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ORIGINAL PAPER

Factors Associated with HPV Vaccination Uptake and HPV-Associated Cancers: A County-Level Analysis in the State of Alabama

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Abstract

Despite availability of a safe, effective vaccination, uptake and completion rates of human papillomavirus (HPV) vaccination remain low in the United States. This is particularly true in the southeast, which also sees some of the highest rates of HPV-associated (HPVa) cancers. We aimed to identify areas in Alabama in need of intervention with respect to HPVa cancers and HPV vaccination, and factors potentially associated with these rates by performing county-level secondary data analysis using state and national data sources. Alabama ranks 15th nationally in HPVa cancer rates, with 66.7% and 80.8% of counties having higher HPVa cancer rates than the national incidences of males and females, respectively. Regarding HPV vaccination, 95.5% and 98.5% of Alabama's counties have uptake rates less than the national averages for males and females, respectively. The seven counties with the highest HPV vaccination uptake ranged in rates from 60.2 to 73.6%. Counties with the highest HPV vaccination rates for adolescents were majority African American with low adult educational attainment rates and high rates of poverty and publicly-insured children/adolescents. These counties were also located in Alabama's Black Belt region, traditionally known for low socioeconomics, reduced access to social services, and negative health outcomes. Some counties with the highest rates of HPVa cancers also had among the highest rates of HPV vaccination, indicating a potential association between perceived susceptibility and desire to get HPV vaccine in these communities, warranting further investigation. Future work is needed to translate these findings into actionable intervention practices to increase HPV vaccination.

Keywords HPV · Human papillomavirus · Vaccination · Cancer · Prevention

Introduction

With over 150 related strains, human papillomavirus (HPV) is the most common sexually transmitted infection in the United States (US) [1, 2]. Over 79 million Americans are currently infected and an estimated 14 million people become newly infected each year [1]. Over 90% and 80% of sexually active men and women, respectively, will be infected with at least one strain of HPV, and approximately 50% of infections are with high risk, cancer-causing strains. While most HPV infections are cleared by the immune system within two years, if the infection persists it can cause serious health issues such as genital warts and/or cancer [2, 3]. HPV-associated (HPVa) cancers include cervical, vulvar, vaginal, penile, anal, and oropharyngeal, affecting both men and women [3]. Over 33,000 new cancers attributable to HPV are diagnosed each year in the US [4]. Incidence rates of HPVa cancers are particularly high in the southeastern US, demonstrating particular need for interventions related to HPV prevention in this region [5]. Alabama, specifically, ranks 5th in incidence and 7th in mortality for oropharyngeal cancer in the US; 3rd in incidence and 1st in mortality with respect to cervical cancer; and 15th overall for all HPVa cancers combined [6].

However, there has been an effective, widely-available HPV vaccination for cancer prevention, available in the US since 2006 [7]. The current HPV vaccine administered in the US protects against nine different high-risk (cancer-causing) HPV strains and is administered in a 2- or 3-dose series, depending on age of vaccine initiation [1, 7]. When administered appropriately, the vaccine has demonstrated extremely high efficacy in preventing infection with cancer-associated

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strains of HPV, with protection rates close to 100%. Between June 2006 and December 2017, over 100 million doses of the HPV vaccine were distributed in the US with demonstrated safety. Despite exhibiting efficacy and safety, however, uptake and completion of the vaccine has been far below the Healthy People 2020 goal of 80% coverage. In 2017, the National Immunization Survey-Teen (NIS-Teen) estimated the national rate of HPV vaccination initiation for adolescents aged 13–17 years in the US to be 65.5%, with a completion rate of 48.6%, although 88.7% and 85.1% received the tetanus-diphtheria-pertussis (Tdap) vaccine and at least one dose of the meningococcal (MenACWY) vaccine, respectively. HPV vaccination rates in the southeastern US, including Alabama, are among the lowest in the nation, indicating the need for drastic improvements at the state, regional, and national levels [8].

Given the dire outcomes in the state, the objective of the current study was to compile and analyze epidemiologic data about the state of Alabama to map rates of HPVa cancers, rates of HPV vaccination, and potentially associated variables across the state, by county, to identify potential correlates and mediating factors. The aim of this work was to identify areas in Alabama in need of intervention with respect to HPVa cancers and HPV vaccination as well as factors potentially associated with these rates to determine ways to improve related health outcomes.

Materials and Methods

Secondary data analysis was conducted using data from the Alabama Department of Public Health Immunization Division state registry: Immunization Patient Resources with Integrated Technology (ImmPRINT) database [9], the Alabama state cancer registry [10], the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER) database [11], the 2016 US census [12], the US Department of Health and Human Services [13], and the US Department of Agriculture's 2013 Rural-Urban Continuum Codes (RUCC) [14].

Data Analysis

Data were analyzed by county to determine rates of HPV vaccination uptake (ImmPRINT), rates of HPVa cancers [9, 11], and other influencing factors including: racial demographics, poverty, educational attainment, health insurance coverage [12], number (and specialty) of healthcare providers in each area [13], and rurality [14]. RUCC divided Alabama counties into urban (codes 1–3) and rural (codes 4–9) groups based on population size and proximity to a metropolitan area [14]. Urban-rural status was determined by applying population and worker commuting criteria to the results of the 2010 census and 2006–2010 American Community Survey [14]. Data were analyzed by county and maps were created to visually demonstrate the varying rates by county.

