. Smith, P.J., et al., *Association Between Health Care Providers9 Influence on Parents Who Have Concerns About Vaccine Safety and Vaccination Coverage.* Pediatrics, 2006. **118**(5): p. e1287-e1292.

41. Gilkey, M.B., et al., *Validation of the vaccination confidence scale: a brief measure to identify parents at risk for refusing adolescent vaccines.* Academic pediatrics, 2016. **16**(1): p. 42-49.

42. Dubé, E., et al., *Vaccine hesitancy.* Human Vaccines & Immunotherapeutics, 2013. **9**(8): p. 1763-1773.

43. Keane, M.T., et al., *Confidence in vaccination: a parent model.* Vaccine, 2005. **23**(19): p. 2486-2493.

44. Benin, A.L., et al., *Qualitative analysis of mothers' decision-making about vaccines for infants: the importance of trust.* Pediatrics, 2006. **117**(5): p. 1532-41.

45. Opel, D.J., et al., *Validity and reliability of a survey to identify vaccine-hesitant parents.* Vaccine, 2011. **29**(38): p. 6598-6605.

46. Roberts, J.R., et al., *Vaccine hesitancy among parents of adolescents and its association with vaccine uptake.* Vaccine, 2015. **33**(14): p. 1748-1755.

47. Oladejo, O., et al., *Comparative analysis of the Parent Attitudes about Childhood Vaccines (PACV) short scale and the five categories of vaccine acceptance identified by Gust et al.* Vaccine, 2016. **34**(41): p. 4964-4968.

48. National Vaccine Advisory Committee, *Assessing the State of Vaccine Confidence in the United States: Recommendations from the National Vaccine Advisory Committee.* Public Health Report, 2015. **130**: p. 573-595.

49. Gilkey, M.B., et al., *The Vaccination Confidence Scale: a brief measure of parents' vaccination beliefs.* Vaccine, 2014. **32**(47): p. 6259-6265.

50. Jarrett, C., et al., *Strategies for addressing vaccine hesitancy – A systematic review.* Vaccine, 2015. **33**(34): p. 4180-4190.

51. Porter, R.M., et al., *Cancer-salient messaging for Human Papillomavirus vaccine uptake: A randomized controlled trial.* Vaccine, 2018.

52. Goodman, J.K., C.E. Cryder, and A. Cheema, *Data collection in a flat world: The strengths and weaknesses of Mechanical Turk samples.* Journal of Behavioral Decision Making, 2013. **26**(3): p. 213-224.

53. Buhrmester, M., T. Kwang, and S.D. Gosling, *Amazon's Mechanical Turk: A new source of inexpensive, yet high-quality, data?* Perspectives on psychological science, 2011. **6**(1): p. 3-5.

54. Huff, C. and D. Tingley, *"Who are these people?" Evaluating the demographic characteristics and political preferences of MTurk survey respondents.* Research & Politics, 2015. **2**(3): p. 2053168015604648.

