Knowledge of the Human Papillomavirus Vaccine: An Analysis using Together for Health Virginia Population Health Survey

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Abstract

Purpose: The purpose of this analysis was to identify key predictors which impact knowledge of the Human Papillomavirus vaccine in adults aged 21 to 45 in Virginia.

Methods: Data was collected from the Together for Health Virginia Population Surveys administered by Virginia Commonwealth University and the University of Virginia. Logistic regression was performed on data using the variables sex, age, rurality, race, education, income, occupation, and type of health insurance coverage.

Results: There was a statistically significant positive relationship between knowledge of the HPV vaccine and part-time occupation (OR: 4.288, CI: 1.492-13.325), younger age (OR: 2.31, CI: 1.088-4.905), and higher education (OR: 2.683, CI: 1.227-5.870). There was a statistically significant negative relationship between knowledge of the vaccine and being male (OR: 0.437, CI: 0.248-0.771), living in an urban area (OR: 0.511, CI: 0.267-0.977), and identifying in the lower income category (OR: 0.246, CI: 0.093-0.651).

Conclusion: This study identified 6 key predictors in knowledge of the HPV vaccine among adults in Virginia. Future studies should explore, in particular, the category of students and residents of urban areas. Despite these results, knowledge of the HPV vaccine does not translate to intention to receive the vaccine. Therefore, future studies should additionally study attitudes, behaviors, and potential barriers.

Background:

Human Papillomavirus (HPV) infects about 14 million people in the United States each year, making it the most prevalent sexually transmitted disease in the country (Fueta & Chido-Amajuoyi, 2020). Although there are over 200 subtypes of the virus, 14 types are responsible for 5% to 10% of all cancers. Of these 14 subtypes, strains 16 and 18 are considered the most oncogenic (Lehtinen & Dillner, 2013). It is estimated that over 90% of cervical and anal cancers, 75% of vaginal cancers, and 70% of oropharyngeal and vulvar cancers are caused by HPV. Large percentages of penile (63%), oral (32%), and laryngeal (21%) cancers are also caused by the virus (Saraiya et al., 2015). It is estimated that in 2021 alone, over 4,000 women will die from cervical cancer in the United States (American Cancer Society, 2021). In addition to the high rates of morbidity and mortality due to HPV-derived cancers, are the staggering economic costs. According to the President's Cancer Panel Annual Report from 2012 to 2013, the annual economic burden stands at approximately $8 billion in the United States (Chesson et al., 2012). These human and financial costs can be reduced by preventing HPV infections.

The HPV vaccine is an extremely effective preventative measure against the most cancer-related strains. The most commonly heard of vaccine is Gardasil by Merck. Originally quadrivalent protecting against only HPV 6/11/16/18, the nonvalent Gardasil9 vaccine protects against HPV 6/11/16/18/31/33/45/52/58 (Gardasil, 2021). As of 2020, Gardasil9 is the only vaccine being used in the United States (Saslow et al., 2020). There are two doses given at various monthly intervals depending on if the vaccine recipient is younger or older than 15. The vaccine is aimed at those aged 9 to 14 because they are less effective after commencement of sexual intercourse and potential exposure to HPV. In trial, the nonvalent Gardasil9 vaccine was

found to be as effective at preventing HPV 6/11/16/18 when compared to the quadrivalent vaccine, but is also protective against HPV 31/33/45/52/58 (Joura et al., 2015).

Despite this convenient and effective vaccine, the United States is well below vaccinating the Healthy People 2020 target of 80% of females aged 13 to 15. Utilizing data from 2008-2018, only 48.9% and 47.1% of females and males, respectively, aged 13 to 15 had received 2 or 3 doses. When considering 13 to 17-year old's, only 53.7% and 48.7% of females and males, respectively, were vaccinated (HPV Vaccination, 2021). In the state of Virginia, rates for up to date HPV vaccines for females and males 13 to 17 in 2016 were 41.1% and 37.4%, respectively. 50.7% and 56.4% of females and males 13 to 17, respectively, received one or more doses (Walker, 2017). While higher than the national average for one or more doses, Virginia is still well below vaccination rates necessary for herd immunity. Interestingly, Virginia was the first state to mandate three doses of the HPV for adolescent girls entering middle school in 2008 (expanded to adolescent boys as of 2020) (*§ 32.1-46*). However, the bill included an opt-out option if parents read educational materials on HPV. The rates in the years following the new law indicate that the mandate was not effective. One difference-in-differences study found that controlling for demographic factors, females in Virginia were less likely to be vaccinated when compared to South Carolina and Tennessee, control states that did not have an HPV vaccine school mandate (Pierre-Victor et al., 2017).

