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Multilevel Factors Associated with HPV Vaccine Initiation and Completion among Mexican American Young Adult Women from Federally Qualified Health Centers in Orange County, CA

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ABSTRACT

Latina women experience cancer disparities exacerbated by multilevel factors. An understanding of how multilevel factors influence Latinas' use of prevention services, can inform culturally tailored interventions. Using cross-sectional surveys guided by the NIMHD Health Disparities Research Framework, we sought to identify individual (HPV vaccine hesitancy, HPV knowledge, HPV vaccine conspiracy beliefs), interpersonal (strength of provider communication, mother-daughter communication), and community (negative HPV vaccine messages, number of times offered the HPV vaccine, clinic wait times) factors associated with HPV vaccine initiation and completion among Mexican American young adult women. At the individual level, HPV vaccine hesitancy and HPV vaccine conspiracy beliefs were associated with HPV vaccine initiation and completion. HPV vaccine knowledge was not associated with initiation or completion. At the individual level, strength of provider communication and HPV mother-daughter communication was associated with HPV vaccine initiation. Only HPV mother-daughter communication was associated with HPV vaccine completion. At the community level, longer clinic wait times and number of times the HPV vaccine has been offered was associated with HPV vaccine initiation. Exposure to negative HPV vaccine messages was not associated with HPV vaccine initiation but was associated with HPV vaccine completion. Longer clinic wait times and number of times the HPV vaccine was offered was not associated with completion. Findings suggest multilevel factors that influence HPV vaccine initiation can differ from factors that influence completion, an important factor to consider when designing interventions tailored to meet the needs of this population or when implementing evidence-based strategies for HPV vaccination.

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Introduction

Latina women in the U.S. continue to be disproportionately affected by cervical cancer outcomes compared to their non-Latina White counterparts.^{1,2} Among U.S. women between 2000 and 2019, Latina women had higher hysterectomy corrected incidence of regional, local and distant cervical cancer compared to non-Latina White women.¹ The prevalence of cervical cancer among Latinas warrants an urgent need to understand drivers of cancer prevention strategies. A southern California Los Angeles-based assessment found Latina women accounted for 50% of cervical cancer cases, of which 41% were of Mexican ancestry.² Latinas are a heterogeneous ethnic group with varying health behaviors and outcomes. Research should continue to explore cancer disparities by subgroup to

inform ways to better reach populations at highest disadvantage of cervical cancer disparities. Studies exploring cervical cancer disparities by Latino racial and ethnic subgroup found Mexican women had the highest incidence in comparison to Cuban, New Latinos (i.e., individuals from countries in the Americas where Spanish is the official language), and Puerto Ricans.³ More studies are needed to inform effective strategies that support cancer prevention practices (e.g., HPV vaccination) among Mexican American young adult women at high-risk of adverse cervical cancer outcomes.

The HPV vaccine is routinely offered in adolescence, making parents and guardians the primary decision makers for HPV vaccination. To ensure health autonomy, HPV vaccination efforts are also needed for young adults. HPV vaccine initiation rates

among young adult women in the U.S. are low.⁴ Latina young adults have reported lower vaccination initiation rates (~22%) than non-Latina Whites (28%).⁴ HPV vaccine completion rates among young adult women are also low (16.8%), particularly foreign-born women (7.2%) compared to U.S.-born women (18.5%).⁵ A deeper understanding of HPV vaccine initiation and completion decisions among Latina women is needed to better alleviate cervical cancer disparities among Latina women. Unvaccinated Latina women routinely receiving health care services may be more amenable to receiving preventive services such as the HPV vaccine.

HPV vaccine decisions are multifaceted and operate at various levels of influence (e.g., individual, interpersonal and community level).⁶ Our previous clinic-based studies exploring HPV vaccine decision narratives among Latina women found individual (e.g., low HPV knowledge, trust in sexual partner, personal vaccine beliefs, fear, motherhood), interpersonal (provider communication, mother-daughter communication, cultural norms), and community (e.g., health insurance, clinic wait time, misinformation) factors to HPV vaccine delay and refusal.^{6,7} Quantitative studies are needed to validate findings from formative research and begin to explore the complex associations between factors that influence HPV vaccine initiation and completion.

Understanding how factors associated with HPV vaccine initiation and completion are interrelated are also necessary to comprehend the effect these factors on HPV vaccine behaviors. Mexican American young adult women participants described adequate provider communication, mother's approval and more information may ease their hesitancy about the HPV vaccine.⁶ Vaccine conspiracy beliefs may be associated with vaccine knowledge and vaccination intention.⁸ This study also examined associations between HPV vaccine hesitancy and provider communication, mother-daughter communication, and HPV conspiracy beliefs. We also looked at the associations between HPV conspiracy beliefs and HPV knowledge.

The National Institute on Minority Health and Health Disparities (NIMHD) framework presents key drivers of health disparities in their respective levels of influence (i.e., individual, interpersonal, community, societal).⁹ Additionally, the NIMHD framework describes domains of influence (i.e., biological, behavioral, physical and built environment, sociocultural environment, health care system). In an effort to provide a foundation for exploring multilevel factors influencing HPV vaccination and to inform future clinic-based interventions, we explored sociocultural

environmental factors across three levels of influence (i.e., individual, interpersonal, community) identified in the NIMHD framework and literature that influence HPV vaccine initiation and completion.

The primary objective of this study was to propose a parsimonious conceptual model using multiple mediator path analysis to investigate the direct effects of individual, interpersonal and community factors associated with HPV vaccine initiation and completion among Mexican American young adult women. The secondary objective of this study is to explore differences in factors associated with HPV vaccine uptake compared to those associated completion. To accomplish this, we first ran bivariate analyses to decide which individual, interpersonal, community factors should be further investigated. Next, we ran models with individual, interpersonal, community factors, separately. Lastly, we included one final model with all significant individual, interpersonal, community factors.

