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Predictors of Non-Vaccination Against Human Papillamovarius Among Us Women Aged 18-26

H. Elsa Larson
University of Rhode Island, helarson@my.uri.edu

PREDICTORS OF NON-VACCINATION AGAINST HUMAN PAPILLOMAVIRUS AMONG US WOMEN AGED 18-26

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H. ELSA LARSON

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H. ELSA LARSON

APPROVED:

Thesis Committee:

Major Professor: Cynthia Willey

Andrea L. Paiva

Aisling R. Caffrey

Nasser H. Zawia
DEAN OF THE GRADUATE SCHOOL

UNIVERSITY OF RHODE ISLAND

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ABSTRACT

HPV vaccination is routinely recommended for young adult women aged 18-26 regardless of previous sexual activity or history of HPV-related disease. As of 2010, only 21% of US women had received ≥1 doses of HPV vaccine. The objective of this study was to describe United States (US) women aged 18-26 who do not initiate vaccination and identify a minimum subset of variables to develop a predictive model of non-vaccination. Data from the 2010 National Health Interview Survey Adult Cancer Supplement were used to examine US women aged 18-26 (*N*=1,866). Descriptive statistics, univariate procedures, and multivariate logistic regression were conducted. Results indicate that 78% of eligible women did not receive vaccination, and 35% of unvaccinated women were not aware of the vaccine. Eight variables were retained for the final model (age aOR=2.93, 95% CI=2.00, 4.30; marital status aOR=1.75, 95% CI=1.02, 3.01; live birth in the past 5 years aOR=2.77, 95% CI=1.75, 4.39, current birth control use aOR=0.45, 95% CI=0.31, 0.64; region aOR=0.50, 95% CI=0.31, 0.79; recent doctor's visit aOR=0.45, 95% CI=0.39-0.84; flu shot receipt aOR=0.36, 95% CI=0.24, 0.54; tetanus shot receipt aOR=0.40, 95% CI=0.26, 0.62). This model showed good fit to the data (Hosmer-Lemeshow chi-square=14.41(8); p=0.07; max rescaled R-square=0.27; c statistic=0.80). These findings show that older age, being married, having children, living in the South, and not receiving other preventive health services are associated with non-vaccination. These findings identify a subgroup of at-risk women who might benefit from targeted vaccine promotion campaigns to increase HPV vaccine uptake.

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INTRODUCTION

Human papillomavirus (HPV) is the most common sexually transmitted infection in the United States (CDCa, 2012). It is estimated that 80% of sexually active females will be exposed to HPV before they reach 50 years of age (Meyers, McCrory, Nanda, Bastian, & Matchar, 2000). Sexually active young women under 25 are at greatest risk for HPV infection and prevalence of HPV has been shown to be highest among women aged 20-24 (Dunne et al., 2007). Most HPV infections clear on their own, but persistent infection with certain types of HPV can cause genital warts, cervical cancer, or other cancers of the vagina, anus, head, and neck (Huang, 2008). Over 40 HPV types infect the genital area and types are categorized by their associated risk to cancer. High-risk types of HPV (specifically 16 and 18) have been associated with 70% of cervical cancers diagnosed worldwide and low risk-types of HPV (types 6 and 11) may cause low-grade cervical cell changes and are associated with 90% of genital warts (Koutsky, 1997).

Two vaccines (GARDASIL® and CERVARIX®) are currently available to prevent HPV infection in females. In 2006, the Food and Drug Administration (FDA) approved GARDASIL® (Merck & Co.) for the prevention of cervical cancer, pre-cancerous lesions, and genital warts in females (FDA, 2006). GARDASIL® is a quadrivalent vaccine (HPV4) protective against HPV types 6, 11, 16, and 18 (Future II Study Group, 2007). In 2009, the FDA approved CERVARIX® (GlaxoSmithKline)

for the prevention of cervical cancer (FDAa, 2009). CERVARIX® (HPV2) is a bivalent vaccine protective against high-risk HPV types 16 and 18 (Harper, 2008). The HPV2 and HPV4 vaccines are not live vaccines and both are composed of virus-like particles prepared from L1 capsid proteins (CDC, 2010). Both vaccines have been demonstrated to be highly protective against oncogenic types 16 and 18 and both are administered as a three-dose series over six months. HPV4 was also approved as the only HPV vaccine for use in males aged 9-26 for the prevention of genital warts and anal cancer (FDA, 2009b; FDA, 2010)

The Advisory Committee on Immunization Practices (ACIP) has recommended routine vaccination with HPV4 for girls aged 11-12 and catch-up vaccination for females aged 13-26 since 2007 (Markowitz et al., 2007). Vaccine should ideally be administered before sexual exposure to HPV, but vaccination is also recommended for females up to age 26 regardless of previous sexual activity. ACIP recommendations were updated in 2010 after the approval of HPV2 to extend recommendation of routine vaccination in these age groups to either HPV4 or HPV2 (CDC, 2010). Updated recommendations also included routine use of HPV4 in males. Despite ACIP recommendations and new developments in HPV vaccines, uptake of HPV4 and HPV2 continues to be low among adolescents aged 13-17 recommended for routine 'catch-up' and lower for adult males and females aged 18-26 (CDC, 2011; CDC, 2012b).

The Centers for Disease Control and Prevention (CDC) provides national estimates of HPV vaccine coverage annually. CDC monitors national vaccine

coverage using two major surveillance systems. The National Immunization Survey – Teen (NIS) (CDC, 2012c) provides coverage estimates for adolescents aged 13-17 and the National Health Interview Survey (NHIS) (NCHS, 2012) provides coverage estimates for adults. The 2011 NIS – Teen results indicated 53% of girls aged 13-17 reported receiving ≥1 dose of the vaccine series and 35% reported receipt of all three doses (CDC, 2011). CDC further reported that HPV vaccine coverage rates are lower in younger girls indicating they are not receiving routine vaccination at the recommended age of 11 or 12. Data are limited for boys, but 8% of boys aged 13-17 had initiated the vaccine series compared to 1% in 2010. Of young adults, the 2010 NHIS found that only 21% of females had received ≥1 dose, up from 17% in 2009. Less than 1% of males aged 19-26 had received ≥1 dose (CDCb).

Low uptake among males may be partially explained by the fact that they are a new population recommended for vaccination. Continued low uptake among females suggests a need to better understand the specific barriers to HPV vaccination, especially among late adolescent and young adult women at highest risk of infection, and with lowest coverage of the vaccine. The national target population for HPV vaccination is girls and boys aged 11 or 12 to complete vaccination before sexual debut and provide optimal protective benefit. However, vaccinating young adult women between the ages of 18 and 26 has been shown to contribute to reducing cervical cancer rates in the population while providing a strong clinical benefit to individual females, even if they are already sexually active (Harper & Paavonen, 2008; Adams, Jasani, & Fiander, 2009).

Previous research has demonstrated that women who have previously been exposed to HPV would still benefit from vaccination because it is unlikely that they would have been exposed to all HPV types covered in the vaccine. In a study of 3,276 women aged 19-24, less than 1% were co-infected with both high-risk types 16 and 18, and no women were found to be infected with all four types (Dempsey, Gebremariam, Koutsky, & Manhart, 2008). Recent research also suggests that HPV vaccines induce high virus-neutralizing antibodies in young adult women and provides high protective efficacy comparable to the protective effect in young teenage girls (Westra et al., 2011). HPV vaccines are prophylactic, not therapeutic, and while only women negative to vaccine-specific HPV types would optimally benefit from vaccination, clinical and cost-effectiveness research support comprehensive vaccination for women up to age 26 (Kim, Orethndahl, & Goldie, 2009). However, women in this age range are more likely to experience significant barriers to accessing the vaccine. To increase vaccine uptake among young adult women, further study is needed to better understand person factors associated with vaccine initiation or non-vaccination among women aged 18 to 26.

More data have become available over the past few years to suggest demographic, socioeconomic, healthcare, and knowledge characteristics are significantly related to young adult women receiving the HPV vaccine. Reports from the NHIS and NIS-Teen surveys indicated differences in vaccine uptake by demographic and socio-economic characteristics. For example, among adolescents in the 2011 NIS - Teen, black adolescents were less likely to complete the vaccine series

than whites, and completion was lower among adolescents living below the poverty line (CDC, 2011). However, initiation of the vaccine series was higher among Hispanics than whites. There are less available data to describe females over 17 years of age, but the 2010 NHIS reported differences based on ethnicity. Hispanic women had less coverage than non-Hispanic whites, but no other racial or ethnic differences were observed (CDCb, 2012). An early study of vaccine uptake reported that vaccine initiation among women aged 18-26 in the 2007 National Immunization Survey was positively associated with higher socioeconomic status, not being married, and having health insurance coverage (Jain et al., 2007). In a university-based clinic system, vaccine series initiation among young adult women was reported to be negatively associated with public insurance, white race, and older age (Dempsey, Cohn, Dalton, & Ruffin, 2011). Socio-demographic factors such as age, race, ethnicity, and socioeconomic status have also been associated with increased knowledge about HPV and the HPV vaccine (Ragin et al., 2009) and HPV-related knowledge has been shown to be another predictor of HPV vaccine initiation among young women (Allen et al., 2009; Licht et al., 2010). A study examining reasons for non-vaccination among young women in a large administrative claims database implied improved educational interventions about HPV and the vaccine may improve uptake. The authors reported the main reasons for non-vaccination were being married or in a monogamous relationship, believing the vaccine was too new, concern about side effects, and uncertainty about insurance coverage and that a physician's recommendation for

vaccination resulted in a 4-fold greater likelihood of vaccination (Zimet, Weiss, Rosenthal, Good, & Vichin, 2010; Rosenthal, Weiss, Zimet, Good, & Vichnin, 2011).

Increasing vaccine initiation among young adult women is a necessary component of the national HPV vaccination program. Vaccine coverage is low for most recommended adult vaccines, and far below national targets (CDCb, 2012). Improvement in vaccine uptake among adults is needed to reduce morbidity and mortality of vaccine-preventable diseases such as HPV. More research to better describe and understand this distinct group of women and their personal reasons for non-vaccination would benefit targeted interventions for young adult women. The objectives of this study were to describe women aged 18-26 in a recent national sample who report non-vaccination against HPV, determine predictors of HPV non-vaccination, and identify a minimum subset of variables to develop a predictive model of non-vaccination.

