



Educating healthcare providers to increase Human Papillomavirus (HPV) vaccination rates: A Qualitative Systematic Review



Shuk On Annie Leung^a, Babatunde Akinwunmi^b, Kevin M. Elias^a, Sarah Feldman^{a,*}

^a Division of Gynecologic Oncology, Department of Obstetrics and Gynecology, Brigham and Women's Hospital, Harvard Medical School, Dana-Farber Cancer Institute, Boston, MA, United States

^b Department of Global Education, Harvard Medical School, Boston, MA, United States

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ABSTRACT

Objectives: HPV vaccination rates in the United States lag behind other developed countries. Educational interventions are primarily directed at patients and parents rather than healthcare providers (HCPs), despite evidence that provider recommendation is a key determinant of vaccine uptake. The objectives for this review are to synthesize the available evidence related to the knowledge, attitudes, and beliefs of HCPs surrounding HPV vaccination, to summarize provider-specific educational interventions which have been evaluated, and to review existing provider-specific educational resources from national organizations and whether they align with the gaps identified.

Methods: A systematic search was performed using PubMed, Web of Science, CINAHL, and ERIC with MeSH terms human papillomavirus, vaccine, education, workshop, training, knowledge, attitude, belief, intention, and healthcare provider. Full text articles were obtained for studies that described the knowledge and attitudes of providers and/or impact of educational interventions. Data extraction was performed by four independent reviewers. Websites of American organizations with an interest in HPV vaccination were manually searched for provider resources.

Results: 1066 publications were identified, and 98 articles were fully reviewed with 40 ultimately included. Providers' knowledge on HPV was generally low with a correspondingly low vaccine recommendation rate. Provider-specific education (e.g., didactic session and communication training) with complimentary interventions demonstrated increased knowledge and vaccine series initiation and completion. Themes identified in descriptive studies highlighted providers' lack of general HPV and vaccine knowledge, low self-confidence in counselling and addressing parental concerns, and discomfort in discussing sexual issues related to vaccination. Many American organizations have provider-specific resources; however, the effectiveness of these materials has not been established.

Conclusions: HPV knowledge among providers remains low. Educational interventions to improve knowledge and communication appear to be effective. A breadth of resources from national organizations are available but their efficacy and level of utilization is largely unknown. Coordinated efforts are needed to evaluate provider-specific educational resources to improve vaccine uptake in the US.

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* Corresponding author at: Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115, United States.

E-mail address: sfeldman@partners.org (S. Feldman).

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1. Introduction

Human papillomavirus (HPV) is the most common sexually transmitted infection in the United States [1] and causes anogenital warts, anogenital cancers (cervical, vaginal, vulvar, penile, and anal), and oropharyngeal cancers. Approximately 33,700 new cases of HPV-associated cancers occur in the US annually and the majority could be prevented by vaccination [2,3]. Despite the potential for vaccines to decrease HPV-related diseases, the nation will fall short of meeting the Healthy People 2020 goal of an HPV vaccination rate of 80%. In 2017, only 53% and 46% of females and males aged 13–17 years were up to date with the HPV vaccine as recommended [4].

Vaccine-related knowledge and positive attitudes towards the vaccine (i.e., belief in the safety and efficacy of the vaccine) are among the personal cognitive factors associated with vaccine uptake [5]. Various educational and delivery methods have been utilized to improve HPV knowledge among adolescents and parents such as information sheets, slide presentations, and brief educational videos [6]. In addition to parents, healthcare providers (HCP) play a significant role in the acceptance and utilization of the HPV vaccine and other cervical cancer prevention services [7,8]. For example, it has been shown that high-quality recommendations by physicians can increase HPV vaccination series initiation and completion by 3- and 9-fold, respectively [9,10]. This underscores the need for HCPs to have comprehensive training to acquire the necessary knowledge to provide quality counseling to parents and patients.

In response, provider-specific educational resources have been developed by national organizations such as the Centers for Disease Control and Prevention (CDC) [11], American Cancer Society (ACS), American Academy of Pediatrics (AAP) [12], National HPV Vaccination Roundtable [13], American College of Obstetricians and Gynecologists (ACOG) [14], American Academy of Family Physicians (AAFP) [15], American Head and Neck Society (AHNS) [16], American Dental Society (ADA) [16]. This is in addition to the wealth of resources developed by regional groups and publicly available in various formats.

The efforts and interest in reaching HCPs as an influential group is encouraging but much remains unknown with respect to the promotion and dissemination of these resources, the extent to which resources are utilized by HCPs, and ultimately the efficacy of these various resources in improving HCP recommendations and vaccine uptake. A first step in addressing these questions is to understand the knowledge gaps of HCPs and whether these align with existing resources. The objectives for this review are (1) to synthesize the available evidence related to the knowledge, attitudes, and beliefs of HCPs surrounding HPV vaccination to identify existing HPV knowledge gaps; (2) to summarize provider-specific educational interventions which have been evaluated; and (3) to review existing provider-specific educational resources from national organizations and whether they align with the knowledge gaps identified.

2. Methods

2.1. Search strategy

This is a qualitative systematic review based on meta-ethnography as described by Noblit and Hare [17]. Briefly, meta-ethnography uses a process of comparison and cross-interpretation between studies while preserving the context of the primary data. This synthesis process provides a higher level of analysis to generate new research questions and reduce research duplication. We used the PRISMA checklist to guide the design and reporting of our study ([Supplemental Material Table 1](#)) [18]. The authors searched PubMed, Web of Science, CINAHL, and ERIC for available literature on this subject using variations and Boolean connectors with the following terms: human papillomavirus, vaccine, education, workshop, training, knowledge, attitude, belief, intention, and healthcare provider. Manual search for references within some of the identified articles and previous systematic reviews was also performed to identify additional related articles. For the purposes of this review, healthcare provider was defined as an individual qualified to provide vaccination recommendation and counselling (e.g., physicians, physician assistants, registered nurses, nurse practitioners, and school nurses). The following criteria were used for inclusion of articles: (1) original articles published in a peer-reviewed, English language journal (including quantitative and qualitative, experimental, quasi-experimental, and observational studies), (2) studies conducted in the US only due to the heterogeneity of vaccination programs globally, and (3) methodology that specifically focused on healthcare provider knowledge, belief, attitudes, and behavior regarding HPV vaccination and/or healthcare provider-specific interventions in vaccine recommendation. Articles without full text (e.g., conference abstracts or book section only), commentaries, editorials, or personal perspectives were excluded. Systematic search was performed for abstracts of all articles published up to February 2018 and further manual search was performed for articles published from February 2018 to January 2019. Articles were retrieved and reviewed for relevance. Full text articles were obtained for studies that met the inclusion criteria and data extraction was completed independently by four reviewers (AL, BA, KE and SF). Eligible studies were further classified as descriptive or interventional studies (see [Fig. 1](#)).

