



A Multilevel Intervention to Increase HPV Vaccination among Asian American Adolescents

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Abstract

Human papillomavirus (HPV) is the most common sexually transmitted infection in the US. HPV vaccine is a viable source of prevention against high-risk strains that are likely to cause cancer. However, particularly among racial and ethnic minorities such as Chinese Americans, HPV vaccination rates are suboptimal. The goal of this study was to evaluate the effect of a culturally tailored intervention on HPV vaccine uptake in Chinese Americans. We designed and implemented a multilevel longitudinal pilot study to examine the efficacy of the HPV intervention among Chinese American parents/guardians. We recruited 180 participants from federally qualified health center and community-based clinics that serve predominantly low-income Chinese Americans in Philadelphia. Participants were randomized into an intervention group ($n = 110$) or a control group ($n = 70$). The intervention group received an HPV specific intervention, while the control group received a general health intervention. The primary outcome was medical record-confirmed receipt of first shot and completion of HPV vaccine within six months of receiving the interventions. Repeated measure ANOVA was utilized to examine the intervention effect on knowledge between intervention and control groups. Knowledge differed significantly, with participants in the intervention group demonstrating the greatest improvement following the intervention. A multivariable logistic regression was used to examine the association between HPV vaccine initiation and study group assignment. There was a significant effect of provider recommendation, parent's gender, and health insurance status on HPV vaccine uptake. This study demonstrated positive impact of a culturally tailored intervention on HPV vaccination uptake among Chinese Americans.

Keywords Human papillomavirus · Vaccination · Chinese American adolescents · Community-based participatory research

Introduction

In the United States, human papillomavirus (HPV) is the most common sexually transmitted infection (STI), affecting an estimated 79 million Americans [1]. Each year there are an estimated 14 million new cases of HPV in the United States [2]. HPV is most prevalent among teenagers and young adults [1]. It is associated with genital warts and various forms of cancer, such as cervical, penile, and oropharyngeal cancer [3]. There are more than 40 strains of HPV with varying implications on human health. High-risk strains, HPV-16 and HPV-18, are strongly associated with cancer development. The estimated incidence of cancers related to HPV is 19,400 for women and 12,100 for men [1, 3, 4]. Among these malignancies, cervical cancer (CC) is the most common. For CC specifically, the incidence rate in the United States is 8 cases per 100,000 persons [5].

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Improving vaccination rates could eradicate CC by offering improved protection against the most harmful strains of HPV [2]. A report in England found that young female adults between ages 19 and 21 and ages 22 and 24 experienced tremendous declines in the prevalence of HPV-16 and -18 following the 10-year mark of the HPV vaccine adoption [6]. To prevent the onset of CC and HPV, the Advisory committee on immunization practices (ACIP) established recommendations for adolescent uptake of the HPV vaccine and now recommends vaccine initiation between ages 11 and 12; the vaccine can be initiated as young as age 9. In addition, the HPV vaccine is recommended for women between ages 13 and 26 and for men between ages 13 and 21 [2, 7].

HPV vaccination rates for Asian American adolescents remain suboptimal despite increasing public health efforts in the past decade. The estimated completion rate for two or three doses of HPV vaccine was 60.1% for adolescent Asian American females between ages 13 and 15 [8]. The completion rates for Asian American adolescent males was 41% [9]. Completion rates for both male and female Asian American adolescents suggest significant room for improvement to reach the goal of 80% vaccination rates established in the Healthy People 2020 plan [8, 9]. A previous study conducted in California found low vaccine awareness and low vaccine initiation and completion among Chinese Americans [10]. In addition, several studies have found lower rates of HPV vaccine uptake among Asian Americans when compared to other racial groups in the United States [11, 12]. Given the low rates of HPV vaccination among Asian Americans, it is imperative to conduct studies in this population with hopes of bridging gaps in vaccine utilization to optimize prevention of the harmful complications associated with HPV.

