American Journal of
Preventive Medicine

RESEARCH ARTICLE

Implementation of Strategies to Improve Human Papillomavirus Vaccine Coverage: A Provider Survey

Emily B. Walling, MD, MPHS,[1,2] Sherry Dodd, BA,[3] Neil Bobenhouse, MA,[3] Evelyn Cohen Reis, MD,[4] Randy Sterkel, MD,[3] Jane Garbutt, MD[5]

Introduction: Human papillomavirus (HPV) vaccine coverage in the U.S. is persistently suboptimal, despite research describing barriers to vaccination and strategies to increase vaccination coverage. The objective was to assess providers' approach to the HPV vaccine and their implementation of strategies to increase HPV vaccination coverage. The hypothesis was that adoption of improvement measures to address underuse of the HPV vaccine has not occurred.

Methods: Community pediatric providers from two Midwestern practice-based research networks completed self-administered electronic surveys. Data were collected over 6 months in 2015 and organized and analyzed in 2016.

Results: There were 100 providers that participated. Despite agreement with national recommendations, some providers delayed their recommendation until the adolescent was older and many reported missed vaccination opportunities. Many providers experienced parental concerns including safety of the HPV vaccine, belief their child was not at risk of HPV infection, and their child's resistance to receiving multiple shots. Providers identified the following as barriers to adherence to Advisory Committee on Immunization Practices guidelines: bad publicity of the HPV vaccine, information about the HPV vaccine on the web, and a lack of a follow-up system for those who delayed HPV vaccine initiation. Approximately half of the participants had implemented strategies to address these barriers beyond offering immunization-only appointments.

Conclusions: Participants were aware of barriers to HPV vaccine use, but many had not adopted a systematic approach to increase vaccine coverage. A better understanding of the challenges facing providers to adopting improvement measures and a strategy to address barriers to implementation are needed to improve HPV coverage.

Am J Prev Med 2019;56(1):74–83.

INTRODUCTION

Infection with the human papillomavirus (HPV) leads to approximately 27,000 new cases of cancer in the U.S. in men and women every year.[1] A safe and effective vaccine against the viral serotypes most commonly associated with HPV-related cancers has been available in the U.S. since 2006. However, coverage is suboptimal, variable across the country, and inferior to other developed nations.[2–4] Additionally, there is a gap between uptake of the HPV vaccination and two other adolescent vaccines: the tetanus, diphtheria, and pertussis booster; and the quadrivalent meningococcal conjugate vaccine.[3] Collectively, this indicates there are barriers specific to vaccination against HPV.

From the [1]Division of Hematology and Oncology, Department of Pediatrics, Washington University, School of Medicine, St. Louis, Missouri; [2]Department of Pediatrics and Communicable Diseases, Division of Hematology and Oncology, University of Michigan, Ann Arbor, Michigan; [3]Department of Pediatrics, Washington University School of Medicine, St. Louis, Missouri; [4]Department of Pediatrics, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania; and [5]Division of General Medical Sciences, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri

Address correspondence to: Emily B. Walling, MD, MPHS, University of Michigan School of Medicine, Medical Professional Building, 1500 East Medical Center Drive SPC 5718, Ann Arbor MI 48109.
E-mail: wallinge@med.umich.edu.

0749-3797/$36.00
https://doi.org/10.1016/j.amepre.2018.07.038

A large body of literature has described barriers to HPV vaccination and outlined feasible interventions to increase coverage. For example, provider-focused interventions, such as specific recommendation strategy and content, positively impact initial vaccine uptake whereas family-focused interventions, such as parental reminder systems, have successfully increased series completion.[5–16] Despite availability of strategies to increase HPV vaccination coverage, rates remain low. This suggests a disconnect between availability of improvement measures and implementation by providers. In this study, pediatric providers in the midwestern U.S. completed a self-administered survey with the objectives of assessing current practice for providing the HPV vaccine, perception of barriers to vaccination, and implementation of improvement measures in increasing vaccination coverage. The hypothesis is that many providers have not adopted methods to address underuse of the HPV vaccine.

METHODS

Participants

Pediatric care providers were recruited from two practice-based research networks (PBRNs): Washington University Pediatric and Adolescent Ambulatory Research Consortium (WU PAARC), associated with Washington University (36 practices, 84 clinicians serving ≅140,000 patients), and Pediatric PittNet, associated with the University of Pittsburgh (23 practices, 200 clinicians serving ≅200,000 patients). All providers (pediatricians and advanced-level practitioners) were eligible to participate and invited by an e-mail from their network director to complete the web-based survey. Data were collected anonymously over a 6-month period in 2015 and managed using Research Electronic Data Capture (REDCap) hosted at WU.[17] The WU Human Protection Office approved this study with waiver of written consent. The University of Pittsburgh IRB accepted this approval.