APPENDICES

Appendix 1: United States Immunization Schedule

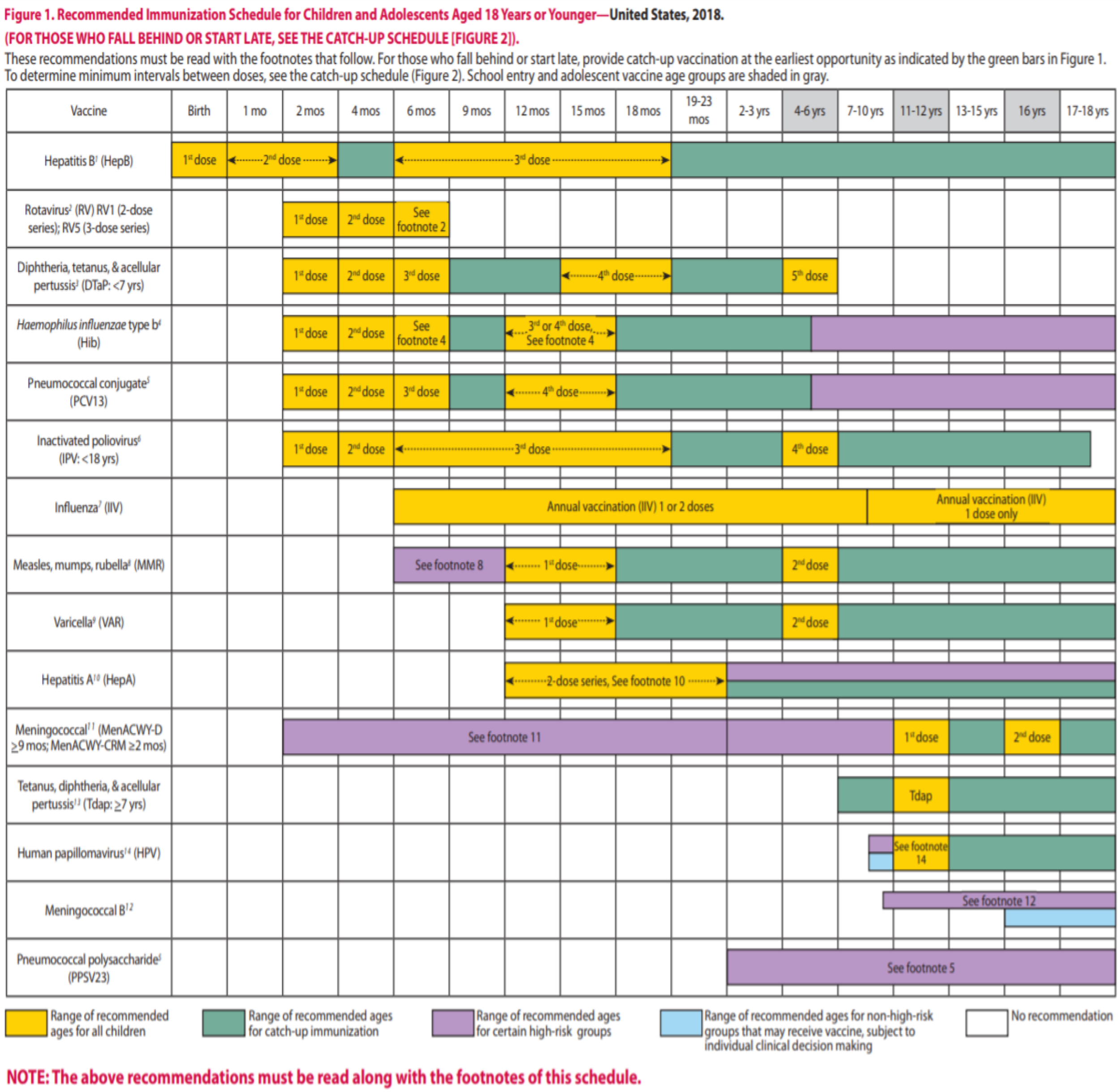


Figure 1. Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger—United States, 2018.

(FOR THOSE WHO FALL BEHIND OR START LATE, SEE THE CATCH-UP SCHEDULE [FIGURE 2]).

These recommendations must be read with the footnotes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars in Figure 1. To determine minimum intervals between doses, see the catch-up schedule (Figure 2). School entry and adolescent vaccine age groups are shaded in gray.

Vaccine	Birth	1 mo	2 mos	4 mos	6 mos	9 mos	12 mos	15 mos	18 mos	19-23 mos	2-3 yrs	4-6 yrs	7-10 yrs	11-12 yrs	13-15 yrs	16 yrs	17-18 yrs
Hepatitis B[1] (HepB)	1st dose	←2nd dose→					←3rd dose→										
Rotavirus[2] (RV) RV1 (2-dose series); RV5 (3-dose series)			1st dose	2nd dose	See footnote 2												
Diphtheria, tetanus, & acellular pertussis[3] (DTaP: <7 yrs)			1st dose	2nd dose	3rd dose			←4th dose→				5th dose					
Haemophilus influenzae type b[4] (Hib)			1st dose	2nd dose	See footnote 4		←3rd or 4th dose, See footnote 4→										
Pneumococcal conjugate[5] (PCV13)			1st dose	2nd dose	3rd dose		←4th dose→										
Inactivated poliovirus[6] (IPV: <18 yrs)			1st dose	2nd dose			←3rd dose→					4th dose					
Influenza[7] (IIV)									Annual vaccination (IIV) 1 or 2 doses						Annual vaccination (IIV) 1 dose only		
Measles, mumps, rubella[8] (MMR)					See footnote 8		←1st dose→					2nd dose					
Varicella[9] (VAR)							←1st dose→					2nd dose					
Hepatitis A[10] (HepA)								←2-dose series, See footnote 10→									
Meningococcal[11] (MenACWY-D ≥9 mos; MenACWY-CRM ≥2 mos)							See footnote 11							1st dose		2nd dose	
Tetanus, diphtheria, & acellular pertussis[13] (Tdap: ≥7 yrs)														Tdap			
Human papillomavirus[14] (HPV)														See footnote 14			
Meningococcal B[12]															See footnote 12		
Pneumococcal polysaccharide[5] (PPSV23)														See footnote 5			

Range of recommended ages for all children | Range of recommended ages for catch-up immunization | Range of recommended ages for certain high-risk groups | Range of recommended ages for non-high-risk groups that may receive vaccine, subject to individual clinical decision making | No recommendation

NOTE: The above recommendations must be read along with the footnotes of this schedule.