Methods

Study design and participant selection

This study took place between October 2021 and May 2022 aimed at investigating the extent to which individual, interpersonal and community factors are associated with HPV initiation and completion. Participants were recruited *via* email from two University of California, Irvine (UCI)-affiliated Federally Qualified Health Centers (FQHC) in Orange County, California and participated in a one-time 15-minute online survey that was emailed. Eligibility criteria included patients that have visited a UCI-affiliated FQHC in the past year, self-identified as female and Mexican or Mexican American, were between the ages of 18 and 26 at the time of the survey, have lived in California for the past 3 years, recall being offered the HPV vaccine by a medical provider, were aware of their HPV vaccine status and can read and write in English or Spanish. Participants who indicated they did not have a mother figure were excluded from the analysis, but not from the survey. The Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices (ACIP) provides HPV vaccine guidelines by age group. Our study was interested in HPV vaccination decisions in adulthood to ensure parental vaccine hesitancy was not a determinant of HPV vaccine delay and refusal. For this reason, our study included participants 18 years of age and older. Additionally, ACIP recommends providers routinely

offer the HPV vaccine through the age of 26. For adults 27 through 45, ACIP recommends that patients engage in a shared decision-making process with their provider to decide if HPV vaccination is recommended. For this reason, we only recruited participants under 27 years of age and only included individuals who stated they had been offered the HPV vaccine by a provider. Our study investigated potentially modifiable multilevel factors (i.e., individual, interpersonal, community) that can influence HPV vaccine decisions. In an effort to control for the temporality of community-level factors (e.g., access to health insurance), we only included individuals who stated they lived in California for at least 3 years. Only completed surveys were used in the analysis.

Sample size

All patients attending a UCI-affiliated FQHC signed a waiver consenting to be contacted for research purposes at time of their health care visit. Researchers obtained access to an email list of patients from the two FQHC with patients between the ages of 18 and 26 and self-identified as Latina. Researchers also had access to patients' preferred language and HPV vaccination status verified through electronic medical records. Of the email list of 3,908 Latina patients who visited a UCI-affiliated FQHC in the past 3 years, 3,256 patients (83.5%) preferred communicating in English and 642 (16.4%) preferred communicating in Spanish. From the list of 3,256 potentially eligible patients with a listed email, patients were randomly sampled by English language preference in cohorts of 200 until $n=100$ U.S.-born was reached. Patients were then randomly sampled by Spanish language preference in cohorts of 200 until the study reached $n=100$ Mexican-born participants. A total of 2,960 patients were emailed, and 324 initiated the survey. Among those that initiated the survey, 218 respondents met eligibility criteria, consented, and finished the survey (7% response rate). All 218 study participants were provided a \$20 e-gift card as compensation for completing the survey. Four participants were excluded from this study because they did not correctly answer one or both attention check questions on the survey, resulting in 214 (US-born = 114, Mexican-born = 100). We then excluded 15 participants who did not report having a mother or mother figure, an interpersonal factor included in half of the tested models. Our final study sample included $N=199$ participants (US-born = 111, Mexican-born = 88) who were

included in this analysis. Previous work supports that this sample size is sufficient for the number of variables in the models.¹⁰ Please see the participant flow-chart in [Figure 1](#).

Study procedure

Researchers used Mailchimp, an email marketing platform to invite participants to participate in the survey and provided a link to the survey in their preferred language which was accessible by computer or phone. Participants had the option to unsubscribe from future emails. Potentially eligible participants were sent no more than three email reminders. Those interested clicked on the survey link provided in the email and directed to a prescreening survey to determine eligibility. If eligible, participants were provided the study information sheet made available for download. Participants were asked to read the information sheet and check a box if they consent to participate in the study. This study was approved by UCI's Institutional Review Board.

Survey development, back translation and pilot testing

All survey items had a 'Refuse to answer' option and were first constructed in English. A bilingual language expert translated survey items into Spanish. Bilingual research staff performed the back translation. Discrepancies were resolved. An English and Spanish version of the surveys was developed using a survey web application, REDCap. The English survey was pilot tested by five bilingual-bicultural Latinas. The Spanish survey was pilot tested by 5 bilingual or mostly Spanish-speaking women.

Variables

Two dependent variables, HPV vaccine initiation and HPV vaccine completion, were evaluated separately. Participants were asked "Have you ever received the HPV vaccine?" Response categories were coded as 0 (*Never initiated the HPV vaccine*); 1 (*Initiated and waiting to receive additional shots*); 2 (*Initiated and discontinued*); 3 (*Initiated and completed the vaccine*) and 4 (*Refuse to answer*). For HPV vaccine initiation, category responses were then collapsed into 0 (*Never initiated the HPV vaccine*), and 1 (*have initiated the HPV vaccine*). 'Refuse to answer' responses were treated as missing. For HPV vaccine completion, category responses were then collapsed into 0 (*Have*