Results

State and County-Level Demographics

The state of Alabama consists of 67 counties. The state's overall population is comprised of 66.2% White, 26.4% African American, 4.0% Hispanic, 1.2% Asian/Pacific Islander, <1% American Indian/Alaskan Native, and 1.6% identifying as ≥ 2 races [12]. This compares with the reported national population racial distribution of: 62.0% White, 12.3% African American, 17.3% Hispanic, 5.4% Asian/Pacific Islander, <1% American Indian/Alaskan Native, and 2.3% identifying as ≥ 2 races [12]. Among Alabama counties, racial demographics vary widely, with White populations ranging from 15.8 to 96.6% and African American populations ranging from 0.4 to 82.1% (Fig. 1) [12]. Regarding educational attainment, 24.0% of Alabamians 25 years and older have a bachelor's degree or higher (county range 8.6–47.5%) [12]. Using USDA Rural-Urban Continuum Code classifications, 32 counties (47.8%) are classified as rural (RUCC code ≥ 6), meaning almost half of Alabama counties have a population of 20,000 or less [14]. Eleven counties (16.4%) are designated as, "completely rural" (RUCC code ≥ 8), with populations of 2500 or less (Fig. 2a) [14]. Regarding poverty and income, 40 counties (59.7%) have poverty rates above the state average of 18.4%, and 65 counties (97.0%) have poverty rates exceeding the national average of 12.7% (Fig. 2b) [12]. Alabama's median household income is $44,758, compared to the national median of $55,322 [12]. Among Alabamians, 88.4% of the total population is insured, similar to the national average of 88.3% [12]. Of those insured in Alabama, 66.4% have private insurance versus 35.4% who are publicly insured (Fig. 3a) [12]. For uninsured populations, counties range from 8.2 to 19.1% [12]. When looking specifically at children ages 0–21, the state average of Medicaid-eligible children is 55.3% (county range 30.8–94.9%). Throughout the state, 48 counties (71.6%) have an annual percentage of Medicaid-eligible children above 60%, with 22 counties (32.8%) having an annual percentage above 70% (Fig. 3b) [15]. With respect to healthcare provider access, Alabama has 3166 practicing primary care physicians (i.e., general practice, family medicine, internal medicine, and pediatrics) [16]. However, there are significant disparities in healthcare access with 22 counties (32.8%) lacking pediatricians (Fig. 3c), and two counties (Coosa and Lamar) also lacking primary care providers [13].

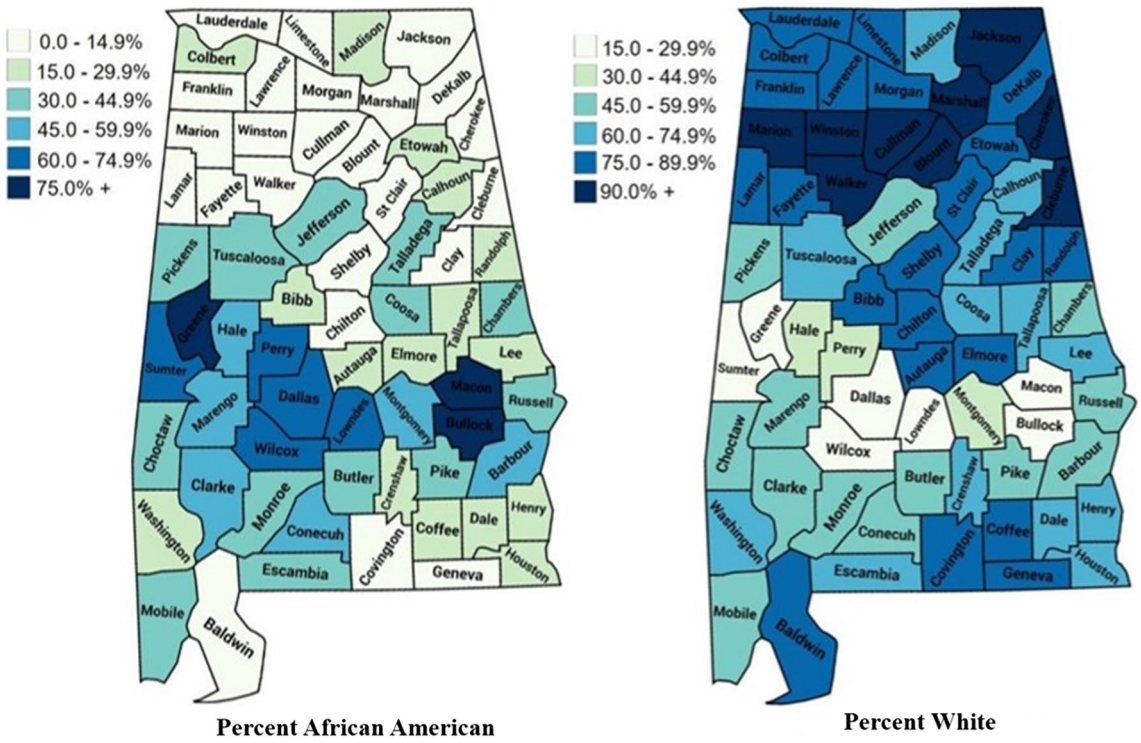

Fig. 1 Racial demographics in Alabama by county (2016)

