Published in final edited form as:

Womens Health Issues. 2019 ; 29(1): 31–37. doi:10.1016/j.whi.2018.09.007.

Obesity and Disparities in Human Papillomavirus Vaccination for U.S. Adolescent Girls and Young Women

John A. HARRIS, MD, MSc^{a,b}, Alison A. GARRETT, MD^{a,c}, and Aletha Y. AKERS, MD, MPH^d

^aDepartment of Obstetrics, Gynecology and Reproductive Sciences, University of Pittsburgh, 300 Halket Street, Pittsburgh, PA 15213,

^bMagee-Womens Research Institute and Foundation, 204 Craft St, Pittsburgh, PA 15213;

^cMagee-Womens Hospital of UPMC, 300 Halket Street, Pittsburgh, PA 15213,

^dThe Craig Dalsimer Division of Adolescent Medicine, The Children's Hospital of Philadelphia, 3401 Civic Center Blvd, Philadelphia, PA 19104,

Abstract

Background: Obesity is recognized as a barrier to receiving women's preventive health services, including cervical and breast cancer screening. Little is known about whether obesity is associated with a lower incidence of human papillomavirus (HPV) vaccination, another important preventive care service for adolescent girls and young women. The objective of this study was to determine if adolescent girls and young women with obesity are less likely to receive HPV vaccination compared to individuals with normal weight.

Methods: We examined whether HPV vaccination was associated with obesity status in women aged 9 to 30 years surveyed from 2009 to 2016 by the U.S. National Health and Nutrition Examination Study. Results from logistic and linear regression models were adjusted for age, race, income, insurance status, self-reported health, and health care utilization, accounting for the weighted survey design.

Results: The final cohort included 5,517 women. 32.9% of participants reported vaccination, with a mean age at vaccination of 15.8 years. Adolescent girls and young women with obesity were less likely to report vaccination; the adjusted odds ratio of vaccination was 0.79 ($p=0.01$) compared to normal weight women. Among those vaccinated, the age at vaccination was significantly higher for women with obesity, 16.3 years compared to 15.2 years ($p=0.002$), but there was no difference in the completion of the vaccination series rate by obesity.

Conclusions: Adolescent girls and young women with obesity were less likely to report HPV vaccination and, if they were vaccinated, received the vaccination at a later age.

Corresponding Author: John A. Harris, Magee-Womens Hospital of UPMC, 300 Halket Street, Suite 2328, Pittsburgh, PA 15213, phone 412-641-1597, fax 412-641-1133, harrisja@mail.magee.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Conflicts of interest: The authors have no conflicts of interest to disclose.

Keywords

Obesity; human papillomavirus; cervical cancer prevention; adolescent health; quality of health care

Introduction

Genital human papillomavirus (HPV) infection is common in the U.S., with approximately 80% of women contracting the virus sometime during their lifespan (Koutsky, 1997). HPV infection is often asymptomatic, but cervical cancer, anogenital condyloma, and other HPV-associated cancers may develop among a small percentage of women (Kim & Goldie, 2008). HPV vaccination has been an important preventive service available to adolescent girls and young women since the first vaccine was approved for use in 2006 (US Food and Drug Administration, 2006). The trials for the original HPV vaccines showed a greater than 90% efficacy in preventing Grade 2 or 3 cervical intraepithelial neoplasia, or adenocarcinoma in situ among women not previously infected (Kahn 2009). Recommended by the U.S. Advisory Committee on Immunization Practices and the World Health Organization, HPV vaccination is recognized as an important preventive health intervention for all eligible women (World Health Organization Publication, 2017). Despite the prevalence of HPV, the severity of HPV-related disease, and the availability of an effective vaccine, only 55.0% of adolescent women received two or more doses of the vaccine in the U.S. in 2016 (Walker et al., 2017). There are many factors associated with receiving timely HPV vaccination, including an individual's race, socioeconomic status, geographic location, attitude towards vaccinations, comfort with medical injections, willingness to follow a schedule, awareness of sexual health concepts, and provider recommendation (Niccolai, Mehta, & Hadler, 2011; Pruitt & Schootman, 2010; Rosenthal et al., 2011; Ylitalo, Lee, & Mehta, 2013).

Obesity, defined as a body mass index greater or equal to 30 kg/m², is common among adolescent girls and young women: 21% of girls 12–19 years old and 37% of women 20–39 years old in the US have obesity. 10% of women 20–39 year old have the most severe type of obesity, Class III Obesity (defined as a body mass index greater or equal to 40 kg/m²) (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016; Ogden, Carroll, Kit, & Flegal, 2014). Obesity is associated with many chronic medical conditions, but it is also associated with disparities in the receipt of care; women with obesity are less likely to receive recommended preventive care services including cervical and breast cancer screening (N. M. Maruthur, S. Bolen, F. L. Brancati, & J. M. Clark, 2009a; N. M. Maruthur, S. D. Bolen, F. L. Brancati, & J. M. Clark, 2009b; Puhl & Heuer, 2010).