2.2. Thematic analysis from descriptive studies

For descriptive studies, information on the study objective, design, and population, and key findings were collected. Themes and subthemes were further identified through content analysis of the data and key findings reported in the articles. Studies were assessed with the perspective of identifying provider needs related to knowledge, attitudes, and beliefs which may be of interest to educational program development. SF conducted an independent review of the themes and subthemes providing validation of data

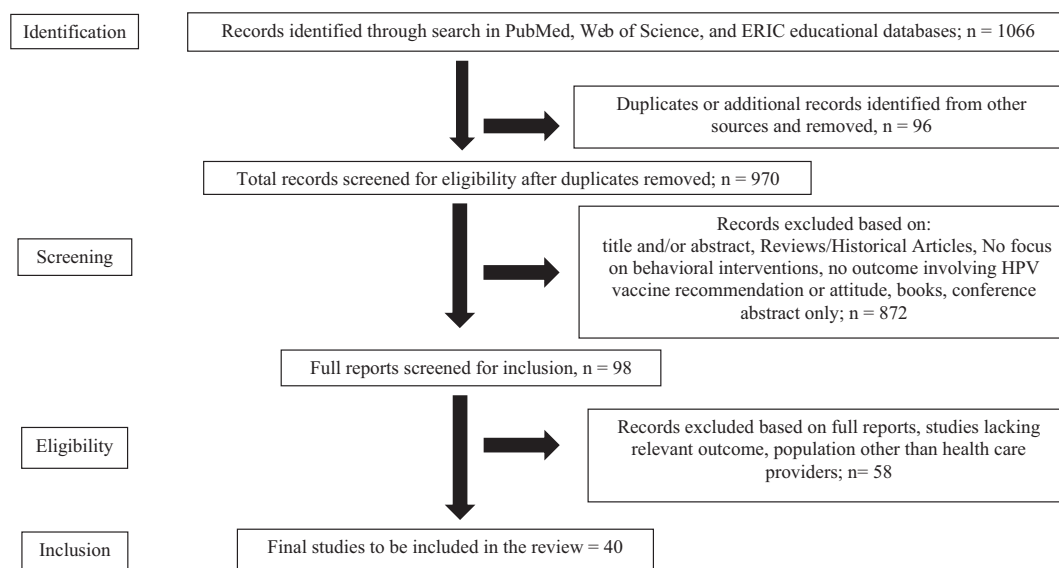


Fig. 1. PRISMA flow chart of studies identified in the systematic review.

classification, as well as reviewing the abstracted data to ensure that the data aligned with the proposed themes and subthemes. Discrepancies in classification were resolved through discussion among all authors.

2.3. Analysis of interventional studies

Educational interventions in this review refer to didactic presentations, group sessions, webinars, videos, clinical vignettes and simulations, with or without hardcopy handouts. For interventional studies, information on the purpose of the study, study design, study population, description of provider-specific education intervention, key outcomes, and recommendations were collected. The risk of bias of individual interventional studies was assessed using the Revised Cochrane Risk of Bias (RoB 2.0) tool for randomized controlled trials and the Risk of Bias in Non-Randomized Studies - of Interventions (ROBINS-I) tool for non-randomized studies [19,20]. Appraisal of each domain and of an overall risk of bias rating for each article was performed by two reviewers. Any discrepancy in risk-of-bias rating was discussed to achieve consensus.

Provider-specific educational resources created and endorsed by various US organizations that held HPV vaccine campaigns were retrieved from the following organizational websites: CDC “You are the Key”, AAP “HPV Champion Toolkit”, AAP Same Way, Same Day”, American Cancer Society, ACOG “HPV Toolkit 2016”, American Cancer Society, National HPV Vaccination Roundtable, AAFP, AHNS, and ADA. The content of the provider-specific educational resources noted above was then compared to the themes and subthemes identified from the descriptive studies in an effort to identify HCP provider needs (i.e., existing gaps) and how the existing resources address these needs.

3. Results

3.1. Study characteristics

1066 publications were identified with 98 articles reviewed in full text and ultimately 40 articles met the inclusion for review. There were 10 interventional studies (five randomized trials and five quasi-experimental pre-test/post-test design) and 30 descriptive studies (21 surveys, 4 qualitative studies using

semi-structured interviews, and 5 mixed-methods studies). The details of the descriptive and interventional studies are summarized in Tables 1 and Table 2, respectively. The earliest among the studies selected in this review was 2005, and study sites included hospitals, clinics, schools, and community centers. Separately, a manual search yielded a recent qualitative systematic review of US clinicians’ knowledge, attitudes, and practices regarding HPV vaccination [21].

3.2. Thematic analysis of descriptive studies in identification of knowledge gaps

Table 1 summarizes the key findings from the descriptive studies. The themes and subthemes identified are listed in Table 3 to facilitate comparison to sample existing provider-specific educational resources. It is important to note that the resources selected for comparison are not exhaustive, and that Table 3 serves as an illustrative example of how one might map themes to a resource under consideration. Thematic analysis revealed the following key areas of focus in addressing provider knowledge gaps: HPV knowledge, HPV vaccine knowledge, provider self-efficacy and normative beliefs, gender differences and sexuality, and communication strategies.

Within the descriptive studies, there was relatively lower HPV knowledge in the areas related to HPV prevalence in different populations, oncogenic versus non-oncogenic strains, and head and neck manifestations and other HPV associated cancers (anal, oropharyngeal, penile, vulvar, and vaginal). Specifically, Gnagi et al., reported that 53% of HCPs never discuss oropharyngeal cancer when counseling patients on HPV vaccine and up to 95% of HCPs identified a need for increased education on head and neck manifestations of HPV [22]. With respect to vaccine specific knowledge, HCPs in the studies identified safety and efficacy, dosing schedule, vaccine recommendations for men who have sex with men, differences between the 4-valent and 9-valent HPV vaccines, age of eligibility, as well as cost and insurance as areas in which they would like more information.

In addition to the foundational HPV knowledge, studies highlighted the importance of exploring providers’ personal motivations in vaccine recommendation, which consist of the providers’ personal belief in vaccine benefit [23], belief that recommendation will effect change [23–25], and perceived importance of adhering

Table 1
Summary of descriptive studies and key findings. MD: Physicians; PA: Physician Assistants; FP: Family Physicians; PCP: Primary Care Provider; RN: Registered Nurse; NP: Nurse Practitioners.