METHOD

Design Overview and Sample Selection

National Health Interview Survey

This study used data collected by the 2010 National Health Interview Surveys (NHIS) to develop a prediction model, and then used data from the 2011 NHIS to examine the robustness of significant multivariate-adjusted predictors an independent sample. The National Health Interview Survey (NHIS) is a primary source of information on the health of the civilian non-institutionalized population of the United States. It is considered a major data collection program of the National Center for Health Statistics (Centers for Disease Control and Prevention) and used by the Department of Health and Human Services to monitor health trends, track progress towards reaching national health objectives, and provide national estimates. Due to the collection of many demographic and socio-economic variables, NHIS data are frequently used by public health researchers for epidemiological studies to identify and describe groups at higher risk for certain health conditions and to examine barriers to health care access and utilization. More information about the National Health Interview Surveys is available here: http://www.cdc.gov/nchs/nhis.htm.

NHIS Sampling Design

NHIS is a cross-sectional interview survey conducted annually among a nationally representative sample of households. NHIS uses a stratified, multistage, cluster sampling design. Black, Hispanic, and Asian persons are intentionally

oversampled to ensure adequate representation in the sample. Institutionalized individuals are excluded; examples of these individuals include patients in long-term care facilities, persons on active duty with the Armed Forces, and incarcerated persons. Basic person weights are used to analyze person record data and person weights are adjusted to Census control totals for sex, age, and race/ethnicity populations. NHIS data are for public use and the data sets, documentation, survey instruments, and sample statements for various statistical software packages are available for download online.

Data collection is continuous through the year and a probability sample of the US non-institutionalized population is interviewed each week. Face-to-face interviews are conducted by personnel from the U.S. Bureau of Census using computer-assisted personal interviewing. One adult from each household is randomly selected to self-report responses for the Sample Adult File. For the Family File, all household members 17 years of age or older are invited to participate and respond for themselves; a responsible adult household member (18 years or older) is allowed to provide responses for children and other adults not present at the time of interview. The questionnaire contains the "core" questionnaire which includes three components (Family, Sample Adult, and Sample Child) to cover a broad range of health and demographic items, including vaccine coverage. A "supplement" questionnaire may be included in some years of the NHIS to monitor current health issues. The core questionnaire consistently includes questions specific to vaccination [e.g. Hepatitis A and B, Influenza, pneumococcal polysaccharides vaccine (PPV), Herpes Zoster,

Tetanus-Diphtheria-Pertussis (Tdap)] to inform national coverage estimates. In 2008, new questions were added to the NHIS to assess vaccine coverage related to the recent approval and ACIP recommendations for HPV vaccination. In 2010, an Adult Cancer File Supplement was included as the yearly supplement to examine adult cancers including cervical cancer. This file includes additional questions specific to cervical screening history, HPV vaccination history, attitudes about HPV vaccination, and reasons for non-vaccination.

Design Overview and Sample Selection

Initial analyses were based on 27,157 adults (18 years or older) from the 2010 Adult Cancer File. The sample for analysis was restricted to a subset of late adolescent women aged 18-26 (*N*=1,866) who reported yes or no to the survey question, "ever received the HPV shot or vaccine?" The Adult Cancer Files was then merged with the Person and Adult Files to obtain additional-level demographic and health information. All data used for analysis was obtained from public-use data files made available by the National Center for Health Statistics. All personally-identifying information is removed from the data files prior to data release. This study met exemption criteria for oversight by the University of Rhode Island Institutional Review Board.

Measures

The dichotomous outcome variable was initiation of the HPV vaccine series defined as receipt of ≥1 doses of the HPV vaccine. HPV vaccine initiation is defined by the NHIS variable name SHTHPV1 ("*ever received the HPV shot or vaccine*").

Since the outcome of interest was non-initiation of vaccination, a response of *no* was coded as 1 (*n*=1,458; 72.50%) and a response of *yes* was coded as 0 (*n*=408; 20.29%). All other responses including *doctor refused when asked* (*n*=1; 0.05%), *refused* (*n*=7; 0.35%), *not ascertained* (*n*=119; 5.9%) and *don't know* (*n*=18; 0.90%) were excluded from the analysis.

The predictor variables were derived from the Adult, Person, or Adult Cancer Files. The predictor variables of interest were selected based on previous research describing factors associated with HPV vaccine receipt. The data dictionary (variable summary and frequency reports of the Adult Cancer, Person, and Adult Files) were then scanned to match factors related to variables in the questionnaire. The 2010 NHIS Survey Description document was also consulted for analytic recommendations regarding variable recodes and assessment of commonly used variables such as public health insurance and income (NCHS, 2010). The large number of predictor variables selected for analysis were grouped into four domains to establish an organizing framework for the study: 1) demographic, 2) socioeconomic, 3) health services utilization, and 4) HPV awareness.

Thirty-nine variables were identified for exploratory analysis and grouped into categories. Variables and their original response categories are presented in Table 1. The goal of this exploratory analysis was to examine the characteristics of each variable, determine if the variable could potentially be used in a modeling analysis, and, if necessary, prepare potential variables for bivariate tests of association. Means and frequencies of each variable were examined and then crosstabs between the

potential predictor and the outcome variable were conducted to examine cell size. To ensure reliable estimates, variables were required to contain 30 or more observations per cell (NCHS, 2010). Variables with small cell counts were then manipulated to facilitate statistical analyses. For example, categorical variables with multiple levels may have been collapsed to increase cell counts and examine the relationship between predictor and outcome.

Initial demographic variables included age (categorized to 18-21, 22-25, and 26), race recoded (recoded to white, non-white), ethnicity (Hispanic, not Hispanic), marital status (recoded to married, not married), primary language (recoded to English, non-English), born in US (yes, no), US census region (South, Northeast, Midwest, and West), and given birth in the past 5 years (yes, no). Assessment of parametric form was conducted for the continuous variable of age (Hosmer & Lemeshow, 2000). To examine the association of age to vaccine receipt, age was categorized into 1 year intervals from 18-26 using 18 as the reference group and then plotted against the log odds of vaccine initiation. The plot demonstrated a nonlinear relationship and suggested three previously specified levels for age (18-21, 22-25, and 26).

Socioeconomic variables included no insurance coverage (yes, no), private insurance coverage (yes, no), public insurance coverage (yes, no) including Medicare, Medicaid, and other state or government plans as described in the 2010 NHIS Survey Description, education (recoded to college education yes or no), and income (recoded to <$20,000, $20,000-$34,999, and >$35,000). College education was also examined

as a multilevel categorical predictor with four levels: less than high school, high school, some college, college or higher.

Health utilization variables included ever receiving a Pap test (yes, no), abnormal Pap test results (yes, no), HPV diagnosis (yes, no), reported health status (recoded to excellent/very good, good/fair/poor), has usual place of care (yes, no), place to go when sick (recoded to doctor's office or clinic, other), seen/talked to a doctor in past 12 months (yes, no), seen/talked to an OB/GYN in past 12 months (yes, no), currently using birth control (yes, no), receipt of flu shot in the past 12 months (yes, no), receipt of Hepatitis A vaccine (yes, no), receipt of Hepatitis B vaccine (yes, no), receipt of tetanus shot in the past 10 years (yes, no), had an STD test in past 5 years (yes, no), saw a doctor for an STD (yes, no), and ever been tested for HIV (yes, no).

HPV-related knowledge variables included ever heard of HPV (yes, no) and ever heard of the HPV vaccine (yes, no). Other HPV-related attitudes and awareness items included in the 2010 Adult Cancer Supplement that were exclusive to women who did not initiate vaccination were examined for descriptive purposes (e.g. interest in the HPV vaccine, reasons for non-vaccination, and willingness to get the vaccine at lower cost).

Statistical Analyses

Step 1: Variable Selection

The goal of this analysis was to identify the variables significantly associated with HPV vaccine initiation in simple bivariate analyses, and retain these variables for

model development. Associations between the outcome and each predictor variable were examined using *t* tests for continuous variables or chi-square tests of independence for categorical variables. Variables were retained for further analysis if associations were significant at the $p<.20$ level based on the Wald chi-square statistic, provided more than 30 observations per cell, or if they are supported through theory or empirical research. The 0.20 level was chosen as a screening criterion for variable selection rather than the traditional 0.05 level because this cut-off may fail to identify variables that would be important when combined in a multivariate model (Hosmer & Lemeshow, 2000).

Step 2: Unadjusted Odds Ratios

Variables that were retained based on bivariate associations were examined further to assess the strength of their relationship to the outcome. Univariate logistic regressions, unadjusted odds ratios, and 95% confidence intervals were calculated for each predictor. Variables significant at the traditional $p<.05$ with standard error of the prevalence estimate <30% were considered to be strong predictors and selected for retention in further modeling analyses (NCHS, 2006). At this stage, collinearity diagnostics in each group were reviewed. Variables with a condition index over 30, with a variance inflation factor (VIF) over 10, or pairs that explain more than 50% of the variance were to be dropped from the analysis (Menard, 1995). Finally, potential interaction terms between significant variables in each variable grouping were examined. Interaction terms were evaluated to ensure they satisfied the hierarchy principle recommended by Kleinbaum and Klein (Kleinbaum & Klein, 2002). The

hierarchy principle states that all lower-order components of the model must be retained if there is a significant higher-order interaction term. In other words, it would be inappropriate to remove a main effects variable from the model if the model contains an interaction term involving that variable.

Step 3: Separate Multivariable Logistic Regression Models

Variables that met criteria for retention in the last step were entered into four separate multiple logistic regression models based on groups. This approach allows related significant variables to compete with each other to identify the strongest predictors, thereby facilitating the selection of a minimum subset of variables to predict the outcome (Snyder, Willey, McKenna, Foley & Coleman, 2005). Variables from the group-specific models that were significant at the $p<.05$ level were retained for inclusion in the final model.

Step 4: Final Model

The retained predictors were tested in a final model to identify the most parsimonious equation to predict HPV non-vaccination. After the main effects were identified, interaction effects were examined. The results of the modeling approach were confirmed by backwards selection procedure. Multivariate-adjusted variables significant at the $p<.05$ level were considered final predictors and the model was judged to fit the data by a nonsignificant Hosmer-Lemeshow goodness of fit test at the 0.05 level of significance, and by the C-statistic. Values for the C-statistic range from 0.5 to 1.0 and a value of 0.5 indicates the model is no better than chance at predicting group membership. Typically, values higher than 0.7 indicate acceptable

discrimination, values higher than 0.8 indicate excellent discrimination, and values higher than 0.9 indicate outstanding discrimination (Hosmer & Lemeshow, 2000). Area under the curve, sensitivity, specificity, and max rescaled R-square were also presented to display the predictive power of the logistic model. After the model was specified, its predictive capacity was tested by testing the model in the 2011 NHIS dataset as a confirmatory analysis.