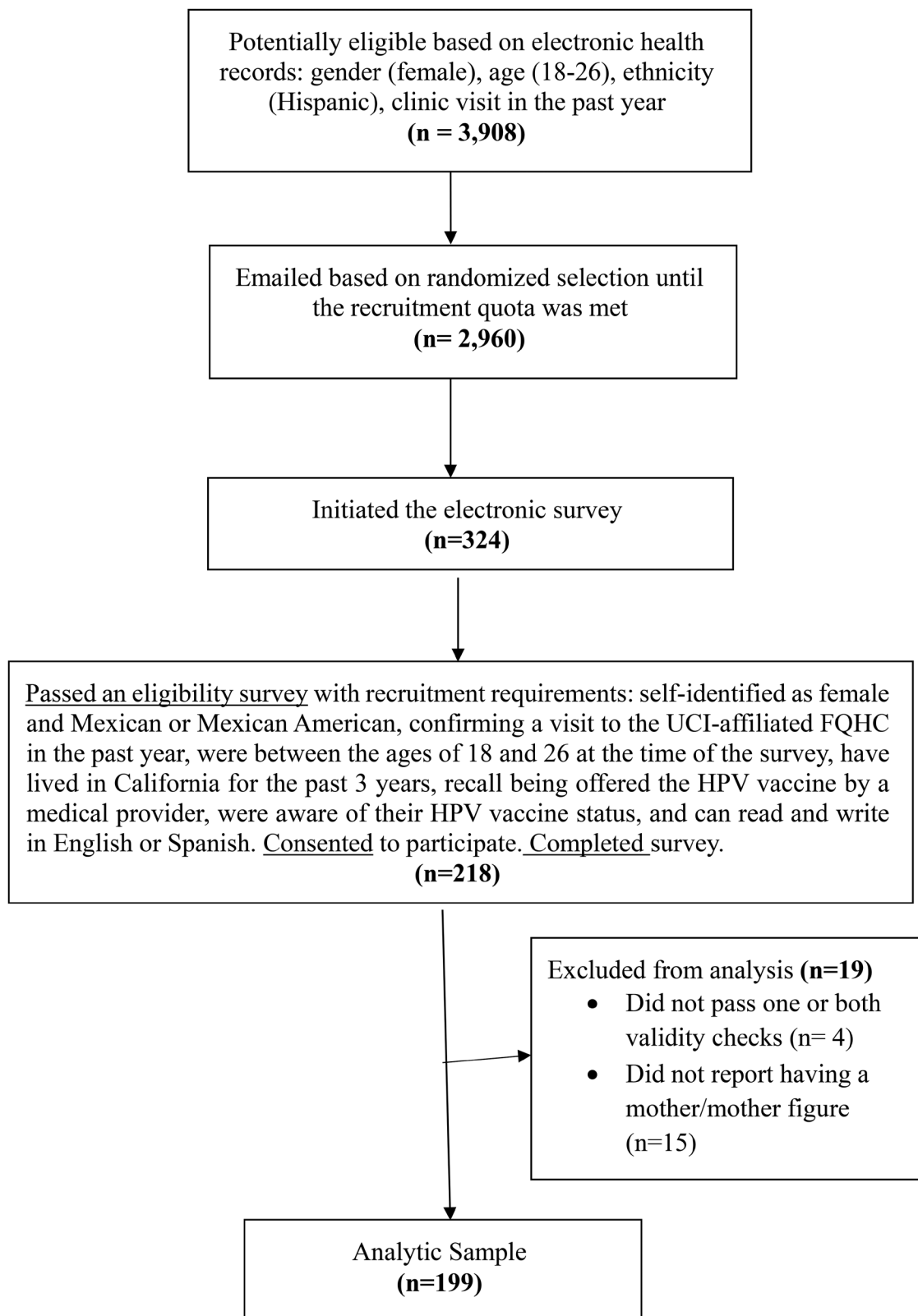


Figure 1. Flow chart of recruitment and selection of analytic sample.

never initiated or have initiated but not completed recommended doses), and 1 (Initiated and completed recommended HPV vaccine doses). 'Refuse to answer' responses were treated as missing.

At the individual level, HPV vaccine hesitancy, HPV vaccine conspiracy beliefs, HPV knowledge, provider trust, and cultural *Marianismo* beliefs were measured. A 10-item HPV vaccine hesitancy scale with

responses ranging from 1 (*strongly agree*) to 7 (*strongly disagree*) was adapted to measure HPV vaccine hesitancy.¹¹ Items were summed and averaged. Higher scores indicate higher HPV vaccine hesitancy. The 7-item Vaccine Conspiracy Belief Scale was used to evaluate negative vaccine perceptions.¹² Responses ranged from 1 (*strongly disagree*) to 7 (*strongly agree*). Higher scores reflect higher levels of vaccine conspiracy beliefs. Responses were summed and averaged. General HPV knowledge scale is a 16-item scale with response options of true, false and don't know.¹³ Correct responses were summed and averaged with higher scores reflecting higher HPV knowledge. The 10-item Wake Forest Physician Trust Scale measured provider trust.¹⁴ Category responses ranged from 1 (*strongly agree*) to 5 (*strongly disagree*). Responses were coded and recoded so that higher scores reflect higher provider trust. Responses were then summed and averaged. We investigated *Marianismo*, feminine Latino cultural beliefs related to sexuality and obedience,¹⁵ measured using the Marianismo Belief Scale.¹⁵ This 23-item scale ranged from 1 (*strongly disagree*) to 4 (*strongly agree*).

At the interpersonal level, HPV mother-daughter communication and strength of provider recommendation were measured. To evaluate mother-daughter communication, the HPV mother-daughter communication scale (HPV MDCS) was used. The HPV MDCS included 4 questions informed by Family Communication Pattern Theory designed to target *socio-orientation* and *concept-orientation* and previous studies exploring HPV parent-daughter communication.¹⁶ An example item is, E.g., My mom/mother figure nonverbally encouraged me to get vaccinated for HPV (e.g., scheduled my appointment, brought me a HPV vaccine pamphlet to read). Response categories ranged from 1 (*strongly agree*) to 5 (*strongly disagree*). Responses were then recoded so higher scores reflect higher mother support for receiving the HPV vaccine. Responses were summed and averaged. Strength of provider communication questions previously used to classify practitioners with HPV recommendation profiles (i.e., engagers, protocol followers, ambivalent) were used to evaluate provider strength of the HPV recommendation.¹⁷ An example question is, "When my provider recommended the HPV vaccine, he/she told me the HPV vaccine offered protection against HPV-associated cancers (e.g., cervical cancer)." Response categories included 1 (Yes), 2 (No), and 3 (Don't remember). Total 'Yes' responses were summed and averaged with higher scores reflecting stronger provider HPV recommendations.