Why are vaccination rates so low? Why do mandates prove to be ineffective? There are a multitude of factors that have been researched such as costs and access, scrutiny over an STD-preventing vaccine, and lack of education. The HPV vaccine requires three doses given months apart. The vaccine cost is usually not a problem as most children are covered through private insurance and public programs. Many childhood vaccine organizations cover uninsured,

Medicaid eligible, Native American and Alaskan Native children (North & Niccolai, 2016). However, there are other costs including transportation and taking time off work to accompany children to appointments, especially in rural regions. For example, one study found that in Kentucky, women in rural areas were 7 times less likely to receive their follow-up vaccine doses compared to women living in urban areas (Crosby et al., 2011). In Virginia, 46% of counties are rural and 72% are medically underserved, highlighting access due to geographic location as a potential predictor for low vaccination rates (HRSA, 2017).

A second major reason for low vaccination rates for HPV is because it is perceived as the "sex vaccine" and that vaccinating their children will increase risky sexual behaviors. However, it was found that HPV vaccination status is not associated with earlier sexual behavior nor an increased number of sexual partners (Brouwer et al., 2019). Further, by mandating vaccination in Virginia, parents distrusted the vaccine more due to "perceived political involvement" (Pitts & Tufts, 2013). Another study found that 23% of parents in the United States were hesitant due to concern about side effects and the novelty of the vaccine (Szilagyi, 2020). Ultimately, this barrier boils down to lack of knowledge. One study found that that 60.1% and 31.6% of men and women, respectively, aged 18 to 26 years old did not know that HPV causes cervical cancer. Of US adults, over 70% did not know HPV can cause anal, penile or oral cancers (Suk et al., 2019). Even among survivors of HPV-related cancers, it was found that only 33.2% knew that their cancer was caused by HPV and less than 60% felt that the HPV vaccine was safe (Shelal et al., 2019).

These numbers are alarming and more research is warranted in order to improve vaccination rates. While there are studies exploring HPV vaccination rates in Virginia, there is data lacking on predictors of HPV vaccine knowledge throughout the state. This paper explores

the role of sex, race, age, geographic setting (rural or metropolitan), education level, income, occupation status, and health insurance type on if one has heard of the HPV vaccine in Virginia.

Methods:

Data analyzed in this study are from the Together for Health Virginia Population Health Survey administered by the Virginia Commonwealth University (VCU) and the University of Virginia (UVA). The purpose of this survey was to obtain state-level data on cancer-related beliefs, attitudes, behaviors, and information sources. Virginia counties within the cancer center catchment boundaries of the two universities were targeted (Appendix A). Survey data collection was approved by the Institutional Review Board (IRB) at both universities. Sex, age, Black race indicator, rurality, and HPV vaccine knowledge are dichotomized variables. Existing education, income, occupation, and insurance categories from the survey were combined. The category "Other" in Occupation includes the smallest categories: those who are disabled (4.52%), students (2.02%), homemakers or stay-at-home parents (4.91%) and those categorized as "other" in the original survey (1.25%). The category "Other" in health insurance similarly combined the smallest categories: Alaska Native, Indian, and Tribal health services (0.29%), TRICARE (4.56%), purchased health coverage on one's own (4.06%), "some other source" (1.61%), and no coverage (1.56%). Multivariate analysis was performed using SAS. Univariate analysis can be found in Appendix B.

Results:

Table 1: Demographic Characteristics of Survey Participants

Characteristic	Percent	Confidence Interval
Sex (n=1496)		
Male	47.91%	43.49% - 52.34%
Female	52.09%	47.66% - 56.51%
Age (n=1496)		
21 to 45 years old	47.98%	43.49%-52.47%
45≤ years old	52.02%	47.53% - 56.51%
Black (n=1496)		
Yes	18.83%	14.95%-22.71%
No	81.17%	77.29%-85.05%
Rurality (n=1496)		
Urban	33.74%	29.66%-37.83%
Rural	66.26%	62.17%-70.34%
Education (n=1427)		
Not completed high school	7.72%	5.19%-10.25%
High school or some college	60.83%	56.58%-65.08%
College or Graduate School	31.45%	27.58%-35.32%
Individual Income (n=1193)		
Less than 35k	32.01%	27.00%-37.03%
35k to 49,999	12.64%	9.57%-15.71%
50k to 99,999	29.13%	24.70%-33.57%
100k+	26.21%	22.36%-30.06%
Occupation (n=900)		
Full-time	51.40%	45.72%-57.09%
Part-time	8.53%	5.13%-11.92%
Retired	22.21%	18.07%-26.36%
Other	17.86%	13.21%-22.50%
Health Insurance (n=1363)		
Employer	52.43%	47.79%-57.06%
Medicare	22.40%	18.84%-25.95%
Medicaid	13.09%	9.14%-17.04%
Other	12.08%	9.36%-14.82%
Heard of HPV Vaccine (n=1436)		
Yes	72.26%	68.26%-76.25%
No	27.74%	23.75%-31.73%