RESULTS

Sample Characteristics

Of women aged 18-26 in this sample, 78.1% (*n*=1,458) did not initiate HPV vaccination. Summary characteristics of non-vaccinated women including select demographics, socioeconomic, and health utilization variables are presented in Table 2. Mean age was 22.6 years (SD=2.4). The majority were white (49.6%), unmarried (78.2%), had health insurance (75.4%), and had at least some college education (57.5%).

Reasons for non-vaccination, vaccine awareness, and other HPV-vaccine related attitudes are presented in Table 3. Reasons to not initiate vaccination varied. Of unvaccinated women, 34.6% reported they had not heard of the HPV vaccine and 62.9% reported they were not interested in receiving it. The three main reasons for not receiving the vaccine were "does not need vaccine" (40.4%), "don't know enough about the vaccine" (13.5%), and "worried about safety of the vaccine" (10.8%). Summary characteristics of the other women who received at least one dose of the vaccine series (*n*=408) are presented in Table 4.

Bivariate Results

Table 5 summarizes the results of preliminary statistical tests to screen a large number of potential predictor variables. Most items that were related to demographics, socioeconomic, and health services utilization were significantly associated with vaccine initiation. Nine variables (full-time work, previous STD test,

ever heard of HPV vaccine, five health insurance variables related to public insurance, and one item related to insurance ineligibility) could not be examined statistically because of small counts. Variables that met established criteria for retention (e.g. significant univariate odds ratios) were examined in category-specific logistic regression models.

Model 1: Demographics Variables

Age, region, race, ethnicity, primary language, marital status, born in the US, and live birth in the past 5 years were all significant independent predictors of vaccine initiation. Age, region, marital status, and live birth in the past 5 years remained statistically significant when adjusted for other variables. Table 6 presents the unadjusted and adjusted odds ratios and 95% confidence levels. In multivariate analyses, older age, 22-25 years (aOR=2.30, 95% CI=1.79, 2.95) and 26 years (aOR=1.83, 95% CI=1.25, 2.69), being married (aOR=1.49, 95% CI=1.04, 2.14), and having had a live birth in the past 5 years (aOR=1.81, 95% CI=1.36, 2.40) were associated with higher odds, or increased risk, of non-vaccination. Living in the Midwest (aOR=0.73, 95% CI=0.54, 0.99) or West (aOR=0.67, 95% CI=0.49, 0.90) was associated with lower odds of being in the non-vaccinated group. Potential interactions were assessed at the univariate level, and then adjusted for multivariate analyses. At the univariate level, there were significant interactions between race and age of 22-25 years ($p<.0001$), race and age of 26 years ($p=.03$), marital status and age of 22-25 years ($p<.0001$), live birth and age of 22 and 25 years ($p<.0001$), live birth and age of 26 years ($p=.007$), live birth and marital status ($p<.0001$), live birth and

race (p<.0001), race and Midwest (p=.02), and race and West (p=.04). No interaction terms remained significant in the multivariate model. Multicollinearity was also assessed and no multicollinearity was detected at this level. The model fit the data well as evidenced by a nonsignificant Hosmer and Lemeshow goodness of fit test (chi-square=1.55, Pr>chi-square=0.67).

Model 2: Socioeconomic Variables

In univariate analyses, no insurance coverage, private insurance coverage, Medicaid coverage, and college education were significant independent predictors of vaccine initiation. College education and no insurance coverage remained statistically significant multivariate-adjusted predictors when entered into the category-specific model. Table 7 presents the unadjusted and adjusted odds ratios and 95% confidence intervals. In multivariate analyses, no insurance coverage (aOR=1.86, 95% CI=1.16, 3.00) was associated with increased risk of non-vaccination, while having a college education (aOR=0.74, 95% CI=0.75, 0.95) was associated with decreased risk of being non-vaccinated. Education and insurance coverage showed a significant interaction at the univariate level (p=.01), but it was not demonstrated to be significant at the multivariate level. Multicollinearity diagnostic procedures were also conducted and no multicollinearity between variables was detected. The model fit the data well as evidenced by a nonsignificant Hosmer and Lemeshow goodness of fit test (chi-square=1.48, Pr>chi-square=.82).

Model 3: Health Services Utilization Variables

In univariate analyses, tetanus shot in the past 10 years, Hepatitis A vaccine, Hepatitis B vaccine, flu shot in the past year, current birth control use, having been diagnosed with HPV, doctor's visit within the past 12 months, and having a usual place of care were all significant independent predictors of non-vaccination. Tetanus shot, flu shot, current birth control use, doctor's visit in the past year, and usual place of care remained statistically significant in multivariate analysis. Unadjusted and adjusted odds ratios with 95% confidence intervals are presented in Table 8. Multivariate results indicated that tetanus shot (aOR=0.45, 95% CI=0.27, 0.75), flu shot (aOR=0.52, 95% CI=0.34, 0.78), current birth control use (aOR=0.47, 95% CI=0.32, 0.69), doctor's visit in past year (aOR=0.56, 95% CI=0.32, 0.69), and usual place of care (aOR=0.51, 95% CI=0.28, 0.94) were associated with decreased odds of being non-vaccinated. Significant interactions at the univariate level were found between tetanus shot and flu shot ($p<.0001$), usual place of care and doctor's visit in the past year ($p<.0001$), and birth control pills and doctor's visit in the past year ($p<.0001$). No interaction terms were determined to be multivariate-adjusted predictors and no multicollinearity was detected in this category. The model fit the data well as evidenced by a nonsignificant Hosmer and Lemeshow goodness of fit test (chi-square=12.32, Pr>chi-square=0.13).

Model 4: HPV Awareness

Two variables were initially examined for this model. The variable "heard of HPV vaccine" was eliminated due to small cell count (Table 9). Having heard of HPV was associated with decreased odds of being in the non-vaccinated group (OR=0.24,

95% CI=0.16, 0.35), but was not chosen for inclusion in the final model due to potential error (e.g. women who report HPV vaccination, but have not heard of HPV).

Final Model

Significant variables identified in category-specific logistic models were entered into one final model. The nonsignificant variables from the category-specific models were deleted to achieve the aim of specifying the most parsimonious model able to predict non-vaccination. Eleven variables included in the preliminary model included age, no insurance coverage, marital status, college education, usual place of care, live birth in the past 5 years, birth control, doctor's visit in past year, flu shot in the past year, and tetanus shot in past 10 years (Table 10). In multivariate analysis, no insurance coverage, college education, and usual place of care did not remain statistically significant. To confirm this approach, a backwards selection procedure was conducted and results supported the deletion of usual place of care and college education, but supported the retention of insurance coverage in the model. To address the discordance in results, two models were specified and compared using the likelihood ratio test (Kleinbaum & Klein, 2002). Both models excluded college education and usual place of care, but the first model excluded no insurance coverage, and the second model included no insurance coverage. Results of the likelihood ratio test indicated the first model that excluded insurance coverage fit the data better (deviance difference 1026.69-1025.04=1.65, DF difference 12-11=1, $\chi 2(1)=3.84$). Since the deviance difference is less than the chi-square critical value, the model with

more parameters is not an improvement over the partial model. Both models are presented here.

The first model was developed according to the model-building approach described previously, and without the variable of insurance coverage. This model included eight significant multivariate-adjusted predictors of non-vaccination (Table 11). Variables significantly associated with increased odds of non-vaccination included older age (22-25 years compared to 18-22 years) (aOR=2.93, 95% CI=2.00, 4.30), being married (aOR=1.75, 95% CI=1.02, 3.01) and having a live birth in the past 5 years (aOR=2.77, 95% CI=1.75, 4.39). Variables significantly associated with decreased odds of being in the non-vaccination group included living in the West as compared to the South (aOR=0.50, 95% CI=0.31, 0.79), currently being on birth control (aOR=0.45, 95% CI=0.31, 0.64), flu shot receipt in past year (aOR=0.36, 95% CI=0.24, 0.54), tetanus shot in the past 10 years (aOR=0.41, 95% CI=0.26, 0.62), and seeing a doctor in the past year (aOR=0.57, 95% CI=0.39, 0.84). Multiple potential interaction terms were assessed. Five interaction terms were significant at the univariate level: 22-25 years of age and live birth ($p<.0001$), 22-25 years of age and marital status ($p<.0001$), 22-25 years of age and Northeast ($p=.002$), 22-25 years of age and West ($p=.003$), marital status and live birth ($p<.0001$). No interaction terms were significant as multivariate-adjusted predictors. No multicollinearity was detected (Table 12). This model showed good fit to the data as evidenced by a nonsignificant Hosmer & Lemeshow goodness of fit test (chi-square=14.41(8); Pr>chi-square=.07) and a significant model chi-square of 193.30(11); Pr>chi-square=<.0001. The c-

statistic was 0.795 indicating a strong prediction capacity. Max rescaled R-square was 0.268. Area under the curve is presented in Figure 2 and classification tables are presented in Table 13.

The second model included insurance coverage based on the backwards selection procedure results (Table 14). This model included nine significant multivariate-adjusted predictors of non-vaccination. Variables associated with increased odds of non-vaccination included older age (22-25 years compared to 18-22 years) (aOR=2.91, 95% CI=1.99, 4.27), being married (aOR=1.81, 95% CI=1.06, 3.17), having a live birth in the past 5 years (aOR=2.67, 95% CI=1.69, 4.23), and not having insurance coverage (aOR=1.70, 95% CI=1.06, 2.72). Variables associated with protection against being in the non-vaccination group included living in the West (as compared to South) (aOR=0.49, 95% CI=0.31, 0.78), currently being on birth control (aOR=0.46, 95% CI=0.32, 0.66), flu shot receipt in past year (aOR=0.36, 95% CI=0.24, 0.54), tetanus shot in the past 10 years (aOR=0.42, 95% CI=0.27, 0.66), and seeing a doctor in the past year (aOR=0.63, 95% CI=0.43, 0.93). Six interaction terms were significant at the univariate level: 22-25 years of age and live birth ($p<.0001$), 22-25 years of age and marital status ($p<.0001$), 22-25 years of age and Northeast ($p=.002$), 22-25 years of age and West ($p=.003$), no insurance coverage and Midwest ($p=.003$), and marital status and live birth ($p<.0001$). No interaction terms were significant as multivariate-adjusted predictors. Multicollinearity was assessed and no multicollinearity was detected (Table 15). This model showed also good fit to the data as evidenced by a nonsignificant Hosmer & Lemeshow goodness of fit test (chi-

square=10.24(8); Pr>chi-square=.24) and a significant model chi-square of 198.05(12); Pr>chi-square=<.0001. The c-statistic was 0.797 indicating a strong prediction capacity (Hosmer & Lemeshow, 2000). Max rescaled R-square was 0.27. Area under the curve is presented in Figure 3 and classification tables are presented in Table 16.