Measures

The WU PAARC research team developed the 73-item survey tool. Questions were generated from the Centers for Disease Control and Prevention (CDC) recommendations for recommending the HPV vaccine and a review of evidence-based strategies to increase HPV vaccine acceptance.[6,8,11–15,18,19] All questions were based on participant recall and did not include a formal review of their records. The self-administered survey took ≅10 minutes to complete. At the time this study was conducted, recommendations were for three doses of the HPV vaccine, and the survey questions and results reflect this recommendation.

Participants were asked questions to assess agreement with Advisory Committee on Immunization Practices (ACIP) HPV vaccination guidelines and their experience with parental vaccine hesitancy (in general and towards the HPV vaccine). Likert scales were used to indicate their level of agreement (*strongly agree* to *strongly disagree*) with the significance of the morbidity of HPV-associated diseases and the presence of vaccine hesitancy in their practice. Participants indicated their level of agreement with statements that they were confident addressing parental concerns about the HPV vaccine and that their recommendation for the HPV vaccine influenced the parent's decision.

Participants were asked questions to assess adherence to ACIP recommendations for administration of the HPV vaccine and CDC recommendations for discussing the HPV vaccine with parents. Participants chose from a list of age ranges to indicate when they recommended the HPV vaccine for girls and boys. Participants were asked to estimate overall HPV vaccine coverage in their practice and the average length of time patients took to complete the three-dose series (*6 months*, *6 months to 1 year*, *1–2 years*, *2–3 years*, *3 years*). Participants indicated how frequently they emphasized cancer and genital wart prevention when recommending the HPV vaccine (*always*, *most of the time*, *sometimes*, *rarely*, *never*).

Participants indicated the frequency (*all or most of the time*, *some of the time*, *rarely*, or *never*) parents raised listed concerns to elicit provider perceived parental barriers to HPV vaccination. To assess the significance of provider barriers to adhering to ACIP recommendations, participants indicated the significance (*very significant*, *significant*, *not significant*) of listed potential barriers. Concerns and barriers solicited were not specific to vaccine series initiation or completion.

Participants chose from a list of options to indicate their adoption of and willingness to adopt (*I already use this*, *I would use this*, *I may use this*, *I would not use this*) strategies to increase vaccine initiation and completion.

Demographic and practice characteristics were collected. The presence and capabilities of an electronic medical record (EMR) were queried, as this technology can assist with tracking vaccination coverage.[20,21]

Statistical Analysis

Data were organized and analyzed in 2016. There were nonsignificant differences between responses, so the following scales were collapsed into one category: strongly agree and agree responses were reported as agreed, and strongly disagree and disagree responses as disagreed. All/most of the time and some of the time responses were reported as the proportion of providers indicating they heard this concern frequently. Very significant and significant responses were reported as significant barriers. "I would use this" and "I may use this" responses were reported as interventions participants were willing to implement. Data are reported as percentages for categorical variables. Continuous variables were summarized as median and interquartile range (IQR). The Fisher exact test was used to compare responses among the following subgroups to detect differences in practice: PBRNs (WU PAARC versus Pediatric PittNet); provider type (physician versus advanced-level practitioner); and access to an EMR (EMR versus no EMR). Providers from the two PBRNs did not differ on 96% of survey responses, so data were combined and reported together. A probability of $p<0.05$ (two-tailed) was used to establish statistical significance. All statistical analyses were done using Stata, version 12.1.

RESULTS

One hundred surveys (47 WU PAARC, 53 Pediatric PittNet) were returned from 284 invited providers.

Completed and partially completed surveys were used to calculate the overall response rate resulting in overall participation of 35% (56% WU PAARC, 27% Pediatric PittNet, $p<0.001$).[22] The lowest question completion rates (78%) were for estimates of HPV vaccine coverage for girls and boys in their practice by age 15 years. The median completion rate for the remaining questions was 100% (range, 82%−100%). Demographics of participants and nonparticipants were not compared.

Participants were mostly pediatricians (85%); female (73%); Caucasian (83%); and experienced clinicians (median time in practice 18 years, IQR, 10−16 years; Table 1). No significant differences in survey responses were noted by provider type. Participants from the two PBRNs differed significantly ($p<0.01$) by practice location, type, and access to an EMR. WU PAARC had more respondents from suburban practices whereas Pediatric PittNet had more respondents from urban and rural practices. Most worked in pediatric group or multispecialty practices, but many (19%) WU PAARC participants worked in single- or two-person practices compared with zero Pediatric Pittnet participants. Most (90%) had access to an EMR (80% WU PAARC, 100% Pediatric PittNet). Participants reported limited EMR vaccination tracking capabilities: 58% tracked upcoming immunizations, 49% prompted when a patient was due for vaccine, and only 24% tracked missed vaccinations.