The distributions of sex and age were about even between men and women and those 21 to 45 and 45 and older. Most participants were not Black (81.17%), had completed high school or some college (60.83%), worked full time (51.40%), had employer sponsored health insurance (52.43%) and lived in a rural area (66.26%) (Table 1). Rurality in this survey was defined using the U.S. Department of Agriculture, Economic Research Service (ERS) rural-urban continuum codes. Metro or Urban Counties were coded 1 to 3. Nonmetro or Rural counties are coded 4 to 9 (USDA ERS, 2020). The income distribution was more evenly divided with a slight majority (31.01%) having an income less than $35,000 (Table 1).

Because the predictors included in our model are conceptually related, correlations were run between each variable to examine the possibility of multicollinearity. All correlations had Pearson Correlation Coefficients below 0.36679 except for education and income which had a value of 0.50511 (Appendix C). For this reason, regression was run twice, including and excluding income as a predictor.

Knowledge of the HPV vaccine was the primary dependent variable in this model. The survey read: “A vaccine to prevent HPV prevention is available and is called the HPV shot, cervical cancer vaccine, GARDASIL, or Ceravix. Before today, have you ever heard of the HPV vaccine?” The answer choices were “Yes” or “No.”

Table 2: Logistic Regression: Modeling knowledge of the HPV vaccine based on sex, age, education level, income, rurality, insurance type

	Model 1: Including Income		Model 2: Excluding Income	
Parameter	**Estimate**	**Odds Ratio**	**Estimate**	**Odds Ratio**
Intercept	**1.4932***** (0.3784)		**1.0441**** (0.3356)	
Male	**-0.8273**** (0.2886)	**0.437** (0.248-0.771)	**-0.6214*** (0.2565)	**0.537** (0.325-0.889)
21-45 years old	**0.8373*** (0.3835)	**2.310** (1.088-4.905)	**0.8126*** (0.3263)	**2.254** (1.188-4.276)
Black	**-0.4867** (0.6378)	**0.615** (0.176-2.150)	**-0.4705** (0.4282)	**0.625** (0.270-1.448)
Urban	**-0.6712*** (0.3299)	**0.511** (0.267-0.977)	**-0.3928** (0.2816)	**0.675** (0.389-1.173)
Education <high school College or Graduate School ref= completed high school/some college	 **-0.7512** (0.5892) **0.9871*** (0.3987)	 **0.472** (0.148-1.500) **2.683** (1.227-5.870)	 **-1.0698** (0.6024) **0.7488**** (0.2985)	 **0.343** (0.105-1.119) **2.115** (1.177-3.799)
Income Less than 35k 35k to 49,999 100k+ ref= 50k to 99,999	 **-0.5285** (0.4911) **-1.4009**** (0.4947) **-0.0805** (0.4948)	 **0.589** (0.225-1.546) **0.246** (0.093-0.651) **0.923** (0.349-2.438)	 - - -	 - - -
Occupation Part-Time Retired Other ref=Full-Time	 **1.4559**** (0.5377) **0.6770** (0.4069) **0.5489** (0.5549)	 **4.288** (1.492-13.325) **1.968** (0.885-4.375) **1.731** (0.582-5.147)	 **1.4262*** (0.4964) **0.5093** (0.3586) **0.6373** (0.4555)	 **4.163** (1.571-11.028) **1.664** (0.823-3.364) **1.891** (0.774-4.624)
Health Insurance Medicare Medicaid Other Ref=Employer	 **-0.6317** (0.4321) **0.2497** (0.5571) **-0.1826** (0.4593)	 **0.532** (0.228-1.242) **1.284** (0.430-3.833) **0.833** (0.338-2.053)	 **-1.0616*** (0.3850) **-0.2684** (0.4850) **-0.7333** (0.4550)	 **0.346** (0.162-0.736) **0.765** (0.295-1.981) **0.480** (0.198-1.163)