A variety of factors have been posited to explain these disparities in preventive care services. Patients with obesity may avoid medical care due to embarrassment, perceived disrespectful provider interactions, and inadequate equipment or facilities for delivering services (e.g., lack of large blood pressure cuffs or inappropriately sized beds or exam rooms) (Budd, Mariotti, Graff, & Falkenstein, 2011; Gudzone, Beach, Roter, & Cooper, 2013; Kolata, 2016; Phelan et al., 2015). Providers may inadvertently fail to recommend certain preventive care because they are focused on weight management counseling or treating obesity and

related diseases. One large study identified disrespectful treatment, embarrassment with being weighed, negative attitudes of providers, unsolicited weight loss advice, and poorly fit equipment and facilities as reasons why women with obesity were more likely to delay screening for breast and cervical cancer (Amy, Aalborg, Lyons, & Keranen, 2006). Previous studies have noted mixed findings when assessing disparities by body weight in receipt of HPV, pneumococcus, or influenza vaccinations, but no HPV vaccination studies have included adolescent and adult women in a large, nationally representative sample or controlled for known confounders such as differences in healthcare utilization (Harper et al., 2014; Harris, Moniz, Iott, Power, & Griggs, 2016; Sundaram, Mason, & Basta, 2016).

The objective of this study was to determine if women with obesity have a lower prevalence of HPV vaccination, a higher age of vaccination, a lower prevalence of HPV infection, a lower prevalence of vaccination series completion, and a lower prevalence of sexual activity compared to adolescent girls and women with normal weight in the United States, by using questionnaire, physical examination, and laboratory data from the U.S. National Health and Nutrition Examination Study from 2009 to 2016.

Methods

NHANES is a program of the National Center for Health Statistics, Centers for Disease Control and Prevention. It is a cross-sectional, nationally representative health examination and survey, which was started in 1960 and has been continuously administered since 1999. It is designed to represent the U.S. civilian noninstitutionalized population through a complex, stratified, multistage probability cluster design. From 2009 to 2016, NHANES oversampled people who were Hispanic, non-Hispanic black, non-black Asian, low-income non-Hispanic non-black non-Asian white, or 80 years old and older.

Each participant in NHANES self-reports demographic information including race/ethnicity, household income, healthcare utilization including a vaccination history, and a sexual history. Within the NHANES Mobile Examination Center, participants completed a physical exam where height and weight are measured using calibrated equipment and standardized procedures. The entire NHANES testing protocol was approved by the Research Ethics Review Board of the National Center for Health Statistics and written consent was obtained for all adult participants.

Since 2006, HPV vaccination has been approved for adolescent girls and young women 9 to 26 years old. We used data from 2009 to 2014; a woman vaccinated in 2006 at 26 years old would be 29 in 2009. Adolescent girls and young women aged 9 to 30 with complete demographic, healthcare utilization, and sexual history information were eligible for inclusion in this study.

The main outcome was self-report of HPV vaccination. During each wave of NHANES, women 9 to 59 years old were asked: "Human Papillomavirus (HPV) vaccine is given to prevent cervical cancer in girls and women. There are two HPV vaccines available called Cervarix and Gardasil. It is given in 3 separate doses over a 6 month period. Have you ever received one or more doses of the HPV vaccine?" The response "Don't know" was coded as

a negative response. The age of vaccination was ascertained through the following question: “How old were you when you received your first dose of the vaccine?” Completion of vaccination was self-reported in response to the question: “How many doses of the [HPV] vaccine have you received?” 3 doses was defined as a complete vaccination series, and less than 3 doses was defined as an incomplete vaccination series.

Secondary outcomes included the incidence of HPV high-risk types (defined as subtypes 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, and 68) on self-collected vaginal swabs collected during the 2011–2012 study wave. Adolescent girls and young women participants in the 2011–2012 wave of NHANES gave biologic specimens including a Dacron vaginal swab (Catch-All, Epicentre) for HPV infection. The self-collected vaginal swab was shipped to the CDC and then refrigerated at 4° Celsius for HPV DNA identification and genotyping. DNA was extracted using a QIAamp kit (Qiagen, Valencia, CA). Presence of high-risk HPV strains were determined with the Cobas HPV Test (Roche Molecular Diagnostics). Data of HPV prevalence is publicly available for participants 18 years and older.

Other outcomes included sexual activity and sexually transmitted infections, which are risk factors for HPV infection. Sexual activity was defined using the following question: “Ever had vaginal, anal or oral sex?” Responses “no”, “refused”, and “don’t know” were all coded as “no”. It was asked of all women aged 14 years and older. History of sexual transmitted infection (STI) was ascertained using a positive answer to any of the following questions: “Has a doctor or other health care professional ever told you that you had genital herpes?”, “Has a doctor or other health care professional ever told you that you had genital warts?”, “In the past 12 months, has a doctor or other health care professional told you that you had gonorrhea, sometimes called GC or clap?”, and “In the past 12 months, has a doctor or other health care professional told you that you had chlamydia?” Participants reporting a positive answer to any of these questions were coded as having an STI.