At the community level, the number of times offered the HPV vaccine at a clinic, clinic wait times, difficulty making appointments, reliable transportation to doctor visits and exposure to negative HPV vaccine messages were measured as independent items building on past work exploring clinic-based factors.¹⁸ To measure number of times offered the HPV vaccine, participants were asked to approximate, "How many times has the HPV vaccine been offered to you by a medical provider?" To evaluate clinic wait times, participants were asked to respond to the following question. "When I have an appointment, I don't wait very long in the waiting room before being seen by a healthcare professional." Difficulty making appointments was assessed by asking participants, "It is easy to make an appointment at my typical healthcare clinic." Reliable transportation was evaluated by asking participants to respond the statement, "I have reliable transportation to get to the clinic." All responses categories ranged from 1 (*Strongly agree*) to 5 (*Strongly disagree*). Exposure to negative HPV vaccine messages was evaluated by asking participants to select all that apply to the statement "I have heard/read/saw negative things about the HPV vaccine from:" with response categories 1 (*My mom/mother figure*), 2 (*My significant other*), 3 (*Siblings*), 4 (*Friends*), 5 (*TV*), 6 (*Radio*), 7 (*Online*), 8 (*Other*), and 9 (*Never heard anything negative about the HPV vaccine*). Participant responses were then recoded to equal 1 (*have heard negative HPV vaccine messages*), and 0 (*Never heard anything negative about the HPV vaccine*).

Four sociodemographic variables found to be significantly associated with HPV vaccine initiation and/or completion (i.e., higher education, having received the COVID-19 vaccine, normally receiving the flu vaccine and employment) but only higher education level was found to be associated with the number of times the HPV vaccine has been offered. Therefore, only education was included in models that used the number of times a participant was offered the HPV vaccine. To capture education level, participants were asked to indicate their highest level of education achieved. Response options were 1 (*No formal education*); 2 (*Grade School [1st–8th grade]*); 3 (*High School [9th–12th grade] and did not graduate*); 4 (*High school graduate or equivalent*); 5 (*Vocational business or trade school*); 6 (*2-year junior college/community college/Associates degree*); 7 (*4-year college or university*); 8 (*Graduate or professional school or higher [M.A., M.S., Ph.D., J.D., M.D.]*); and 9 (*Refuse to answer*). Receipt of the COVID-19 vaccine was measured by asking,

“Have you received the COVID-19 vaccine?” Response options were 0 (*No*), 1 (Yes, I received one dose but discontinued the series); 2 (Yes, I received one dose and waiting to receive additional doses); 3 (Yes, I received all recommended); and 4 (*Refuse to Answer*). Responses were recoded to 0 (*No*), 1 (Received at least one dose). Normal receipt of the flu vaccine was measured by asking, “Do you typically receive the flu vaccine when offered?” Response options were 0 (*Never*); 1 (*Almost Never*); 2 (*Sometimes*); 3 (*Almost Always*); 4 (*Always*); and 5 (*Refuse to Answer*). Employment was captured by asking, “Are you currently employed?” Response options were 0 (*No*), 1 (*Yes*); 2 (*Refuse to Answer*). Refuse to answer was coded as missing.

Two attention check questions were asked at the midpoint and three-fourths of the way through the survey using the question, “Please select ‘Agree’ for this question.” Response categories ranging from 1 (Strongly agree) to 4 (Strongly disagree) among other Likert scale questions.

Statistical analysis

All variables were screened for extreme values, ceiling and floor effects. To obtain participant characteristics (Table 1), means and standard deviations were calculated for continuous variables and frequencies and proportions were calculated for categorical variables. Cronbach alpha scores were computed to assess inter-item reliability for HPV vaccine hesitancy ($\alpha=0.75$), HPV vaccine conspiracy beliefs ($\alpha=0.91$), HPV knowledge ($\alpha=0.86$), provider trust ($\alpha=0.90$), cultural Marianismo beliefs ($\alpha=0.93$), HPV mother-daughter communication ($\alpha=0.65$) and strength of provider recommendation ($\alpha=0.78$). All scales had acceptable inter-item reliability. No scales were measured at the community level.

The NIMHD framework recognizes conceptual overlap between factors and their respective levels of influence. Therefore, this study used path analysis to advance the understanding of associations between factors known to contribute to HPV vaccine initiation and completion in the literature. To build a parsimonious path analysis model, first bivariate associations were tested between all independent variables and each dependent variable using logistic regression (Table 2). Final models are presented with odds ratios and exponentiated confidence intervals. Stata 17 was used for descriptive and bivariate analyses.

Next, block testing in a series of path analysis models with the *gsem* command in Mplus 8 was used to

Table 1. Characteristics of young adult Mexican American women sampled from two federally qualified health centers in orange county, California ($N=199$).

Characteristics	N(%) or Mean $\pm$ SD
HPV vaccination status	
Never initiated	32(16)
Initiated	24(12)
Completed	143(72)
Age	24 $\pm$ 1.7
Age at HPV initiation ^a	16 $\pm$ 4.4
Relationship status ^b	
Single	38(19)
In a relationship	88(44)
Married/living with significant other	44(39)
Divorced	0
Refused to answer	1(.01)
Monthly income before taxes	
\$0–\$2,000	94(47)
\$2,001–\$4,000	60(30)
\$4,001–\$6,000	3(2)
\$6,000+	8(4)
Don't know/don't want to answer	34(17)
Health care coverage	
Private	58(29)
Medi-Cal (Medicaid)	121(61)
Uninsured	12(6)
Refused to answer	8(4)
Nativity	
U.S. born	111(56)
Mexican born	88(44)
Highest educational attainment	
4-year university or higher	177(89)
Number of individuals in household	4 $\pm$ 2.0
Has children	44(22)
Currently sexually active	92(46)
Uses condoms always or almost always ^{c,d}	8(9)
On birth control ^c	46(50)

Note. Figures may not sum to 100% due to missing data or rounding error.