All participants (100%) agreed that the HPV vaccine was safe and most (96%) agreed that HPV-related diseases pose a significant health problem. Most (98%) agreed the HPV vaccine should be provided at age 11 or 12 years for girls and boys. More participants endorsed parental hesitancy toward vaccination for the HPV vaccine than for other childhood vaccines (73% vs 41%, $p<0.001$). Everyone (100%) was confident addressing parental concerns about the HPV vaccine, although fewer (81%) were confident that their recommendation influenced parental decision making.

Most discussed (94% and 95%) and recommended (91% and 90%) the HPV vaccine at the well-child check for girls and boys at ages 11 and 12 years. However, some purposely delayed their recommendation until age 13−14 years for girls (overall 8%: WU PAARC 17% vs Pediatric PittNet 0%, $p<0.001$) and boys (overall 10%: WU PAARC 19% vs Pediatric PittNet 2%, $p<0.001$). Most consistently emphasized cancer prevention when recommending the HPV vaccine for girls (97%) and boys (84%). The median estimates for completion of three doses of HPV vaccine by their 15th birthday were 50% (IQR, 30%−75%) for girls and 40% (IQR, 30%−60%) for boys. Few (3%) reported the three-dose series was completed within 6 months (38% 6 months−1 year, 43% 1−2 years, 15% 2−3 years). A minority (33%) had practice coverage data on which to base their estimates, and many commented that their estimates were guesses. Most (75%) always recommended co-administration of the HPV vaccine with the other adolescent vaccines.

Most participants indicated they heard the following concerns frequently from parents when recommending the HPV vaccine: vaccine safety (91%); child's lack of immediate risk of HPV infection (90%); child's resistance to receiving multiple shots in one visit (79%); and parents feeling generally unprepared to discuss the vaccine (72%). Half reported parents frequently raised concerns about the following: lack of child's long-term risk of HPV infection (55%); vaccine encouraging sexual activity (52%); three-dose requirement (49%); religious objections (47%); and vaccine efficacy (41%).

Most participants identified bad publicity about the HPV vaccine (84%) and information about the HPV vaccine on the web (78%) as barriers to their ability to implement ACIP HPV vaccination guidelines. Half identified the following as barriers: lack of a provider or patient follow-up system for series completion (49%); their personal belief that the targeted group was too young (48%); and a lack of a follow-up system for parents who choose to delay vaccination (42%). Many commented that parent's poor understanding of their child's risk of contracting HPV and low health literacy were barriers to HPV vaccination (Table 3).

Most participants (89%) educated parents about the HPV vaccine when the vaccine was first recommended. For those who initially refused vaccination, most (83%) provided information again at subsequent well-child checks but fewer (31%) did so at subsequent acute care visits. The information provided was most often in the form of verbal counseling (91%) and printed materials from the CDC (83%; Table 2).

Most participants increased access to the vaccine by providing immunization-only visits (97%) and offering the vaccine at acute care visits (56%). Half had implemented a provider reminder strategy to administer the HPV vaccine (50%); used a communication strategy to address parental hesitancy (48%); or provided parents with their child's immunization record to track their vaccine schedule (44%). Some strategies to increase HPV vaccination coverage were used exclusively by participants with access to an EMR including (EMR access versus no access): monitoring practicewide vaccination coverage (28% vs 0%); using reminders for parents (18% vs 0%); and maintaining a registry of unvaccinated patients (5% vs 0%; Table 4).

Table 1. Participant and Practice Characteristics[a]

Characteristics	*n* (%) (N=100)	WU PAARC, *n* (%)	Pediatric PittNett, *n* (%)	Overall, *n* (%)	Median (IQR), %
Provider					
Position					
Pediatrician	85 (85)				
Nurse practitioner	10 (10)				
Physician assistant	5 (5)				
Gender					
Male	27 (27)				
Female	73 (73)				
Years in practice					
>10	23 (23)				
5–10	77 (77)				
Ethnicity					
Hispanic or Latino	5 (5)				
Non-Hispanic or Latino	95 (95)				
Race					
Caucasian	83 (83)				
African American	2 (2)				
Asian	7 (7)				
Other	8 (8)				
Practice					
Practice arrangement					
1–2 physician group		**9 (19)**	—	9 (9)	
Group/multispecialty practice		**38 (81)**	**49 (98)**	87 (90)	
Other (academic center/nonprofit)		—	**1 (2)**	1 (1)	
Practice setting					
Urban		**8 (17)**	**24 (47)**	32 (33)	
Suburban		**37 (79)**	**20 (39)**	57 (58)	
Rural		**2 (4)**	**7 (14)**	9 (9)	
Racial composition of practice patients					
Caucasian					75 (40–85)
African American					10 (5–50)
Asian					5 (2.5–10)
Other					2.5 (2–5)
Patients insured by Medicaid					36 (10–60)
Practicewide EMR availability and capability, % yes					
Does your practice use an EMR?		**80**	**100**	**90**	
If yes, can it track vaccinations?				58	
If yes, can it provide prompts for overdue vaccines?				49	
If yes, can it calculate catch-up vaccines?				24	

Note: Boldface indicates statistical significance ($p<0.01$).
[a]PBRN subgroup analysis reported when significant differences were present. Percentages reflect proportion of question respondents.
EMR, electronic medical record; PBRN, practice-based research network; WU PAARC, Washington University Pediatric and Adolescent Ambulatory Research Consortium.