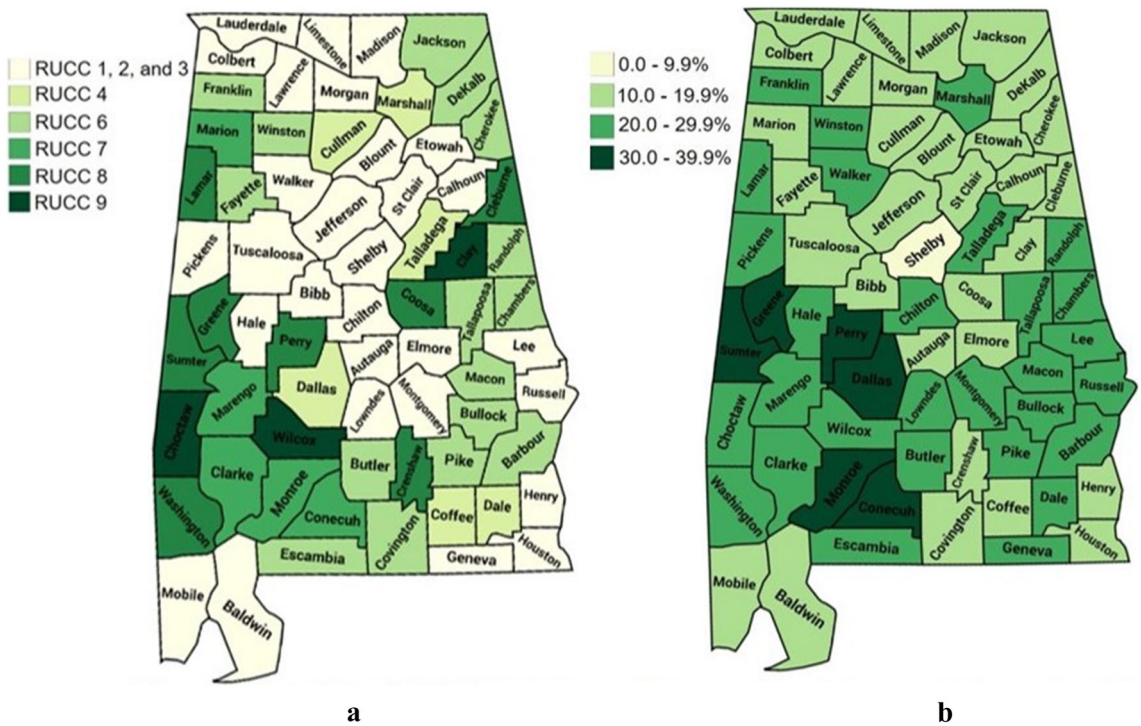

Fig. 2 **a** Rurality (2013) and **b** Percent poverty (2016) in Alabama by county

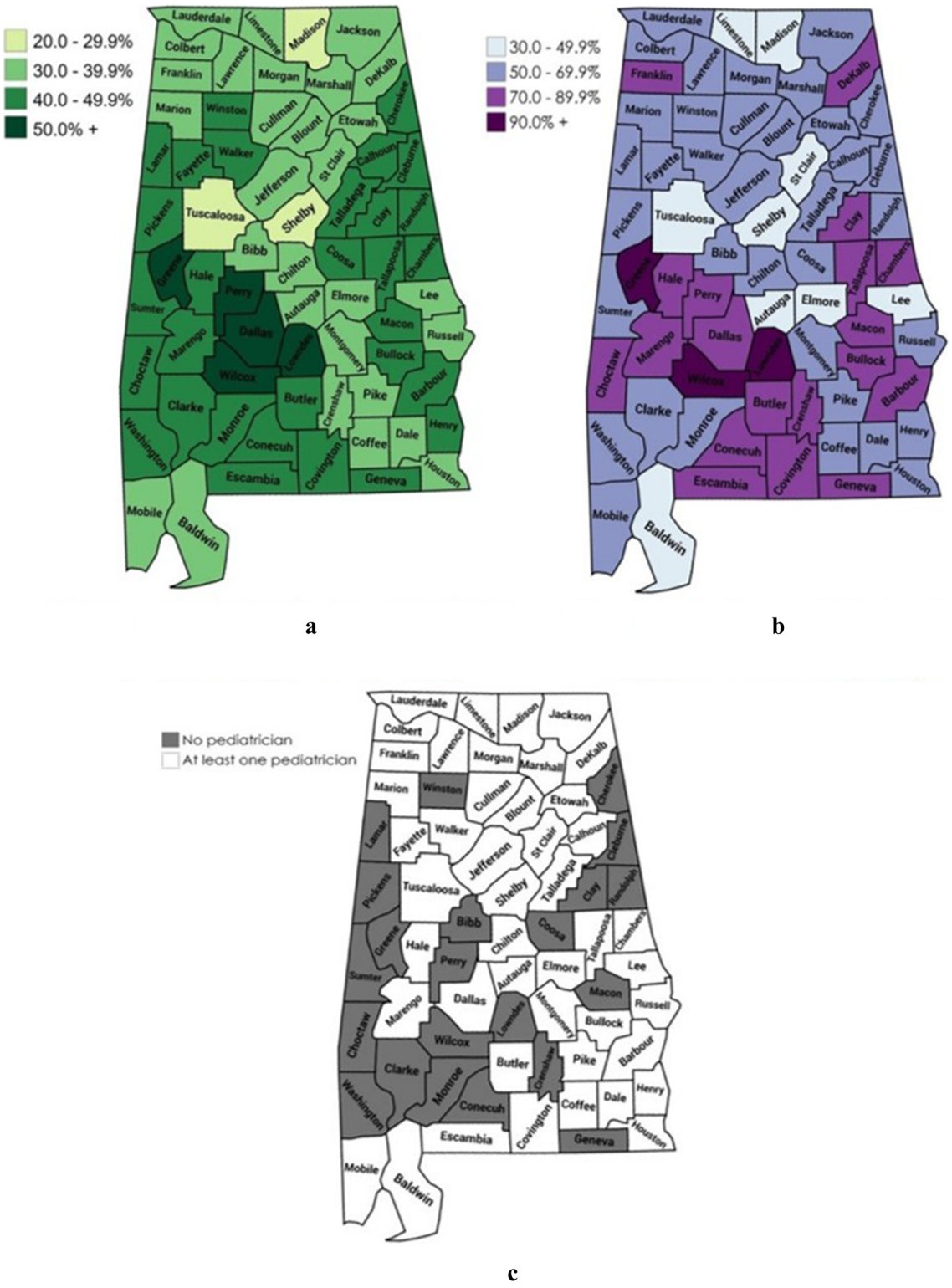

Fig. 3 Healthcare demographics in Alabama by county. **a** Individuals with Public Health Insurance (2018), **b** Annual Medicaid-Eligible Children (2016), **c** Pediatrician Presence (2018)