Reference	Study Population	Study Purpose	Key Findings
Quantitative studies			
Walling, et al. [63]	Pediatricians	Assessed providers' approach to the HPV vaccine and their implementation of strategies to increase HPV vaccination coverage	<ul style="list-style-type: none"> The most common parental concerns identified were HPV vaccine safety, lack of immediate risk of HPV infection whereas the least common were cost and vaccine efficacy. The most significant barriers identified were previous bad publicity of the HPV vaccine and information about HPV on the web whereas costs of vaccine administration and low Medicaid reimbursement was the least significant.
Farias et al. [75]	Pediatricians	Linked physician-reported barriers and characteristics with the uptake of HPV vaccination initiation through survey and health records	<ul style="list-style-type: none"> Relative risk of vaccine initiation was lower for patients whose physician reported concerns about HPV vaccine safety (RR 0.75), efficacy (RR 0.73), and financial burden of the vaccine of the vaccine on patient (RR 0.72). After adjusting for patient and physician characteristics, only financial burden was significantly associated (adjusted RR 0.76). Stronger perception of role as opinion leaders predictive of positive attitudes
Rosen et al. [24]	School nurses	Examined attitudes towards HPV vaccine, HPV and vaccine knowledge, perception of role as opinion leader, and support in providing health education	<ul style="list-style-type: none"> Stronger perception of role as opinion leaders predictive of positive attitudes HPV and vaccine knowledge also predictive of positive attitudes
Kulczycki et al. [76]	PCP, Pediatricians	Determine variables predictive of likelihood to prescribe HPV vaccine using logistic regression model through survey	<p>More likely to prescribe the HPV vaccine if respondent (1) believed the guidelines were clear (OR 1.85), (2) agreed w/ mandate requirement (OR 2.39), (3) Felt comfortable discussing the HPV vaccine, and (4) had >25% of their patients using public assistance (OR 3.82)</p>
White et al. [77]	RNs	Determined knowledge and attitudes about HPV and HPV vaccine for males	<ul style="list-style-type: none"> Majority agree that males should be vaccinated to protect themselves and their partners Less knowledgeable about male HPV infection and the availability or indications of HPV vaccine for males Less knowledgeable on HPV strains that cause cancer
Malo et al. [39]	MD, parents	Identified motivational messages physicians would use to recommend HPV vaccine and that would motivate parental acceptance	<ul style="list-style-type: none"> Message needs to explicitly express a strong recommendation for vaccination Speak directly to prevention of anal/cervical cancer Emphasize control over whether their child becomes infected with HPV
Gnagi et al. [22]	MD	Demonstrated need for increased education regarding otolaryngology-related manifestations of HPV	<ul style="list-style-type: none"> Information on vaccine effectiveness, safety, and prevalence of HPV infection is needed Gap in knowledge on HPV and recurrent respiratory papillomatosis and oropharyngeal cancer "Rarely" or "never" discuss head and neck HPV manifestations with patients Perceive that parents are more likely to consent to vaccinate girls than boys
Allison et al. [78]	Pediatricians, FP	Described self-reported recommendation practices, estimate the frequency of parental deferral of HPV vaccination, identify characteristics associated with not discussing it	<ul style="list-style-type: none"> Physicians were more likely to strongly recommend the vaccine for older age groups and for girls than boys. More than half reported that >25% of parents deferred vaccination for their 11–12-year-old children 12% of pediatricians and 33% of family physicians were only somewhat likely or unlikely to bring up the HPV vaccine again if parents initially deferred. Physicians reported that knowing the patient is not sexually active as reasons for deferring discussion
Berkowitz et al. [79]	MD, PA, NP	Described providers' practice, recommendations and beliefs about HPV vaccination using national surveys (National Ambulatory Medical Care Survey, National Hospital Ambulatory Medical Care Survey)	<ul style="list-style-type: none"> Areas for improvement in knowledge: 60% believe there will be fewer numbers of abnormal pap tests among vaccinated females, 60% believe there will be fewer referrals for colposcopy among vaccinated females, 20%–31% recommend vaccination based on the number of sexual partners, contrary to guidelines
Berkowitz et al. [80]	MD, NP	Described providers' beliefs about the effectiveness of the HPV vaccine using 2012DocStyles survey	<ul style="list-style-type: none"> Knowledge about HPV vaccine effectiveness in preventing anal, vaginal, vulvar, and oropharyngeal cancers was low Only 14.5% of providers recommended the vaccine to all age-eligible females and many providers recommend to ages younger or older than ages recommended by the ACIP
Suryadevara et al. [29]	Pediatricians	Described vaccine attitudes among pediatric HCP attending immunization conferences	<ul style="list-style-type: none"> 5% do not routinely recommend HPV vaccine to eligible patients and 4% believed it increases the likelihood of unprotected sexual activity HPV vaccine was most commonly identified with safety concerns (26%) 59% believe that media play an influential role in parental vaccine decision making

Table 1 (continued)

Reference	Study Population	Study Purpose	Key Findings
Gilkey et al. [10]	MD	Described HPV vaccine communication practices among primary care physicians	<ul style="list-style-type: none"> • Recommendations were often weak in consistency and urgency but should be routine (instead of risk-based) and recommend same-day vaccination. • Minority do not strongly endorse HPV vaccine or deliver timely recommendations for girls (26%) or boys (27%) • Fewer than half correctly identified gay and bisexual males as being at increased risk of HPV • Begin discussions by saying that the child was due for HPV vaccine instead of giving information or eliciting questions • Counsel parents that HPV vaccine protects against three disease types (i.e., cervix, other cancers, and genital warts)
McRee et al. [25]	MD, NP	Described providers' vaccine recommendation practices and explored perceptions of parental hesitancy	<ul style="list-style-type: none"> • Providers lack time to probe parents for reasons for vaccination hesitancy and would like a screening tool to identify specific parental concerns or a discussion guide • Providers lack self-efficacy and majority believed they could not change parents' minds • Providers routinely recommended vaccine for boys less often than for girls.
Bynum et al. [81]	MD	Assess factors related to providers' recommendation of the HPV vaccine across different age groups (early, target, and catch-up) among low-income patients	<ul style="list-style-type: none"> • Common factors across age groups were that negatively associated with vaccine recommendation: (1) discomfort discussing STIs with parents, (2) difficulty ensuring completion of three-dose vaccine series, (3) concerns about HPV vaccine efficacy, and (4) concerns that teens will practice risky sexual behaviors • Physicians who reported that majority of their patients were of non-Hispanic black race as well as family medicine physicians were less likely to report recommendation of vaccine
Allison et al. [82]	MD	Described (1) knowledge and attitudes, (2) recommendation and administration practices in boys compared to girls, (3) perceived barriers in boys, (4) personal and practice characteristics associated with recommending the vaccine to boys	<ul style="list-style-type: none"> • Only 31% recommended the vaccine to 11–12 year old boys (vs. 92% for girls) and recommended it more strongly to older male adolescents • Most common barrier was related to financing • Physicians are linking discussion of sexual health issues with recommending the vaccine
Humiston et al. [41]	MD	Assessed which strategies physicians would consider to increase adolescent immunization rates	<ul style="list-style-type: none"> • Strategies to increase immunization rates include nurse prompts to providers at preventive visits, physician education, and scheduled vaccine-only visits • Vaccine-only visits comprised the most commonly used strategy for immunization
Weiss et al. [83]	Pediatricians, FP	Assessed physicians' attitudes and perceptions regarding potential HPV vaccination of males	<ul style="list-style-type: none"> • Significantly more physicians would recommend the HPV vaccine to boys than to girls in the 9–10 age range • Physicians agreed that males should be vaccinated to prevent warts, protect females from cervical cancer, and would provide opportunities to discuss sexual health with adolescent males • Physicians did not strongly agree that parents of male adolescents would be interested, that a gender-neutral HPV vaccine recommendation would increase acceptance or vaccination rates
McCave et al. [23]	MD	Explored providers' perceived barriers, supports, and vaccination actions	<ul style="list-style-type: none"> • Barriers include financial burden and parents' or patients' negative perception of vaccine • Supports include personal belief in the positive impact of HPV vaccine on reducing cervical cancer and comfort in discussing sexual nature of vaccine, and importance of adhering to guidelines
Kahn et al. [26]	MD	Examined MD vaccine recommendations, intention to vaccinate boys, and attitudes towards mandated vaccination for girls	<ul style="list-style-type: none"> • Barriers include concerns regarding vaccine safety, inadequate insurance coverage, and low HPV knowledge • Providers had fair intentions to vaccinate boys • Factors associated with increased likelihood of recommending vaccine include HPV knowledge, valuing information from both professional organizations and professional conferences, and belief in mandated HPV vaccination