Most participants cited the following as strategies they were willing to implement: maintain a registry of unvaccinated patients (84%); use a parent reminder system (81%); use patient-/parent-friendly educational materials (68%); and regularly monitor and review HPV vaccine coverage at their practice (68%).

Half were willing to use a communication strategy to talk to parents about the vaccine (51%); provide parents with their child's immunization record to track their vaccine schedule (48%); or use a system to remind them a child was due for vaccination (44%; Table 4).

DISCUSSION

The community pediatric providers in this sample estimated HPV vaccination rates well below Healthy People

Table 2. Approach to the Human Papillomavirus (HPV) Vaccine (N=100 providers)

Question	Agree, *n* (%) (N=100)	Disagree, *n* (%) (N=100)	Girls, *n* (%) (N=100)	Boys, *n* (%) (N=100)	Overall, *n* (%) (N=100)
Parental hesitancy regarding childhood vaccines is a significant problem in my practice	**41 (41)**	**59 (59)**			
Parental hesitancy regarding the HPV vaccine is a significant problem in my practice	**73 (73)**	**27 (27)**			
I am confident addressing parental concerns about the HPV vaccine	100 (100)	—			
I am confident my recommendation for the HPV vaccine influences parents decision	81 (81)	19 (19)			
The HPV vaccine is safe	100 (100)	—			
HPV related disease pose a significant public health problem	96 (96)	4 (4)			
What is your typical approach to discussing the vaccine with parents of 11–12-year-olds?					
I recommend the HPV vaccine for all 11–12 girls/boys			94 (94)	95 (95)	
I offer the HPV vaccine as optional			2 (2)	1 (1)	
I recommend delaying the HPV vaccine until the girl/boy is older			2 (2)	2 (2)	
I selectively recommend the HPV vaccine			1 (1)	2 (2)	
I do not discuss the HPV vaccine			1 (1)	0 (0)	
What age do you typically first recommend the HPV vaccine?					
11–12 years			90 (91)	90 (90)	
13–14 years			8 (8)	10 (10)	
9–10 years			1 (1)	0 (0)	
How often to you emphasize cancer prevention?					
Always			97 (97)	86 (86)	
Most of the time			3 (3)	8 (8)	
Sometimes			0 (0)	4 (4)	
Rarely			0 (0)	2 (2)	
How often do you emphasize genital wart prevention?					
Always			42 (42)	54 (54)	
Most of the time			24 (24)	19 (19)	
Sometimes			16 (16)	12 (12)	
Rarely			17 (17)	13 (13)	
Never			1 (1)	2 (2)	
Estimate the percentage of patients who receive three doses of the HPV vaccine by their 15th birthday, % (IQR)			50 (30–70)	40 (30–60)	
How often do you recommend co-administration with the other adolescent vaccines?					
Always					75 (75)
Most of the time					10 (10)
Sometimes					9 (9)
Rarely					6 (6)

(*continued on next page*)

Table 2. Approach to the Human Papillomavirus (HPV) Vaccine (N=100 providers) (*continued*)

Question	Agree, *n* (%) (N=100)	Disagree, *n* (%) (N=100)	Girls, *n* (%) (N=100)	Boys, *n* (%) (N=100)	Overall, *n* (%) (N=100)
Never					—
When do you typically provide parents with information about the HPV vaccine? (choose all that apply)					
At the well-child check when I recommend the vaccine					89 (89)
At subsequent well-child checks for those who previously refused the vaccine					83 (83)
At the well-child check a year before I offer the vaccine					31 (31)
When parents request information					23 (23)
At subsequent acute care visits for those who previously refused the vaccine					19 (19)
Included with information about vaccines provided for all newborns					10 (10)

Note: Boldface indicates statistical significance ($p<0.001$).

2020 goals of 80% coverage.[2] Participants were willing to use proven methods to address barriers to HPV vaccination, but only half had implemented strategies beyond providing immunization-only visits to address poor HPV vaccine rates.