SE for Estimate and 95% Confidence Interval for Odds Ratio in Parentheses; *p<0.05; **p<0.01; ***p<0.0001

Given the large sample size, relatively low correlation coefficient (0.50511), and similarities between models, analysis in this paper will consider the model which includes income as a predictor for knowledge of the HPV vaccine (Table 2). There are 6 significant predictors in this model. Being male, living in an urban area, or having an income from $35,000 to $49,999 relative to an income of $50,000 to $99,999 substantially decreased the odds that an individual has knowledge of the HPV vaccine. Compared to females, the odds that males have knowledge of the HPV vaccine are 0.437 times less (CI: 0.248-0.771). Similarly, those living in an urban area are 0.511 times (CI: 0.267-0.977) less likely to have heard of the HPV vaccine. Compared, to those who make $50,000 to $99,9999, those who fall into the bracket of $35,000 to $49,999 were almost 0.246 times (CI: 0.093-0.651) less likely to have heard of the vaccine. On the other hand, increased education – those with a college or graduate school degree were 2.683 times (CI: 1.227-5.870) more likely to have reported that they had knowledge of the HPV vaccine compared to someone with, at minimum, a high school degree. Those who self-identified as “Part-Time” were over 4 times as likely to have knowledge of the HPV vaccine compared to “Full-Time” workers (OR: 4.288, CI: 1.492-13.325).

Discussion:

While there is evidence that rurality is associated with decreased HPV vaccination rates, this study found that there was less knowledge of the HPV vaccine in urban areas (Crosby et al., 2011). Given that this analysis did not control for cost of living in addition to income, this study is limited in understanding the real-life financial situations of survey participants**.** According to the US Census Bureau, 42 out of 50 states have higher poverty rates in urban versus rural areas.

Poverty, which is tied to health literacy, could explain the lower rates of HPV vaccine knowledge in urban areas. Additionally, 2010 census data indicates that rural communities are, on average, comprised of 78% white, non-Hispanic individuals. Urban areas are nearly 15% more racially diverse. Studies have consistently found disparities in health knowledge by race. For example, one study found Hispanic and Black women were significantly less likely to have heard of HPV compared to white women (Gelman et al, 2011). Given this existing literature, the result of having less HPV vaccine knowledge in urban areas can be understood.

Interestingly those who were part of the $35,000 to $49,999 income range, but not those who make less than $35,000, had significantly lower odds of having heard of the vaccine compared to the $50,000 to $99,999 range. This could potentially be explained by the "Part-Time" occupation being a significant predictor for having heard of the HPV vaccine. One possible explanation is that, while the "Other" category contained an option for students, there is a possibility that a disproportionate number of students in higher education self-identified as "Part-Time." As previously shown, increased education was associated with 3-fold higher odds of having heard of the vaccine and would translate to part-time working students also having a greater knowledge.

There are some limitations with this data. The survey was completed by a disproportionate number of younger, affluent, and well-educated volunteers, limiting the generalizability of the survey results. Additionally, many survey answers that are normally continuous were binned into categories, limiting this study's statistical ability to evaluate variables such as age and income.

Conclusion:

This study examined the relationship between knowledge of the HPV vaccine with race, sex, age, rurality, education, income, occupation, and insurance coverage in the state of Virginia. Knowledge is only the first step to increasing HPV vaccination rates. Although this survey indicated that 72.26% of participants have heard of the HPV vaccine, this does not translate to intention to receive it or to vaccinate their children and family members (Table 1).

Results indicated particular knowledge disparities by sex, age, rurality, income, and education. Future studies focusing on these factors should be conducted to elucidate barriers to knowledge to inform new policy. Increased knowledge and use of the HPV vaccine is crucial in reducing the spread of the virus and associated cancer risk.