The main predictor variable was body mass index (BMI). Each subject had height and weight measured based on a set protocol. Body mass index, calculated as weight in kilograms divided by height in meters squared, was calculated for each participant. In NHANES, obesity for adolescent and adult participants is calculated slightly differently. For participants under the age of 20, the CDC sex-specific 2000 BMI-for-age growth charts were used to define underweight (BMI < 5th percentile), normal weight (BMI 5th to 85th percentile), overweight (BMI 85th to < 95th percentiles), and obesity (BMI ≥ 95th percentile). For participants aged 20 years and older, we used NIH obesity categories: underweight (BMI < 18.5 kg/m²), normal weight (BMI 18.5 to <25 kg/m²), overweight (BMI 25 to < 30 kg/m²), and obesity (BMI ≥ 30 kg/m²). At the transition point (age of 20), the classification of BMI categories aligns well between these two definitions.

Age was based on the date of NHANES examination and was grouped in categories of 9 to 13 years, 14 to 18 years, 19 to 24 years, and 25 to 30 years. Race/Hispanic origin was defined based on self-report and categorized as Non-Hispanic white, Non-Hispanic black, Hispanic, and other. Ratio of reported household income to federal poverty level, categorized as less than 2 or greater than or equal to 2, was used as a measure of socioeconomic status. Self-reported general health was reported as five possible responses

and categorized in two categories: good or above, or fair or worse. The total number of reported healthcare visits, categorized as none, one, or 2 or more, was used as a measure of healthcare utilization. Health insurance was categorized as private insurance, non-private insurance, and uninsured based on respondent self-report.

Dichotomous (i.e., self-report of HPV vaccination) outcomes were analyzed with multivariable logistic regression models. Continuous outcomes (i.e., self-reported age of HPV vaccination) outcomes were analyzed with multivariable linear regression models controlling for the covariates noted previously. All statistics include appropriate adjustment for the complex survey design of NHANES. Outcomes are reported as odds ratios and as the probability of each outcome reported as the predicted percent chance of the outcome. The predicted probability is also known as the marginal effect: the predicted outcome probabilities when the independent variable is present or not, holding all other covariates at their known values, because effect sizes cannot be directly inferred from coefficients of logistic regression models.

The statistical power was estimated to be 97% to detect the odds of HPV vaccination for a women with obesity that is 0.75 times the odds of HPV vaccination for a woman with normal weight, assuming a baseline HPV rate of 37%, a Type 1 error of 5%, and 3,100 cases (the sum of normal and obese BMI categories) (Faul, Erdfelder, Buchner, & Lang, 2009). The study was deemed exempt by the University of Pittsburgh Institutional Review Board because the research involves the study of existing, publicly available data. STATA 14.1 (StataCorp LP, College Station, TX) software was used for all analyses except the power analysis, which was completed with GPower 3.1 (GPower, Dusseldorf, Germany).

Results

Of 6204 adolescent girls and women between 9 and 30 years old, 687 were excluded due to missing information on BMI (N=209), family household income (N=476), or HPV vaccine receipt (N=2). The final cohort included 5,517 participants. Of these, 182 (3.3%) were underweight, 2784 (50.5%) were of normal weight, 1108 (20.1%) had overweight, and 1,443 (26.2%) had obesity. The subpopulation with collected HPV infection from the 2011–2012 study wave information included 538 participants, the subpopulation responding to the sexual activity survey questions include 2,211 participants, and the subpopulation responding to the reproductive health questions (sexually transmitted infections) included 2,529 participants. In the full cohort, participants with obesity were more likely to be older, minorities, have incomes closer to poverty level, have public sources of insurance, have more healthcare visits in the past year, and have worse self-reported health. A complete description of all demographic, healthcare utilization information, and outcome data is reported in Table 1.

The prevalence of reporting ever receiving HPV vaccination was 32.9% (95% confidence interval (CI) 30.8 – 35.0%). In the adjusted analysis, only participants with obesity were less likely to have ever received the HPV vaccination, with an odds ratio of 0.79 (95% CI 0.67–0.95) compared to participants of normal weight (Table 2). The predicted prevalence of HPV

vaccination was 30.0% (95% CI 26.6–33.3%) in the obese category compared to 34.9% (95% CI 32.4–37.4%) in the normal weight category.

Among participants who reported vaccination, the mean age at HPV vaccination was 15.8 years (95% CI 15.3 – 16.2 years) among those vaccinated. Participants with obesity were more likely to be vaccinated at an older age compared to participants of normal weight (1.2 years later (95% CI 0.4–1.9 years)). The prevalence of receipt of the complete HPV vaccination series, among women who reported receiving at least one vaccination dose, was 62.1% (95% CI 58.3–65.8%). Participants with obesity were not more or less likely to have completed the HPV vaccination series compared to participants of normal weight (aOR 0.84 (95% CI 0.62–1.14)).