Although providers reported agreement with national recommendations for the HPV vaccine, there was variable adherence with ACIP recommendations for the HPV vaccine. This represents a disconnect between stated support of national recommendations and practical implementation. Indeed, many providers listed their belief that the targeted age group was too young as a barrier to implementing ACIP recommendations. This carried forward in practice; one in ten providers in this sample delayed their recommendation for the HPV vaccine until the adolescent was at least age 13 years and one in four did not co-administer the HPV vaccine with the other adolescent vaccines. Half did not take advantage of acute care checks to reiterate their recommendation for parents who initially refused vaccination. Missed opportunities likely contributed to poor vaccination rates, a finding supported in the literature.[14,23–26]

Most providers in the sample believed parental hesitancy toward the HPV vaccine was a significant problem. Additionally, one in five providers in this sample was not confident that their recommendation for the HPV vaccine influenced parent behavior. These findings are supported by the literature.[23,27–30] The more barriers a provider perceives, the less likely they may be to recommend vaccination.[12,31] These providers may delay their recommendation or be hesitant to make a strong recommendation for the vaccine. Indeed, some providers in this sample indicated the vaccine was optional and cancer prevention was not consistently emphasized, particularly with boys. This, in turn, could reinforce parental hesitancy or belief that the vaccine is not necessary, leading to delay or refusal of the vaccine.[23,32] Multiple studies have shown that a strong recommendation from a trusted provider is particularly important in the case of HPV vaccination.[13–15,19] Presuming parents will agree to vaccination, rather than engaging in a discussion, has been a successful method for adherence to other childhood vaccinations.[33] Indeed, simply announcing the HPV vaccine as one of the three recommended adolescent vaccines with an unequivocal strong recommendation emphasizing cancer prevention and highlighting vaccine safety and efficacy is effective.[34,35]

Providers in this study were willing to use practice-level strategies, but few had adopted them. The Assessment, Feedback, Incentive and Exchange (AFIX) approach endorsed by the CDC is effective for increasing HPV vaccine coverage. AFIX components include regularly monitoring practice-wide vaccination coverage,

Table 3. Perceived Parental Concerns and Provider Barriers to HPV Vaccination

Concerns/barriers	Participants, *n* (%) (N=100)
How often do parents raise concerns about the following?[a]	
HPV vaccine safety	91 (91)
Lack of immediate risk of HPV infection	90 (90)
Child is resistant to receiving multiple shots at once	78 (78)
Unprepared to discuss the HPV vaccine	72 (72)
Lack of long term risk of HPV infection	56 (56)
Risk the HPV vaccine may encourage my child to have sex	52 (52)
Three-dose requirement of the HPV vaccine	50 (50)
Religious objections	48 (48)
HPV vaccine efficacy	42 (42)
HPV vaccine cost	19 (19)
How significant are the following barriers[b]	
Previous bad publicity of the HPV vaccine	81 (83)
Information about HPV on the web	75 (78)
Targeted age group is too young	47 (50)
Lack of follow-up system to complete all three doses	47 (48)
Lack of follow-up system for those who chose to delay	41 (42)
Wish to avoid upsetting parents	20 (21)
Wish to avoid lengthy discussion	15 (16)
Lack of proof vaccine prevents cancer	8 (9)
Up-front costs to purchase the vaccine	8 (8)
Low Medicaid reimbursement	8 (8)
Costs of vaccine administration	3 (3)

[a]Identified as frequently. Frequent concerns: Parental concerns participants reported were raised "all/most of the time" and "some of the time."
[b]Identified as significant. Significant barriers: Barriers to implementing ACIP guidelines participants reported as "very significant" and "significant."
ACIP, Advisory Committee on Immunization Practices; HPV, human papillomavirus.

setting coverage goals, and providing feedback to clinicians and their staff.[8,9,18] A recent review of the impact of a statewide immunization registry linked to EMRs in pediatric practices showed increased HPV vaccine coverage and highlighted the importance of convenient access to coverage information for providers.[36] Many with EMRs did not have the capability to track practice-specific vaccination rates or follow-up with patients who either delayed vaccine initiation or needed to complete the series. Implementation may require additional

Table 4. Use of and Willingness to Implement Improvement Strategies (N=100 Providers)

Strategy	I already use, *n* (%)	I would use, *n* (%)	I would not use, *n* (%)
Provide immunization-only visits	97 (97)	2 (2)	1 (1)
Offer the HPV vaccine at acute care visits	54 (56)	32 (33)	11 (11)
System to remind provider	48 (50)	42 (44)	6 (6)
A communication strategy	47 (48)	49 (51)	1 (1)
Immunization record for parents	42 (44)	43 (45)	10 (11)
Regularly monitor and review coverage	27 (28)	65 (67)	5 (5)
System to remind parent	17 (18)	76 (81)	1 (1)
Give vaccine prior to provider interaction	8 (8)	32 (43)	48 (49)
Keep a registry of unvaccinated patients	5 (5)	80 (85)	10 (10)
Refer patients to retail clinics for the HPV vaccine	0 (0)	17 (18)	79 (82)

HPV, human papillomavirus.

resources for EMR modification and expertise beyond that available within many independent practices. One in ten physicians did not have an EMR at all, compounding the difficulty of adopting this recommended strategy.

