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Screening Tool Predicts Future Underimmunization Among a Pediatric Practice in Tennessee

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Abstract

The Parent Attitudes about Childhood Vaccines (PACV) survey for identifying vaccine-hesitant parents was recently validated in Washington State but did not include all recommended childhood vaccines. The current study compares vaccination rates for all recommended childhood vaccines and PACV scores at one pediatric practice in Tennessee. Children were enrolled at the 2-week well visit, and vaccination rates were assessed at 19 months of age. Outcomes at 19 months of age included mean percentage of days underimmunized and up-to-date status (yes/no) compared with PACV scores. The impact of provider on immunization status was assessed. Complete vaccination data were available for 158 children of 183 enrolled (86%). Higher PACV scores were associated with more days underimmunized ($P < .001$) and being overdue for vaccine doses at 19 months of age ($P < .001$). No difference was seen between providers and up-to-date status. Our study supports the predictive validity of the PACV for underimmunization.

Keywords

vaccine refusal; vaccine hesitancy; immunizations

Introduction

A substantial minority of US parents choose to delay or refuse one or more childhood vaccines.^{1–3} For example, a national telephone survey of parents of children 6 to 23 months old conducted in 2010 found that 22.8% had either refused all (3.4%) or refused or delayed at least one (19.4%) of the recommended childhood vaccines.⁴ Another more recent study in

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Author Contributions

SEW - responsible for data collection, participant enrollment, data analysis, study concept development and manuscript preparation. AM - data analysis and manuscript preparation. DP - manuscript preparation and study concept development. KE - manuscript preparation and study concept development. SW - manuscript preparation and data collection. RR - manuscript preparation and study concept development.

Declaration of Conflicting Interests

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metropolitan Oregon found that rates of alternative immunization schedule use have increased nearly 4-fold between 2006 and 2009.¹

The literature frequently refers to parents who refuse or delay vaccines as vaccine-hesitant parents (VHPs). Among parents who refuse or delay vaccines for their children, experts believe that the majority fall into a subset of parents who are not rigidly opposed to vaccines.^{5,6} Theoretically, this majority may be more willing to receive vaccine information and reconsider vaccination for their children than parents who are firmly opposed to vaccination for reasons such as religion or prominent cultural beliefs.^{7,8} Therefore, more moderate VHPs are a primary target for intervention efforts.

In 2011, Opel et al³ developed a new survey to identify VHPs, the Parent Attitudes about Childhood Vaccines Survey (PACV).^{7,8} The PACV was validated initially among parents of 19- to 35-month-old children in Washington and was recently reported to be predictive of immunization rates at 19 months of age.⁹ However, preliminary studies did not include several of the recommended childhood vaccines in the analysis. The primary objective of the current study was to assess the association of parental PACV score with receipt of all the recommended vaccine doses in children at 19 months of age in Tennessee. The hypothesis was that increasing PACV scores would correspond to greater underimmunization at 19 months. Investigations were also conducted to assess whether vaccination status varied by individual primary care provider (PCP) within a group practice.

Methods

From May 2011 through September 2012, all parents of infants arriving for the 2-week well-child visit at one pediatric clinic were approached for participation. The private pediatric clinic where the study was conducted is a nonresident clinic affiliated with Vanderbilt University Medical Center, and care is provided by 5 board-certified pediatricians. The clinic is located in an urban setting, and the patient population is predominantly privately insured, with immunization rates of 85% to 95% by the 2-year well-child visit.

Parents completed the PACV survey to stratify them according to their level of “vaccine hesitancy.” The PACV consists of 15 questions and is scored from 0 to 100, with higher scores corresponding to increased vaccine hesitancy. For the current study, all parents who completed the PACV survey and whose children continued to be followed by the pediatric clinic for well-child care through 19 months of age were included.

Vaccination records of all children of parents who completed the PACV were reviewed after the child reached 19 months of age. Parent-infant dyads documented to have moved or changed providers prior to 19 months of age were excluded. Vaccination data were collected by one of the authors (SEW) through review of the electronic health record of each participant for all doses of the 9 vaccines recommended by the Advisory Committee on Immunization Practices (ACIP) by 15 months of age (Table 1). The vaccination record is kept up-to-date at each visit (1) by entering information at the time vaccines are administered by the pediatric clinic, (2) by questioning parents about any additional vaccines

received, and (3) through review of historical vaccine data retrieved automatically from the state immunization record and reconciling the vaccination record as needed.