(continued on next page)

Table 1 (continued)

Reference	Study Population	Study Purpose	Key Findings
Kahn et al. [62]	Pediatricians	Assessed intention to administer two hypothetical vaccines (cervical cancer/genital wart vaccine and a cervical cancer vaccine)	<ul style="list-style-type: none"> • More likely to recommend to girls than boys and older versus younger children • More likely to recommend a cervical cancer/genital wart vaccine than a cervical cancer vaccine • Positive variables associated with intention include higher estimate of the percentage of sexually active adolescents, number of young adolescents seen weekly, higher HPV knowledge, likelihood following recommendations of important individuals and organizations regarding immunization • Need to focus on safety and efficacy
Riedesel et al. [27]	FP	Assessed intention to administer two hypothetical vaccines (cervical cancer/genital wart vaccine and a cervical cancer vaccine)	<ul style="list-style-type: none"> • Higher intention to recommend to girls than boys, to older than younger adolescents, and combined cervical cancer/genital wart vaccine than a cervical cancer vaccine • Intention was positively associated with female gender, knowledge about HPV, belief that AAFP endorse vaccination • Barriers include provider reluctance to discuss sexuality issues • Intention to vaccinate depend on safety and efficacy
Qualitative studies			
Shay et al. [84]	MD	Developed a typology characterizing parent-provider communication around HPV vaccine hesitancy	<ul style="list-style-type: none"> • When provider responded to hesitancy with persistence only, most adolescents were vaccinated that day (17 of 18) • The median time for the persistence only group was 3.29 min compared with 2.8 min for the acquiescence only group
Kasting et al. [85]	Pediatricians	Assessed awareness of 9-valent vaccine, anticipated patient and parent questions, and general questions regarding vaccine	<ul style="list-style-type: none"> • HCPs had questions regarding efficacy, side effects, added protection over 4-valent vaccine, dosing schedule, cost, and safety • Half did not think parents or patients would have questions, which differs from other studies that found parents had many questions • Anticipated questions included whether 9-valent was necessary and whether there is long-term data.
Perkins et al. [86]	MD, NP	Examined providers' perceptions of parental concerns about HPV vaccination among immigrants from low-resource settings using semi-structured interviews	<ul style="list-style-type: none"> • Cancer prevention was important to parents but specific concerns regarding safety of vaccine and view that vaccination was unnecessary prior to sexual debut were common • Immigrants from low-resource settings were more receptive to HPV vaccination than Caucasian middle-class parents
Javanbakht et al. [30]	MD	Explored provider perceived barriers to HPV vaccination among girls in a high-risk community with in-depth interviews	<ul style="list-style-type: none"> • Perceived parents worry that vaccination will promote sexual behavior and are uncomfortable with discussing sex with their children, however, this does not align with actual parental concerns. • Perceived parents think that vaccines are only for younger children and not adolescents, thus not covered
Kahn et al. [87]	Pediatricians	Described the range of pediatricians' attitudes about HPV vaccines and to explore factors influencing their intention to recommend	<ul style="list-style-type: none"> • Barrier to recommending the vaccine included perceived parental denial that their child would be at risk for HPV and reluctance for providers to discuss sexuality issues • Intention to recommend varied according to patient age and gender. Providers are more reluctant to vaccinate younger adolescents and have a preference towards vaccinating girls, which is not in line with national guidelines and recommendations
Mixed-methods studies			
Dilley et al. [88]	Pediatricians, Nurses	Determine barriers and facilitators to HPV vaccination in Alabama	<ul style="list-style-type: none"> • Barriers identified include lack of time and clinic logistics, discomfort discussing sex, financial concerns, weak recommendations • Facilitators identified include use of social media for education, trust in doctor, collaboration between physician and nurses
Shay et al. [38]	MD	Developed a tool to describe strength and content of provider recommendations	<ul style="list-style-type: none"> • Only 2% used a presumptive introduction to the HPV vaccine recommendation and 26% had strong recommendations • Providers tempered their recommendations with (1) emphasizing parental choice, (2) advising parents that HPV vaccine is not required for school, or (3) explaining it is not necessary to vaccinate today

Table 1 (continued)

Reference	Study Population	Study Purpose	Key Findings
Schmidt-Grimminger et al. [42]	MD	Examined HPV knowledge, attitudes, and beliefs among North Plains American Indian HCP using community-based participatory research	<ul style="list-style-type: none"> HCP expressed lack of knowledge and awareness of HPV prevalence in their community, concerns about vaccine safety, and discomfort with addressing parental hesitancy The need for culturally appropriate messaging was noted (e.g., fathers and grandparents were identified as specific groups that could be influential in decision-making)
Jim et al. [89]	PCP, NP, PA, MD, Midwives, immunization coordinators	Determine HPV vaccine knowledge, attitudes, and practices among providers working with American Indian/Alaska Native populations	<ul style="list-style-type: none"> Knowledge assessment showed that 46% were unaware that genital warts are not caused by the same HPV types that cause cancer, and 50% mistakenly thought that a pregnancy test should be given before HPV vaccination 92% felt comfortable discussing issues of sexuality with adolescents Barriers identified included parental concerns of safety and that vaccination may encourage earlier or riskier sexual behavior (57%) and parent opposition for moral or religious reasons Funding was the main barrier for 19–26 year old

to professional society recommendations [23,26,27]. McCave et al. [23] used the Theory of Planned Behavior to study influential factors in HPV vaccination recommendations among providers, which states that there are three antecedents to an individual's behavioral intentions: personal attitudes, subjective norms, and perceived behavioral control [28]. The personal attitudes of HCP towards the HPV vaccine and its positive impact on reducing cervical cancer in women was found to be the most influential contributor to HPV vaccination [23]. Furthermore, when HCP internalize the subjective norms of their colleagues and profession (i.e., other providers and societal recommendations from CDC or AAP), they tend to vaccinate at higher rates. For example, Kahn et al. found that physicians were more likely to recommend the vaccine if they valued HPV vaccine information from both professional organizations (OR 1.90; 95%CI 1.15–3.16) and professional conferences (OR 1.68; 95%CI 1.10–2.57) [26]. Lastly, HCPs' perceived behavioral control and self-efficacy and confidence to address parents' concerns may be important to the frequency and strength of recommendation. McRee et al. found that self-efficacy (i.e., confidence in addressing overcoming parental concerns) and outcome expectations beliefs (e.g., belief that they can convince hesitant parents to vaccinate their child) were positively associated with HCP routinely recommending HPV vaccine; unfortunately, 55% of HCP in that study believed they there was not much they could say to change the minds of parents who wish to delay or refuse vaccination [25].