Most providers were willing to employ reminder systems, but only half used provider reminders and few had adopted parent reminder systems. Reminder strategies have been particularly effective with HPV vaccination series completion.[5,6,12] However, similar to EMR systems, implementation of reminder strategies likely requires additional resources that may not be available to many practices.[37] Low resource reminder strategies, such as flagging patient charts, could be a potential strategy.

Limitations

This study has several limitations. The differences observed between the two sampled PBRNs regarding the age providers recommended the HPV vaccine may be explained by differences in practice type and setting. Providers working in suburban settings with more affluent, educated parents are more likely to encounter parental hesitation for vaccination, which may cause them to routinely delay their recommendation for the HPV vaccine.[38] Only one third of participants had practice-level vaccination coverage data on which to base their time to series completion and estimated HPV vaccination rates, likely introducing a recall bias. Participants were a convenience sample of providers who have chosen to be part of a PBRN and the participation rate was low at 35%, introducing a selection bias of providers more attuned to evidence-based practice. However, these findings suggest that even among the most motivated providers, HPV vaccine coverage is low. Additionally, barriers are frequently encountered, and rarely addressed in a systematic way.

Agreement with national guidelines for use of the HPV vaccine was confirmed in this sample. It was beyond the scope of this project to explore reasons behind nonadherence to guidelines or the lack of implementing evidence-based strategies to increase coverage. Future research should explore these avenues and focus on developing strategies to overcome barriers. Certainly, limited resources hinder adoption of methods requiring financial support. However, there are many strategies that do not require increased spending. Providers in this sample indicated that parents frequently felt their child was not at risk of HPV infection and had concerns regarding vaccine safety. This finding may indicate a need for improved education about HPV prevalence and dissemination of existing patient-/parent-friendly education materials to bolster provider's recommendation for the HPV vaccine.[39] Further, reducing missed opportunities and optimizing recommendation practices to address specific parental concerns will require a change in care delivery, but may not need additional resources. Additionally, dissemination of strategies from providers with high vaccination rates requiring minimal resources would be beneficial. Finally, recognizing that primary care providers are busy and incentivizing providers to adopt new methods with maintenance of certification credit or through quality improvement projects can be effective.[40]

CONCLUSIONS

Providers in this sample reported suboptimal coverage in their practice after 10 years of HPV vaccine use. However, many had not adopted strategies to address known system and parental barriers, and some providers did not follow ACIP guidelines. These results suggest that barriers to implementation of strategies shown to improve HPV vaccine coverage likely existed for participants in this sample. This may be a pervasive problem in primary care practices. A better understanding of the practical challenges of implementing evidence-based interventions and actionable plans to address these barriers is needed to improve HPV vaccination rates.

ACKNOWLEDGMENTS

The authors would like to acknowledge Professors Vetta Sanders-Thompson, PhD, and Robert Strunk, MD, for their guidance developing the survey tool and the pediatric providers who participated in this project.

This work was completed while Dr. Emily Walling was at Washington University.

Funding is from an NIH/Clinical and Translational Science Award Grant UL1-TR000448 (WU-PAARC) and NIH/Clinical and Translational Science Award Grant UL1-TR000005 (Pediatric PittNet).

Author responsibilities were as follows: EBW conceptualized the project, developed the survey tool, participated in data analysis and interpretation, and drafted the manuscript. SD and NB contributed to survey tool development. SD coordinated WU-PAARC physician recruitment and managed data collection. SD, NB, ER, and RS contributed to manuscript revisions. ER coordinated physician recruitment and data collection from Pediatric PittNet. ER and RS participated in data interpretation. RS advised on survey tool development. JG served as a senior advisor, oversaw development of the survey tool, completed the analysis and interpretation of the data, and oversaw manuscript revisions. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of work.

Dr. Reis has received salary support as a co-investigator on a sponsored research agreement with Pfizer and Merck. The other authors have no financial relationships relevant to this article to disclose. The authors have no conflicts of interest to disclose.