Given that the recommendations established by ACIP apply to minors (persons under age 18), it is critical to engage parents to promote HPV vaccination awareness and uptake. Previous studies have identified factors associated with parents' intention toward and uptake of HPV vaccine, including parent gender, income, education, and HPV-related knowledge and children's health insurance coverage. For example, previous studies have identified lack of HPV-related knowledge as a factor inhibiting parents from making informed decisions on HPV vaccination for their children [10, 11, 13–16]. Researchers also found that higher family income [15] and higher parental education [15, 17] are associated with higher HPV-related knowledge and vaccine initiation and completion rates. In addition, health insurance coverage for children is related to HPV vaccination uptake.

An external factor that plays a critical role in parents' decision-making about HPV vaccination is health providers' recommendation [15, 17]. HPV vaccination recommendation has been consistently associated with greater parental intention of and actual HPV vaccine uptake in various groups [18–20], including Asian Americans [21, 22].

Lastly, among immigrant populations, acculturation may play a role in parents' intention of and actual uptake of HPV vaccine. Previous research has shown that acculturation factors, such as country of birth, years living in the United States, English proficiency, and cultural beliefs affect individual knowledge, awareness, and acceptability of the HPV vaccine [23–26].

Guided by community-based participatory research (CBPR), we designed and implemented an intervention to raise awareness of HPV vaccine among Chinese American parents or guardians and to promote uptake of HPV vaccination among their children. The objective of this study was to evaluate the effect of the intervention among Chinese Americans, including its efficacy among Chinese American parents/guardians.

Methods

Study Design

We designed and conducted a longitudinal pilot study to evaluate the efficacy of an HPV vaccination intervention among Chinese American parents and guardians of teenagers. Specifically, we used multilevel and trauma-informed approaches to engaging parents/guardians, healthcare providers, adolescents, and community leaders in the planning, development, and implementation process. We recruited Chinese American community members who self-identified as a Chinese parent or guardian and who had at least one child between ages 11 and 18 who had ever received HPV vaccine. Guided by community-based participatory research (CBPR) principles, we collaborated with a community health centers that predominantly serves low-income Chinese American community in Philadelphia. In collaboration with health providers at the community health center, we designed the program with age, culturally and linguistically appropriate content and delivery modalities. A total of 180 participants were recruited for this study with 110 in the intervention group and 70 in the control group. The intervention group received an HPV specific intervention, while the control group received a general health intervention.

Multilevel and Multimedia Intervention

Working closely with the parents/guardians, healthcare providers, adolescents, and community leaders, we designed a culturally tailored behavioral intervention, which included four major components.

Interventional Videos

Two multimedia educational videos were developed and tailored to reflect Chinese social and cultural contexts. From watching the videos, we reinforced parents' awareness, knowledge, attitude, intention, and actual uptake of HPV vaccination. The first video included interactive educational modules on HPV vaccination, formatted with tailored messages and dialogue among pediatricians, parents, and female/male adolescents.

- Module 1, pediatrician to parents. In this module, a well-known pediatrician demonstrated the routine physical exam and vaccine injection for a child.
- Module 2, conversation about the HPV vaccine. This conversation happened between two parents. Two moms talked about the HPV vaccine, their confusions and concerns about the HPV vaccine, the knowledge that they gained from the doctor, and their decisions to take the HPV vaccine for their children.
- Module 3, communication in parents to adolescents. This module was to activate parents' and children's motivation about taking the HPV vaccine by discussing the benefits of taking the vaccine.
- Module 4, conversation between two adolescents. A perspective from kids about their interpretation about the HPV vaccine, what they care about most concerning the vaccine, and the factors that affect their intention to take the HPV vaccine.

The second video was an interview of a well-known pediatrician. The discussion encompassed several topics that most concerned Chinese parents, including: (1) what do most parents want to know about the HPV vaccine; (2) safety of the HPV vaccine; (3) HPV vaccine and sexual activity; (d) what do children worry about; (4) why children need three shots; (5) why children need to receive the vaccine earlier; and (6) what is the most crucial point for parents to know about the vaccine.

Interactive Discussion

After participants watched two videos, they typically would have many questions that they wanted to discuss with the health educator. The interactive discussion enabled participants to reflect on what they learned and reinforce the knowledge that they learned from the two videos.

Bilingual HPV Printed Educational Materials

Besides the interventional videos, four printed materials were adapted from the Center for disease control and prevention (CDC). Participants could share these with their family

members and friends to learn more about HPV vaccination. The printed materials included: (1) HPV vaccine is for girls and boys; (2) what HPV can cause; (3) the primary data of HPV infection, and (4) vaccine tracking chart for parents' use. The health educator distributed these materials at the end of each interventional session.