^aIncludes participants that initiated and completed.

^bResponses were ‘Check all that apply.’

^cDenominator includes respondents that indicated they are sexually active.

^dResponse options were: always, almost always, sometimes, almost never, never.

Table 2. Bivariate logistic regressions between individual, interpersonal and community factors associated with HPV vaccine initiation and completion ($N=199$).

Variable	HPV initiation OR [95% CI]	HPV completion OR [95% CI]
Individual-level factors		
HPV vaccine hesitancy	0.33 [0.17, 0.64]	0.41 [0.24, 0.70]
HPV vaccine conspiracy beliefs	0.44 [0.28, 0.72]	0.58 [0.42, 0.80]
HPV knowledge	9.97 [1.25, 79.50]	4.95 [0.74, 33.2]
Provider trust	1.08 [0.79, 1.49]	1.08 [0.78, 1.49]
Marianismo cultural beliefs	1.49 [0.58, 3.84]	1.46 [0.64, 3.34]
Interpersonal-level factors		
Strength of provider communication	11.36 [1.79, 72.29]	4.57 [1.27, 16.44]
HPV mother-daughter communication	2.86 [1.28, 6.36]	2.20 [1.13, 4.27]
Community-level factors		
No. times offered the HPV vaccine	1.99 [1.12, 3.56]	1.27 [0.91, 1.78]
Inconvenience making an appointment	0.90 [0.59, 1.37]	0.83 [0.57, 1.21]
Long wait time during doctor visits	0.53 [0.36, 0.78]	0.53 [0.33, 0.86]
Unreliability of transportation	0.66 [0.39, 1.11]	0.78 [0.47, 1.31]
Exposure to negative health messages	0.53 [0.13, 0.95]	0.35 [0.14, 0.90]

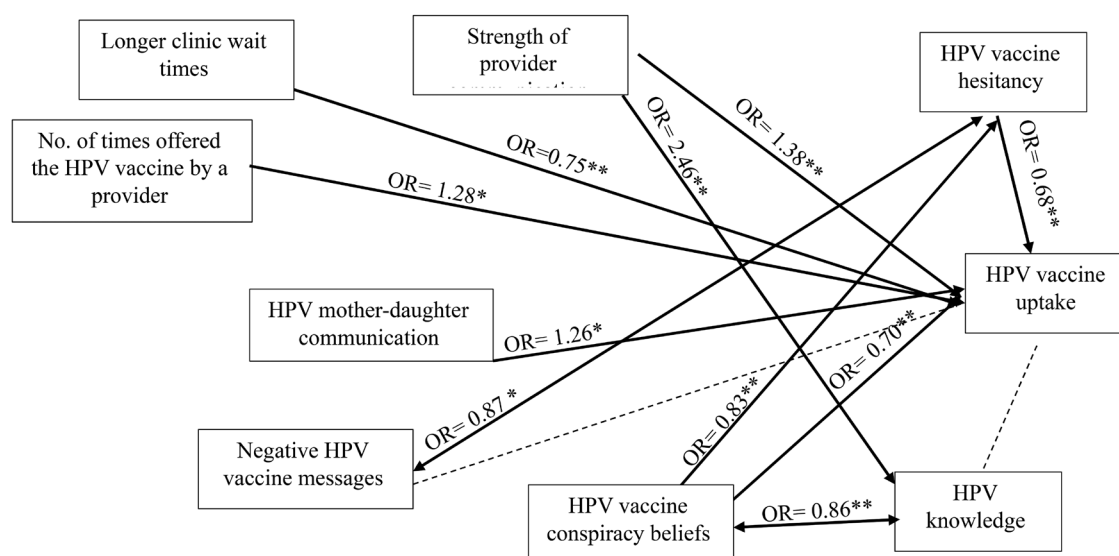


Figure 2. Path analysis model demonstrating individual, interpersonal and community factors associated with HPV vaccine initiation ($N=199$).

Note. Standardized results. Model controlled for education level; * <0.05 significance level, ** <0.01 significance level, *** <0.001 significance level. Solid lines depict statistically significant associations. Dotted lines depict non-significant associations.

test the direct effect of statistically significant associations found in the bivariate analysis of individual, interpersonal and community factors and HPV vaccine initiation and completion separately. Separate path analyses explored individual, interpersonal and community level factors separately and evaluated by HPV vaccination status (e.g., initiation, completion). Subsequent multiple mediator path analysis models with all statistically significant associations were conducted to assess multilevel influence. Maximum-likelihood estimator and gauss-hermite integration was used to obtain standardized results in the model. Missing data from all covariates were imputed with 50 aggregated datasets. Imputed and non-imputed results were compared to ensure consistency. Odds ratios and confidence intervals are reported in Table 2. Standardized results are reported (Figure 1 and 2). All models were screened for appropriate fit using four indices (i.e., Comparative Fit Index, Tucker Lewis Index, Root Mean Square Error, Chi-Square Test of Model Fit).

Power calculation and sample size

Power calculation and sample size were estimated in MPLUS using Monte Carlo simulation study. First, we assessed power of each multilevel model (initiation, completion), separately. Next, we determined sample size needed for the multilevel HPV initiation and completion models by adjusting the sample size to acquire adequate power of 80% or more for each of the variables in the final multilevel models.