REFERENCES

1. Jemal A, Simard EP, Dorell C, et al. Annual report to the nation on the status of cancer, 1975–2009, featuring the burden and trends in human papillomavirus (HPV)–associated cancers and HPV vaccination coverage levels. *J Natl Cancer Inst.* 2013;105(3):175–201. https://doi.org/10.1093/jnci/djs491.
2. Office of Disease Prevention and Health Promotion, HHS. Immunization and Infectious Diseases, Healthy People 2020. www.healthypeople.gov/2020/topics-objectives/topic/immunization-and-infectious-diseases/objectives. Accessed March 6, 2016.
3. Walker TY, Elam-Evans LD, Singleton JA, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years—United States, 2016. *MMWR Morb Mortal Wkly Rep.* 2017;66(33):874–882. https://doi.org/10.15585/mmwr.mm6633a2.
4. FUTURE I/II Study GroupDillner J, Kjaer SK, Wheeler CM, et al. Four year efficacy of prophylactic human papillomavirus quadrivalent vaccine against low grade cervical, vulvar, and vaginal intraepithelial neoplasia and anogenital warts: randomised controlled trial. *BMJ.* 2010;341:c3493. https://doi.org/10.1136/bmj.c3493.
5. Szilagyi PG, Humiston SG, Gallivan S, Albertin C, Sandler M, Blumkin A. Effectiveness of a citywide patient immunization navigator program on improving adolescent immunizations and preventive care visit rates. *Arch Pediatr Adolesc Med.* 2011;165(6):547–553. https://doi.org/10.1001/archpediatrics.2011.73.
6. Szilagyi PG, Albertin C, Humiston SG, et al. A randomized trial of the effect of centralized reminder/recall on immunizations and preventive care visits for adolescents. *Acad Pediatr.* 2013;13(3):204–213. https://doi.org/10.1016/j.acap.2013.01.002.
7. Matheson EC, Derouin A, Gagliano M, Thompson JA, Blood-Siegfried J. Increasing HPV vaccination series completion rates via text message reminders. *J Pediatr Health Care.* 2014;28(4):e35–e39. https://doi.org/10.1016/j.pedhc.2013.09.001.
8. Perkins RB, Zisblatt L, Legler A, Trucks E, Hanchate A, Gorin SS. Effectiveness of a provider-focused intervention to improve HPV vaccination rates in boys and girls. *Vaccine.* 2015;33(9):1223–1229. https://doi.org/10.1016/j.vaccine.2014.11.021.
9. Gilkey MB, Dayton AM, Moss JL, et al. Increasing provision of adolescent vaccines in primary care: a randomized controlled trial. *Pediatrics.* 2014;134(2):e346–e353. https://doi.org/10.1542/peds.2013-4257.
10. Fiks AG, Grundmeier RW, Mayne S, et al. Effectiveness of decision support for families, clinicians, or both on HPV vaccine receipt. *Pediatrics.* 2013;131(6):1114–1124. https://doi.org/10.1542/peds.2012-3122.
11. Centers for Disease Control and Prevention (CDC). Vaccines. AFIX: overview and effectiveness. www.cdc.gov/vaccines/programs/afix/. Accessed April 30. 2016.
12. Chao C, Preciado M, Slezak J, Xu L. A randomized intervention of reminder letter for human papillomavirus vaccine series completion. *J Adolesc Health.* 2015;56(1):85–90. https://doi.org/10.1016/j.jadohealth.2014.08.014.
13. Gilkey MB, McRee A-L. Provider communication about HPV vaccination: a systematic review. *Hum Vaccines Immunother.* 2016;12(6):1454–1468. https://doi.org/10.1080/21645515.2015.1129090.
14. Rahman M, Laz TH, McGrath CJ, Berenson AB. Provider recommendation mediates the relationship between parental human papillomavirus (HPV) vaccine awareness and HPV vaccine initiation and completion among 13- to 17-year-old U.S. adolescent children. *Clin Pediatr (Phila).* 2015;54(4):371–375. https://doi.org/10.1177/0009922814551135.
15. Darden PM, Jacobson RM. Impact of a physician recommendation. *Hum Vaccines Immunother.* 2014;10(9):2632–2635. https://doi.org/10.4161/hv.29020.
16. Finney Rutten LJ, St Sauver JL, Beebe TJ, et al. Association of both consistency and strength of self-reported clinician recommendation for HPV vaccination and HPV vaccine uptake among 11- to 12-year-old children. *Vaccine.* 2017;35(45):6122–6128. https://doi.org/10.1016/j.vaccine.2017.09.056.
17. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377–381. https://doi.org/10.1016/j.jbi.2008.08.010.
18. Gilkey MB, Malo TL, Shah PD, Hall ME, Brewer NT. Quality of physician communication about human papillomavirus vaccine: findings from a national survey. *Cancer Epidemiol Biomark Prev.* 2015;24(11):1673–1679. https://doi.org/10.1158/1055-9965.EPI-15-0326.
19. Bundy DG, Persing NM, Solomon BS, et al. Improving immunization delivery using an electronic health record: the ImmProve project. *Acad Pediatr.* 2013;13(5):458–465. https://doi.org/10.1016/j.acap.2013.03.004.
20. Stockwell MS, Natarajan K, Ramakrishnan R, et al. Immunization data exchange with electronic health records. *Pediatrics.* 2016;137(6):e20154335. https://doi.org/10.1542/peds.2015-4335.
21. American Association for Public Opinion Research. Standard definitions: final dispositions of case codes and outcome rates for surveys. www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf. Revised 2016. Accessed October 8, 2016.
22. Perkins RB, Clark JA, Apte G, et al. Missed opportunities for HPV vaccination in adolescent girls: a qualitative study. *Pediatrics.* 2014;134(3):e666–e674. https://doi.org/10.1542/peds.2014-0442.
23. Neubrand TPL, Breitkopf CR, Rupp R, Breitkopf D, Rosenthal SL. Factors associated with completion of the human papillomavirus vaccine series. *Clin Pediatr (Phila).* 2009;48(9):966–969. https://doi.org/10.1177/0009922809337534.
24. Daley MF, Crane LA, Markowitz LE, et al. Human papillomavirus vaccination practices: a survey of U.S. physicians 18 months after licensure. *Pediatrics.* 2010;126(3):425–433. https://doi.org/10.1542/peds.2009-3500.
25. Vadaparampil ST, Kahn JA, Salmon D, et al. Missed clinical opportunities: provider recommendations for HPV vaccination for 11–12 year old girls are limited. *Vaccine.* 2011;29(47):8634–8641. https://doi.org/10.1016/j.vaccine.2011.09.006.
26. Reiter PL, Stubbs B, Panozzo CA, Whitesell D, Brewer NT. HPV and HPV vaccine education intervention: effects on parents, healthcare staff, and school staff. *Cancer Epidemiol Biomark Prev.* 2011;20(11):2354–2361. https://doi.org/10.1158/1055-9965.EPI-11-0562.
27. Fu LY, Bonhomme L-A, Cooper SC, Joseph JG, Zimet GD. Educational interventions to increase HPV vaccination acceptance: a systematic review. *Vaccine.* 2014;32(17):1901–1920. https://doi.org/10.1016/j.vaccine.2014.01.091.
28. O'Leary ST, Lockhart S, Barnard J, et al. Exploring facilitators and barriers to initiation and completion of the human papillomavirus (HPV) vaccine series among parents of girls in a safety net system. *Int J Environ Res Public Health.* 2018;15(2):185. https://doi.org/10.3390/ijerph15020185.
29. Allison MA, Hurley LP, Markowitz L, et al. Primary care physicians' perspectives about HPV vaccine. *Pediatrics.* 2016;137(2):1–9. https://doi.org/10.1542/peds.2015-2488.
30. Rutten LJF, St Sauver JL, Beebe TJ, et al. Clinician knowledge, clinician barriers, and perceived parental barriers regarding human papillomavirus vaccination: association with initiation and completion rates. *Vaccine.* 2017;35(1):164–169. https://doi.org/10.1016/j.vaccine.2016.11.012.
31. Cabana MD, Ebel BE, Cooper-Patrick L, Powe NR, Rubin HR, Rand CS. Barriers pediatricians face when using asthma practice guidelines. *Arch Pediatr Adolesc Med.* 2000;154(7):685–693. https://doi.org/10.1001/archpedi.154.7.685.
32. Opel DJ, Mangione-Smith R, Robinson JD, et al. The influence of provider communication behaviors on parental vaccine acceptance and visit experience. *Am J Public Health.* 2015;105(10):1998–2004. https://doi.org/10.2105/AJPH.2014.302425.
33. Malo TL, Gilkey MB, Hall ME, Shah PD, Brewer NT. Messages to motivate human papillomavirus vaccination: national studies