Text Message Reminders to Participants

After the initial intervention session, we also sent four reminder text messages, in both English and Chinese, to participants that included more information on HPV vaccine benefits and HPV vaccine access.

Data Collection

We administered three assessments to study participants at baseline (pre-intervention), post-intervention, and six-month follow-up. We administered the baseline and post-intervention surveys to participants at the community health centers. Each assessment was approximately 20 min in length, and participants had the option of answering the questions in either English or Chinese. Onsite language assistance was available from a trained bilingual community health educator. We administered a six-month follow-up assessment to study participants by telephone. Informed consent forms and HIPAA authorization forms were obtained from each eligible participant who volunteered to participate in the study. This study was reviewed and approved by Temple University Institutional Review Board (protocol number PT 22842).

Measurement

Outcome Measures

The primary outcome of interest for this study was HPV vaccine uptake assessed at six-month follow-up. Specifically, at the six-month follow-up assessment, we measured whether any children aged 11 to 18 of the participants had initiated the HPV vaccine schedule. Additionally, we measured whether any of the children had completed the HPV vaccine schedule, i.e., received all 3 shots. Both outcome measures are dichotomous variable (yes v. no).

Baseline Measures

We collected information on study participants' socio-demographics, such as age in years, educational attainment (whether they had a high school degree), annual household income (less than \$20,000 v. greater than \$20,000), years living in the United States (binary; less than 15 years v. greater than 15 years), health insurance status (yes v. no), and sex (male v. female). In addition, we used seven questions to

assess participants' knowledge of HPV and HPV vaccine. We summed their answers to compute an HPV knowledge score, which ranged from 0 to 7, with a higher numeric value indicating a higher level of knowledge. We also asked participants whether their children's pediatrician had recommended HPV vaccine (yes v. no). In addition, we assessed participants' intention toward HPV vaccine uptake for their children (yes v. no).

Post-Intervention Measures

Following the completion of the interventions, we administered a post-intervention survey covering the same questions on HPV-related knowledge.

Statistical Plan

We used t-tests and chi-square tests to compare the sociodemographic and health-related characteristics of participants between the intervention and control group. We conducted repeated measure analysis of variance (ANOVA) to examine the intervention effects on HPV-related knowledge. Finally, we used binary logistic regression to examine the intervention effects on the initiative of HPV vaccine schedule at six-month follow-up. All analyses were conducted in Stata 16 [27], except for the repeated measure ANOVA, which was conducted in SPSS 24 [28].

Results

As results in Table 1 show, there were no significant differences between intervention and control groups for all sociodemographic factors except for age. The control group were on average 3.29 years older than the intervention group. Overall, the majority of the study participants were female, had lived in the United States for more than 15 years, did not have a high school degree, and had health insurance coverage. Only about one-third of the parents or guardians reported that they received HPV vaccine recommendations from their children's pediatrician.

We also examined the changes in mean HPV knowledge scores from baseline to post-intervention, by study group. Results in Table 2 show that HPV knowledge scores increased for both groups ($p < 0.001$), but the magnitude was significantly higher for the intervention group, with an increase of 4.29, compared to an increase of 0.73 for the control group ($p = 0.001$). This indicates a significant intervention effect on the HPV-related knowledge.

At six-month follow-up, we assessed if any adolescent children of the participants initiated or completed the HPV vaccine. Results presented in Table 3 show that 72 participants (65.45%) in the intervention group reported having at least one child aged between 11 and 18 that initiated and completed the vaccine schedule. In comparison, only two