Cross-Validation Model: 2011 National Health Interview Survey

To further examine the robustness of the significant predictors in final model, these predictors were tested in an independent sample using a reduced set of variables. The 2011 National Health Interview Survey is structured to allow analysis across multiple years. Six of the eight significant multivariate-adjusted predictors from the final model were included in the 2011 person-level files; live birth in the past 5 years and current birth control use were exclusive to the 2010 Adult Cancer File Supplement and not available for 2011-level analysis. Parametric assessment for age was assessed and revealed a non-linear pattern with three distinct age groups (18-24, 25, and 26). In 2011, 71.5% (n=1,655) women reported not receiving the HPV vaccine and 28.4% (n=659) reported receipt of ≥1 dose. Five variables were significant multivariate-adjusted predictors of non-vaccination (Table 17); region was the only variable that was not strictly statistically-significant when adjusted for other variables, but one-level (West) was borderline significant (p=.05). Variables that showed increased risk of non-vaccination included age (25 years) (aOR=1.61, 95% CI=1.19, 2.19) and age (26 years) (aOR=2.42, 95% CI=1.70, 3.43), and marital status (aOR=2.38, 95% CI=1.78, 3.19). Variables protective against non-vaccination included receipt of flu vaccine in

past year (aOR=0.60, 95% CI=0.49, 0.75), receipt of tetanus shot in past 10 years (aOR=0.46, 95% CI=0.36, 0.57), and seeing a doctor within the past year (aOR=0.62, 95% CI=0.51, 0.77). Multicollinearity was assessed using the procedure described previously and no multicollinearity was detected (Table 18). This model showed a good fit to the data as evidenced by a nonsignificant Hosmer-Lemeshow goodness of fit (chi-square=2.80(8); Pr>chi-square=.94), a c-statistic of .696, and a max re-scaled R-square of .13. Area under the curve is presented in Figure 5 and classification tables are presented in Table 19.

DISCUSSION

Seven years after the approval of the first HPV vaccine, US women aged 18-26 continue to have lower HPV vaccine coverage compared to adolescent girls. The goal of this study was to describe US women who have not initiated the vaccine series, examine their reasons for non-vaccination, and identify predictors of non-vaccination. We found that 78% of women recommended for routine vaccination did not receive the vaccine, and 35% of unvaccinated women had not ever heard of the vaccine. Current findings indicate that non-vaccinated women differed from vaccinated women on several key socio-demographic and healthcare utilization variables. Women who were older, married, and had children were at higher risk for being unvaccinated, while women who lived in the West, had a recent doctor's visit, and practiced preventative health behaviors such as using birth control, receiving a yearly flu vaccine, or recent tetanus vaccine were more likely to be vaccinated. These findings suggest that there are subgroups of 18-26 year old women at higher risk for non-vaccination, and findings may inform targeted interventions to increase vaccine delivery to these subgroups.

In our study, older age was the strongest predictor of non-vaccination status. Being 22-25 years old was associated with a nearly three-fold increase in the odds of being unvaccinated compared to being 18-21 years old. Previous research examining HPV vaccine uptake in young adult women has reliably demonstrated younger age to be strongly associated with vaccine initiation (Licht, 2010; Dempsey, 2011; Chao,

Velicer, Slezak & Jacobsen, 2010; Rosenthal, 2011; Tiro et al., 2012; Marchard, Glenn, & Bastani, 2013). Younger age may be a protective factor against non-vaccination due to the increased likelihood that younger women have access to health care and may still qualify for "safety net" vaccine delivery programs such as the Vaccine For Children (VFC) program (Marchard, 2013; Dempsey 2008). The VFC program provides free vaccines, including HPV vaccines, to low-income, uninsured children and adolescents aged 18 years or younger. Younger women are also more likely to be enrolled as full-time college students and are generally required to be covered under their college health plan or parental health insurance. Increased vaccine coverage of college-aged women may be associated with receipt of other vaccinations due to pre-matriculation vaccine requirements, parental influence, and access to the HPV vaccine through college health centers (Licht, 2010).

Women outside of college, or uninsured older women, can face significant financial barriers to accessing the vaccine. Of unvaccinated women in our sample who were asked if they would receive the vaccine if it was free or lower cost, 96% said yes. HPV vaccines are the most expensive vaccines to date with retail costs averaging about $130 per dose ($390 for full series) (CDC, 2012d). It has been previously demonstrated that young adults aged 18-26 in the US are at high-risk for being uninsured (or under-insured to cover vaccines) when they reach the age where they cease to be covered under parental insurance, and have not yet established their own work-based health insurance (Park, Mulye, Adams, Brindis, & Irwin, 2007; Nicholson et al., 2009). In our study, not having health insurance was a significant

univariate predictor of non-vaccination, though it dropped out of the final model. Further exploration of this variable is warranted. Findings from other national probability samples have indicated insurance coverage to be a univariate and multivariate-adjusted predictor of vaccination. An early 2007 analysis of adult women in the National Immunization Survey (Jain, 2007) indicated that insurance coverage was positively associated with vaccine uptake and a 2010 analysis of the National Family Growth Survey found insurance coverage to be significantly associated with vaccine initiation regardless of age (Liddon, Leichliter, & Markowitz, 2012). Further examination of current vaccine assistance programs for uninsured young people is needed to examine how these programs can better respond to national vaccine needs and gaps. Marchand et al. (2012) suggest catch-up vaccination rates among uninsured, low-income women may be increased by revising age inclusion criteria for adolescent vaccine safety-net programs to consider young adults up to age 26, as well as encouraging community health centers to participate in manufacturer-based cost assistance programs (Merck's Patient Assistance Program and GlaxoSmithKline's Cervarix program).

In addition to age, we found demographic variables such as marital status and having children to be significant risk factors for non-vaccination. Married women were 84% more likely to be unvaccinated compared to unmarried women; women who had children were more than twice as likely to be unvaccinated compared to women without children. These findings may reflect a belief among women, and potentially among their providers, that they are not at risk for HPV or would not

benefit from vaccination. In a 2010 study of young women's reasons for non-vaccination, the authors found that 55% of women reported they did not initiate vaccination because they were married or in a monogamous relationship (Zimet, 2010). A perceived lack of need due to perceived low risk (e.g. being in a committed relationship, few or no sexual partners) has been shown to be a predictor of non-vaccination in other population surveys (Grant, Kravitz-Wirtz, Breen, Tiro, & Tsui, 2009; Jain, 2007). We also found that 63% of unvaccinated women reported they were not interested in receiving the vaccine. When asked about their main reason for not receiving the vaccine, 44% of women reported reason they did not need it. Despite evidence to support universal vaccine recommendations for this age group, some women may incorrectly think they do not need the vaccine because they are low risk, already infected with HPV, or too old to receive any protective benefit. Routine use of the HPV vaccine in catch-up women, even if they were already sexually active, was recommended over a targeted risk-factor approach due to the ubiquitous nature of HPV infection and data showing that it is unlikely that women exposed to one type of HPV have been exposed to all types covered in the vaccine. Thus, older women can obtain partial clinical benefit from vaccination after sexual debut, or after exposure to HPV. Misconceptions regarding vulnerability to HPV disease and HPV vaccine efficacy reflect important gaps in young women's HPV-related knowledge, and efforts to increase vaccine uptake would benefit from information-driven campaigns that aim to correct key observed misperceptions. While general knowledge about HPV, the association between HPV and cervical cancer, and the availability of a preventive

vaccine is high among young women, more complex information about HPV transmission, screening, other disease consequences have been demonstrated to be low in samples of young women (Allen, 2009; Licht et al., 2010; Lopez & McMahan, 2007; Sandfort & Pleasant, 2009; Gerend & Magloire, 2008). Knowledge-based campaigns may benefit from providing additional clinical information about HPV transmission, HPV disease, and prevention to inform more accurate risk perceptions for HPV.

Additionally, disagreements among national leaders about vaccine recommendations for 18-26 year old women can contribute to public confusion or misperceptions of vaccine benefit. While ACIP recommends universal vaccination, the American Cancer Society (ACS) cites insufficient evidence to recommend vaccination in all 19-26 year old females (Saslow et al., 2007). ACS instead suggests providers base their decision to vaccinate on the patient's individual risk factors for previous HPV exposure and number of sexual partners. Conflicting national guidelines reflect discordant opinions among health care providers about the public health and clinical benefits of vaccination for women who are already sexually active. Unvaccinated women are likely to be influenced by their providers' opinions when making decisions about vaccination (Brewer & Fazekas, 2007; Hopfer & Clippard, 2011). A 2010 study of insured women aged 19-26 showed that women who received a physician's recommendation for vaccination were more likely to be vaccinated (Rosenthal, 2010); further, a strong recommendation resulted in a 4-fold greater likelihood of vaccination than one that was not strong. It is has been shown that

physicians who disagree that the vaccine can provide protective benefit to an older female do not recommend HPV vaccination and advise against it (Goff, Mazor, Schaffer, Corey, & Blake, 2011). In our sample, 7% of women indicated their main reason for not receiving the vaccine was because their doctor did not recommend it. Zimet et al. (2010) found that 5% of 18-26 women did not initiate vaccination because their doctor recommended against it. Further research is needed to examine the proportion of physicians who do not support adult HPV vaccination, or do not recommend it to their patients for other reasons.

In addition to multiple risk factors for non-vaccination status, we also found several factors to be protective against non-vaccination. First, US census region of residence was found to have a protective effect against non-vaccination. In univariate analyses, living in the Midwest or West was associated with increased odds of vaccination compared to those living in the South, but in multivariate analyses only living in the West was associated with increased odds of vaccination. Recent research specific to geographic variability in HPV vaccine uptake has also demonstrated that 18-26 year olds in the Midwest and West regions were more likely to be vaccinated than young women in the Northeast (Wei, Moore, & Green, 2013). The authors believed geographic variability may be influenced by regional providers' likelihood of recommending vaccine and by women's knowledge and attitudes regarding HPV and HPV vaccines. There is little other research to explain geographic variability, but a 2010 study from CDC revealed HPV vaccine coverage to be lower among adolescent girls living in the Southeastern US compared to girls living in other regions (CDC,

2011b). Further, areas with higher poverty rates may explain geographic variability; among girls in six US states, girls living in higher-poverty states were shown to be less likely to be vaccinated (Pruitt & Schootman, 2010).