Appendix A: Catchment Area Counties by University

UVA catchment area counties*

VCU catchment area counties

Overlap counties: *Appomattox, Buckingham, Campbell, Charlotte, Cumberland, Halifax, Louisa, Pittsylvania, Prince Edward, Spotsylvania, Stafford, Danville City, Fredericksburg City, Lynchburg City, and Martinsville City.*

*Red border indicates the counties are a part of WV

Appendix B: Regression coefficients of Univariate Analysis for each predictor variable on outcome

Male	Age 21-45	Black	Urban	Education	Income	Occupation	Health Insurance
-0.7042*** (0.2066)	0.7393** (0.2257)	-0.4937 (0.2725)	-0.1566 (0.2091)	Less than high school: -1.3559*** (0.3748) College or Graduate school: 0.5701** (0.2193)	<$35k: -0.6157* (0.3069) $35k-$49: -1.0047** (0.3507) $100k+: 0.3925 (0.3167)	Part-Time: 0.6915 (0.4657) Other: -0.0635 (0.3609) Retired: -0.6059* (0.2973)	Medicare: -0.8645*** (0.2471) Medicaid: -0.4263 (0.3975) Other: -0.9278** (0.3111)

SE in parentheses; *p<0.05, **p<0.01, ***p<0.001

Appendix C: Correlation Matrix

	Sex	Age 21-45	Black	Urban	Education	Income	Occupation	Health Insurance
Sex		-0.04610	0.06804	0.0662	-0.01559	-0.17531	0.01318	-0.05291
Age 21-45	-0.04610		-0.01902	0.02853	-0.09072	-0.05601	0.34023	0.14513
Black	0.06804	-0.01902		-0.14817	-0.13600	-0.20502	-0.05393	0.03168
Urban	0.06662	0.02853	-0.14817		0.05322	0.03548	0.05226	-0.01109
Education	-0.01559	-0.09072	-0.13600	0.05322		0.50511	-0.20327	-0.23243
Income	-0.17531	-0.05601	-0.20502	0.03548	0.50511		-0.32420	-0.37107
Occupation	0.01318	0.34023	-0.05393	0.05226	-0.20327	-0.32420		0.36679
Health Insurance	-0.05291	0.14513	0.03168	-0.01109	-0.23243	-0.37107	0.36679	

References

American Cancer Society. Cancer Facts & Figures 2021. Atlanta, Ga: American Cancer Society; 2021.

Bureau, U. C. (n.d.). *A Comparison of Rural and Urban America: Household Income and Poverty*. The United States Census Bureau. Retrieved April 29, 2021, from https://www.census.gov/newsroom/blogs/random-samplings/2016/12/a_comparison_of_rura.html

Chesson, H. W., Ekwueme, D. U., Saraiya, M., Watson, M., Lowy, D. R., & Markowitz, L. E. (2012). Estimates of the annual direct medical costs of the prevention and treatment of disease associated with human papillomavirus in the United States. *Vaccine*, *30*(42), 6016–6019. https://doi.org/10.1016/j.vaccine.2012.07.056

Crosby, R., Casey, B., Vanderpool, R., Collins, T., & Moore, G. (2011). Uptake of Free HPV Vaccination Among Young Women: A Comparison of Rural Versus Urban Rates. *The Journal of Rural Health : Official Journal of the American Rural Health Association and the National Rural Health Care Association*, *27*, 380–384. https://doi.org/10.1111/j.1748-0361.2010.00354.x

Defining Rural Population. (2017, April 28). [Text]. Official Web Site of the U.S. Health Resources & Services Administration. https://www.hrsa.gov/rural-health/about-us/definition/index.html

Fueta, P. O., & Chido-Amajuoyi, O. (2020). Prevalence of HPV infection in the United States: A Comparison of HPV Infection Trends Pre and Post-HPV Vaccine Implementation. *Pediatrics*, *146*(1 MeetingAbstract), 571–571. https://doi.org/10.1542/peds.146.1_MeetingAbstract.571

Gardasil 9 suspension for injection—Summary of Product Characteristics (SmPC)—(Emc). (n.d.). Retrieved April 29, 2021, from https://www.medicines.org.uk/emc/product/7330/smpc#gref

Gelman, A., Nikolajski, C., Schwarz, E. B., & Borrero, S. (2011). Racial Disparities in Awareness of the Human Papillomavirus. *Journal of Women's Health*, *20*(8), 1165–1173. https://doi.org/10.1089/jwh.2010.2617

HPV Vaccination | Cancer Trends Progress Report. (n.d.). Retrieved April 29, 2021, from https://progressreport.cancer.gov/prevention/hpv_immunization

Human papillomavirus (HPV) and cervical cancer. (n.d.). Retrieved April 14, 2021, from https://www.who.int/news-room/fact-sheets/detail/human-papillomavirus-(hpv)-and-cervical-cancer