Table 1 Sociodemographic and health-related characteristics of participants, by study group (N = 180)

| | Intervention n (%) or mean (sd) | Control n (%) or mean (sd) | <i>t</i> (df), <i>p</i> χ^2 (df), <i>p</i> |
|--------------------------------------|------------------------------------|-------------------------------|--|
| Age | 42.09 (0.73) | 45.38 (1.21) | 2.49 (175), .02 |
| Sex | | | 1.72 (1), .19 |
| Male | 35 (31.8%) | 29 (41.4%) | |
| Female | 75 (68.2%) | 41 (58.6%) | |
| Years in the U.S. | | | .75 (1), .39 |
| ≤15 yrs | 55 (50.0%) | 29 (43.3%) | |
| > 15 yrs | 55 (50.0%) | 38 (56.7%) | |
| Education | | | .12 (1), .73 |
| Below high school | 61 (55.45%) | 37 (52.9%) | |
| High school or above | 49 (44.55%) | 33 (47.1%) | |
| Income | | | 2.05 (1), .15 |
| 0–\$19,999 | 56 (50.91%) | 28 (40.00%) | |
| \$20,000 or more | 54 (49.09%) | 42 (60.00%) | |
| Health insurance | | | 2.11 (1), .15 |
| Yes | 101 (91.82%) | 68 (97.14%) | |
| No | 9 (8.18%) | 2 (2.86%) | |
| Pediatrician recommended HPV vaccine | | | .17 (1), .68 |
| Yes | 36 (32.7%) | 25 (35.7%) | |
| No | 74 (67.27%) | 45 (64.29%) | |

sd standard deviation, *df* degree of freedom

Table 2 Changes in HPV-related knowledge, by study group (N = 180)

| | Intervention | | | Control | | | Repeated measure ANOVA F (df), p |
|---------------------|--------------|-------------|----------------------|-------------|-------------|--------------------|-------------------------------------|
| | Baseline | Post | t (df), p | Baseline | Post | t (df), p | |
| HPV knowledge score | 1.26 (1.74) | 5.55 (2.10) | - 17.49 (109), <.001 | 0.96 (1.54) | 1.69 (2.16) | - 3.33 (69), <.001 | 101.19 (1), .001 |

df degree of freedom, ANOVA analysis of variance

Table 3 HPV vaccine uptake rates at 6-month follow-up, by study group (N = 180)

| | Intervention n (%) | Control n (%) | $\chi^2(df), p$ |
|---|-----------------------|------------------|-----------------|
| Any children aged 11–18 <i>initiated</i> vaccine schedule | | | 69.24 (1) <.001 |
| Yes | 72 (65.45%) | 2 (2.9%) | |
| No | 38 (34.55%) | 68 (97.1%) | |
| Any children aged 11–18 <i>completed</i> vaccine schedule | | | n/a |
| Yes | 72 (65.45%) | 0 (0.0%) | |
| No | 38 (34.55%) | 70 (100.0%) | |

df degree of freedom

participants (2.9%) in the control group reported initiation of the vaccine schedule for their children, and none completed the schedule. Chi-square test results showed that the initiation rate was significantly higher in the intervention group than that in the control group ($p < 0.001$).

Logistic regression results presented in Table 4 show significant intervention effects on the initiation of the HPV vaccine schedule for at least one child. Specifically, the odds

of children's HPV vaccine initiation for participants in the intervention group was 485.44 times of the odds for those in the control group, with other variables held constant. In addition, three covariates in the regression model were significantly associated with vaccine initiation. Pediatrician's recommendation was associated with a higher likelihood of reporting vaccine initiation at follow-up (odds ratio: 3.45, 95% CI: 1.03 – 11.53). Interestingly, female parents or guardians were only about one-third (odds ratio: 0.32, 95% CI: 0.11 – 0.90) as likely as male parents or guardians to report vaccine initiation. Health insurance coverage was positively associated with vaccine initiation (odds ratio: 11.05, 95% CI: 2.38 – 108.16).

Discussion

This study evaluated the effects of intervention among Chinese American parents or guardians to children between the age of 11 and 18, to promote HPV vaccine uptake among Chinese American teenagers. We found that the culturally appropriate intervention had significant effects on HPV-related knowledge among parents or guardians, and HPV vaccine uptake among their children. This is consistent with the increasing body of literature on the efficacy of