HPVa Cancers in Alabama

For overall HPVa cancer incidence, Alabama is ranked 15th in the US [4]. Among males, Alabama's HPVa cancer incidence is 10.9 [17], and of the 45 counties for which there is available data on male HPVa cancer incidence, 30 counties (66.7%) have higher HPVa cancer rates than the national incidence of 10.4 [17]. In the eight counties with the highest rates of male HPVa cancers, median age ranged from 31.2 to 43.2 years old. For females, Alabama's HPVa cancer incidence is 15.6 [17]. Of the 52 counties with data available, 42 (80.8%) have higher rates of female HPVa cancer than the national incidence of 13.6 (Fig. 4) [17]. For the 13 counties with the highest rates of female HPVa cancers, the median age range 34.8–43.9 years old. Of the eight and 13 counties with the highest rates of HPVa cancers for males and females, respectively, only three of these counties overlapped for both sexes (Tallapoosa, Chambers and Macon) [17]. There was substantial variation regarding access to care in counties with the highest rates of male and/or females HPVa cancers, with the Primary Care Provider (PCP) ratio ranging from 1542:1 to 4506:1 in counties with the highest rates of male HPVa cancer and ranging from 1085:1 to 5493:1 in counties with the highest rates of female HPVa cancer. When examining the geographic location, 75% of counties with the highest rates of HPVa cancer among males, and over 50% of these counties for females, were located in the southeastern portion of Alabama.

With respect to specific HPVa cancers, Alabama has the 3rd highest cervical cancer incidence and is first in cervical cancer mortality in the US [4, 6]. The rate of cervical cancer incidence in Alabama is 9.0 per 100,000 (county range 5.0–18.4), with a mortality rate of 3.5 per 100,000 (county range 2.3–4.8), compared to national cervical cancer incidence and mortality rates of 7.5 and 2.3, respectively [17]. Additionally, Alabama has the 5th highest incidence of oropharyngeal cancer and 7th highest mortality in the US [6]. The incidence rate of oropharyngeal cancer in Alabama is 13.0 per 100,000 (county range 9.5–20.3) [17], with a mortality rate of 2.7 per 100,000 (county range 1.5–5.7), compared to national rates of 11.6 and 2.5, respectively [17].

HPV Vaccination in Alabama

According to NIS-Teen data, the combined HPV vaccination uptake rate (≥ 1 dose) for males and females ages 13–17 in the state of Alabama is 58.0%, compared with the national average of 65.5%, placing Alabama 44th in the US for HPV vaccination uptake (county range 33–66%, median = 44.5%) [9, 18]. Sixty-four (95.5%) and 66 (98.5%) of Alabama's counties have uptake rates less than the national averages of 62.6% for males and 68.6% for females, respectively [9]. HPV vaccination uptake in Alabama is higher among females (61.1%) than males (55.1%), comparable to the national discrepancy in female (68.6%) versus male (62.6%) HPV vaccination uptake [8]. Completion rates (two doses

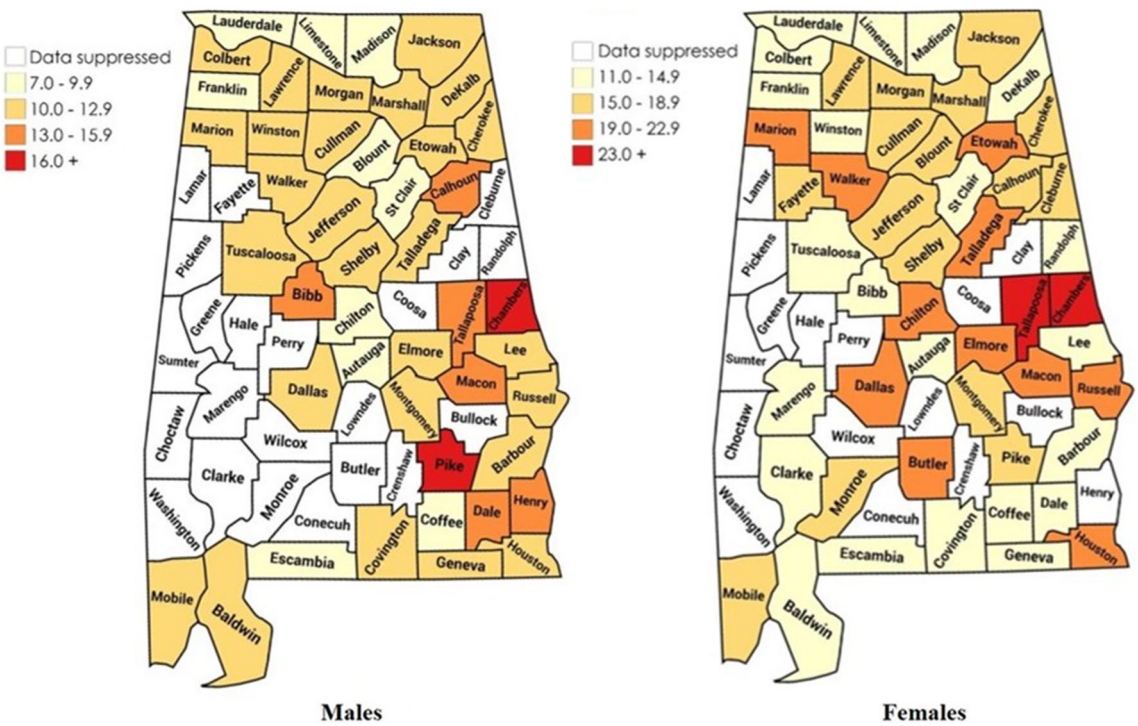

Fig. 4 HPV-associated cancer incidence in males and females in Alabama by county (2006–2015)