Healthcare utilization, or more specifically, health prevention behaviors, such as having had a doctor's visit in the past year, current birth control, flu vaccine receipt, and tetanus vaccine receipt were also found to be protective factors. In a recent review of HPV vaccine uptake among adolescent women, a study showed that 43% of adolescents who received HPV vaccine also received a second preventative health service (Etter, Zimet, & Rickert, 2012). In univariate analyses in our study, having a usual place of care, or medical home, was a significant predictor of vaccine initiation. It is reasonable to assume that vaccinated, insured women with recent health care visits are engaging in other health care prevention behaviors such as pregnancy prevention and adherence to other recommended vaccines.

Among the significant healthcare utilization predictors, receipt of flu vaccine in the past year was found to be the most protective factor. Women who received a flu vaccine were almost three times as likely to have initiated the HPV vaccine series. Receipt of other vaccines has been shown to predict HPV vaccination behavior in other national probability samples. For example, Jain et al., (2007) found that young women who were vaccinated against Hepatitis B were more likely to have received at least one dose of the HPV vaccine series. Receipt of flu vaccine has also been shown to influence uptake of other vaccines such as Tdap (Miller, Kretsinger, Euler, Lu, & Ahmed, 2011). Women who report receipt of multiple recommended vaccines may

have more confidence in vaccine safety and efficacy. Further research is needed to better understand the variables that predict public confidence in vaccines. Among unvaccinated women in this sample, concerns about not knowing enough about the vaccine and concerns about the safety of the vaccine emerged as the second and third most frequently reported reasons for non-vaccination. These results reflect previous findings from young women who cited concerns about lack of sufficient information about the vaccine, and concerns about side-effects or the vaccine being too new (Zimet, 2010). Addressing lack of public confidence in vaccines is emerging as a research priority to identify new interventions to increase vaccine coverage (Larson, Cooper, Eskola, Katz, & Ratzan, 2011). Health communications campaigns may benefit from acknowledging lack of public confidence in vaccines, and working with target populations to develop vaccine messages that build public trust in vaccines. New messages are needed that communicate the excellent safety and efficacy record of both vaccines, while providing accurate information about risk-benefit ratio of vaccines. Campaigns should direct unvaccinated individuals to objective (non-industry) sources of vaccine safety information (such as the CDC or other trusted entity) so individuals are confident in their ability to make informed decisions about their personal risks and benefits of vaccination.

Limitations

The current study has several limitations. First, results are based on one cross-sectional analysis and further examination of findings to predict non-vaccination will require longitudinal designs. Second, NHIS relies exclusively on self-report measures

and is not confirmed by objective measures. All self-report data are vulnerable to recall and misclassification bias and caution should be used when interpreting rates of vaccination and other data. Third, the NHIS was restricted to noninstitutionalized civilian adults and generalization to the wider population cannot be inferred. Oversampling of ethnic and racial minority groups may inflate estimates relating to these groups. Additionally, there is potential coverage bias or bias that exists for the exclusion of households without landline telephones (Blumberg & Luke, 2012). For example, in comparative analyses between people with landline phone only and people with wireless phones only, wireless people tended to be older, in poverty, living in the Midwest, South, or West as compared to the Northeast, and Hispanic or Black. Fifth, multivariate models required complete data on all variables used in the model and this reduced sample size, thereby potentially reducing the statistical power of the model. Lastly, estimates were not weighted in SUDAAN to account for the complex sampling design.

Implications

Current findings contribute to previous research demonstrating disparities in vaccine uptake among 18-26 year old women. While vaccine uptake in this age group has increased since 2007, young adults lag far behind adolescent girls aged 11-17 and it is unlikely optimal vaccine coverage targets will be met among this group unless evidence-based targeted programs are designed and implemented to address the variables known to predict non-vaccination. Significant challenges exist in developing effective, scalable interventions to reach high-risk subgroups of adult women. Many

variables significant in multivariate analyses can be considered "static" and not amenable to intervention. Infrastructure and funding for adult vaccine uptake are lacking to adequately address structural barriers to vaccination, but vaccine promotion programs may benefit from further examination specific to HPV and HPV vaccine knowledge and attitudes, personal reasons for not receiving vaccination, and general public confidence in vaccines. In the US, adult vaccine coverage (adults ≥19 years of age) of recommended vaccines continues to be low, and lower than objectives set for Healthy People 2020. In addition to general public health practice recommendations of increased access to vaccines through non-traditional venues (e.g. pharmacies, workplaces, and community events), clinic reminder systems, and reduced financial barriers, programs of research to increase vaccine uptake may also benefit from interventions that aim to increase physician recommendation for vaccination, increase perceived risk for HPV without vaccine, increase perceived benefit of the vaccine, and decrease inflated concerns about safety and side-effects.

Table 1. All Potential Predictors and Original Response Categories

Race Recode	White only, Black only, American Indian/Alaskan Native only, Asian only, Multiple Race, Not Released
Race/Ethnicity	Hispanic, White, Non- Hispanic Black, Other
Hispanic Ethnicity	Yes, No
Marital Status	Separated, Divorced, Married, Single/Never Married, Widowed, Unknown
Born in US	Yes, No, Refused, Don't Know
Language	Only Spanish, Mostly Spanish, Spanish and English, Mostly English, Only English, Other, Not Ascertained
Region	Northeast, Midwest, South, West
Age	Continous
Live birth within past 5 years	Yes, No, Refused, Don't Know, Not Ascertained
Medicaid	Yes, Yes but no information, No, Refused, Don't Know, Not Ascertained
Medicare	Yes, Yes but no information, No, Refused, Don't Know, Not Ascertained
State Children's Health Insurance Program coverage	Yes, Yes but no information, No, Refused, Don't Know, Not Ascertained
State-sponsored health plan	Yes, Yes but no information, No, Refused, Don't Know, Not Ascertained
Other government health plan	Yes, Yes but no information, No, Refused, Don't Know, Not Ascertained
Military health care coverage	Yes, Yes but no information, No, Refused, Don't Know, Not Ascertained
Ineligible because of age/school	Mentioned, Not Mentioned, Refused, Don't Know, Not Ascertained -
Private Insurance	Yes, Yes but no information, No, Refused, Don't Know, Not Ascertained
No Coverage	Not covered, covered, refused, don't know, not ascertained
Education	Less than 8th grade, 9th-12th grade, HS or GED, AA, some college, Bachelors, masters, doctoral, Refused, Don't Know, Not Ascertained
Total earnings last year	$0-4,999, $5,000-$9,999, $10,000-$14,999, $15,000-$19,999, $20,000-$24,999, $25,000-$29,999, $30,000-$34,999, $35,000-$39,999, $40,000-$44,999, $45,000-$54,999, $55,000-$64,999, $65,000-$74,999, over $75,000, Refused, Don't Know, Not Ascertained
Full time work	Yes,No, Refused, Don't Know, Not Ascertained
Pap test ever	Yes,No, Refused, Don't Know, Not Ascertained
Abnormal Pap test results - past 3 years	Yes,No, Refused, Don't Know, Not Ascertained
Told by doctor had HPV	Yes,No, Refused, Don't Know, Not Ascertained
Reported Health Status	Excellent, Very Good, Good, Fair, Poor, Refused, Don't Know, Not Ascertained
Has usual Place to go when sick	Yes,No, Refused, Don't Know, Not Ascertained

Place to go when sick	Doctor's office, clinic, hospital ER, hospital outpatient, some other place, doesn't go to one place, refused, don't know, not ascertained
Currently taking birth control pills, implants, or shots	Yes,No, Refused, Don't Know, Not Ascertained
Seen/talked to doctor in past 12 months	Yes,No, Refused, Don't Know, Not Ascertained
Seen/talked to OB/GYN in past 12 months	Yes,No, Refused, Don't Know, Not Ascertained
	Yes,No, Refused, Don't Know, Not Ascertained
Flu shot past 12 months	Yes,No, Refused, Don't Know, Not Ascertained
Hepatitis A vaccine - ever (Y,N)	Yes,No, Refused, Don't Know, Not Ascertained
Hepatitis B vaccine - ever (Y,N)	Yes,No, Refused, Don't Know, Not Ascertained
Tetanus shot in past 10 years (Y,N)	Yes,No, Refused, Don't Know, Not Ascertained
Had STD past 5 years	Yes,No, Refused, Don't Know, Not Ascertained
Saw a doctor for STD	Yes,No, Refused, Don't Know, Not Ascertained
Ever been tested for HIV (Y,N)	Yes,No, Refused, Don't Know, Not Ascertained
Heard of HPV	Yes,No, Refused, Don't Know, Not Ascertained
Heard of HPV vaccine/shot	Yes,No, Refused, Don't Know, Not Ascertained

Table 2. Selected Sample Characteristics of non-vaccinated women (*n*=1,458)*

Characteristic	N	%
Age		
18-20	322	22.1
21-23	528	36.2
24-26	608	41.7
Insurance Coverage		
Yes	1041	75.4
No	412	28.3
Married		
Yes	315	21.6
no	1140	78.2
Race/ethnicity		
Hispanic	366	24.0
non-Hispanic white	685	46.9
non-Hispanic black	296	20.3
non-Hispanic other	111	7.6
Region		
Northeast	188	12.9
Midwest	325	22.3
South	566	38.8
West	379	25.7
Education		
Less than high school	242	16.6
High school	377	25.9
Some college	576	39.6
College or higher	260	17.9
Annual Income		
0-19,999	759	52.1
20,000-34,999	241	16.5
≥35,000	116	8.0
Given birth in past 5 years		
Yes	540	37.0
no	918	62.9
Currently on birth control		
Yes	452	31.0
no	999	68.5
Ever had Pap test		

Yes	1139	78.1
no	312	21.4
Seen a doctor in past year		
Yes	785	53.8
No	672	46.1
Flu shot last 12 months		
Yes	159	17.6
No	744	82.5
Tetanus shot last 10 years		
Yes	871	59.7
No	535	36.7
Hepatitis A vaccine		
Yes	345	23.7
no	927	63.6
Hepatitis B vaccine		
Yes	805	55.2
No	556	38.1

* Some totals may not add up to 100% due to missing responses to deleted categories