Table 4 Logistic regression on the probability of any children aged 11 to 18 initiating the HPV vaccine schedule

| Predictors | Odds ratio (95% CI) |
|--|------------------------------------|
| Intervention group (ref: control) | 485.44 (43.26, 5,447.54)*** |
| Pediatrician's recommendation (ref: no) | 3.45 (1.03, 11.53)* |
| HPV knowledge score | 0.75 (0.56, 1.02) |
| Intention for HPV vaccine (ref: no) | 0.26 (0.04, 1.80) |
| Age (in years) | 0.98 (0.92, 1.03) |
| Female (ref: male) | 0.32 (0.11, 0.90)* |
| High school or above (ref: less than high school) | 0.44 (0.16, 1.17) |
| Annual household income \geq \$20 k (ref: <\$20 k) | 0.56 (0.21, 1.50) |
| Years lived in U.S. > 15 years (ref: < 15 years) | 1.74 (0.68, 4.44) |
| Health insurance (ref: no) | 16.05 (2.38, 108.16)** |
| Intercept | 0.02 |
| Likelihood ratio statistics (df), p | 105.43 (10), <.001 |
| Pseudo R ² | 0.45 |

CI confidence interval, ref reference group, *df* degree of freedom

* $p < .05$; ** $p < .01$; *** $p < .001$

community-based, culturally appropriate interventions in promoting HPV vaccination among the underprivileged, underserved populations [29–32]. It is noteworthy that our intervention achieved a 65% initiation and completion rate, which was much higher than initiation and completion rates in a Chinese American sample (25% initiation rate and 9% completion rate) from a previous study [10].

In addition, our study findings attest to the effectiveness of an HPV-focused intervention when compared to general health education. The HPV-related knowledge of parents or guardians was significantly associated HPV vaccine initiation among children (results not shown). The significance of this association, however, was lost when we added study group assignment into the model. This suggests that increased HPV-related knowledge of parents or guardians directly leads to HPV vaccine uptake. However, it is also possible that knowledge directly affected vaccine uptake through other psychological factors, such as self-efficacy and perceived risks/susceptibility [33, 34]. Previous research has suggested complicated mechanisms through which various psychosocial factors interact to affect health behaviors such as screening and vaccination [35–39].

Health insurance status was the second strongest predictor for HPV vaccine initiation in our study. This finding was consistent with the results of a systematic review, which identified health insurance status as a predictor for HPV vaccine initiation and completion [40]. We also found that pediatrician's recommendation for HPV vaccine was a significant predictor of HPV vaccine initiation, which was also consistent with previous findings [19, 20]. The role of health insurance and healthcare provider recommendations echoes the significance of having the capacity to access healthcare services as well as the ability to afford coverage that accommodates individual need. These findings shed light on future interventions that aim to address barriers to HPV vaccination on multiple levels, from health system to health provider to the individual level. Specifically, policy makers and public health efforts need to address systematic barriers to health insurance, especially among underprivileged and underserved communities; provide better access to health care resources that are culturally and linguistically appropriate in immigrant communities; and enhance health provider awareness and knowledge of HPV. To meet the Healthy People 2020 goal and increase HPV vaccination rates nationwide, multi-level intervention efforts are urgently needed.

Moreover, parent gender was a significant predictor of HPV vaccine uptake. Female parents were less likely to report vaccine uptake compared to male parents or guardians. This finding contradicts the existing literature, as a previous study found that male parents were less likely than female parents to report vaccine uptake among adolescents [20]. One possible explanation is that male parents or

guardians played a more effective role in the decision-making process of HPV vaccine uptake in the Chinese American community. More research is needed to test this theory.

This study is not without limitations. This study formed a community sample through convenient sampling. Therefore, the findings could not be generalized to the greater population. We recruited the participants at a community-based federally qualified health center, which might lead to sampling bias. Specifically, we might have under-sampled those who were less medically aware and those who utilize healthcare services through other health providers. Future iterations of this study could benefit from planning for a more expansive repertoire of community-based organizations and healthcare entities to capture a wider range of individuals from the target population.

Conclusions

In conclusion, we found that our culturally tailored intervention significantly increased HPV-related knowledge among Chinese American parents or guardians and increased HPV vaccine uptake among their adolescent children. The findings of this study contribute to the growing body of the literature on the efficacy of culturally tailored interventions in promoting cancer preventive behaviors in medically underserved populations.