As mentioned previously, there is a disparity in male and female vaccination rates and HCP's level of comfort in the discussion of sexuality issues surrounding the vaccine and concern of sexual behavior after vaccination was also a point raised in the studies [23,27,29,30]. Suryadevara et al. reported that 4% of pediatricians believed administering HPV vaccine to adolescents increases the likelihood of unprotected sexual activity [29]. McCave et al. found that HCPs who feel comfortable talking with parents about the sexual implications of the vaccine was second only to personal belief in the positive impact of the vaccine as the most influential support to HPV vaccination [23]. Conversely, HCPs who state that parents worry that vaccination will promote sexual activity and are uncomfortable discussing sex with their children, report this as a significant barrier to vaccination [30]. This highlights the misconception HCPs hold that parents are concerned that vaccination against an STI may encourage earlier or riskier sexual behavior [31], possibly stemming from their personal discomfort in discussing the sexual issues associated with vaccination, when

studies have shown that less than 8% of parents hold this belief in reality [32–34]. Interestingly, Riedesel et al. found that over 90% of family physicians were somewhat or very comfortable discussing adolescent sexual activity [27], which is inconsistent with previous studies [35,36], but those who did report discomfort addressing sexuality issues also reported lower intention to recommend HPV vaccination.

The last theme identified in the descriptive studies was the educational gap in practical communication strategies to disseminate knowledge and counsel parents and patients. HCPs should be encouraged to initiate the conversation routinely rather than “just in time” or “risk-based” (e.g., frequency of sexual activity) as this might fail to protect many adolescents before exposure [37]. Specifically, beginning discussion about the HPV vaccine by saying the “child is due” compared with giving information, suggesting the vaccine, or eliciting questions is correlated to higher-quality recommendation [10]. This is also referred to as the “presumptive approach”, which assume parents are ready to vaccinate their child [38]. Motivational interview techniques have been suggested to improve vaccine uptake where clinicians are trained to elicit parents' primary concern about the HPV vaccine and to end with a strong recommendation [39,40]. Lists of perceived parental concerns, some of which stem from the media, can be found in several studies and may serve as a useful starting point for creating provider-specific educational resources [23,25,30]. Time constraints were also mentioned as a communication barrier with half of the providers in one study indicating they did not have enough time during visits to probe parents' reasons for vaccine hesitancy (47%); suggested solutions include information sheets tailored to specific parental concerns and scheduling vaccine-only visits [25,41]. Furthermore, parents and patients who are non-English speaking, from immigrant populations, or from minority or low-income groups require tailored communication approaches and additional attention from the provider [25,30]. For example, a study of the North Plains American Indian population highlighted the need for educational materials in their native language as well as outreach to elders who are important opinion leaders in their community [42].

3.3. Effectiveness of provider-specific educational interventions

Analysis of the interventional studies demonstrated that provider-specific interventions are effective in improving provider knowledge as well as vaccine uptake (Table 1). All 10 studies

included an educational presentation with varied educational content while four of the five randomized trials included additional interventions such as practice-specific fact sheets, parental education website, disease images depicting diseases associated with HPV, decision aid for HPV vaccination, repeated contact with providers, individualized feedback, provision of continuing medical education (CME) credits, and electronic health record (EHR) prompts [43–45]. Berenson et al. and Reiter et al. demonstrated that a 30-minute structured presentation can improve provider knowledge both subjectively and objectively. The specific educational gaps they identified included prevalence of HPV and age distribution of HPV infection, incidence of cervical cancer in Hispanic women, percentage of cervical cancer cases where HPV can be found, and vaccination schedule and age of eligibility [46,47]. Kumar et al. utilized a 20 min training video which resulted in improved knowledge (e.g., HPV-related disease in males and changes in vaccine response with age) and comfort in counselling vaccine-hesitant parents and facilitating vaccine completion [48]. Suryadevara et al. who focused on providers and staff, and Shukla et al. who focused on oral health professionals, both utilized an educational lecture followed by CDC-based information booklet that providers can use to educate and distribute to their patients [49,50]. Suryadevara et al. reported an improved HPV vaccine series initiation and completion rates by as much as 20%. Shukla et al. reported increased self-reported patient interaction regarding HPV prevention (37.5%), HPV knowledge (91.6%), and clarity in their role in educating their patients about HPV (82.6%). Overall, the five non-randomized interventional studies addressed some of the knowledge gaps and provider needs identified in the descriptive studies (e.g., prevalence, gender differences, addressing parental hesitancy).

The risk of bias for the five non-randomized interventional studies was assessed using ROBINS-I (Supplemental Material Table 2) and were all classified as moderate risk of bias overall. All had “moderate” risk of bias with confounding due to the fact that participation was voluntary and thus participants with lower baseline knowledge and/or greater interest might have been more likely to participate; furthermore demographic data was not available from Kumar et al. Deviations from intended interventions was also a potential bias in the studies by Suryadevara et al. and Shukla et al. Lastly, missing data was also a potential bias in the studies by Kumar et al. and Shukla et al. as 13 of 109 providers were excluded due to incomplete surveys and differential response rates to questions respectively.

With respect to vaccination rates, Perkins et al. found that provider-focused interventions (i.e., meetings with provider every 4–6 weeks, focused education, individual feedback on vaccination rates, and CME credits) improved both vaccine initiation and completion [43]. Similarly, Fiks et al. reported an increased vaccination rate in their combined intervention group (i.e., EHR-based clinician-focused vaccine alerts, educational presentation, audit and feedback, and automated telephone reminder calls to patients) from a baseline of 16–25%, 65–73% and 63–76% among adolescents presenting to the practice who are eligible for HPV doses 1, 2, and 3, respectively [44]. They concluded that automated telephone reminder calls to patients were instrumental to vaccine series completion whereas the other interventions were key to vaccine initiation. Of note, the authors also performed a cost analysis and reported an incremental cost per number vaccinated of \$24, \$42, and \$189 for HPV doses 1, 2, and 3, respectively with the combined intervention. McLean et al. also reported increased vaccine coverage (18.7% vs. 12.6% among 11–12 years old in the intervention vs. control group; among 13–17 years old, the increase was 8.7% vs. 7%) using multicomponent interventions [51]. Thus, combined with other interventions, educational presentations to providers appear to improve knowledge and quality of recommendations

which may be associated with increased vaccination rates. Although knowledge alone is necessary but not sufficient to change behavior, it forms an important foundation in the application of health behavioral theories (e.g., Health Belief Model and the Theory of Planned Behavior) which may explain the associated increase in vaccination rates [52]. In addition to educational presentations, training in communication approach was demonstrated to impact vaccine initiation rate. Brewer et al. demonstrated that announcement training increased HPV vaccination coverage by 5.4% compared to conversation training or control [53]. Similarly, Dempsey et al. found that the “presumptive approach” to opening the HPV vaccine conversation, in combination other interventions, increased vaccine initiation by 11.3% compared to 1.8% in the control group [45].