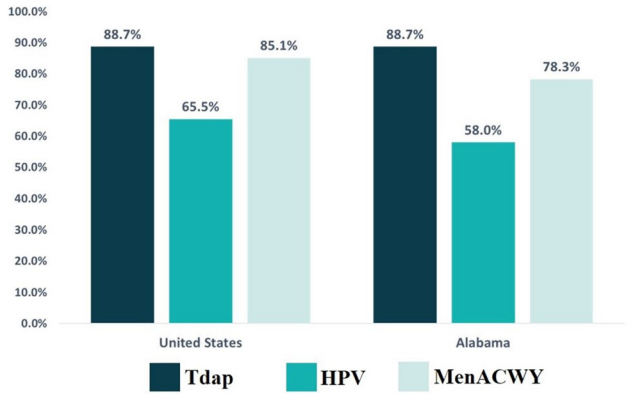

Fig. 5 Comparing HPV vaccination, Tdap, and MenACWY (2017)

or three doses depending on age of initiation) are also low in Alabama at 40.3% for male and female adolescents, compared to the national completion rate of 48.6% [8]. HPV vaccination rates are drastically lower than those of Tdap and MenACWY vaccination rates in the US, which are reported to be 88.7% and 85.1%, respectively, among adolescents ages 13–17 [8]. Vaccination patterns in Alabama mirror these national trends with state Tdap and MenACWY rates estimated to be 88.7% for Tdap and 78.3% for MenACWY for those 13–17 years old (Fig. 5) [8].

In the current analysis, we identified seven counties with the highest HPV vaccination uptake for females (Bullock, Dallas, Hale, Lowndes, Macon, Perry, and Wilcox) where HPV vaccination uptake ranged from 60.2 to 73.6% [9]. Four of these counties also demonstrated the highest rates of HPV vaccination uptake for males (Bullock, Dallas, Lowndes, and Wilcox), ranging from 60.0 to 65.4% [9]. Many commonalities were observed within these seven counties. With respect to race, over 50% of the population in each county was African American (range 58.3–82.1%) while 40% or less of the population in each county was White (range 15.1–40.0%) [12]. All seven counties demonstrated educational attainment below the state average (24.0%) for individuals who have obtained a bachelor's degree or higher (range 10.3–20.0%) [12]. These counties are also comparable with respect to poverty rates, ranging from 24.9 to 39.8% [12]. Similarly, all seven counties have extremely large populations of Medicaid-eligible children (range 73.8 to 94.0%) [15]. Geographically, five of these seven counties are located in the lower/central portion of Alabama, clustered together. The remaining two are also clustered together but toward the lower/central-eastern part of the state. Interestingly, all seven counties are located in the area of Alabama historically known as the Black Belt. Some notable differences were observed among the seven counties with the highest rates of HPV vaccination uptake, however, including substantial variation in RUCC designations (ranging from 2 to 9), as well as with respect to provider access, with at least one pediatrician present in three of these counties, but no pediatrician presence in the other four [13, 14].

Discussion

In the current study, we aimed to identify areas in Alabama in need of intervention to increase HPV vaccination and reduce HPVa cancers and determine factors potentially associated with current rates of each. While many states in the southeastern US have high rates of HPVa cancers, Alabama stands out, ranking 15th in the US, with among the highest rates of cervical and oropharyngeal cancer incidence and mortality [4, 6, 14, 15]. Within the state, 66.7% and 80.8% of counties with available data have higher rates of HPVa cancers than the national average for males and females, respectively [17]. These statistics demonstrate the significant risk that HPVa cancers pose to Alabamians and the dire need for statewide initiatives to increase awareness, education, prevention, screening, and treatment.

Of the eight and 13 counties with the highest rates of HPVa cancers for males and females, respectively, only three of these counties overlapped for both sexes (Tallapoosa, Chambers and Macon) [17]. Geographic trends were observed for both HPVa cancers as well as HPV vaccination within the state, as counties located in the southeastern portion of Alabama had the highest rates of HPVa cancers (75% for male HPVa cancers and 53.8% for female HPVa cancers) [17]. The three overlapping counties with highest rates for both males and females are located in this region and are neighboring counties, appearing as a small cluster when viewed on a map (Fig. 4). Given the broad range of PCP ratios within these counties, more research is needed to better understand issues such as access to care, trust of the medical community, and access and uptake of screening and preventive services.

Interestingly, some of the counties with highest rates of HPVa cancer also had among the highest rates of HPV vaccination uptake in the state—a previously unobserved trend. One potential explanation for this is that increased perceived susceptibility to HPVa cancers, based on observed rates and outcomes within the community, may increase motivation for HPV vaccination among both healthcare providers and parents. This may be especially true for smaller, rural areas where communities are closely-knit and have a great deal of peer influence. The association between HPVa cancer rates and HPV vaccination uptake needs further analysis to determine statistical significance. Additionally, qualitative research is needed to assess perceptions and motivations regarding HPVa cancer and HPV vaccination within these communities.