Table 3. HPV Vaccine Attitudes and Awareness of Non-Vaccinated Women*

Question	n	%
Heard of HPV (n=1458)		
Yes	1089	74.7
No	368	25.2
Heard of HPV vaccine (n=1458)		
Yes	954	65.4
No	504	34.6
Interested in getting HPV vaccine (n=1458)		
Yes	480	32.9
No	917	62.9
Would get vaccine if the cost was $360-500 (n=408)		
Yes	96	20.0
No	377	78.5
Would get vaccine if free or lower cost (n=404)		
Yes	386	95.5
No	11	2.7
Main reason would not get HPV vaccine (n=988)		
does not need vaccine	395	40.4
not sexually active	70	7.20
too expensive	27	2.8
too old for vaccine	28	2.9
doctor didn't recommend it	76	7.8
worried about safety of vaccine	106	10.8
don't know where to get vaccine	3	0.3
my spouse/family member is against it	4	0.4
don’t know enough about the vaccine	132	13.5
already have HPV	25	2.6

* Some totals may not add up to 100% due to missing responses or deleted categories

Table 4. Selected Sample Characteristics of Vaccinated Women (n=408)*

Characteristic	N	%
Age		
18-20	170	41.6
21-23	135	33.1
24-26	103	25.2
Insurance Coverage		
Yes	340	83.9
No	65	16.1
Married		
Yes	45	11.03
no	363	88.9
Race/ethnicity		
Hispanic	82	20.1
non-Hispanic white	230	56.3
non-Hispanic black	71	17.4
non-Hispanic other	25	6.1
Region		
Northeast	54	13.2
Midwest	108	26.4
South	129	31.6
West	117	28.6
Education		
Less than high school	46	11.2
High school	82	48.2
Some college	197	48.2
College or higher	83	20.3
Annual Income		
0-19,999	180	61.4
20,000-34,999	47	16.0
≥35,000	66	22.5
Given birth in past 5 years		
Yes	82	20.1
no	326	79.9
Currently on birth control		
Yes	205	50.3
no	202	49.6
Ever had Pap test		

Yes	332	81.5
no	75	18.4
Seen a doctor in past year		
Yes	291	71.3
No	117	28.6
Flu shot last 12 months		
Yes	78	37.1
No	132	62.8
Tetanus shot last 10 years		
Yes	317	81.2
No	73	18.7
Hepatitis A vaccine		
Yes	152	43.1
no	201	56.9
Hepatitis B vaccine		
Yes	263	75.4
No	92	24.5

* Some totals may not add up to 100% due to missing responses to deleted categories

Table 5. Summary of Bivariate Associations between Potential Predictors and Non-vaccination

Variable Grouping	p value
Demographic Variables	
Race Recode (white, not white)	0.048*
Race/Ethnicity (Hispanic, White, Non-Hispanic Black, Other)	0.0098*
Hispanic Ethnicity (Yes, No)	0.0369*
Marital Status (Married, not married)	<.0001*
Born in US (Y,N)	0.0057*
Language (English, Other)	0.0006*
Region	0.0519*
Age	<.0001*
Live birth within past 5 years	<.0001*
Socioeconomic Variables	
Medicaid (Y,N)	0.0448*
Medicare	-
SCHIP coverage	-
State-sponsored health plan	-
Other government health plan	-
Military health care coverage	-
Ineligible because of age/school	-
Private Insurance (Y,N)	<.0001*
No Coverage (Y,N)	<.0001*
Education (<HS, HS, some college, ≥college)	0.0006*
College Education (Y, N)	<.0001*
Total earnings last year	0.3522
Full time work (Y,N)	-
Health Utilization	
Pap test ever (Y, N)	0.177*
Abnormal Pap test results - past 3 years (Y, N)	0.0761*
Told by doctor had HPV	0.0022*

(Y,N)	
Reported Health Status (Excellent/Very good vs. Good/Fair/Poor)	0.2602
Has usual Place to go when sick (Y, N)	<.0001*
Place to go when sick (doctor's office/clinic vs. other)	0.8058
Currently taking birth control pills, implants, or shots (Y,N)	<.0001*
Seen/talked to doctor in past 12 months (Y,N)	<.0001*
Seen/talked to OB/GYN in past 12 months (Y,N)	0.2211*
Flu shot past 12 months (Y,N)	<.0001*
Hepatitis A vaccine - ever (Y,N)	<.0001*
Hepatitis B vaccine - ever (Y,N)	<.0001*
Tetanus shot in past 10 years (Y,N)	<.0001*
Had STD past 5 years (Y,N)	0.1062*
Saw a doctor for STD (Y,N)	-
Ever been tested for HIV (Y,N)	0.2711
Knowledge	
Heard of HPV (Y, N)	<.0001
Heard of HPV vaccine/shot (Y,N)	-

* variables significant at exploratory level of p<.20

Table 6. Model 1: Demographic Variables							
Variable	Unadjusted OR	95% CI	p	aOR	95% CI	p	SE
Age							
(ref) 18-21							
22-25	2.67	2.10-3.39	<.0001	2.30	1.79-2.95	<.0001	0.12
26	2.20	1.53-3.18	<.0001	1.83	1.25-2.69	0.00	0.19
Region							
(ref) South							
Northeast	1.07	0.74-1.55	0.97	0.75	0.51-1.10	0.15	0.19
Midwest	0.92	0.68-1.25	0.13	0.73	0.54-0.99	0.05	0.15
West	1.35	1.02-1.79	0.01	0.67	0.49-0.90	0.01	0.15
Race (White, Not-White)	0.77	0.60-0.99	0.04	0.77	0.58-1.01	0.06	0.13
Language (English, Other)	0.64	0.50-0.83	0.00	0.75	0.54-1.04	0.09	0.16
Marital Status (Yes, No)	2.22	1.59-3.10	<.0001	1.49	1.04-2.14	0.03	0.18
Born in US (Yes, No)	0.62	0.44-0.87	0.01	0.88	0.58-1.32	0.55	0.20
Live birth past 5 years (Yes, No)				1.81	1.36-2.40	<.0001	0.14
Hispanic (Yes, No)	0.75	0.57-0.98	0.03	0.87	0.61-1.25	0.47	0.18
model chi-square (LR)=119.46, p=<.0001							
Hosmer-Lemeshow chi square=1.86, p=.985							

Table 7. Model 2: Socioeconomic Variables							
Variable	Unadjusted OR	95% CI	p	aOR	95% CI	p	SE
Private Insurance (Yes, No)	0.51	0.41-0.64	<.0001	0.84	0.54-1.28	0.42	0.21
No Insuance Coverage (Yes, No)	2.07	1.55-2.76	<.0001	1.86	1.16-3.00	0.009	0.24
Medicaid (Yes, No)	1.34	1.00-1.80	<.0001	1.29	0.81-2.07	0.27	0.23
College Education (Yes, No)	0.06	0.48-0.78	<.0001	0.74	0.75-0.95	0.02	0.12
model chi-square (LR)=46.59, p=<.0001							
Hosmer-Lemeshow chi square=1.48, p=.829							

Table 8. Model 3: Health Services Utilization Variables							
Variable	unadjusted OR	95% CI	p	aOR	95% CI	p	SE
Tetanus shot (Y/N)	0.37	0.28-0.49	<.0001	0.45	0.27-0.75	0.002	0.26
Hep B shot (Y/N)	0.47	0.36-0.61	<.0001	0.85	0.53-1.38	0.53	0.24
Hep A shot (Y/N)	0.49	0.38-0.62	<.0001	0.66	0.43-1.01	0.05	0.21
Flu Shot (Y/N)	0.36	0.26-0.50	<.0001	0.52	0.34-0.78	0.001	0.2
Doctor's Visit Past Year (Y/N)	0.47	0.37-0.59	<.0001	0.56	0.35-0.87	0.01	0.22
Current birth control use (Y/N)	0.44	0.35-0.55	<.0001	0.47	0.32-0.69	0.0001	0.19
Has Usual Place of Care (Y/N)	0.46	0.34-0.62	<.0001	0.51	0.28-0.94	0.03	0.3
Told by doctor had HPV (Y/N)	0.56	0.38-0.81	0.002	1.05	0.50-2.18	0.88	0.37
model chi-square (LR)=76.53, p=<.0001							
Hosmer-Lemeshow chi square=12.32, p=.137							

Table 9. Model 4: HPV Awareness				
Variable	aOR	95% CI	p	SE
heard of HPV	0.24	0.16, 0.35	<.0001	0.19

Table 10. Full Model (*N*=1,041; no=846, yes=195)

Variable	aOR	95% CI	p	SE
Age				
18-21 (ref)				
22-25	3.39	2.26-5.09	<.0001	0.20
26	1.82	1.01-3.28	0.045	0.30
Marital Status	1.83	1.04-3.21	0.036	0.28
No insurance	1.60	0.97-2.62	0.061	0.25
College education	0.69	0.46-1.05	0.0867	0.21
Region				
South (ref)				
Northeast	0.64	0.36-1.13	0.1305	0.28
Midwest	0.64	0.39-1.03	0.0697	0.24
West	0.48	0.30-0.77	0.0027	0.24
Usual place of care	0.78	0.47-1.31	0.3594	0.26
Live birth in past 5 years	2.62	1.59-4.29	0.0001	0.25
Currently on birth control	0.46	0.32-0.66	<.0001	0.18
Doctor visit past 12 months	0.64	0.42-0.97	0.0352	0.20
Flu shot in past year	0.35	0.23-0.52	<.0001	0.20
Tetanus shot in past 10 years	0.44	0.28-0.69	0.0004	0.23

model chi-square (LR)=213.55 (14), p=<.0001

Hosmer-Lemeshow chi square=7.84 (8), p=.448

Table 11: Final Model (*N*=1067; no=868, yes=199)

Variable	aOR	95% CI	p	SE
Age				
18-21 (ref)				
22-25	2.93	2.00-4.30	<.0001	0.19
26	1.49	0.85-2.61	0.156	0.28
Married	1.75	1.02-3.01	0.042	0.27
Region				
South (ref)				
Northeast	0.65	0.38-1.14	0.136	0.27
Midwest	0.65	0.41-1.04	0.077	0.23
West	0.50	0.31-0.79	0.003	0.23
Live birth in past five years	2.77	1.75-4.39	<.0001	0.23
Currently on birth control	0.45	0.31-0.64	<.0001	0.17
Doctor visit past year	0.57	0.39-0.84	0.0045	0.19
Flu shot in past year	0.36	0.24-0.54	<.0001	0.20
Tetanus shot in past 10 years	0.40	0.26-0.62	<.0001	0.22

model chi-square (LR)=193.30 (11), p=<.0001
Hosmer-Lemeshow chi square=14.41(8), p=.071
Max Rescaled R-square=0.268
Percent Concordant=79.1
Percent Discordant=20.2
c=.795