The risk of bias for the five randomized studies was assessed using RoB 2.0 and four were assessed as “some concerns” overall and one assessed as “high risk” (Supplemental Material Table 3). Dempsey et al. had one domain with “some concerns” which was the risk of bias arising from the randomization process because the HPV vaccination rates among those aged 11–17 years differed between the two arms at baseline (37.1% in control versus 31.6% in intervention). Similarly, Brewer et al. was classified as “some concerns” in the randomization process due to differences in baseline vaccination rates. In Perkins et al. “some concerns” of bias was present from the randomization process because boys in the study were more likely to have initiated HPV vaccination at control practices (13.5%) compared with intervention practices (1.3%). Fiks et al. had “some concerns” for risk of bias due to deviations from intended interventions (effect of adhering to intervention) as 26% of the participants in the intervention group did not participate in the clinician educational program. Lastly, McLean et al. was classified as high risk based on the assignment of intervention versus control was based on the adolescent population seen in the department (larger for intervention group) resulting in higher baseline vaccination coverage for the intervention group. Furthermore, only 53% of the providers participated in the educational component in the intervention group.

3.4. Provider-specific educational resources from American Organizations

Multiple professional organizations have acknowledged the educational needs of providers, and various campaigns and initiatives directed at providers are available online. Although an exhaustive search of available resources from the many organizations with an interest in HPV vaccination is beyond the scope of this study, we present a selected summary of available provider-education initiatives.

The CDC website includes clinician factsheets, resources on answering parents’ questions (e.g., #HowIRecommend video series), HPV coverage data, schedules and recommendations, and resources translated into Spanish [11]. The AAP HPV Champion toolkit includes printable resources, social media resources to share messages on HPV vaccine, videos, a sample Plan-Do-Study-Act improvement cycle for implementing office change, and teaching tools to provide education to colleagues [12]. The AAP “HPV Vaccine: Same Way, Same Day” is a free downloadable App consisting of brief, interactive role-play simulation to help the user practice introducing the vaccine and addressing concerns of parents who are hesitant about the vaccine [54]. The ACOG Toolkit includes the organization’s committee opinion of HPV vaccination, FAQ sheet for patients, physician script and suggestions on how to recommend the vaccine to patients and colleagues (e.g., mothers of 11 and 12 year-olds, patients in the catch-up population, pediatricians and family physicians), office posters, vaccine information statement, coding information and standing orders [14].

Table 2
Summary of interventional studies.

Author	Population	Intervention	Educational content	Outcome	Recommendations
Pre-/post-intervention survey studies					
Kumar et al. [48]	MD, RN, Residents, allied health professionals	20-min training video with clinical vignettes	HPV knowledge, vaccine efficacy in adolescent, addressing concerns of vaccine-hesitant parents	Improved knowledge (HPV prevalence in males, age-based variation in vaccination response), attitude, and comfort with counselling	<ul style="list-style-type: none"> • Even after watching the video, over half of the providers find that HPV's sexual transmission makes it difficult to discuss and other modalities of training is needed. • Clinical vignettes to model helpful counseling strategies is effective
Suryadevara et al. [49]	Healthcare providers, nurses, office staff	On-site educational sessions with booklets	Vaccine hesitancy, HPV disease and HPV vaccine, role of HPV vaccine in cancer prevention	Across six sites, vaccine series completion rates post intervention increased by 12–20% for 11- to 12-year-olds, and from 7–23% for 13- to 18-year old	<ul style="list-style-type: none"> • Use of a general cancer prevention education booklet that bundles all 5 cancer prevention topics is effective • Stronger recommendations are needed for male adolescents
Shukla et al. [50]	Oral health professionals	2-hr structured presentation	Role of HPV in oropharyngeal cancers, HPV vaccinations, and how to recommend	Self-reported ↑ interaction with patients about HPV and vaccination (37%), 67% vs. 26% felt prepared in talking about HPV before/after training, greater clarity in their role in educating their patients about HPV, an increase in knowledge about HPV	<ul style="list-style-type: none"> • HPV education for oral health professionals is needed • Clarifying provider's role in educating their patients about HPV should be included in educational interventions
Berenson et al. [46]	MD, MS	30-minute structured presentation	Unspecified	Knowledge scores improved from 8–15 (out of 16) post-intervention	<ul style="list-style-type: none"> • Address knowledge gaps in incidence of cervical cancer in Hispanic women • Address knowledge gaps in dosing interval and schedule, and age for vaccination.
Reiter et al. [47]	MD, parents, school staff	30-minute structured presentation	Prevalence, transmission, HPV-associated disease, vaccine efficacy and safety, dosage schedule, efficacy and safety, and coverage	Low level of baseline HPV and vaccine knowledge which improved post intervention both subjectively and objectively	<ul style="list-style-type: none"> • Address knowledge gaps in prevalence of HPV, age distribution, and percentage of cervical cancer cases where HPV can be found • Structured presentation can improve knowledge
Randomized trials					
Dempsey et al. [45]	MD, NP, MA, PA	Communication training (30 min webinar and 2 1-hr group training sessions), Practice specific fact sheet, parent education website, images related to HPV disease, decision aid for vaccination	Opening the HPV vaccine conversation with a "presumptive approach" followed by the use of motivational interviewing techniques	Proportion of eligible adolescents initiating the HPV vaccine was 1.8% in the control group vs. 11.3% in the intervention group	<ul style="list-style-type: none"> • HCP reported that communication training and fact sheets were the most useful interventions • "Presumptive approach" to the initial HPV vaccine conversation can increase HPV vaccine initiation
Brewer et al. [53]	MD, PA, NP	1-hr announcement training, conversation training, or none	Announcement training (announcing the child is due for 3 vaccines, placing HPV vaccine in the middle of the list, and saying they will vaccinate today). Conversation training built on principles of shared decision making (introducing vaccines, placing HPV in the middle, and inviting parents' questions).	Clinics that received announcement training had increased HPV vaccine initiation at 6 months (5.4% difference). Clinics that received conversation training did not differ from control arm.	<ul style="list-style-type: none"> • Train providers to use announcements as an approach to address low HPV vaccination uptake in primary care clinics.