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Author Contributions GM and YT contributed to the study conception and design. Materials preparation and data collection were performed by SZ, PS, and SL. Analysis was performed by LZ, TL and MQW, The first draft of the manuscript was written by LZ. All authors commented on previous version of the manuscript. All authors read and approved the final manuscript.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval This study was reviewed and approved by Temple University Institutional Review Board (protocol number PT 22842).

Consent to Participate Informed consent forms and HIPAA authorization forms were obtained from each eligible participant who volunteered to participate in the study.

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References

- Centers for Disease Control and Prevention. (2019). Genital HPV infection – Fact sheet. Retrieved October 6, 2020, from <https://www.cdc.gov/std/hpv/stdfact-hpv.htm>.
- Kaiser Family Foundation. (2018). The HPV vaccine: Access and use in the U.S. Retrieved October 6, 2020, from <https://www.kff.org/womens-health-policy/fact-sheet/the-hpv-vaccine-access-and-use-in-the-u-s/>.
- United States Department of Health and Human Services. (2019). Human papillomavirus (HPV). Retrieved October 6, 2020, from <https://www.hhs.gov/opa/reproductive-health/fact-sheets/sexually-transmitted-diseases/hpv/index.html>.
- National Cancer Institute. (2019). HPV and cancer. *cgvArticle*. Retrieved October 6, 2020, from <https://www.cancer.gov/about-cancer/causes-prevention/risk/infectious-agents/hpv-and-cancer>.
- U.S. Cancer Statistics Working Group. (2020). U.S. cancer statistics data visualizations tool, based on 2019 submission data (1999–2017): U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute. Retrieved October 6, 2020, from <https://gis.cdc.gov/grasp/USCS/DataViz.html>.
- Public Health England. (2020). Surveillance of type-specific HPV in sexually active young females in England, to end 2018, 14(2), 13.
- Centers for Disease Control and Prevention. (2016). HPV vaccine recommendations. Retrieved October 6, 2020, from <https://www.cdc.gov/vaccines/vpd/hpv/hcp/recommendations.html>.
- United States Department of Health and Human Services. (2019). IID-11.4. Increase the percentage of female adolescents aged 13 through 15 years who receive 2 or 3 doses of human papillomavirus (HPV) vaccine as recommended. Retrieved from https://www.healthypeople.gov/node/4657/data_details.
- United States Department of Health and Human Services. (2019). IID-11.5. Increase the percentage of male adolescents aged 13 through 15 years who receive 2 or 3 doses of human papillomavirus (HPV) vaccine as recommended. Retrieved from https://www.healthypeople.gov/node/10676/data_details.
- Bastani, R., Glenn, B. A., Tsui, J., Chang, L. C., Marchand, E. J., Taylor, V. M., & Singhal, R. (2011). Understanding suboptimal human papillomavirus vaccine uptake among ethnic minority girls. *Cancer Epidemiology Biomarkers and Prevention*, 20(7), 1463–1472. <https://doi.org/10.1158/1055-9965.EPI-11-0267>
- Lee, H. Y., Kwon, M., Vang, S., DeWolfe, J., Kim, N. K., Lee, D. K., & Yeung, M. (2015). Disparities in human papillomavirus vaccine literacy and vaccine completion among Asian American Pacific Islander undergraduates: Implications for cancer health equity. *Journal of American College Health*, 63(5), 316–323. <https://doi.org/10.1080/07448481.2015.1031237>