Among the subgroup that was tested for HPV, the prevalence of HPV infection was 50.0% (95% CI 44.1–55.9%). Participants with obesity were not more or less likely to have HPV detected on vaginal swab compared to participants of normal weight (aOR 0.95 (95% CI 0.52 – 1.72) (Table 3). Among the subgroup providing information on sexual activity, the prevalence of ever reporting sexual activity was 91.9% (95% CI 90.4 – 93.1%). Participants with obesity were not more or less likely to report sexual activity compared to participants of normal weight (aOR 0.67 (95% CI 0.42–1.06) (Table 4). The adjusted mean prevalence of ever reporting STI was 16.3% (95% CI 14.3–18.5%). Participants with obesity were not more likely to report having ever had an STI or pelvic inflammatory disease, with an aOR of 0.75 (95% CI 0.53 – 1.04) compared to participants of normal weight.

Discussion

Consistent with disparities noted in the receipt of other preventive women's health services, adolescent girls and women with obesity were found to be less likely to have received the HPV vaccination. And if they had been vaccinated, they received it at a later age. Although less likely to receive vaccination, adolescent girls and women with obesity were as likely to report having ever been sexually active and were equally likely to have a current HPV infection, report sexual activity, or to have ever had an STI as normal weight individuals. This finding suggests that obesity is an important factor that moderates receipt of recommended HPV services in accordance with national clinical care guidelines.

Our finding that adolescent girls and women with obesity were less likely to receive HPV vaccination services is similar to the findings of other studies that demonstrate that obesity was associated with a lower likelihood of receiving recommended preventive health services. Obesity was a barrier to receipt of cervical and breast cancer screening among women in systematic reviews and multiple meta-analyses that included more than 30 peer-review publications (Cohen et al., 2008; Maruthur et al., 2009a; Maruthur et al., 2009b). This disparity in HPV vaccination, in addition to previously identified disparities in cervical cancer, may place woman with obesity at increased risk to develop cervical dysplasia, treatment related morbidity (such as preterm birth), and even cancer.

Each of these secondary HPV vaccination is important, but for different reasons: the age of vaccination marks the beginning of immunologic resistance to HPV, and completion of

vaccination series confers maximum immunologic resistance. We observed a significant trend towards older age at vaccination with increasing weight. Even a small difference in age of vaccination may be significant clinically. The CDC and Advisory Committee on Immunization Practices recommend a 2-dose vaccine schedule for those less than 15 years old, but a 3-dose schedule for those older. The delay noted among adolescent girls with obesity may lead to the use of a more complex vaccine schedule that is associated with lower compliance. Also, any delay in vaccination increases in the risk for unvaccinated exposure, as HPV exposure risk increases with age. Once women started receiving vaccination, there was no relationship between body mass index and receiving the full vaccination series. The absence of difference in vaccination completion is encouraging that obesity does not play a role in compliance once the vaccination process is begun. Lastly, we examined significant risk factors for HPV infection, and we noted no significant differences in sexual activity or STIs across obesity classes. This suggests that there are no differences in HPV infection or underlying risk factors for HPV infection among women of varying obesity classes and highlights the importance of reducing disparities in vaccination quality measures.

Our findings suggest that interventions to increase vaccination rates should consider the age of vaccination among adolescent girls and women with obesity. Patient-focused education should encourage HPV vaccination for all groups regardless of gender, race, age (within the ages indicated for vaccine administration), sexuality, or body size. Provider-focused education should describe the known disparities in HPV vaccination and encourage self-evaluation of unconscious bias that may affect provider recommendations for HPV vaccination.

Obesity, based on the theory of planned behavior and the theory of obesity stigma and adverse health outcomes, is associated with people being less likely to receive preventive care services due to patient avoidance of healthcare. This may explain why some women are less likely to begin and complete the HPV vaccination series (Figures 1 and 2) (Amy et al., 2006; Askelson et al., 2010; Brawner et al., 2013; Cohen et al., 2008; Fisher, Kohut, Salisbury, & Salvadori, 2013; Maruthur et al., 2009a; Maruthur et al., 2009b). Also, obesity stigma may cause providers (or parents and guardians) to assume that young women with obesity are less likely to be sexually active and therefore at lower risk of acquiring HPV (Bajos, Wellings, Laborde, & Moreau, 2010; Puhl & Heuer, 2010; Regan, 1996). Providers are more likely to recommend HPV vaccination to patients they believe are at higher risk for current or near future sexual activity and therefore higher risk for contracting HPV (Rosenthal et al., 2011). Women with obesity may be more likely to feel isolated and may be more likely to be viewed as less attractive; past studies have noted that women with obesity are less likely to be sexually active, but if sexually active, they are more likely to engage in high-risk sexual behaviors (Akers et al., 2009; Eisenberg, Neumark-Sztainer, & Lust, 2005; Ratcliff, Jenkins, Reiter-Purtill, Noll, & Zeller, 2011). For these reasons, these two theories suggest the association between obesity and receipt of HPV vaccination may be moderated by changing patient attitudes, norms, and perceived behavioral control as well as provider obesity bias.