Results

Participant characteristics

Among participants in this study ($N=199$), 20% ($n=40$) never received the HPV vaccine, 4% initiated the HPV vaccine and were awaiting additional shots ($n=8$), 8% initiated the HPV vaccine and discontinued the series ($n=16$), and 68% initiated and completed the HPV vaccine ($n=135$). The mean age of participants was 24 years ($SD = 2$). Approximately 66% of participants initiated the HPV vaccine by age 17. Most participants (99%) indicated they had some English-speaking ability, including 4 out of the 6 participants that completed the survey in Spanish. Approximately 60% of participants were employed at least part-time. More than half of the participants (55%) indicated their household incomes was at or below \$3,000. The vast majority (89%) had at least a high school diploma or equivalent. From this sample, 88% indicated they were currently sexually active, 19% indicated they are currently single, 45% indicated they had children, 84% indicated they had health insurance, 12% indicated they had not received at least one dose of the COVID-19 vaccine. See Table 1 for additional demographics.

Bivariate analysis

Bivariate analysis (Table 1) showed HPV vaccine initiation was significantly negatively associated with HPV vaccine hesitancy ($OR = 0.33$, $CI: 0.17, 0.64$), negatively associated with HPV vaccine conspiracy

beliefs (OR = 0.44, CI: 0.28, 0.72), positively associated with HPV knowledge (OR = 9.97, CI: 1.25, 79.55), positively associated with HPV mother-daughter communication (OR = 2.86, CI: 1.28, 6.36), positively associated with strength of provider recommendation (OR = 11.36, CI: 1.79, 72.29), positively associated number of times offered the HPV vaccine by a provider (OR = 1.99, CI: 1.12, 3.56), and negatively associated with longer clinic wait times (OR = 0.53, CI: 0.36, 0.78) and exposure to negative health messages (OR = 0.35, CI: 0.13, 0.95). HPV vaccine completion was significantly negatively associated with HPV vaccine hesitancy (OR = 0.41, CI: 0.24, 0.70), negatively associated with HPV vaccine conspiracy beliefs (OR = 0.58, CI: 0.42, 0.80), positively associated with HPV mother-daughter communication (OR = 2.20, CI: 1.13, 4.27), positively associated with strength of provider recommendation (OR = 4.57, CI: 1.27, 16.44), and negatively associated with longer clinic wait times (OR = 0.53, CI: 0.33, 0.86). All associations were in the direction of anticipated findings.

Individual-level factors associated with HPV vaccine uptake and completion

First, path analysis models explored the associations between individual-level factors and HPV vaccine initiation and completion, separately. HPV vaccine hesitancy (OR = 0.69, CI: 0.55, 0.86) and HPV vaccine conspiracy beliefs (OR = 0.70, CI: 0.53, 0.92) were significantly negatively associated with HPV vaccine initiation. Knowledge was not statistically significantly associated with HPV vaccine initiation (OR = 1.20, CI: 0.99, 1.44). Knowledge was negatively associated with HPV vaccine hesitancy (OR = 0.75, CI: 0.60, 0.93) and HPV vaccine conspiracy belief (OR = 0.73, CI: 0.58, 0.93). Similarly, in model 2, HPV vaccine hesitancy (OR = 0.73, CI: 0.60, 0.88) and HPV vaccine conspiracy beliefs (OR = 0.77, CI: 0.63, 0.94) were negatively associated with HPV vaccine completion. Knowledge was not statistically significantly associated with HPV vaccine completion (OR = 0.91, CI: 0.13, 6.49). Knowledge was negatively associated with HPV vaccine hesitancy (OR = 0.70, CI: 0.54, 0.92) and HPV vaccine conspiracy beliefs (OR = 1.45, CI: 1.09, 1.92).

Interpersonal-level factors associated with HPV vaccine uptake and completion

Next, path analysis models explored the associations between interpersonal-level factors and HPV vaccine

initiation and completion, separately. HPV mother-daughter communication (OR = 1.26, CI: 1.04, 1.53) and strength of provider recommendation (OR = 1.36, CI: 1.08, 1.72) were significantly positively associated with HPV vaccine initiation. HPV vaccine completion was positively associated with HPV mother-daughter communication (OR = 1.32, CI: 1.07, 1.64), but not strength of provider recommendation (OR = 1.16, CI: 0.95, 1.42).

Community-level factors associated with HPV vaccine uptake and completion

Path analysis models then explored the associations between community-level factors and HPV vaccine initiation and completion, separately. HPV vaccine initiation was significantly positively associated with number of times offered the HPV vaccine by a provider (OR = 1.32, CI: 1.05, 1.67), and positively associated with longer clinic wait times (OR = 0.76, CI: 0.61, 0.94), but not associated with negative HPV vaccine messages (OR = 0.88, CI: 0.72, 1.06). Interestingly, HPV vaccine completion was not associated with number of times offered the HPV vaccine by a provider (OR = 1.17, CI: 0.96, 1.44), nor associated with longer clinic wait times (OR = 0.85, CI: 0.70, 1.03), but was significantly negatively associated with negative HPV vaccine messages (OR = 0.76, CI: 0.62, 0.94).