- Wong, C. A., Berkowitz, Z., Dorell, C. G., Price, R. A., Lee, J., & Saraiya, M. (2011). Human papillomavirus vaccine uptake among 9- to 17-year-old girls. *Cancer*, 117(24), 5612–5620. <https://doi.org/10.1002/cncr.26246>
- Adjei Boakye, E., Tobo, B. B., Rojek, R. P., Mohammed, K. A., Geneus, C. J., & Osazuwa-Peters, N. (2017). Approaching a decade since HPV vaccine licensure: Racial and gender disparities in knowledge and awareness of HPV and HPV vaccine. *Human Vaccines and Immunotherapeutics*, 13(11), 2713–2722. <https://doi.org/10.1080/21645515.2017.1363133>
- Nan, X., Zhao, X., & Briones, R. (2014). Parental cancer beliefs and trust in health information from medical authorities as predictors of HPV vaccine acceptability. *Journal of Health Communication*, 19(1), 100–114. <https://doi.org/10.1080/10810730.2013.811319>
- Polonijo, A. N., & Carpiano, R. M. (2013). Social inequalities in adolescent human papillomavirus (HPV) vaccination: A test of fundamental cause theory. *Social Science and Medicine*, 82, 115–125. <https://doi.org/10.1016/j.socscimed.2012.12.020>
- Zhu, L., Zhai, S., Siu, P. T., Xia, H. Y., Lai, S., Zambrano, C. N., & Ma, G. X. (2019). Factors related to Chinese parents' HPV vaccination intention for children. *American Journal of Health Behavior*, 43(5), 994–1005. <https://doi.org/10.5993/AJHB.43.5.10>
- Berenson, A. B., Rahman, M., Hirth, J. M., Rupp, R. E., & Sarpom, K. O. (2015). A brief educational intervention increases providers' human papillomavirus vaccine knowledge. *Human Vaccines and Immunotherapeutics*, 11(6), 1331–1336. <https://doi.org/10.1080/21645515.2015.1022691>
- Anderson, A., Taylor, Z., Georges, R., Carlson-Cosentino, M., Nguyen, L., Salas, M., & Bhaloo, T. (2018). Primary care physicians' role in parental decision to vaccinate with HPV vaccine: Learnings from a South Texas Hispanic patient population. *Journal of Immigrant and Minority Health*, 20(5), 1236–1242. <https://doi.org/10.1007/s10903-017-0646-9>
- Lau, M., Lin, H., & Flores, G. (2012). Factors associated with human papillomavirus vaccine-series initiation and healthcare provider recommendation in US adolescent females: 2007 National survey of children's health. *Vaccine*, 30(20), 3112–3118. <https://doi.org/10.1016/j.vaccine.2012.02.034>
- Reiter, P. L., McRee, A.-L., Pepper, J. K., Gilkey, M. B., Galbraith, K. V., & Brewer, N. T. (2013). Longitudinal predictors of human papillomavirus vaccination among a national sample of adolescent males. *American Journal of Public Health*, 103(8), 1419–1427. <https://doi.org/10.2105/AJPH.2012.301189>
- Taylor, V. M., Burke, N., Do, H., Liu, Q., Yasui, Y., & Bastani, R. (2012). HPV vaccination uptake among Cambodian mothers. *Journal of Cancer Education*, 27(1), 145–148. <https://doi.org/10.1007/s13187-011-0269-0>
- Yi, J. K., Lackey, S. C., Zahn, M. P., Castaneda, J., & Hwang, J. P. (2013). Human papillomavirus knowledge and awareness among Vietnamese mothers. *Journal of Community Health*, 38(6), 1003–1009. <https://doi.org/10.1007/s10900-013-9709-6>
- Gao, E., Zuo, X., Wang, L., Lou, C., Cheng, Y., & Zabin, L. S. (2012). How does traditional Confucian culture influence adolescents' sexual behavior in three Asian cities? *The Journal of Adolescent Health Official Publication of the Society for Adolescent Medicine*, 50(30), S12–S17. <https://doi.org/10.1016/j.jadohealth.2011.12.002>
- Jeudin, P., Liveright, E., del Carmen, M. G., & Perkins, R. B. (2014). Race, ethnicity, and income factors impacting human