This study has several limitations. HPV vaccination data was self-reported and may be limited by recall bias (under-reporting) or social desirability (over-reporting). The reported prevalence in this analysis was similar to previous analyses, which suggests both types of bias were either low in this study or similar to prior work (Markowitz et al., 2016; Oliver et al., 2017). Although the overall study sample size was large ($n > 5,000$), the size of key sub-populations, particularly women with obesity, were relatively small, which limits the statistical power for assessing differences among subgroups. The whole cohort did not undergo HPV testing (only the 2011 – 2012 participant wave) or answer questions related to sexual activity or STIs, and so this study is underpowered to see small differences by body mass index related to those outcomes. Certain factors that may help explain vaccination associations were not included in NHANES questionnaires and were therefore unavailable for this current study, such as the experience of obesity stigma, previous counseling about HPV vaccination, or participants' reasons for declining vaccination, if counseled.

Implications for Practice and/or Policy

Adolescent girls and women with obesity were found to be less likely to have received the HPV vaccination after controlling for confounding factors. HPV vaccination is an effective public health intervention that prevents HPV-related cancer and disease, but vaccination rates are low among eligible individuals. Focusing on subgroups particularly at risk for HPV-related disease as well as under-vaccination is an important intervention for public health departments, primary care providers, and school-based programs. Obesity affects a large percentage of the people eligible for HPV vaccination, and so decreasing these disparities would be a high-impact way to improve overall vaccination rates. Additionally, this population is often the focus of broad programs addressing obesity and diet-related disease. These same programs can increase health by addressing disparities in preventive care services such as HPV vaccinations, thereby improving the health of adolescent girls and women with obesity.

Acknowledgements

Dr. Harris is funded by National Institute of Child Health and Human Development under grant K12HD063087. Dr. Akers is funded by Bayer Healthcare and the John Templeton Foundation. The project described was supported by the National Institutes of Health through Grant Number UL1-TR-001857.

Biography

John A. Harris, MD MSc is an Assistant Professor in the Department of Obstetrics, Gynecology and Reproductive Sciences at the University of Pittsburgh, Pittsburgh, PA.

Alison A. Garrett MD is an Obstetric and Gynecology Resident Physician at Magee-Women's Hospital of UPMC, Pittsburgh, PA.

Aletha Y. Akers is an Assistant Professor of Obstetrics and Gynecology and Pediatrics, Children's Hospital of Philadelphia, Philadelphia, PA.