Delay was assessed for each dose of the recommended vaccines. A vaccine dose was considered delayed if not received within 30 days of the latest recommended age for vaccination according to the ACIP vaccination schedule (eg, if a vaccine dose was recommended to be administered by 2 months of age, the dose was considered delayed if not received by 3 months of age [93 days of life]).^{10,11} If the child did not receive at least one of the recommended vaccine doses due by 15 months of age when he or she reached 19 months of age, the child was considered not up-to-date regarding vaccination status. Demographic information on the following variables was also collected via parental self-report: parental age, number of children in the home, annual household income, race/ethnicity, insurance status (private, public, self-pay), and parental level of education.

The outcome of undervaccination at 19 months of age was assessed in 2 ways: (1) the proportion of days underimmunized and (2) the proportion of children who were up-to-date for all recommended vaccine doses in each of 10 mutually exclusive PACV score groups. The total number of days of underimmunization was calculated for each child using a previously reported method.^{9,12} Briefly, the days of underimmunization were determined by first calculating the difference between the age that each vaccine dose was administered and the age at which the dose was considered late, according to the ACIP recommended schedule. The days late for all vaccine doses were summed for each child to determine the total days of underimmunization. The percentage of days underimmunized was calculated by dividing the total days of underimmunization by the total days for potential underimmunization (2890 days if no vaccine doses received by 19 months of age). Linear regression was used to assess the association between PACV score and mean percentage days underimmunized and then adjusted for race (binary, white versus any other reported race) and income (binary, reported annual income 75 000 or greater vs any other reported income). Variables were selected a priori based on previous studies.^{13,14}

When comparing parental PACV scores and whether a child was up-to-date for all recommended vaccine doses by 19 months of age, parental PACV scores were separated into 10 mutually exclusive tiers (PACV score groups) as previously described.⁹ Each PACV score group contains a 10-point range within the 100-point scale (eg, tier 1 includes scores from 0 to <10 and tier 2 includes scores from 10 to <20). The proportion of children receiving all recommended vaccine doses by 19 months was compared with the PACV score group using Pearson's χ^2 test and then adjusted for race and income using logistic regression. Mean PACV scores were compared between parent-infant dyads who were up-to-date and those who were not using a 2-sample *t* test.

The relationship between total days underimmunized and the participant's PCP was also evaluated. Using the electronic health record for chart review, the PCP was determined by evaluating which provider was listed as the PCP and verifying that this provider was primarily responsible for most, or all, of the child's well-child visits from birth to 19 months of age. The association of PCP with total days underimmunized and up-to-date status at 19 months was evaluated using the Kruskal-Wallis test and Pearson's χ^2 test, respectively.

Interaction effect of PCP with the PACV score on the outcome of days underimmunized was also tested for significance. When significant, the association of PACV score and days underimmunized was evaluated using linear regression for each PCP.

All analyses were conducted using Stata version 12. The Vanderbilt Institutional Review Board reviewed and approved the study. Written informed consent was obtained prior to completion of the PACV survey.

Results

A total of 193 parents of 2-week-old infants were approached to complete PACV surveys. Of these, 183 (95%) completed the PACV. Complete vaccine data at 19 months was available for 158 enrollees (86%); 25 infants did not have vaccine data available at 19 months because they had changed provider clinics and, thus, were excluded from analysis. Enrollee demographics are presented in Table 2. The majority of parents reported race as white and insurance as private, and the mean age was 32 years. Among the entire sample, the mean PACV score was 20.5 (standard deviation [SD] = 19.7) and the mean percentage of days underimmunized was 4.1% (SD = 0.1). There were no significant differences in PACV scores, race, and insurance status between participants included in our analysis versus those excluded because of lack of full vaccine record. However, there was a significant difference in the reported age, income, and educational status of participants who were excluded compared with those included in our analysis. Excluded participants reported age as approximately 1 year younger and reported lower annual household incomes, and fewer disclosed their annual household income and/or educational status (Table 2).

The mean percentage of days underimmunized at 19 months increased overall with increasing PACV score ($P < .001$, linear regression, unadjusted). This association remained significant after adjustment for race and income ($P < .001$).

In all, 23 children (14.6%) of enrolled participants were not up-to-date by 19 months of age for all vaccine doses recommended by 15 months of age. A significant association was found between higher PACV score groups and not being up-to-date on vaccines ($P < .001$, Pearson's χ^2 test; Table 3). This association remained significant after adjusting for race and income: $P < .001$; odds ratio = 1.83 (1.43–2.36). The mean PACV score among the 23 parents whose children were not up-to-date by 19 months was 41.8 (SD = 5.2), while the mean PACV score among parents whose children were up-to-date was 16.8 (SD = 1.4). This also represents a significant difference ($P < .001$, t test).