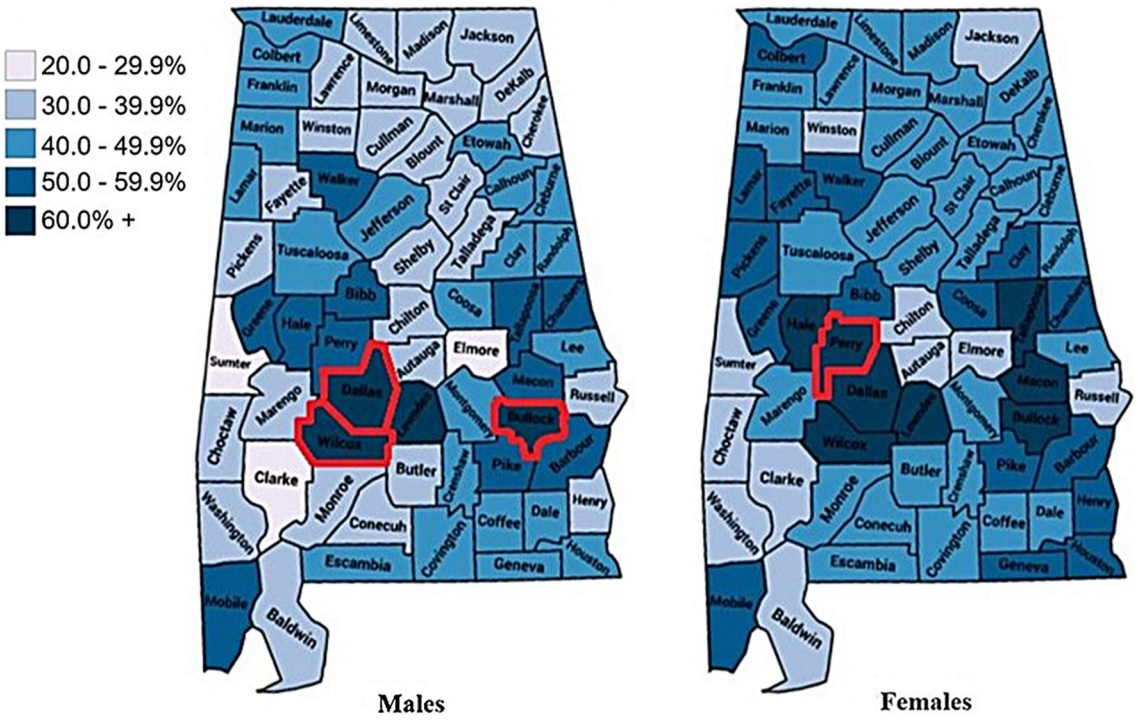

Fig. 6 HPV vaccination uptake among males and females in Alabama, ages 13–17 (2018)

The most prominent initiative needed to reduce rates of HPVa cancers, both nationally and in Alabama, is increased HPV vaccination. Despite its effectiveness, HPV vaccination remains underutilized in the US as well as in Alabama, which ranks 44th in HPV vaccine initiation among adolescents [7, 9, 18]. There is a wealth of existing literature exploring reasons for low HPV vaccination coverage in the US, with evidence supporting various explanations, including demographic factors such as race, socioeconomic status, and education [19–21]. Less tangible factors, such as parental knowledge about HPV, healthcare provider recommendations, religious and cultural influences, and concerns about the HPV vaccination (e.g. regarding safety, leading to promiscuity, and other misperceptions) also influence low vaccination rates [20, 22]. Examining state vaccination registry data, findings from the current study determined that within Alabama only one county (Perry) had HPV vaccination uptake rates greater than the national average for females and only three counties (Bullock, Dallas, and Wilcox) for males (Fig. 6), demonstrating the need for improvement in essentially the entire state [9, 18]. However, four counties did demonstrate HPV vaccination uptake rates of 60.0% or higher for adolescent males (ages 13–17), as did seven for females in that age range [9]. All four counties with the highest uptake among males also had the highest uptake among females (Bullock, Dallas, Lowndes, and Wilcox) [9].

Each of these counties is comprised of well over half African American residents. While existing literature considers race as a risk factor for HPVa cancers, the relationship between race and HPV vaccination has been less clearly defined. The current data indicate that counties with large proportions of African American residents had higher levels of HPV vaccination uptake than those with larger proportions of White residents, supporting some previous work suggesting this racial association [18, 19, 23, 24]. These counties also had similar socioeconomic factors with above-average rates of poverty, low rates of educational attainment, and extremely high rates of Medicaid-eligible children (with two counties above 93%). These demographics, though, are consistent with existing literature which has found that poorer, less educated individuals, often with public insurance, frequently have higher rates of HPV vaccination uptake because they are more willing to comply with healthcare provider recommendations rather than questioning the advice [19, 23, 25]. Interestingly, only three of these seven counties had a resident pediatrician, which is counterintuitive to what would be expected to produce such high rates of HPV vaccination. With nearly every county having only one county health department, few—if any—pediatricians, and documented shortages of primary care physicians (projected to be a deficit of − 30.7% by 2025 [26]), this opens the opportunity for future research into what setting(s) adolescents are being vaccinated with such limited options and how to improve vaccination access.

Perhaps most interesting of the current findings are the geographic trends observed with respect to counties with

the highest rates of HPV vaccination—all seven of these counties are located in in Alabama's Black Belt region. Alabama's Black Belt area is part of a national Black Belt region that spans from Texas to Virginia, with its name originating from the rich, fertile soil found there [27]. Today, these counties are noted for having very rural, frequently agriculturally-based economies with large proportions of African American residents and high levels of socioeconomic and health disparities [28]. These include high rates of poverty and unemployment, poor access to social services, education, and medical care, and high rates of negative health outcomes including stroke, chronic diseases, and cancer mortality rates [28, 29]. Counties located in this region are not known as leaders in preventive medicine—quite the contrary. Improved understanding of how these counties have achieved the highest HPV vaccination rates in the state is greatly needed and could potentially be adapted into targeted interventions to improve vaccination rates in other disparate rural areas.