Multilevel factors associated with HPV vaccine initiation

Guided by prior models, path analysis models explored interpersonal and community factors for initiation (Figure 2) and completion (Figure 3). HPV vaccine initiation was significantly negatively associated with HPV vaccine hesitancy (OR = 0.68, CI: 0.51, 0.91), negatively associated with HPV vaccine conspiracy beliefs (OR = 0.83, CI: 0.53, 0.92), positively associated with strength of provider recommendation (OR = 1.38, CI: 1.08, 1.76), positively associated with HPV mother-daughter communication (OR = 1.26, CI: 1.04, 1.53), positively associated with the number of times offered the HPV vaccine by a provider (OR = 1.28, CI: 1.04, 1.59), and negatively associated with longer clinic wait times (OR = 0.75, CI: 0.62, 0.94). Knowledge was not statistically associated with HPV vaccine initiation (OR = 1.20, CI: 0.99, 1.45), but was significantly negatively associated with HPV vaccine hesitancy (OR = 0.90, CI: 0.77, 0.96), negatively associated with HPV vaccine conspiracy beliefs (OR =

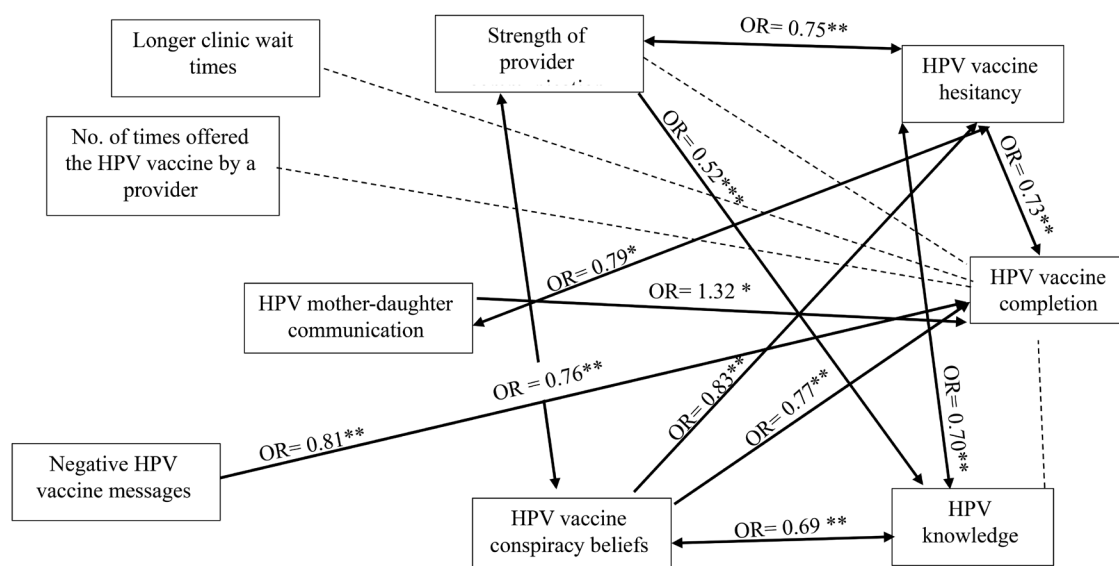


Figure 3. Path analysis model demonstrating individual, interpersonal and community factors associated with HPV vaccine completion ($N=199$).

Note. Standardized results. Model controlled for education level; * < 0.05 significance level, ** < 0.01 significance level, *** < 0.001 significance level. Solid lines depict statistically significant associations. Dotted lines depict non-significant associations.

0.86, CI: 1.02, 1.20), and positively associated with strength of provider recommendation (OR = 1.11, CI: 1.02, 1.19). HPV mother-daughter communication was negatively associated with HPV vaccine hesitancy (OR = 0.87, CI: 0.77, 0.80). Power of the each variable in the final multilevel model ranged from 92–94%. A sample size of $n=120$ was required to retain an adequate power of above 80%.

Multilevel factors associated with HPV vaccine completion

HPV vaccine completion was significantly negatively associated with HPV vaccine hesitancy (OR = 0.73, CI: 0.62, 0.89), negatively associated with HPV vaccine conspiracy beliefs (OR = 0.77, CI: 0.76, 0.78), positively associated with HPV mother-daughter communication (OR = 1.32, CI: 1.09, 1.58), and negatively associated with encountering negative HPV vaccine messages (OR = 0.81, CI: 0.68, 0.90). Knowledge was not statistically associated with HPV vaccine completion (OR = 0.99, CI: 0.76, 1.20), but was significantly negatively associated with HPV vaccine hesitancy (OR = 0.70, CI: 0.68, 0.72), negatively associated with HPV vaccine conspiracy beliefs (OR = 0.69, CI: 0.68, 0.70), and positively associated with strength provider recommendation (OR = 1.92, CI: 0.51, 0.53). HPV vaccine completion was not associated with strength of provider recommendation (1.16, CI 0.95, 1.42). Number of times offered the HPV vaccine by a provider (1.20, CI: 0.97, 1.48) and longer clinic wait times

were not associated with HPV completion (OR = 0.85, CI: 0.70, 1.03). HPV mother-daughter communication (OR = 0.79, CI: 0.66, 0.96), and strength of provider recommendation (OR = 0.75, CI: 0.61, 0.92) were significantly negatively associated with HPV vaccine hesitancy. Strength of provider recommendation was negatively associated with HPV vaccine conspiracy beliefs (OR = 0.76, CI: 0.62, 0.93). Power of the each variable in the final multilevel model ranged from 94–96%. A sample size of $n=115$ was required to retain an adequate power of above 80%.

Discussion

Among participants in this study, individual- (i.e., HPV vaccine hesitancy, HPV conspiracy beliefs), interpersonal- (i.e., strength of provider recommendation, mother-daughter communication), community- (i.e., number of times the HPV vaccine is offered, clinic wait times) level factors were associated with HPV vaccine initiation. Individual- (i.e., HPV vaccine hesitancy, HPV vaccine conspiracy beliefs), interpersonal- (i.e., HPV mother-daughter communication), and community- (i.e., exposure to negative HPV messages) level factors were also associated with HPV vaccine completion. Standardized results of direct effects of multilevel factors showed HPV vaccine hesitancy had the strongest individual-level association for both initiation and completion. At the interpersonal level, strength of provider communication was strongest for HPV vaccine initiation and mother-daughter commu-

nications was strongest for completions. Community-level factors also differed, with clinic wait times having the strongest association for initiation, and exposure to negative messages was strongest for completion. Future FQHC-based HPV vaccine interventions would benefit from targeting factors that strongly influence both initiation and completion.