Table 12. Multicollinearity Diagnostics for Final Model

Number	Eigenvalue	Condition Index	Intercept	age	marital status	region	live birth	birth control	flu shot	tetanus shot	doctor's visit
1	5.50049	1	0.00151	0.00332	0.00719	0.00318	0.00862	0.00956	0.00752	0.00762	0.0086
2	0.89002	2.48599	0.000156	8.3E-05	0.39063	4.27E-07	0.17654	0.02645	0.08943	0.01755	0.02601
3	0.73412	2.73727	0.00168	0.00256	0.12859	0.0075	0.00129	0.00532	0.75316	0.00419	0.00221
4	0.57421	3.09504	0.00167	0.00485	0.01113	0.00387	0.00111	0.95014	0.00545	0.01249	0.02101
5	0.52561	3.23495	6.37E-05	1.22E-05	0.4308	0.000727	0.67765	0.000329	0.0679	0.00948	0.01794
6	0.36063	3.90542	0.00197	0.01199	0.00289	0.01059	0.03478	0.000172	0.01374	0.12	0.84461
7	0.26388	4.56559	0.00946	0.049	0.01733	0.05698	0.09146	0.000865	0.03341	0.77883	0.0176
8	0.11478	6.92258	1.89E-05	0.53759	0.00181	0.45857	0.0072	0.00194	0.02212	9.84E-05	0.000917
9	0.03625	12.31867	0.98347	0.39059	0.00963	0.45858	0.00136	0.00522	0.00727	0.04973	0.0611

Table 13. Classification Table for Final Model

Probability Level	Correct		Incorrect		Percentages				
		Non-Event		Non-Event		Sensitivity	Specificity	False Positive	False Negative
0	868	0	199	0	81.3	100	0	18.7	.
0.1	868	0	199	0	81.3	100	0	18.7	.
0.2	867	0	199	1	81.3	99.9	0	18.7	100
0.3	863	14	185	5	82.2	99.4	7	17.7	26.3
0.4	861	20	179	7	82.6	99.2	10.1	17.2	25.9
0.5	831	54	145	37	82.9	95.7	27.1	14.9	40.7
0.6	814	76	123	54	83.4	93.8	38.2	13.1	41.5
0.7	741	97	102	127	78.5	85.4	48.7	12.1	56.7
0.8	631	136	63	237	71.9	72.7	68.3	9.1	63.5
0.9	428	173	26	440	56.3	49.3	86.9	5.7	71.8
1	0	199	0	868	18.7	0	100	.	81.3

Table 14: Backwards Elimination Procedure (*N*=1,063; no=864, yes=199)

Variable	aOR	95% CI	p	SE
Not covered	1.70	1.06-2.72	0.027	0.24
Age				
18-21 (ref)				
22-25	2.91	1.99-4.27	<.0001	0.19
26	1.51	0.86-2.65	0.14	0.28
Married	1.81	1.06-3.17	0.028	0.27
Region				
South (ref)				
Northeast	0.68	0.39-1.18	0.175	0.28
Midwest	0.67	0.42-1.07	0.099	0.23
West	0.49	0.31-0.78	0.002	0.23
Live birth	2.67	1.69-4.23	<.0001	0.23
birth control pills	0.46	0.32-0.61	<.0001	0.17
doctor visit past year	0.63	0.43-0.93	0.021	0.02
Flu shot	0.36	0.24-0.54	<.0001	0.20
Tetanus shot	0.42	0.27-0.66	0.0002	0.22

model chi-square (LR)=198.05 (12), p=<.0001
Hosmer-Lemeshow chi square=10.24(8), p=.247
Max Rescaled R-square=0.27
Percent Concordant=79.3
Percent Discordant=20.0
c=.797

Table 15. Mulitcollinearity Diagnostics for Backwards Elimination Model

Number	Eigenvalue	Condition Index	Intercept	age	marital status	region	live birth	birth control	flu shot	tetanus shot	doctor's visit	no insurance
1	5.74815	1	0.00133	0.00305	0.00635	0.00293	0.00793	0.00852	0.00665	0.00667	0.00737	0.00571
2	0.92541	2.49228	1.01E-05	0.000483	0.06117	0.00073	0.09521	0.03999	0.2026	0.01665	0.03335	0.2308
3	0.85271	2.59636	0.000794	0.000378	0.47483	0.00167	0.07041	0.000736	0.02236	0.00464	0.00193	0.20439
4	0.67355	2.92133	0.000369	0.000397	0.00275	0.00263	5.82E-05	0.10066	0.6784	0.0079	0.01579	0.19296
5	0.56181	3.19868	0.0016	0.00427	0.00789	0.00456	0.05	0.78477	0.01873	0.02694	0.05994	0.03454
6	0.50936	3.35934	5.06E-06	8.67E-06	0.3914	0.00036	0.71029	0.05236	0.01262	0.000204	0.00222	0.07927
7	0.34552	4.07876	0.000817	0.00711	0.00588	0.00478	0.00156	0.00385	0.0022	0.26832	0.7124	0.05083
8	0.23382	4.95821	0.01178	0.08118	0.04121	0.0815	0.05709	0.000213	0.02655	0.6088	0.08855	0.17328
9	0.11447	7.0862	2.07E-05	0.52343	0.00125	0.4709	0.00678	0.00221	0.02257	4.75E-07	0.00168	0.000975
10	0.03522	12.77487	0.98328	0.37969	0.00728	0.42994	0.000657	0.00668	0.00732	0.05988	0.07678	0.02725

Table 16. Classification Table for Backwards Elimination Model

Probability Level	Correct		Incorrect		Percentages				
		Non-Event		Non-Event		Sensitivity	Specificity	False Positive	False Negative
0	864	0	199	0	81.3	100	0	18.7	.
0.1	864	0	199	0	81.3	100	0	18.7	.
0.2	863	4	195	1	81.6	99.9	2	18.4	20
0.3	859	15	184	5	82.2	99.4	7.5	17.6	25
0.4	857	19	180	7	82.4	99.2	9.5	17.4	26.9
0.5	829	53	146	35	83	95.9	26.6	15	39.8
0.6	798	82	117	66	82.8	92.4	41.2	12.8	44.6
0.7	745	99	100	119	79.4	86.2	49.7	11.8	54.6
0.8	636	135	64	228	72.5	73.6	67.8	9.1	62.8
0.9	425	173	26	439	56.3	49.2	86.9	5.8	71.7
1	0	199	0	864	18.7	0	100	.	81.3

Table 17. 2011 Cross-Validation Model (*N*=2,220; no=1568, yes=639)

Variable	aOR	95% CI	p	SE
Age				
18-24 (ref)				
25	1.61	1.19-2.19	.0021	0.15
26	2.42	1.70-3.43	<.0001	0.17
Married	2.38	1.78-3.19	<.0001	0.14
Region				
South (ref)				
Northeast	0.55	0.41-0.75	.0002	0.15
Midwest	0.78	0.61-1.01	0.06	0.12
West	0.78	0.60-1.00	0.05	0.12
Doctor visit past year	0.62	0.51-0.77	<.0001	0.10
Flu shot in past year	0.60	0.49-0.75	<.0001	0.11
Tetanus shot in past 10 years	0.46	0.36-0.58	<.0001	0.10

model chi-square (LR)=222.86 (11), p=<.0001
Hosmer-Lemeshow chi square=2.80(8), p=.94
Max Rescaled R-square=0.137
Percent Concordant=68.6
Percent Discordant=29.2
c=.696

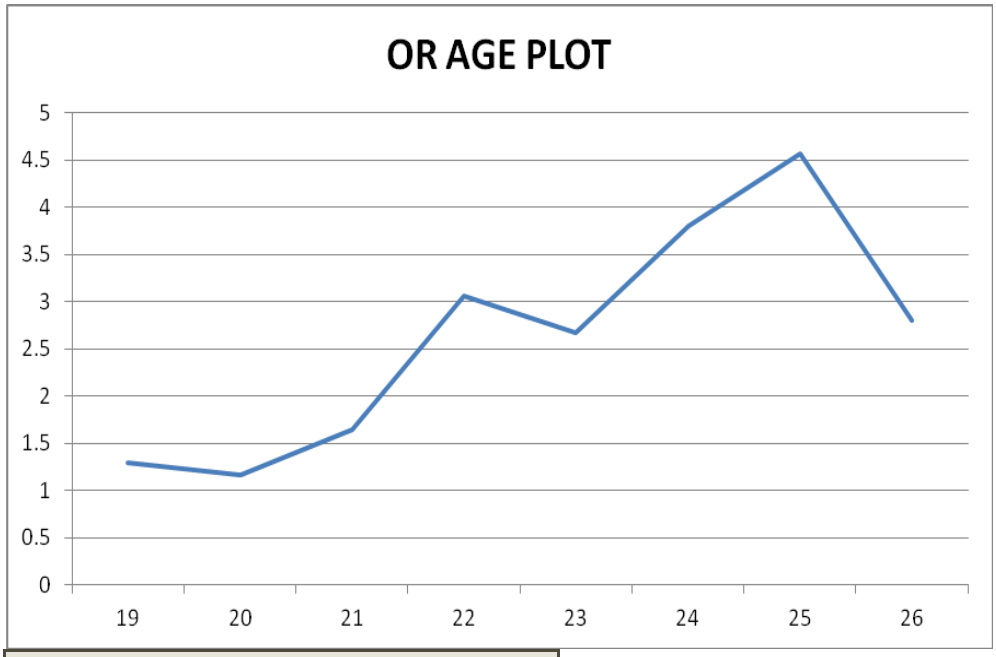
Table 18. Multicollinearity Diagnostics for 2011 Cross-Validation Model (6 Variables)

Number	Eigenvalue	Condition Index	Intercept	age	marital	region	flu shot	tetanus shot	doctor's visit
1	4.71516	1	0.00247	0.00732	0.00993	0.0043	0.012	0.01055	0.01208
2	0.80857	2.41484	3.38E-05	0.00201	0.67812	2.67E-05	0.20254	0.00545	0.01346
3	0.64357	2.70677	0.0025	0.00438	0.20891	0.00618	0.76757	0.01343	0.01848
4	0.34783	3.68183	0.00613	0.06062	0.06245	0.02947	0.00752	3.79E-06	0.82418
5	0.28083	4.09759	0.00257	0.07873	0.02296	0.01484	0.0032	0.8575	0.08004
6	0.16212	5.39299	0.01271	0.66127	0.01548	0.2746	0.000856	0.03312	0.00173
7	0.04192	10.60582	0.97358	0.18566	0.00215	0.67059	0.00632	0.07994	0.05003