Joura, E. A., Giuliano, A. R., Iversen, O.-E., Bouchard, C., Mao, C., Mehlsen, J., Moreira, E. D., Ngan, Y., Petersen, L. K., Lazcano-Ponce, E., Pitisuttithum, P., Restrepo, J. A., Stuart, G., Woelber, L., Yang, Y. C., Cuzick, J., Garland, S. M., Huh, W., Kjaer, S. K., … Luxembourg, A. (2015). A 9-Valent HPV Vaccine against Infection and Intraepithelial Neoplasia in Women. *New England Journal of Medicine*, *372*(8), 711–723. https://doi.org/10.1056/NEJMoa1405044

Lehtinen, M., & Dillner, J. (2013). Clinical trials of human papillomavirus vaccines and beyond. *Nature Reviews. Clinical Oncology*, *10*(7), 400–410. https://doi.org/10.1038/nrclinonc.2013.84

North, A. L., & Niccolai, L. M. (2016). Human Papillomavirus Vaccination Requirements in US Schools: Recommendations for Moving Forward. *American Journal of Public Health*, *106*(10), 1765–1770. https://doi.org/10.2105/AJPH.2016.303286

Pierre-Victor, D., Page, T. F., Trepka, M. J., Stephens, D. P., Li, T., & Madhivanan, P. (2017). Impact of Virginia's School-Entry Vaccine Mandate on Human Papillomavirus Vaccination Among 13-

17-Year-Old Females. *Journal of Women's Health (2002)*, *26*(3), 266–275. https://doi.org/10.1089/jwh.2016.5869

Pitts, M. J., & Adams Tufts, K. (2013). Implications of the Virginia human papillomavirus vaccine mandate for parental vaccine acceptance. *Qualitative health research*, *23*(5), 605–617. https://doi-org.proxy01.its.virginia.edu/10.1177/1049732312470871

Rrn-race-and-ethnicity-web.pdf. (n.d.). Retrieved April 29, 2021, from http://www.ruralhome.org/storage/research_notes/rrn-race-and-ethnicity-web.pdf

Saraiya, M., Unger, E. R., Thompson, T. D., Lynch, C. F., Hernandez, B. Y., Lyu, C. W., Steinau, M., Watson, M., Wilkinson, E. J., Hopenhayn, C., Copeland, G., Cozen, W., Peters, E. S., Huang, Y., Saber, M. S., Altekruse, S., & Goodman, M. T. (2015). US Assessment of HPV Types in Cancers: Implications for Current and 9-Valent HPV Vaccines. *JNCI Journal of the National Cancer Institute*, *107*(6). https://doi.org/10.1093/jnci/djv086

Saslow, D., Andrews, K. S., Manassaram-Baptiste, D., Smith, R. A., & Fontham, E. T. H. (2020). Human papillomavirus vaccination 2020 guideline update: American Cancer Society guideline adaptation. *CA: A Cancer Journal for Clinicians*, *70*(4), 274–280. https://doi.org/10.3322/caac.21616

Shelal, Z., Cho, D., Urbauer, D. L., Lu, Q., Ma, B. Y., Rohrer, A. M., Kurian, S., Sturgis, E. M., & Ramondetta, L. M. (2020a). Knowledge matters and empowers: HPV vaccine advocacy among HPV-related cancer survivors. *Supportive Care in Cancer*, *28*(5), 2407–2413. https://doi.org/10.1007/s00520-019-05035-1

Shelal, Z., Cho, D., Urbauer, D. L., Lu, Q., Ma, B. Y., Rohrer, A. M., Kurian, S., Sturgis, E. M., & Ramondetta, L. M. (2020b). Knowledge matters and empowers: HPV vaccine advocacy among HPV-related cancer survivors. *Supportive Care in Cancer*, *28*(5), 2407–2413. https://doi.org/10.1007/s00520-019-05035-1

Suk, R., Montealegre, J. R., Nemutlu, G. S., Nyitray, A. G., Schmeler, K. M., Sonawane, K., & Deshmukh, A. A. (2019). Public Knowledge of Human Papillomavirus and Receipt of Vaccination Recommendations. *JAMA Pediatrics*, *173*(11), 1099. https://doi.org/10.1001/jamapediatrics.2019.3105

Walker, T. Y. (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*. https://doi.org/10.15585/mmwr.mm6633a2

USDA ERS - Documentation. (n.d.). Retrieved May 4, 2021, from https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/documentation/

§ 32.1-46. (Effective July 1, 2021) Immunization of patients against certain diseases. (n.d.). Retrieved April 29, 2021, from https://law.lis.virginia.gov/vacode/title32.1/chapter2/section32.1-46/