Comparable to previous studies, findings from the current work demonstrated a particularly concerning discrepancy between Tdap and MenACWY vaccination rates and HPV vaccination rates (88.7% vs. 78.3% vs. 58.0%) in Alabama that is reflective of trends observed nationally (Fig. 5) [8, 30, 31]. This disparity signifies a substantial missed opportunity for vaccination in the adolescent population and indicates that while adolescents are participating in vaccination, there are significant barriers within this population that are unique to HPV vaccination [32–35]. This disparity specific to HPV vaccination, consistent with previous literature, indicates the vital need for further investigation to determine what HPV vaccine-specific barriers exist and how they can be addressed to increase rates of uptake and completion [30, 31, 36]. Additionally, it is essential that providers understand that to obtain an accurate view of HPV vaccination missed opportunity they must compare their HPV vaccination rates to their own Tdap and MenACWY rates, rather than comparing their HPV vaccination rates to state or national HPV vaccination rates.

Limitations

As an analysis of secondary data, the current study was limited by the data available. Regarding HPVa cancer incidence, data was suppressed for many counties for several cancer types due to overall low incidence of these cancers as well as because of the low populations within some counties, making us unable to quantify and rank all counties with respect to each HPVa cancer. In order to examine HPV, Tdap, and MenACWY vaccination rates between states and the national rates, the overall Alabama rates used for those analyses were those reported by NIS-Teen. However, because NIS-Teen data are an estimation of vaccination coverage among adolescents ages 13–17 years old generated using a limited sample [37], they may not most accurately represent the adolescent population in Alabama. The state averages reported by NIS-Teen were not consistent with averages reported from the state's ImmPRINT database (with NIS-Teen rates substantially higher), indicating likely inflation of vaccination rates in the NIS-Teen data as a result of sampling methods. Important to note, though, is that vaccination rates generated by ImmPRINT (comprising the county-level data reported here) are likely to be underestimations of these rates due to under-reporting and provider non-use of the ImmPRINT system. All data were reported with the greatest accuracy and consistency possible, adjusting sample characteristics to mirror age ranges and any other characteristics needed to maintain data quality. Additionally, the results and conclusions of the current study were made observationally so interpretation should be performed with caution. Formal data analysis is needed to determine and validate the statistical significance of the trends observed here.

Conclusions

This study uniquely analyzes HPVa cancer and HPV vaccination rates within the state of Alabama. Findings indicate a potential association between high rates of HPVa cancers and greater rates of HPV vaccination, leading to speculation regarding the influence of perceived susceptibility and perceived risk on HPV vaccination uptake in these communities warranting further investigation. There was an overall disparity in the state with respect to rates of Tdap vs. MenACWY vs. HPV vaccination, indicating barriers specific to HPV vaccination. The counties with the highest HPV vaccination rates for male and female adolescents were predominantly African American with low rates of adult educational attainment and high rates of poverty and publicly-insured children and adolescents. Also, these counties were located in Alabama's Black Belt region, an area traditionally known for poor socioeconomics, low access to social services, and negative health outcomes. Future research should utilize qualitative methods to explore several of the current themes in more depth to assess the validity of concepts theorized here such as what methods are being implemented in the counties that demonstrate the greatest success in HPV vaccination uptake and who is implementing these measures. Also, the same variables examined here should be assessed with respect to HPV vaccination completion rates to determine possible associations or disparities. Establishing an association between perceived risk and increased HPV vaccination would promote development of targeted, theory-based intervention strategies to effectively increase vaccination uptake that could be translated to other

settings and populations. Further expansions of this work should also examine HPVa cancer mortality and its potential association with perceived risk and protection motivation on the provider, parent, and patient levels. Each of these should be examined with respect to access to care, screening and preventive services (both availability and uptake), cancer stage at diagnosis, and related factors. Finally, all these concepts should be examined on a broader platform to see their relevance and applicability on a national level. The broader goal of this study is to identify potential trends affecting HPV vaccination and HPVa cancers that may be applicable in other parts of the US and potentially amenable to interventions derived from this work. The current findings can be used to inform and guide stakeholders for future initiatives in policy, healthcare, and public health.

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Compliance with Ethical Standards

Conflict of interest The authors declare no known conflicts of interest.