REFERENCES

- Akers AY, Lynch CP, Gold MA, Chang JC-C, Doswell W, Wiesenfeld HC, ... Bost J (2009). Exploring the relationship among weight, race, and sexual behaviors among girls. *Pediatrics*, 124(5), e913–e920. [PubMed: 19841106]
- Amy NK, Aalborg a., Lyons P, & Keranen L (2006). Barriers to routine gynecological cancer screening for White and African-American obese women. *Int J Obes (Lond)*, 30(1), 147–155. doi: 10.1038/sj.ijo.0803105 [PubMed: 16231037]
- Askelson NM, Campo S, Lowe JB, Smith S, Dennis LK, & Andsager J (2010). Using the Theory of Planned Behavior to Predict Mothers' Intentions to Vaccinate Their Daughters Against HPV. *J Sch Nurs*, 26(3), 194–202. doi:10.1177/1059840510366022 [PubMed: 20335232]
- Bajos N, Wellings K, Laborde C, & Moreau C (2010). Sexuality and obesity, a gender perspective: results from French national random probability survey of sexual behaviours. *BMJ*, 340. doi: 10.1136/bmj.c2573
- Brawner BM, Baker JL, Voytek CD, Leader A, Cashman RR, Silverman R, ... Frank I (2013). The development of a culturally relevant, theoretically driven HPV prevention intervention for urban adolescent females and their parents/guardians. *Health Promot Pract*, 14(4), 624–636. doi: 10.1177/1524839912462389 [PubMed: 23099659]
- Budd GM, Mariotti M, Graff D, & Falkenstein K (2011). Health care professionals' attitudes about obesity: an integrative review. *Appl Nurs Res*, 24(3), 127–137. doi:10.1016/j.apnr.2009.05.001 [PubMed: 20974067]
- Cohen SS, Palmieri RT, Nyante SJ, Koralek DO, Kim S, Bradshaw P, & Olshan AF (2008). Obesity and screening for breast, cervical, and colorectal cancer in women: a review. *Cancer*, 112(9), 1892–1904. doi:10.1002/cncr.23408 [PubMed: 18361400]
- Eisenberg ME, Neumark-Sztainer D, & Lust KD (2005). Weight-related issues and high-risk sexual behaviors among college students. *J Am Coll Health*, 54(2), 95–101. doi:10.3200/jach.54.2.95-101 [PubMed: 16255321]
- Faul F, Erdfelder E, Buchner A, & Lang A-G (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behav Res Methods*, 41(4), 1149–1160. [PubMed: 19897823]
- Fisher WA, Kohut T, Salisbury CM, & Salvadori MI (2013). Understanding human papillomavirus vaccination intentions: comparative utility of the theory of reasoned action and the theory of planned behavior in vaccine target age women and men. *J Sex Med*, 10(10), 2455–2464. doi: 10.1111/jsm.12211 [PubMed: 23745833]
- Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, & Ogden CL (2016). Trends in obesity among adults in the united states, 2005 to 2014. *Jama*, 315(21), 2284–2291. doi:10.1001/jama.2016.6458 [PubMed: 27272580]
- Gudzune KA, Beach MC, Roter DL, & Cooper LA (2013). Physicians Build Less Rapport With Obese Patients. *Obesity*, 21(10), 2146–2152. doi:10.1002/oby.20384 [PubMed: 23512862]
- Harper DM, Else BM, Bartley MJ, Arey AM, Barnett AL, Rosemergy BE, ... Bonham AJ (2014). In a Safety Net Population HPV4 Vaccine Adherence Worsens as BMI Increases. *PLoS ONE*, 9(7), e103172. doi:10.1371/journal.pone.0103172 [PubMed: 25076128]
- Harris JA, Moniz MH, Iott B, Power R, & Griggs JJ (2016). Obesity and the receipt of influenza and pneumococcal vaccination: a systematic review and meta-analysis. *BMC Obes*, 3, 24. doi:10.1186/s40608-016-0105-5 [PubMed: 27200179]
- Kahn JA (2009). HPV Vaccination for the Prevention of Cervical Intraepithelial Neoplasia. *NEJM*, 361(3), 271–278. doi:10.1056/NEJMct0806938 [PubMed: 19605832]
- Kim JJ, & Goldie SJ (2008). Health and economic implications of HPV vaccination in the United States. *NEJM*, 359(8), 821–832. [PubMed: 18716299]
- Kolata G (2016, 9/25/2016). Why Do Obese Patients Get Worse Care? Many Doctors Don't See Past the Fat. *New York Times*.
- Koutsky L (1997). Epidemiology of genital human papillomavirus infection. *Am J Med*, 102(5a), 3–8.