(continued on next page)

Table 2 (continued)

Author	Population	Intervention	Educational content	Outcome	Recommendations
McLean et al. [51]	MD, NP, PA	Didactic session, discussion component. Distribution of patient educational materials, quarterly feedback, patient reminder/recall	HPV vaccine coverage, departmental performance on vaccination rates, and how to make an effective recommendation for HPV vaccine based on CDC. 30 min discussion reviewing vaccination processes in the department, barriers to HPV vaccination, and review of successful strategies	Vaccine coverage increased by 18.7% vs. 12.6% among 11–12 years old in the intervention vs. control group; among 13–17 years old, the increase was 8.7% vs. 7%. There was no difference between the two groups in series completion.	<ul style="list-style-type: none"> • System-based multi-component interventions that include provider and staff education as well as reminder and recall systems are effective
Perkins et al. [43]	MD, RN, NP, PA	Repeated contact, provider education, individualized feedback, CME credits	HPV-related cancers, vaccine efficacy and safety, motivational interviewing	↑ Vaccine initiation (girls OR 1.6, boys OR 11) and completion (girls OR 1.4, boys OR 23). Sustained improvement in maintenance period (girls OR 1.6, boys OR 25)	<ul style="list-style-type: none"> • Recommend HPV along with other vaccines • Present it as a cancer prevention vaccine • Interactive learning with case discussion and hands-on sessions
Fiks et al. [44]	PCP	EHR alerts, 1-hr educational presentation, performance feedback	Vaccine efficacy and safety, strategies for overcoming barriers to vaccine receipt	↑ Vaccine uptake for doses #1 (HR 1.3) but not #2 & #3	<ul style="list-style-type: none"> • Provider education improves initiation, but telephone reminders are needed for vaccine completion • Make educational resource available both in-person and online

Table 3
 Themes identified from descriptive studies mapped to provider-specific resources from organizations. CDC/ACIP: Centers for Disease Control and Prevention and the Advisory Committee on Immunization Practices (ACIP) “You are the Key”; AAP: American Academy of Pediatrics “HPV Champion Toolkit”, “Same Way, Same Day”, “Answering Questions About HPV Vaccine: A Guide for Dental Professionals”; American Cancer Society (ACS); National HPV Vaccination Roundtable(NVR); ACOG: American College of Obstetricians and Gynecologists HPV Toolkit 2016; AAFP: American Academy of Family Physicians; AHNS: American Head and Neck Society; ADA: American Dental Society; 4vHPV: quadrivalent HPV vaccine; 9vHPV: nine-valent HPV vaccine.

	CDC	AAP	ACS	NVR	ACOG	AAFP	AHNS	ADA
HPV knowledge								
HPV prevalence in different populations [10,42,62,77,79]	•	•	•	•	•	•	•	•
Oncogenic and non-oncogenic strains [27,62,77,83,89]	•	•	•	•	•	•	•	•
Head and neck HPV manifestations and other HPV associated cancers [10,22,80]	•	•	•	•	•	•	•	•
HPV vaccine knowledge								
Safety and Efficacy [26,27,29,39,42,62,63,75,81,85,86,89]	•	•	•	•	•	•	•	•
Dosing Schedule [85]	•	•	•	•	•	•	•	•
Vaccine recommendations for males [77,78,82]	•	•	•	•	•	•	•	•
Difference between 4vHPV and 9vHPV [85]	•	•	•	•	•	•	•	•
Cost and insurance [23,26,75,76,82,89]	•	•	•	•	•	•	•	•
Age of eligibility [27,30,62,80,87]	•	•	•	•	•	•	•	•
Provider self-efficacy and normative beliefs								
Personal belief in vaccine benefits [23]	•	•	•	•	•	•	•	•
Belief that recommendation will effect change [23–25]	•	•	•	•	•	•	•	•
Disseminating and adhering to professional society recommendations [23,26,27,76,79]	•	•	•	•	•	•	•	•
Gender differences and sexuality issues related to the vaccine								
Sexuality issues surrounding the vaccine (i.e., concern regarding sexual initiation post-vaccination) [23,27,29,30,81,82,86–89]	•	•	•	•	•	•	•	•
Disparity in male and female vaccination rates [10,22,25–27,62,78,82,83,87]	•	•	•	•	•	•	•	•
Communication strategies								
Initiating conversation [10,76]	•	•	•	•	•	•	•	•
Presumptive approach [38]	•	•	•	•	•	•	•	•
Motivational interviewing techniques [39,84]	•	•	•	•	•	•	•	•
Formulating a strong recommendation [10,39,88]	•	•	•	•	•	•	•	•
Addressing parental hesitations and concerns [23,25,30,42,63,84,85,87,89]	•	•	•	•	•	•	•	•
Addressing negative media and dispelling myths [29,30,63]	•	•	•	•	•	•	•	•
Time management [25,41,84,88]	•	•	•	•	•	•	•	•
Delivering tailored information that is sensitive to cultural differences and health disparities (e.g. immigrants, minority or low-income groups) [25,30,42,81,86]	•	•	•	•	•	•	•	•

Other organizations with HPV vaccination resources include the National HPV Vaccine Roundtable [13], AAFP [15], AHNS [55], and ADA [16]. Furthermore, videos on basics of HPV and sample clinical vignette that illustrate recommendation techniques have been created by the Immunization Action Coalition [56] and Minnesota

Department of Health [57]. National Cervical Cancer Coalition also provides educational material including fact sheets and infographics [58].

Table 3 maps the themes identified from descriptive studies to provider-specific resources from the above-mentioned

organizations. The available online resources provide comprehensive coverage of knowledge gaps in the areas of HPV and HPV vaccine except for cost and insurance, which is expected, as funding is state-specific and coverage is specific to the insurance plan carried by patients. Of note, information on differences between 4 and valent and 9-valent vaccine is also variable. Although society recommendations are widely available and encouragement to adhere to guidelines is explicit, the impact of provider recommendation is not emphasized nor are provider personal beliefs and biases explored. While there are some resources available addressing gender differences and discussion of sexual issues surrounding the vaccine, as well as communication strategies, not all organizations address these gaps.

One limitation is that the frequency of utilization and efficacy of these resources have largely been unreported. Of the studies reviewed, only Malo et al. included existing provider-specific resources by evaluating messages developed by CDC and asking parents which of the messages would persuade them to get the HPV vaccine for their adolescent and physicians whether they would use the messages to persuade parents [39]. The authors found that parents endorsed messages with information about HPV vaccine effectiveness, HPV prevalence, and the cancers and precancerous conditions HPV vaccine protects against, and vaccine safety. The providers surveyed in the study interestingly did not endorse any of the CDC messages (labeled “long messages”) but rather preferred “brief messages” created by the study authors addressing how parents have control in preventing HPV-associated cancers and providing a strong recommendation to vaccinate. This study highlights a need to assess whether the resources are adequately utilized, whether the messages resonate with the providers they are intended for, and ultimately whether they improve vaccine uptake.