of parents and physicians. *Cancer Epidemiol Biomark Prev.* 2016;25(10):1383–1391. https://doi.org/10.1158/1055-9965.EPI-16-0224.

34. Brewer NT, Hall ME, Malo TL, Gilkey MB, Quinn B, Lathren C. Announcements versus conversations to improve HPV vaccination coverage: a randomized trial. *Pediatrics.* 2017;139(1):e20161764. https://doi.org/10.1542/peds.2016-1764.
35. Stockwell MS, Natarajan K, Ramakrishnan R, et al. Immunization data exchange with electronic health records. *Pediatrics.* 2016;137(6): e20154335. https://doi.org/10.1542/peds.2015-4335.
36. Wolfson D, Bernabeo E, Leas B, Sofaer S, Pawlson G, Pillittere D. Quality improvement in small office settings: an examination of successful practices. *BMC Fam Pract.* 2009;10:14. https://doi.org/10.1186/1471-2296-10-14.
37. Smith PJ, Humiston SG, Marcuse EK, et al. Parental delay or refusal of vaccine doses, childhood vaccination coverage at 24 months of age, and the Health Belief Model. *Public Health Rep.* 2011;126 (suppl 2):135–146.
38. Centers for Disease Control and Prevention (CDC). HPV, materials to keep parents informed. www.cdc.gov/hpv/partners/outreach-parents/materials-parents.html. Published April 20, 2017. Accessed July 20, 2018.
39. Rand CM, Tyrrell H, Wallace-Brodeur R, et al. A learning collaborative model to improve human papillomavirus vaccination rates in primary care. *Acad Pediatr.* 2018;18(2 suppl):S46–S52. https://doi.org/10.1016/j.acap.2018.01.003.
40. Fiks AG, Luan X, Mayne SL. Improving HPV vaccination rates using maintenance-of-certification requirements. *Pediatrics.* 2016;137(3): e20150675. https://doi.org/10.1542/peds.2015-0675.