- Markowitz LE, Liu G, Hariri S, Steinau M, Dunne EF, & Unger ER (2016). Prevalence of HPV After Introduction of the Vaccination Program in the United States. *Pediatrics*, 137(3). doi:10.1542/peds.2015-1968
- Maruthur NM, Bolen S, Brancati FL, & Clark JM (2009a). Obesity and mammography: a systematic review and meta-analysis. *J Gen Intern Med*, 24(5), 665–677. doi:10.1007/s11606-009-0939-3 [PubMed: 19277790]
- Maruthur NM, Bolen SD, Brancati FL, & Clark JM (2009b). The association of obesity and cervical cancer screening: a systematic review and meta-analysis. *Obesity (Silver Spring)*, 17(2), 375–381. doi:10.1038/oby.2008.480 [PubMed: 18997682]
- Niccolai LM, Mehta NR, & Hadler JL (2011). Racial/Ethnic and Poverty Disparities in Human Papillomavirus Vaccination Completion. *Am J Prev Med*, 41(4), 428–433. doi:http://dx.doi.org/10.1016/j.amepre.2011.06.032 [PubMed: 21961471]
- Ogden CL, Carroll MD, Kit BK, & Flegal KM (2014). Prevalence of childhood and adult obesity in the United States, 2011–2012. *Jama*, 311(8), 806–814. doi:10.1001/jama.2014.732 [PubMed: 24570244]
- Oliver SE, Unger ER, Lewis R, McDaniel D, Gargano JW, Steinau M, & Markowitz LE (2017). Prevalence of Human Papillomavirus Among Females After Vaccine Introduction—National Health and Nutrition Examination Survey, United States, 2003–2014. *J. Infect. Dis*, 216(5), 594–603. doi:10.1093/infdis/jix244 [PubMed: 28931217]
- Phelan SM, Burgess DJ, Yeazel MW, Hellerstedt WL, Griffin JM, & van Ryn M (2015). Impact of weight bias and stigma on quality of care and outcomes for patients with obesity. *Obes. Rev*, 16(4), 319–326. doi:10.1111/obr.12266 [PubMed: 25752756]
- Pruitt SL, & Schootman M (2010). Geographic disparity, area poverty, and human papillomavirus vaccination. *Am J Prev Med*, 38(5), 525–533. [PubMed: 20409501]
- Puhl R, & Heuer CA (2010). Obesity stigma: important considerations for public health. *Am J Public Health*, 100(6), 1019–1028. doi:10.2105/AJPH.2009.159491 [PubMed: 20075322]
- Ratcliff MB, Jenkins TM, Reiter-Purtill J, Noll JG, & Zeller MH (2011). Risk-Taking Behaviors of Adolescents With Extreme Obesity: Normative or Not? *Pediatrics*, 127(5), 827–834. doi:10.1542/peds.2010-2742 [PubMed: 21518723]
- Regan PC (1996). Sexual outcasts: The perceived impact of body weight and gender on sexuality. *J. Appl. Soc. Psychol*, 26(20), 1803–1815.
- Rosenthal S, Weiss TW, Zimet GD, Ma L, Good M, & Vichnin M (2011). Predictors of HPV vaccine uptake among women aged 19–26: importance of a physician's recommendation. *Vaccine*, 29(5), 890–895. [PubMed: 20056186]
- Sundaram ME, Mason SM, & Basta NE (2016). HPV vaccine uptake among overweight and obese US adolescents: An analysis of the National Health and Nutrition Examination Survey (NHANES) 2009–2014. *Vaccine*, 34(22), 2501–2506. [PubMed: 27020709]
- US Food and Drug Administration. (2006). June 8, 2006 Approval Letter - Human Papillomavirus Quadrivalent (Types 6, 11, 16, 18) Vaccine, Recombinant. Retrieved from <https://www.fda.gov/biologicsbloodvaccines/vaccines/approvedproducts/ucm111283.htm>
- Walker TY, Elam-Evans LD, Singleton JA, Yankey D, Markowitz LE, Fredua B, ... Stokley S (2017). National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years—United States, 2016. *MMWR. Morbidity and mortality weekly report*, 66(33), 874. [PubMed: 28837546]
- World Health Organization Publication. (2017). Human papillomavirus vaccines: WHO position paper. *Weekly epidemiological record*, 19(92), 241–268.
- Ylitalo KR, Lee H, & Mehta NK (2013). Health care provider recommendation, human papillomavirus vaccination, and race/ethnicity in the US National Immunization Survey. *American journal of public health*, 103(1), 164–169. [PubMed: 22698055]

Figure 1: Conceptual Frameworks for HPV Vaccination and Obesity Stigma and Adverse Health Outcomes.

The theory of planned behavior (A) and the theory of obesity stigma and adverse health outcomes (B).

Table 1:

Characteristics of Survey Respondents (n=5517)

	Underweight^a	Normal	Overweight	Obese
n	182 (3.3%)	2784 (50.5%)	1108 (20.1%)	1443 (26.2%)
Age (years)				
9 – 13	56 (3.2%)	1027 (58.6%)	306 (17.5%)	363 (20.7%)
14 – 18	29 (2.0%)	846 (59.2%)	266 (24.0%)	288 (20.2%)
19 – 24	62 (5.3%)	497 (42.1%)	270 (24.4%)	351 (29.8%)
25 – 30	35 (3.0%)	414 (35.8%)	266 (24.0%)	441 (38.2%)
Race				
Non-Hispanic White	62 (3.6%)	926 (54.4%)	311 (18.3%)	402 (23.6%)
Non-Hispanic Black	38 (2.9%)	557 (42.8%)	276 (21.2%)	432 (33.2%)
Hispanic	40 (2.3%)	798 (46.6%)	404 (23.6%)	471 (27.5%)
Other	42 (5.3%)	503 (62.9%)	117 (14.6%)	138 (17.3%)
Family Income to Poverty Ratio				
<2	100 (3.0%)	1531 (45.9%)	711 (21.3%)	994 (29.8%)
2	82 (3.8%)	1253 (57.5%)	397 (18.2%)	449 (20.6%)
Insurance coverage				
Uninsured	42 (23.1%)	410 (14.7%)	241 (21.8%)	300 (20.8%)
Non-private	58 (31.9%)	992 (35.6%)	434 (39.2%)	606 (42.0%)
Private	82 (45.1%)	1382 (46.6%)	433 (39.1%)	537 (37.2%)
Healthcare visits in part year				
None	29 (3.9%)	368 (49.4%)	164 (22.0%)	184 (24.7%)
1	40 (3.0%)	752 (56.3%)	237 (17.7%)	307 (23.0%)
2	113 (3.3%)	1664 (48.4%)	707 (20.6%)	952 (27.7%)
General Health Condition				
Good or better	165 (3.3%)	2619 (52.7%)	997 (20.1%)	1187 (23.9%)
Fair or worse	17 (3.1%)	165 (30.1%)	111 (20.2%)	256 (46.6%)

^aFor participants under the age of 20 the CDC sex-specific 2000 BMI-for age growth charts were used to define underweight (BMI < 5th percentile), normal weight (BMI 5th to 85th percentile), overweight (BMI 85th to < 95th percentiles), and obesity (BMI ≥ 95th percentile). For participants aged 20 years and older we used NIH obesity categories: underweight (BMI < 18.5 kg/m²), normal weight (BMI 18.5 to <25 kg/m²), overweight (BMI 25 to < 30 kg/m²), and obesity (BMI ≥ 30 kg/m²).