Accessed at: https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html

Appendix 2: Survey Instrument

Thank you for agreeing to take this short survey! This survey will be used to learn more about perceptions related to infectious disease prevention. Your participation is completely voluntary and your answers are completely anonymous. No identifying information will be linked to your answers.

Parent Attitudes about Childhood Vaccines Short Scale. [1]

1. I trust the information I receive about shots.

   Yes No Don't Know

2. It is better for my child to develop immunity by getting sick than to get a shot.

   Yes No Don't Know

3. It is better for children to get fewer shots at the same time.

   Yes No Don't Know

4. Children get more shots than are good for them.

   Yes No Don't Know

5. Overall, how hesitant about childhood shots would you consider yourself to be?

   Hesitant Not Hesitant Not Sure

Vaccine Confidence Scale.[2]

For the following questions, indicate how strongly you agree with the statement. Answers can range from 0 - "strongly disagree" to 10 - "strongly agree".

6. Vaccines are necessary to protect the health of teenagers.
7. Vaccines do a good job in preventing the diseases they are intended to prevent.
8. Vaccines are safe.
9. If I do not vaccinate my teenager, he/she may get a disease such as meningitis and cause other teenagers or adults to get the disease.
10. Teenagers receive too many vaccines.
11. If I vaccinate my teenager, he/she may have serious side effects.
12. In general, medical professionals in charge of vaccinations have my teenager's best interest at heart.

[1] Opel et al. *JAMA* 2013.
[2] Gilkey et al. *Vaccine* 2015.

13. I have a good relationship with my teenager's health care provider.

Behavioral Phenotyping Questions (from AB)

For this part of the survey, you will be given a few scenarios. For each scenario please rate on a scale of 1 to 7 (1 being extremely unlikely and 7 being extremely likely) how likely you think it is that each scenario will happen to **<u>your daughter</u>**.

How likely is it that **<u>your daughter will</u>**…?

14. Become infected with HPV next year?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

15. Have the home she is living in be broken into within the next 3 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

16. Be in an automobile accident in the next 5 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

17. Win the lottery in the next 10 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

18. Get cervical cancer in the next 10 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

19. Get cervical cancer in the next 20 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

20. Imagine that you are staying in a hotel room, and you have just paid $6.95 to see a movie on pay-per-view TV. You are bored 5 minutes into the movie and the movie seems pretty bad. Which of the following options sounds like what you would do?

    - Continue to watch the movie
    - Switch to another channel

For the next questions, you will see two choices about receiving money now or receiving money later. Choose the one you would prefer.

For example, suppose the first question below was chosen as the random payout option. If you choose to receive a $15 gift card in five days, you will have that exact amount added to your gift card in five days. If you choose to receive a $5 gift card today, we will add $5 to your gift card today, and that money will be ready to use in about an hour. Also, as a reminder, this payout is in addition to the $25 you will receive for participating.

21. Receive a $5 gift card today or a $15 gift card in five days?
    - $5 gift card today
    - $15 gift card in five days

22. Receive a $7 gift card today or a $15 gift card in five days?
    - $7 gift card today
    - $15 gift card in five days

23. Receive a $9 gift card today or a $15 gift card in five days?
    - $9 gift card today
    - $15 gift card in five days

24. Receive a $11 gift card today or a $15 gift card in five days?
    - $11 gift card today
    - $15 gift card in five days

25. Receive a $13 gift card today or a $15 gift card in five days?
    - $13 gift card today
    - $15 gift card in five days

26. Receive a $15 gift card today or a $15 gift card in five days?
    - $15 gift card today
    - $15 gift card in five days

27. Receive a $17 gift card today or a $15 gift card in five days?
    - $17 gift card today
    - $15 gift card in five days

Below you will see a list of six gambles or bets. Each gamble has two potential payoffs. For each gamble, a coin flip will determine which payoff is chosen.

This is another choice game where you might receive a payout based on the answer you choose. If this game was randomly chosen as the payout gamble, you would have a 50/50 chance of winning either of the payout options.

For example, in one of the gambles below, there is a 50% chance that the coin flip would be Heads, and you would receive $9.50. There is also a 50% chance that the coin flip would be Tails, and you would receive $11. Suppose you can choose one gamble to take.