References

1. HPV and cancer. Retrieved June 6, 2018 from https://www.cancer.gov/about-cancer/causes-prevention/risk/infectious-agents/hpv-and-cancer?redirect=true#r5.
2. HPV fact sheet. Retrieved June 6, 2018 from https://www.cdc.gov/std/HPV/STDFact-HPV.htm.
3. Human papillomavirus (HPV). Retrieved June 6, 2018 from https://www.cdc.gov/hpv/parents/whatishpv.html.
4. HPV-associated cancer statistics. Retrieved June 6, 2018 from https://www.cdc.gov/cancer/hpv/statistics/index.htm.
5. CDC. (2018). Cancers associated with human papillomavirus by state, 2010–2014. In *USCS data brief*. Atlanta, GA. Retrieved June 29, 2018 from https://www.cdc.gov/cancer/hpv/pdf/hpv-associated-cancer-incidence-by-state-2010-2014-508.pdf.
6. U.S. Cancer Statistics Data Visualizations tool, based on November 2017 submission data (1999–2015). Retrieved June 29, 2018 from http://www.cdc.gov/cancer/dataviz.
7. HPV vaccine: State legislation and statutes. Retrieved June 6, 2018 from http://www.ncsl.org/research/health/hpv-vaccine-state-legislation-and-statutes.aspx.
8. Human papillomavirus (HPV) vaccination coverage among adolescents 13–17 years by State, HHS Region, and the United States, National Immunization Survey-Teen (NIS-Teen), 2017. Retrieved June 10, 2018 from https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/data-reports/hpv/dashboard/2017.html.
9. ImmPRINT. Retrieved June 10, 2018 from https://www.alabamapublichealth.gov/immunization/immprint.html.
10. State cancer profile: Alabama. Retrieved June 10, 2018 from https://www.statecancerprofiles.cancer.gov/quick-profiles/index.php?statename=alabama.
11. Cancer statistics. Retrieved June 6, 2018 from https://www.seer.cancer.gov/statistics/.
12. American fact finder. Retrieved June 6, 2018 from https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml?src=bkmk.
13. Human Resources & Services Administration. (2015). County level data. US Department of Health and Human Services.
14. United States Department of Agriculture. (2013). Rural-urban continuum codes.
15. Medicaid. (2016). Alabama Medicaid statistics: Eligibility and payments. Medicaid.
16. University of Wisconsin Population Health Institute. (2018). County Health Rankings 2018. In *County Health Rankings & Roadmaps*. University of Wisconsin Population Health Institute .
17. Centers for Disease Control and Prevention. (2018). Cancers associated with human papillomavirus, United States—2011–2015. In *USCS data brief*. Atlanta, GA.
18. Walker, T. Y., Elam-Evans, L. D., Yankey, D., Markowitz, L. E., Williams, C. L., Mbaeyi, S. A., et al. (2018). National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years—United States, 2017. *MMWR Morbidity and Mortality Weekly Report, 67*(33), 909–917.
19. Henry, K. A., Swiecki-Sikora, A. L., Stroup, A. M., Warner, E. L., & Kepka, D. (2017). Area-based socioeconomic factors and human papillomavirus (HPV) vaccination among teen boys in the United States. *BMC Public Health, 18*(1), 19.
20. Kessels, S. J., Marshall, H. S., Watson, M., Braunack-Mayer, A. J., Reuzel, R., & Tooher, R. L. (2012). Factors associated with HPV vaccine uptake in teenage girls: A systematic review. *Vaccine, 30*(24), 3546–3556.
21. Marlow, L. A., Wardle, J., Forster, A. S., & Waller, J. (2009). Ethnic differences in human papillomavirus awareness and vaccine acceptability. *Journal of Epidemiology and Community Health, 63*(12), 1010–1015.
22. Holman, D. M., Benard, V., Roland, K. B., Watson, M., Liddon, N., & Stokley, S. (2014). Barriers to human papillomavirus vaccination among US adolescents: A systematic review of the literature. *JAMA Pediatrics, 168*(1), 76–82.
23. Warner, E. L., Ding, Q., Pappas, L. M., Henry, K., & Kepka, D. (2017). White, affluent, educated parents are least likely to choose HPV vaccination for their children: A cross-sectional study of the National Immunization Study—Teen. *BMC Pediatrics, 17*(1), 200.
24. Burdette, A. M., Webb, N. S., Hill, T. D., & Jokinen-Gordon, H. (2017). Race-specific trends in HPV vaccinations and provider recommendations: Persistent disparities or social progress? *Public Health, 142*, 167–176.
25. Henry, K. A., Stroup, A. M., Warner, E. L., & Kepka, D. (2016). Geographic factors and human papillomavirus (HPV) vaccination initiation among adolescent girls in the United States. *Cancer Epidemiology Biomarkers Prevention, 25*(2), 309–317.
26. HRSA. (2016). State-level projections of supply and demand for primary care practitioners: 2013–2015. Services USDoHaH.
27. History and heritage overview. Retrieved April 25, 2019 from http://www.alblackbeltheritage.org/heritage.
28. Black Belt region in Alabama. Retrieved April 25, 2019 from http://www.encyclopediaofalabama.org/article/h-2458.
29. ASTHO. (2010). Alabama health disparities status report.
30. Vielot, N. A., Butler, A. M., Brookhart, M. A., Becker-Dreps, S., & Smith, J. S. (2017). Patterns of use of human papillomavirus and other adolescent vaccines in the United States. *The Journal of Adolescent Health, 61*(3), 281–287.
31. Falik, R. B., Albrecht, S. A., & Cassidy, B. L. (2019). Policy support for expanding the adolescent vaccine school mandate in Pennsylvania to include the human papillomavirus (HPV) vaccine. *Journal of the American Association of Nurse Practitioners, 31*(4), 263–268.
32. Cartmell, K. B., Young-Pierce, J., McGue, S., Alberg, A. J., Luque, J. S., Zubizarreta, M., & Brandt, H. M. (2018). Barriers,

facilitators, and potential strategies for increasing HPV vaccination: A statewide assessment to inform action. *Papillomavirus Research, 5*, 21–31.
33. Boyd, E. D., Phillips, J. M., Schoenberger, Y. M., & Simpson, T. (2018). Barriers and facilitators to HPV vaccination among rural Alabama adolescents and their caregivers. *Vaccine, 36*(28), 4126–4133.
34. Carhart, M. Y., Schminkey, D. L., Mitchell, E. M., & Keim-Malpass, J. (2018). Barriers and facilitators to improving virginia's HPV vaccination rate: A stakeholder analysis with implications for pediatric nurses. *The Journal of Pediatric Nursing, 42*, 1–8.
35. Dilley, S. E., Peral, S., Straughn, J. M. Jr., & Scarinci, I. C. (2018). The challenge of HPV vaccination uptake and opportunities for solutions: Lessons learned from Alabama. *Preventive Medicine, 113*, 124–131.
36. Gilkey, M. B., Moss, J. L., Coyne-Beasley, T., Hall, M. E., Shah, P. D., & Brewer, N. T. (2015). Physician communication about adolescent vaccination: How is human papillomavirus vaccine different? *Preventive Medicine, 77*, 181–185.
37. CDC. (2017). *National Immunization Survey: A user's guide for the 2016 public-use data file*. Atlanta: US Department of Health and Human Services.