4. Discussion

The United States Healthy People 2020 initiatives target of at least 80% HPV vaccination coverage of girls and boys aged 13–15 years old by the year 2020 sparked multiple efforts to address the multiple factors associated with low vaccination rates [59]. High-quality recommendations from HCPs is an effective and practical strategy to increase vaccine uptake [9,10] but the wide range in baseline knowledge among HCPs remains a barrier [21]. In this review, we have identified that interventions aimed to improve provider knowledge surrounding HPV and HPV vaccines and increase provider comfort with conducting vaccine counseling. In turn, these interventions appear to be associated with increased vaccine uptake. Multiple American organizations with an interest in HPV have already created a wealth of publicly accessible online resources which in large part align with the resource gaps identified in this study, but information on the utilization and efficacy of these resources as part of post-implementation evaluation is not widely available.

Although the results from the interventional studies are encouraging, they had moderate risks of bias, and the details of the educational content included and how this content was determined was not detailed. While parts of presentations tailored to local needs are often required, uniformity in the message may be achieved by using standardized slide decks created by national organizations [12,16]. Providers are more likely to act upon information that is sourced from professional society recommendation and guidelines [26]. Based on this review, Shukla et al. and Suryadevara et al. are the only two studies which explicitly referenced the CDC in the design of their intervention. Furthermore, the relative contribution of provider education compared with the other initiatives (e.g., telephone reminders) requires further

exploration. As alluded to by Fiks et al. in their cost analysis, like other medical interventions, evidence for the efficacy of educational interventions is needed to maximize use of limited financial and human resources. Along these lines, Dempsey et al. and Brewer et al. provide evidence that “presumptive approach” or “announcement”, both based on the work by Opel et al. which showed that a communication approach which assumes parents are ready to vaccinate their children rather than a “participatory approach” or “conversation” that engages parents in open-ended discussion, is a more effective strategy suggesting that educational interventions should focus on presumptive communication training [60,61].

In the thematic analysis of the descriptive studies, some of the potential educational content that might be included is described. For example, studies prior to the extended vaccine recommendations for boys consistently demonstrated that HCP were more likely to recommend the vaccine to girls than boys [27,62]; more than a decade later, this gender bias persists [10,22,25,26], highlighting the need for targeted interventions. A recent provider survey by Walling et al. highlights that vaccine safety and negative publicity of the HPV vaccine are still prevalent, thus are important educational issues to address [63]. When compared to the resources created by organizations, while many of the themes align with existing resources, three remaining gaps that were identified but were not strongly emphasized were: cost and insurance, personal belief in vaccine benefits, provider’s belief that the recommendation will result in increased vaccine uptake, and the need to initiate the conversation as part of the overall communication strategy. Inability to pay, limitations in insurance coverage, and reimbursement concerns have been cited as barriers to recommending the vaccine [26,62,64]. Although cost and insurance are unique to the individual patient, practice, and geographical location, guidance on how to locate information relevant to their patient or educational resources focused on drug coverage and how HCPs can advocate for their patients may be helpful. AAP does provide information on coding and reimbursement for providers and given the rate at which reimbursement and funding changes, these financial gaps will hopefully be less relevant moving forward [65]. Self-efficacy is a well-established concept in health behavior theory where, in simple terms, greater self-confidence and belief that one can achieve the desired outcome is associated with positive outcome [66]. Although campaign messages such as “You are the key” seemingly promote the importance of provider recommendation, the literature shows that HCPs remain skeptical of their ability to convince parents and patients. Emphasizing self-efficacy and explicitly conveying the evidence of the positive impact that providers have on vaccine uptake may be as important as foundational HPV knowledge. Based on the findings from Shukla et al. with oral health professionals, one approach to increase self-efficacy might be to clarify the providers’ role in educating their patients about HPV. Furthermore, communication strategies, specifically how best to initiate the conversation warrant further exploration. An effective interaction can address the concerns of parents and motivate a hesitant parent towards vaccine acceptance [67,68], but providers require support in achieving this challenging communication task conducted in short consultations [69–71]. Organizational websites provide videos (e.g., #HowIRecommend, Same Way Same Day) but whether they are adequately utilized and their effectiveness are unknown. In the education literature on communication skills training, role-playing and video-recorded scenarios, when combined with practice with standardized patients, have been shown to be more effective than traditional didactic methods [72,73]. This challenges organizations to explore alternative methods to offer education on communication strategies to diverse healthcare providers moving forward. Recent innovative educational approaches such as team-based learning where medical students are taught and evaluated in small groups

on their HPV knowledge and communication is just one example [74].

There are several limitations to our review. The interventional studies have components in addition to educational presentation, which preclude conclusions on the relative contribution of educational intervention on vaccine uptake. However, the positive trend demonstrated by the studies is encouraging. In the descriptive studies, most were cross-sectional based on convenience sampling with self-reported data. Thus, elucidating changes in knowledge over time, particularly with evolving recommendations and guidelines, is limited and is subject to reporting bias. Thematic analysis was conducted without quality assessment of individual studies nor collection of quantitative variables. Future reviews to examine quantitative variables would be helpful in informing interventional study design and examining variation in vaccine uptake trends (e.g., understanding gender disparity in vaccination rates). Furthermore, our search of key resources from American societies provides material readily available to providers but is far from exhaustive and an expanded search of resources beyond websites would reveal additional innovative resources. We hope readers would use the list provided here as a starting point and further explore resources that may address the unique challenges of their local context. Lastly, the field of HPV vaccine research and practice is rapidly evolving, for example in guidelines (e.g., expanded coverage based on age and gender), epidemiological trends (e.g., increasing incidence of oropharyngeal cancer), and introduction of educational technologies (e.g., apps). Thus there is a need to repeat this review periodically to identify gaps and facilitate ongoing exchange of educational innovations so as to prepare HCPs in their daily work to increase vaccine uptake.

Despite these limitations, this review highlights that provider-specific educational interventions to improve provider knowledge and quality recommendations are a powerful tool in increasing vaccine uptake. The thematic analysis to map learning needs to existing resources illustrated in this review may be a useful method moving forward to inform future educational resource development and curriculum design. Furthermore, a wealth of provider-specific educational resources created by reputable national organizations exist, but may not be adequately utilized and have not been validated. Future work to evaluate existing tools for utilization and efficacy in a coordinated effort to determine the most effective mode of disseminating knowledge to providers (e.g., on-line videos, one-page fact sheets, didactic slide decks, etc) would maximize efforts and reduce redundancy while increase the effectiveness of provider recommendation and the overall goal of increasing HPV vaccine uptake. Evaluation does not need to be limited to randomized controlled trials or academic publications, but depending on the question, resources, and target audience, evaluation tools from public health (e.g., theory-driven program evaluation), medical education curriculum, and quality improvement could be considered.

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Appendix A. Supplementary material

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