Table 2:

Adjusted^a Odds of Human Papillomavirus Vaccination, Age of Vaccination, and Completion of Vaccination Series Among Women aged 9 to 30 by Body Mass Category (n=5517)

	Normal ^b	Underweight	Overweight	Obese
Report HPV Vaccination				
Adjusted Odds Ratio (95% CI)	1.00	0.72 (0.49–1.05)	0.88 (0.731.06)	0.79 (0.67–0.95)
Predicted Prevalence	34.9%	28.0%	32.2%	30.0%
Reported Age of Vaccination				
Adjusted Coefficient ^c (95% CI)	Ref	1.4 (–0.1–2.9)	1.4 (0.7–2.1)	1.2 (0.4–1.9)
Predicted Age of Vaccination	15.2	16.6	16.6	16.3
Completed Vaccination Series				
Adjusted Odds Ratio (95% CI)	1.00	0.69 (0.31–1.54)	0.74 (0.51–1.08)	0.84 (0.62–1.14)
Predicted Prevalence	56.3%	64.6%	57.8%	60.8%

^a Adjusted for age, race, family income to poverty ratio, insurance status, healthcare utilization, and general health status.

^b For participants under the age of 20 the CDC sex-specific 2000 BMI-for age growth charts were used to define underweight (BMI < 5th percentile), normal weight (BMI 5th to 85th percentile), overweight (BMI 85th to < 95th percentiles), and obesity (BMI ≥ 95th percentile). For participants aged 20 years and older we used NIH obesity categories: underweight (BMI < 18.5 kg/m²), normal weight (BMI 18.5 to <25 kg/m²), overweight (BMI 25 to < 30 kg/m²), and obesity (BMI ≥ 30 kg/m²).

^c The coefficient can be interpreted as the number of years until vaccination will happen in comparison to the reference, normal weight.

HPV, human papillomavirus; CI, confidence interval.

Table 3:

Adjusted^a Odds of Human Papillomavirus Infection Among Women aged 9 to 30 by Body Mass Category (n=538)

	Normal ^b	Underweight	Overweight	Obese
Adjusted Odds Ratio (95% CI)	1.00	1.10 (0.25–4.87)	0.87 (0.55–1.38)	0.95 (0.52–1.72)
Predicted Prevalence	51.1%	53.2%	47.9%	49.8%

^aAdjusted for age, race, family income to poverty ratio, insurance status, healthcare utilization, and general health status.

^bFor participants under the age of 20 the CDC sex-specific 2000 BMI-for age growth charts were used to define underweight (BMI < 5th percentile), normal weight (BMI 5th to 85th percentile), overweight (BMI 85th to < 95th percentiles), and obesity (BMI ≥ 95th percentile). For participants aged 20 years and older we used NIH obesity categories: underweight (BMI < 18.5 kg/m²), normal weight (BMI 18.5 to <25 kg/m²), overweight (BMI 25 to < 30 kg/m²), and obesity (BMI ≥ 30 kg/m²).

CI, confidence interval.

Table 4:

Adjusted^a Odds of Sexual Activity and Sexually Transmitted Infection Among Women among women 18 to 30 years old by Body Mass Category

	Normal ^b	Underweight	Overweight	Obese
Reported Sexual Activity (n=1682)				
Adjusted Odds Ratio (95% CI)	1.00	1.03 (0.41–2.59)	1.26 (0.82–1.96)	0.67 (0.42–1.06)
Predicted Prevalence	92.3%	92.5%	93.7%	89.2%
Reported STI (n=2529)				
Adjusted Odds Ratio (95% CI)	1.00	0.63 (0.24–1.62)	0.83 (0.60–1.15)	0.75 (0.53–1.04)
Predicted Prevalence	18.4%	12.5%	15.8%	14.4%

^aAdjusted for age, race, family income to poverty ratio, insurance status, healthcare utilization, and general health status.

^bFor participants under the age of 20 the CDC sex-specific 2000 BMI-for age growth charts were used to define underweight (BMI < 5th percentile), normal weight (BMI 5th to 85th percentile), overweight (BMI 85th to < 95th percentiles), and obesity (BMI ≥ 95th percentile). For participants aged 20 years and older we used NIH obesity categories: underweight (BMI < 18.5 kg/m²), normal weight (BMI 18.5 to <25 kg/m²), overweight (BMI 25 to < 30 kg/m²), and obesity (BMI ≥ 30 kg/m²). CI, confidence interval.

STI, sexual transmitted infection; CI, confidence interval.