There were 5 total PCPs for participants enrolled in the study. A difference was detected in the mean days underimmunized at 19 months, between providers ($P < .001$, Kruskal-Wallis), but no difference was found between providers and up-to-date status at 19 months ($P = .19$, Pearson's χ^2). A significant interaction effect of PCP with PACV score on the days underimmunized was detected ($P < .001$, linear regression). When evaluating days underimmunized by PACV score for each PCP and adjusting for race and income, no association was found for PACV score and days underimmunized for 1 of the 5 PCPs

(provider 2, $P = .67$). However, differences were seen for PACV score and days underimmunized for all other PCPs (using a cutoff of $P = .05$, linear regression).

Discussion

A substantial minority of parents are choosing to delay or omit recommended vaccines for their children. Initial methods to identify parents who are likely to delay or refuse childhood vaccines were published in 2005. Using a 44-item survey to assess parental beliefs and attitudes about childhood vaccines, Gust et al⁵ found that parental attitudes clustered into 5 distinct groups: Immunization Advocates (33.0%), Go Along to Get Alongs (26.4%), Health Advocates (24.8%), Fencesitters (13.2%), and Worrieds (2.6%). The survey was subsequently shortened to 3 items.¹⁵ However, neither version of the survey was tested for content or predictive validity. In 2011, Opel et al³ published the PACV survey, which was developed using a more robust iterative testing process and both qualitative and quantitative methods.⁷ The PACV was subsequently tested for construct validity and reliability (among a cohort of parents of 19- to 35-month-old children) as well as predictive validity (administered to parents of children who were 2 months of age with follow-up vaccination rates analyzed at 19 months of age) in Washington State.^{8,9} Yet because the PACV was developed and validated in Washington State using a limited set of recommended childhood vaccine doses (omitting rotavirus vaccine, 13-valent pneumococcal vaccine, and hepatitis A vaccine), testing of the PACV in additional geographic regions with inclusion of all routinely recommended childhood vaccines was needed. Our study supports the idea that the PACV may be used to successfully identify vaccine-hesitant populations in middle Tennessee with the inclusion of all vaccine doses currently recommended by the ACIP for children by 15 months of age.

Although a valid and reliable screening tool is necessary for identifying the target population of interest, the PACV and its overall score has not yet been shown to clearly distinguish parents who are potentially more amenable to change from parents who are not. For instance, 2 parents may both score highly on the PACV but may have very different reasons for hesitancy and different flexibility in their final vaccine decision making. Review of the completed PACV survey by providers may enhance the provider's ability to "target" responses to specific areas of concern for individual parents. Responses to individual items within the PACV may provide clues to distinguish VHPs who are open to discussion from those who are not. Future work evaluating how individual items within the survey correspond to parents' willingness to change would be valuable and add to the clinical utility of the survey in practice.

Although limited data exist regarding the effectiveness of provider communication strategies with VHPs, tailored strategies addressing the specific reasons for parental hesitancy are likely needed to positively influence a parent's vaccine decision making. The most effective communication techniques are being studied,¹⁶ and the development of strategies to improve vaccine-specific knowledge for pediatric providers to address parental concerns is supported by pediatric residency program directors.¹⁷

Our study also found differences in the proportion of days underimmunized among the patients of the 5 different PCPs within the group practice, yet no difference was noted in the up-to-date status at 19 months. This finding raises an interesting question of whether parents with greater concerns about childhood vaccines are more likely to seek care from a specific provider, or vice versa. The finding that there was no difference in the proportion of patients who were up-to-date at 19 months among patients of different PCPs suggests that the differences seen in days underimmunized disappeared over time. Although the on-time and complete vaccination of infants according to the ACIP vaccination schedule is clearly ideal, with increasing evidence that delay of vaccinations can lead to increased risk of infection with vaccine-preventable diseases and transmission of such diseases^{18,19} or increased risk of vaccine adverse events with an alternative schedule,²⁰ we are encouraged that ongoing relationships with providers, who likely strongly support and encourage vaccination, can lead to eventual complete vaccination status.

Consideration should be given to the limited distribution of PACV scores within the sample because most participants had lower PACV scores suggesting less vaccine hesitancy. However, the percentage of vaccine hesitancy in this population is consistent with estimates in other geographical regions,^{3,5,21} suggesting that our population likely reflects the spectrum of parental attitudes. This consistency supports the generalizability of our results for the predictive validity of the PACV. Additionally, the study did not include the vaccination status of 14% of the initial enrolled population because of loss to follow-up. On review of demographic data for the excluded population, this population varied from the included population as outlined in Table 2. The slightly older mean parental age among included participants (32 compared to 30 years of age in the excluded group) is not thought to be clinically meaningful, and differences in reported income and education are likely a result of a higher proportion of the excluded population having no response or preferring not to answer these questions. However, uncertainty remains regarding what impact the lack of these data may have on the ability to generalize this study's results.