- papillomavirus vaccination rates. *Clinical Therapeutics*, 36(1), 24–37. <https://doi.org/10.1016/j.clinthera.2013.11.001>
25. Lechuga, J., Vera-Cala, L., & Martinez-Donate, A. (2016). HPV vaccine awareness, barriers, intentions, and uptake in Latina women. *Journal of Immigrant and Minority Health/Center for Minority Public Health*, 18(1), 173–178. <https://doi.org/10.1007/s10903-014-0139-z>
 26. Wisk, L. E., Allchin, A., & Witt, W. P. (2014). Disparities in human papillomavirus vaccine awareness among US parents of preadolescents and adolescents. *Sexually Transmitted Diseases*, 41(2), 117–122. <https://doi.org/10.1097/OLQ.000000000000086>
 27. Stata Corp. (2019). Stata statistical software: Release 16. Retrieved August 2, 2020, from <https://www.stata.com/>
 28. IBM Corp. (2016). IBM SPSS statistics for windows. SPSS.
 29. Aragonés, A., Bruno, D. M., Ehrenberg, M., Tonda-Salcedo, J., & Gany, F. M. (2015). Parental education and text messaging reminders as effective community based tools to increase HPV vaccination rates among Mexican American children. *Preventive Medicine Reports*, 2, 554–558. <https://doi.org/10.1016/j.pmedr.2015.06.015>
 30. Brawner, B. M., Baker, J. L., Voytek, C. D., Leader, A., Cashman, R. R., Silverman, R., & Frank, I. (2013). The development of a culturally relevant, theoretically driven HPV prevention intervention for urban adolescent females and their parents/guardians. *Health Promotion Practice*, 14(4), 624–636. <https://doi.org/10.1177/1524839912462389>
 31. Cassidy, B., Braxter, B., Charron-Prochownik, D., & Schlenk, E. A. (2014). A quality improvement initiative to increase HPV vaccine rates using an educational and reminder strategy with parents of preteen girls. *Journal of Pediatric Health Care*, 28(2), 155–164. <https://doi.org/10.1016/j.pedhc.2013.01.002>
 32. Valdez, A., Stewart, S. L., Tanjasiri, S. P., Levy, V., & Garza, A. (2015). Design and efficacy of a multilingual, multicultural HPV vaccine education intervention. *Journal of Communication in Healthcare*, 8(2), 106–118. <https://doi.org/10.1179/1753807615Y.0000000015>
 33. Batista Ferrer, H., Audrey, S., Trotter, C., & Hickman, M. (2015). An appraisal of theoretical approaches to examining behaviours in relation to Human Papillomavirus (HPV) vaccination of young women. *Preventive Medicine*, 81, 122–131. <https://doi.org/10.1016/j.yjmed.2015.08.004>
 34. Brewer, N. T., Gottlieb, S. L., Reiter, P. L., McRee, A.-L., Liddon, N., Markowitz, L., & Smith, J. S. (2011). Longitudinal predictors of HPV vaccine initiation among adolescent girls in a high-risk geographic area. *Sexually Transmitted Diseases*, 38(3), 197–204. <https://doi.org/10.1097/OLQ.0b013e3181f12dbf>
 35. Browne, M., Thomson, P., Rockloff, M. J., & Pennycook, G. (2015). Going against the herd: Psychological and cultural factors underlying the ‘Vaccination Confidence Gap.’ *PLoS ONE*, 10(9), e0132562. <https://doi.org/10.1371/journal.pone.0132562>
 36. Gu, C., Niccolai, L. M., Yang, S., Wang, X., & Tao, L. (2015). Human papillomavirus vaccine acceptability among female undergraduate students in China: The role of knowledge and psychosocial factors. *Journal of Clinical Nursing*, 24(19–20), 2765–2778. <https://doi.org/10.1111/jocn.12871>
 37. Lee, M., Zhu, L., Wang, M. Q., Wei, Z., Tan, Y., Nguyen, M. T., & Ma, G. X. (2017). Psychosocial predictors of HBV screening behavior among Vietnamese Americans. *American Journal of Health Behavior*, 41(5), 561–570. <https://doi.org/10.5993/AJHB.41.5.5>
 38. Tanaka, M., Strong, C., Lee, S., & Juon, H.-S. (2013). Influence of information sources on hepatitis B screening behavior and relevant psychosocial factors among Asian immigrants. *Journal of Immigrant and Minority Health*, 15(4), 779–787. <https://doi.org/10.1007/s10903-012-9753-9>
 39. Wang, L.D.-L., Lam, W. W. T., Wu, J., & Fielding, R. (2015). Psychosocial determinants of Chinese parental HPV vaccination intention for adolescent girls: Preventing cervical cancer. *Psycho-Oncology*, 24(10), 1233–1240. <https://doi.org/10.1002/pon.3859>
 40. Fisher, H., Trotter, C. L., Audrey, S., MacDonald-Wallis, K., & Hickman, M. (2013). Inequalities in the uptake of human papillomavirus vaccination: A systematic review and meta-analysis. *International Journal of Epidemiology*, 42(3), 896–908. <https://doi.org/10.1093/ije/dyt049>

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