At the individual level, study findings showed HPV vaccine hesitancy was associated with both initiation and completion, consistent with previous studies that found HPV vaccine hesitancy among parents of adolescents are associated with HPV vaccine initiation,¹⁹ including hesitancy of Latina mothers.²⁰ While many HPV health messages are targeted at parents' responsibility to learn about HPV to protect their child, future health messages should also be targeted at young adults to highlight the importance of protecting their own health.

Anti-vaccine conspiracy beliefs have been shown to play a role in adolescent vaccine intention.²¹ The COVID-19 pandemic has perpetuated additional COVID-19 vaccine-related conspiracy theories.²² Consistent with our hypothesis, HPV vaccine conspiracy beliefs were negatively associated with both HPV vaccine initiation and completion among Mexican American young adult women. This study was conducted at the start of the COVID-19 pandemic. How anti-vaccine conspiracy beliefs effect intention and completion rates over time should be explored in future studies.

Past empirical studies have shown HPV mother-daughter communication may lead to HPV vaccine initiation among college women.²³ Formative research has presented the importance of mother-daughter HPV communication in young adulthood among Latinas.^{6,17} This study is among the first to empirically show HPV mother-daughter communication is associated with HPV vaccine initiation and completion for Mexican American young adults. Although provider recommendation has been associated with initiation and completion,²⁴ this study did not find strength of provider recommendation to be associated to completion when controlling for additional multi-level variables using path analysis. For participants in this study, HPV mother-daughter communication was the only interpersonal factor associated with both initiation and completion in the path analysis.

Community-level factors encompass factors such as access to care. A previous study conducted among FQHC found proximity of home to clinic was not associated with HPV vaccine initiation, but suggested additional health system factors (e.g., clinic wait times) may influence HPV vaccine initiation.¹⁸ This

study built upon those findings by exploring number of times the HPV vaccine was offered, clinic wait times, and reliability of transportation. The number of times the HPV vaccine has been offered and clinic wait times were both associated with HPV vaccine initiation. Health care system environments play an important role in HPV vaccination rates. Study findings suggest convenience and patient experience also influence HPV vaccine decisions.

Strengths of this study sampled from an ethnic minority community disproportionately impacted by HPV-associated cancer outcomes. While much HPV vaccine literature has focused on parents of adolescents, this study explored young adult women to better understand potential points of intervention for catch-up age groups that benefit from this cancer prevention vaccine. We conducted path analysis to explore the direct effects of multilevel factors that may indicate promising behavioral interventions that support HPV vaccination in FQHC for Mexican-American young adults.

This study explored Mexican American women attending FQHC in Orange County, CA. To target women that are hesitant of receiving the vaccine, this study excluded participants that were unaware of the HPV vaccine or their status. It is possible that many unvaccinated Mexican American young adult women have never heard of the HPV vaccine or are unaware if they received the vaccine, and therefore may not have been included in this study. Future studies should not include unawareness of the vaccine or status as an exclusion criterion but perhaps collect provider-verified vaccination status in place of self-report. Although participants must have been aware of their vaccination status, this study may have recall bias where participants may have incorrectly recalled their status or number of vaccines received. This study may also have been subject to reporting bias where participants reported the behavior they perceived as favorable to the research team. Not all scales had been previously validated in Spanish and our study was unable to verify reliability based on a small number of participants who preferred to take the survey in Spanish. Previous longitudinal studies have individually explored the directionality of many individual-, interpersonal- and community-level factors included in this study. However, this study design was cross-sectional and unable to determine directionality between variables among our sample. Factors investigated in this study are temporal. More studies need to investigate how these factors change across a lifetime and impact HPV vaccine initiation and completion. This study did not distinguish results by age

of HPV vaccine initiation or inquire about time of HPV mother-daughter communication. It is possible factors that influence HPV vaccine initiation and completion vary by age of HPV vaccine initiation. Due to COVID-19 precautions, recruitment conducted remotely online *via* email. Therefore, participants that do not have access to internet may have been excluded from this study. Young adult Latinos appear to have similar rates of smartphones ownership (70%) compared and (68%) compared to non-Latino Whites (70%) respectively.²⁵ To reduce technology barriers, the survey was accessible *via* computer and phone. Participants were recruited *via* email and response rate was lower than other email-based surveys.²⁶ Foreign-born Latinos and non-English native speakers may be less likely to have reliable internet access.²⁷ Lastly, although our study was well powered, final models were exploratory in nature and final variable selection to include in multilevel models were based on significant bivariate associations. It is important to note, these results may not be generalizable to populations that vary significantly from those in our sample.

Conclusions

Factors that influence HPV vaccine initiation and completion are complex, interrelated and may differ. Similar and substantial standardized results among all variables in our models suggest multi-level solutions are needed to combat low HPV vaccination rates in the US. Findings are a starting point for exploring individual, interpersonal and community factors that play a role in HPV vaccine decisions. Future studies should evaluate multi-level factors over time to confirm directionality of all independent variables. Intervention studies can build on consistent findings to improve HPV vaccination rates among Latinas. HPV vaccine messaging should target young adults and aim to mitigate the effects of conspiracy theories and negative HPV messages. Health care clinics serving low-income diverse populations at higher risk of HPV-associated cancers should also be aware that HPV vaccine delay or refusal may be attributed to long clinic wait times and exacerbate health disparities observed in the general population. Health care clinic procedures should be evaluated to ensure optimal efficiency and reduce patients' overall wait time.

Disclosure statement

The authors have no financial or non-financial interests to declare.

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Data availability statement

Data will be made available upon request.

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