Conclusion

The results of this study support the notion that an increasing score on the PACV is associated with increasing underimmunization of children. By including all routinely recommended childhood vaccines in the analysis, the study enhances prior knowledge regarding the PACV's predictive validity. Furthermore, the findings support PACV's predictive validity in an additional geographical region. The PACV may be a beneficial method for practitioners to identify parents with vaccine concerns within the clinical setting. Future efforts to delineate which VHPs are willing to reconsider vaccination decisions would be valuable. Furthermore, effective communication strategies for providers of VHPs are needed.

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Vaccines and the Number of Doses Due by 15 Months of Age According to Recommendations by the Advisory Committee on Immunization Practices.¹¹

Table 1.

Vaccine	Abbreviation	Number of Doses Due by 15 Months of Age
Hepatitis B	HepB	2
Diphtheria, tetanus, and acellular pertussis	DTaP	3
<i>Haemophilus influenzae</i>	Hib	4
13-Valent pneumococcal	PCV13	4
Inactivated polio	IPV	2
Measles, mumps, and rubella	MMR	1
Varicella	VAR	1
Hepatitis A	HepA	1
Rotavirus	RV	3

Table 2.

Demographic Characteristics and Mean PACV Score Among Enrolled Population (Full Vaccine Data Available at 19 Months of Age) and Excluded Population (Excluded Because They Moved or Changed Their Child's Pediatric Clinic).

Variable	Study Population (158)	Excluded (25)	Significance
PACV score, mean (95% CI)	20.5 (17.4–23.6)	21.7 (14.2–29.2)	$P = .8$
Age, mean (years; 95% CI)	32.1 (31.4–32.9)	30.0 (28.2–31.8)	$P < .001$
Race			$P = .9$
White	133 (84%)	21 (84%)	
African American	14 (9%)	2 (8%)	
Other	10 (6%)	2 (8%)	
No response	1 (<1%)	0 (0%)	
Income			$P < .001$
<\$30 000	2 (1%)	1 (4%)	
\$30 000–\$49 999	20 (13%)	3 (12%)	
\$50 000–\$74 999	34 (22%)	7 (28%)	
\$75 000+	54 (34%)	5 (20%)	
Prefer not to answer or no response	48 (30%)	9 (36%)	
No. of children			$P = .6$
1	75 (48%)	17 (68%)	
2	52 (33%)	6 (24%)	
3	20 (13%)	2 (8%)	
>3	4 (3%)	0 (0%)	
No response	7 (4%)	0 (0%)	
Education			$P < .001$
High school graduate or less	2 (1%)	1 (4%)	
Some college	9 (6%)	2 (8%)	
College graduate	46 (29%)	2 (8%)	
Post-college	77 (49%)	13 (52%)	
Prefer not to answer or no response	24 (15%)	7 (28%)	
Insurance			$P = .6$
Private	143 (91%)	25 (100%)	

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Variable	Study Population (158)	Excluded (25)	Significance
Government	8 (5%)	0 (0%)	
No response	7 (4%)	0 (0%)	

Abbreviations: PACV, Parent Attitudes about Childhood Vaccines; CI, confidence interval.

Table 3.

Mean Proportion of Days Underimmunized and Number of Children Not Up-to-Date by 19 Months (580 Days) on All Vaccination Doses Recommended by 15 Months of Age by the Advisory Committee on Immunization Practices,¹¹ According to PACV Score Group.

PACV Score Group	n	Mean Proportion of Days Underimmunized, Percentage (95% CI)	Number Not Up-to-Date, n (Percentage of Group) ^a
0 to <10	73	1.5% (1.0%–2.0%)	3 (4.1%)
10 to <20	26	2.6% (0.3%–5.0%)	2 (7.7%)
20 to <30	22	2.8% (0.7%–4.9%)	4 (18.2%)
30 to <40	16	2.7% (1.0%–4.5%)	3 (18.8%)
40 to <50	7	16.9% (2.4%–31.3%)	3 (42.9%)
50 to <60	7	3.1% (0.6%–5.6%)	3 (42.9%)
60 to <70	3	8.4% (0.9%–17.7%)	2 (66.7%)
70 to <80	3	34.0% (5.2%–73.1%)	2 (66.7%)
80 to <90	0	NA	NA
90 to 100	1	100%	1 (100%)

^a $P < .001$, Pearson's χ^2 .