Table 19. Classification Table for 2011 Cross-Validation Model (6 Variables)

Probability Level	Correct		Incorrect		Percentages				
		Non-Event		Non-Event		Sensitivity	Specificity	False Positive	False Negative
0	1568	0	639	0	71	100	0	29	.
0.1	1568	0	639	0	71	100	0	29	.
0.2	1568	0	639	0	71	100	0	29	.
0.3	1568	0	639	0	71	100	0	29	.
0.4	1556	24	615	12	71.6	99.2	3.8	28.3	33.3
0.5	1476	114	525	92	72	94.1	17.8	26.2	44.7
0.6	1279	276	363	289	70.5	81.6	43.2	22.1	51.2

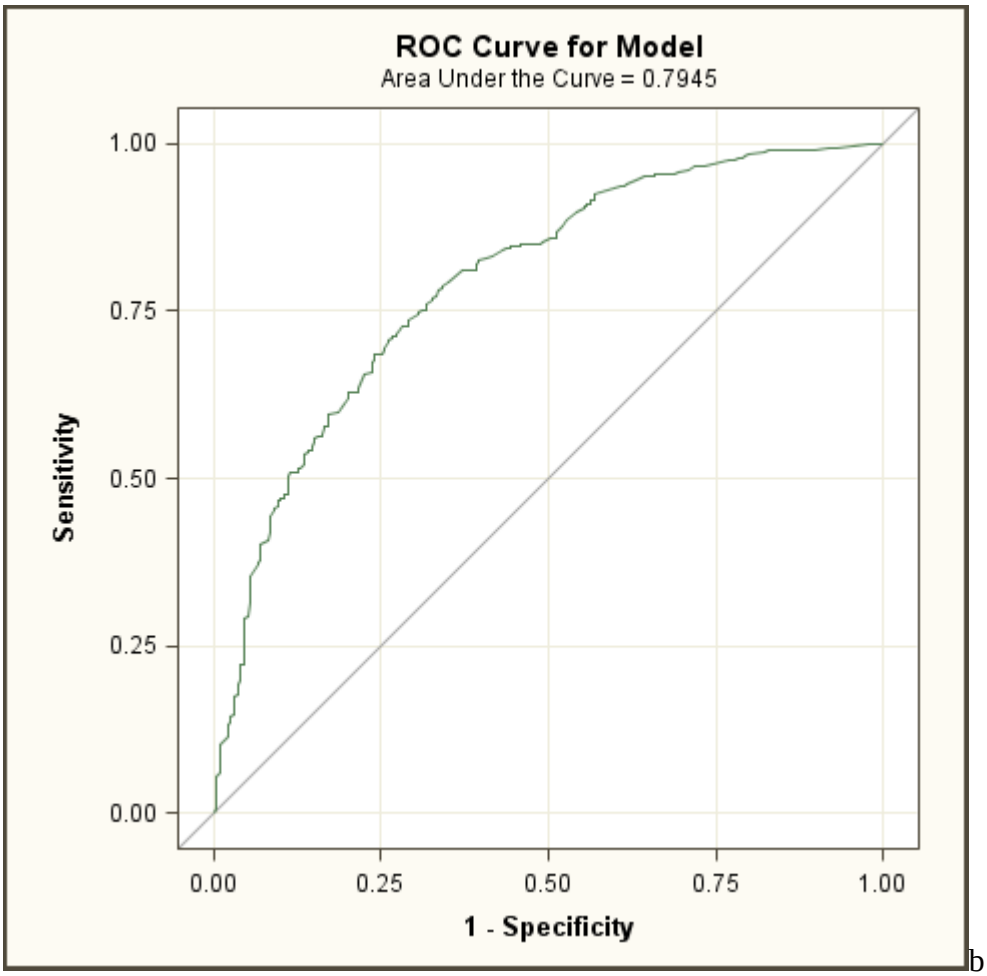
Figure 1: Odds Ratio Plot for Age



Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
AGE_P 19 vs 18	1.295	0.816	2.054
AGE_P 20 vs 18	1.166	0.738	1.842
AGE_P 21 vs 18	1.651	1.042	2.614
AGE_P 22 vs 18	3.06	1.878	4.986
AGE_P 23 vs 18	2.668	1.686	4.222
AGE_P 24 vs 18	3.804	2.308	6.27
AGE_P 25 vs 18	4.565	2.726	7.645
AGE_P 26 vs 18	2.803	1.755	4.476

Figure 2: ROC Curve Final Model



b

Figure 3: ROC Curve Backwards Elimination Model

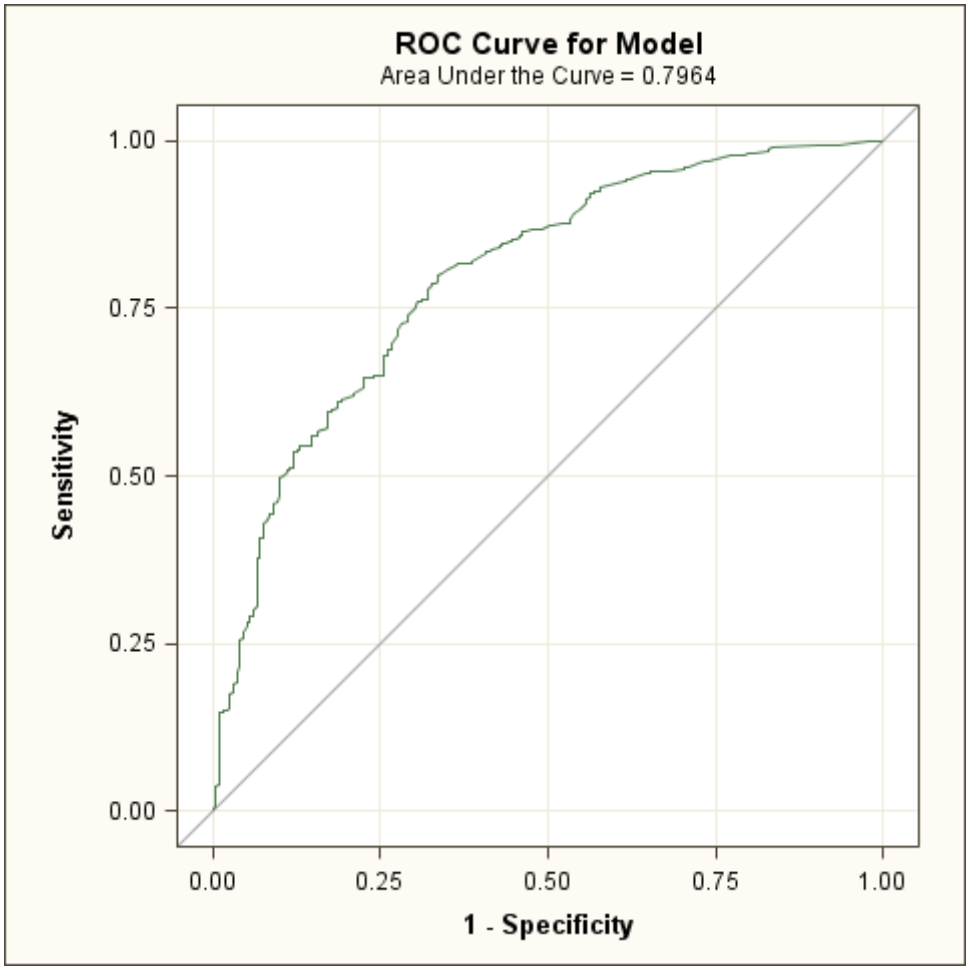
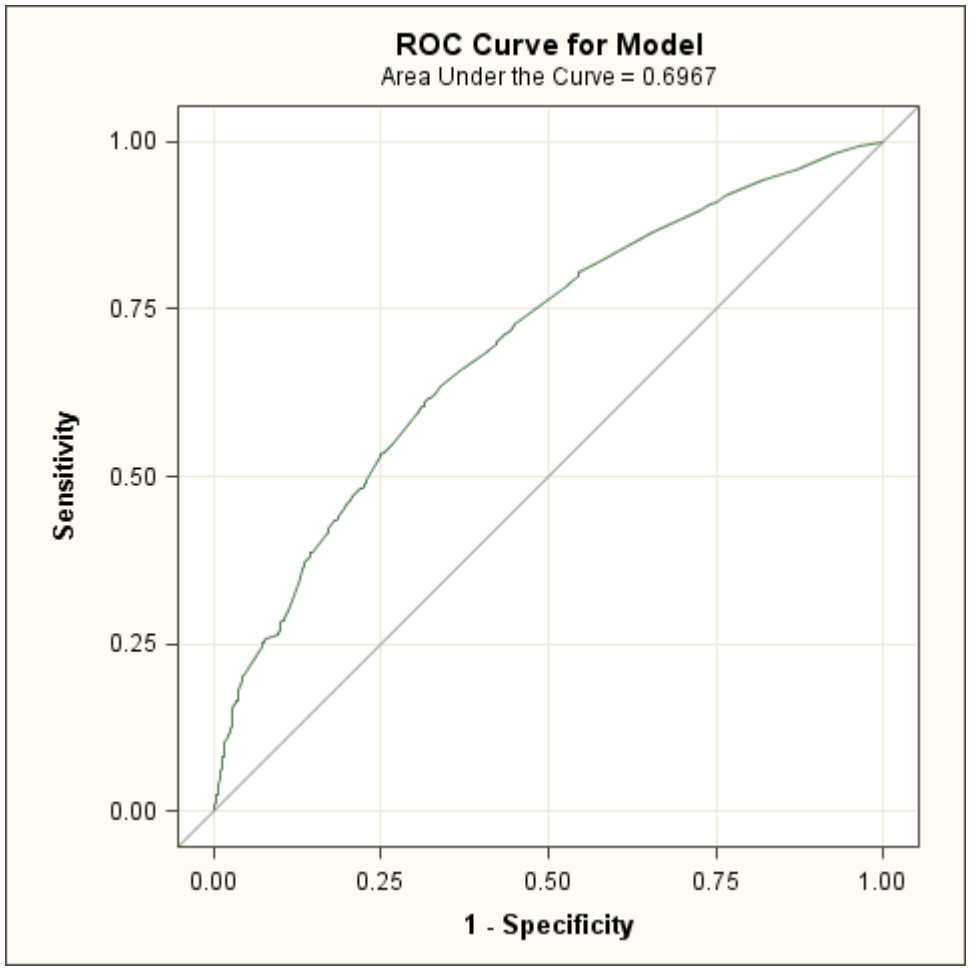


Figure 4: ROC Curve 2011 Cross-Validation Model



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