28. Which gamble do you choose?

    - Heads: $10, Tails: $10
    - Heads: $9.50, Tails: $11
    - Heads: $8.50, Tails: $13
    - Heads: $7, Tails: $16
    - Heads: $5, Tails: $20
    - Heads: $2.50, Tails: $24

The following is a description of a woman picked randomly from the group of 100 women, in which 70 (70%) are supermarket cashiers and 30 (30%) are librarians:

> *Ashley is a 28-year-old women with 2 children. She did very well in school and enjoys knitting. She is fairly quiet, and has a small number of close friends. She likes order and structure and has a passion for detail.*

29. What are the chances that Ashely is a supermarket cashier? Please mark your answer along the scale below. (0 to 100%)

Please read the description of a women and answer the following question.

> *Brittany is 31 years old, single, outspoken, and very bright. In college, she majored in Philosophy. As a student she was deeply concerned with issues of race and social justice, and she is a member of several animal rights organizations.*

30. Order the statements by numbering them from 1-5, making the choice that is the **MOST probable as 1** and the choice that is **LEAST probable as 5**.

___ Brittany is a teacher in an elementary school.
___ Brittany works in a bookstore and takes Yoga classes.
___ Brittany is a bank teller.
___ Brittany is a psychiatric social worker.
___ Brittany is a bank teller and is active in the feminist movement.

Please select how much you agree or disagree with the following statements:

31. Even if it will upset me, I want to know how HPV infection is related to cervical cancer.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

32. Even if it will upset me, I want to know whether my partner is cheating on me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

33. Even if it upset me, I want to know how attractive my peers find me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

34. I would avoid learning how HPV infection can lead to cervical cancer.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

35. I would avoid learning whether my partner is cheating on me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

36. I would avoid learning how attractive my peers find me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

For this part of the survey, you will be given a few scenarios. For each scenario please rate on a scale of 1 to 7 (1 being extremely unlikely and 7 being extremely likely) how likely you think it is that each scenario will happen to **<u>another participant in the study</u>**.

How likely is it that **<u>another participant in this study will</u>**…?

37. Become infected with HPV next year?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

38. Have the home they are living in be broken into within the next 3 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

39. Be in an automobile accident in the next 5 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

40. Win the lottery in the next 10 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

41. Get cervical cancer in the next 10 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

42. Get cervical cancer in the next 20 years?

Extremely Unlikely	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely	Extremely Likely

43. Imagine that you are staying in a hotel room, and you have just begun watching a movie on the TV in your room. You are bored 5-10 minutes into the movie and the movie seems pretty bad. Which of the following options sounds like what you would do?

    - Continue to watch the movie
    - Switch to another channel

Demographic Questions

44. Please indicate your age (in years):

    Age (in years): ____________

45. Please describe your highest education level:

    - Some High School
    - Currently in High School
    - Completed High School
    - General Education Diploma (GED)
    - Some College/University
    - Currently in College/University
    - Completed College/University
    - Some Graduate/Professional School
    - Currently in Graduate/Professional School
    - Completed Graduate/Professional School

46. Please indicate your gender:

    Male   Female   Prefer Not to Answer

47. How many children do you have?

    Number of children: __________

48. How old is your **oldest daughter under 18** years old?

    Age (in years): __________

49. Please describe your marital status:

    - Single, never married
    - Married or domestic partnership
    - Widowed
    - Divorced
    - Separated

50. What was your total household income before taxes during the past 12 months?

- Less than $25,000
- $25,000 to $34,999
- $35,000 to $49,999
- $50,000 to $74,999
- $75,000 to $99,999
- $100,000 to $149,999
- $150,000 to $199,999
- $200,000 or more

51. How would you describe yourself? Please check all that apply.

- White
- Hispanic, Latino or Spanish
- Black or African American
- Asian
- American Indian or Alaska Native
- Native Hawaiian or Other Pacific Islander
- Other

HPV Vaccine Status and Intent to Vaccinate

52. Has your oldest daughter under 18 years old received at least 1 dose of the HPV vaccine?

Yes No I don't know

53. *(If yes to 31)* Do you intend to have your daughter complete the HPV vaccine series?

- Yes
- No
- I don't know.
- My daughter has received all 3 HPV vaccines in the series.

54. *(If 'no' or 'I don't know' to 31)* Do you intend to have your daughter start the HPV vaccine series?

Yes No I don't know

55. Please enter your Amazon Mechanical Turk Worker ID. This information will be used to verify survey completion.

Thank you for completing the survey! Remember, you will be contacted in 2 weeks to take a follow-up survey for this same research study. The first 699 people to come back and take the second survey will receive an additional $2.00 for their participation in this study.