

ORIGINAL RESEARCH

HPV and Genital Warts: Mapping Awareness Through Google Trends in the United States Trends

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ABSTRACT

Background: Human Papillomavirus (HPV) is a sexually transmitted infection in the United States with an estimated 40% prevalence.

Methods: This study assessed Google Trends data for genital warts related search terms from 2004 to 2023. The latest data from the Centers for Disease Control-reported National Immunization Survey 2022 were compared to Google Trends data for patterns or correlations.

Results: Average annual searches for genital warts decreased by 73.7% from 2004 to 2023 with the largest reduction (-23.14%) occurring between 2019 and 2020. West Virginia had the highest twenty-year average searches for genital warts related search terms (94), while Utah was found to have the lowest (44). Minnesota, Massachusetts and Washington were reported in the top ten states with the highest HPV vaccination coverage (≥ 1 dose) and the top ten states with the lowest twenty-year average Google Trend search inquiries for genital warts. Conversely, West Virginia, South Carolina, Oklahoma, Kentucky and Mississippi were found to be in the top ten states with the lowest reported ≥ 1 HPV dose vaccination coverage and among top ten states with highest genital wart searches.

Conclusion: Google Trends data can help identify at-risk regions and guide efforts to improve HPV vaccination rates in the United States.

INTRODUCTION

Human papillomavirus (HPV) infection is one of the most common causes of sexually transmitted infections (STI) globally and is the most common sexually transmitted disease (STD) in the United States (US) with a prevalence of about 40%.¹ More than 100 HPV variants exist of which more than 40 are known to infect mucosal and anogenital regions.¹ There are several high-risk types of HPV including well known variants such as types 16 and 18 that carry oncogenic potential and are associated with cancers of

the anogenital tract.² Low risk types of HPV such as types 6 and 11 are rarely associated with oncogenic potential and are more commonly associated with benign lesions such as condyloma accuminata or anogenital warts.^{3,4}

Unlike with neoplasia, measuring the incidence of genital warts proves difficult due to the lack of population-based registries or STD reporting repositories, relying on indirect tools of measurements reported through insurance claims, hospitals or physicians.⁵ It is estimated that 1% of sexually active adults in the United States have symptomatic

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genital warts.⁶ Data from 1975-1978 reported the annual genital warts incidence at an estimate of 100 per 100,000 persons however more recent prevalence data has estimated annual incidence rate of 100 to 200 cases per 100,000 persons in 2013.^{5,7}

Studies have suggested that the introduction of the quadrivalent HPV vaccine in 2006 led to near 100% equivalent protection against genital warts caused by HPV 6 and 11 in women.^{8,9} However, HPV vaccination rates have been lower than desired, with an estimated 46% of vaccine-eligible adolescents not being up to date as of 2019.¹⁰ Several factors resulting in low vaccination rates have been studied, including: state sex education policy, state religiosity, HPV vaccine mandate, guardian perception and attitude, health care services availability and initial vaccine public perception.^{11,12,13}

Considering the relatively short incubation time to appearance of genital wart after HPV infection, surveilling the public interest of genital warts allows for evaluation of the effectiveness and population utilization of the HPV vaccine.⁸ Google Trends is an accessible tool that allows for real time tracking of search inquiries across various languages and regions, thus providing a means to surveil public interest in and knowledge of infectious diseases. The National Immunization Survey- Teen (NIS) is a group of nationwide telephone surveys of adolescents 13 through 17 years old that provide current population-based state and local area estimated vaccination coverage rates; these surveys can monitor trends in vaccination coverage and identify populations and areas with low coverage.^{14,15}

This study will evaluate for overlap between the most current 2022 CDC reported NIS-Teen and public internet inquiry using Google

Trends to investigate public internet inquiries of genital warts by states in the US in effort to monitor the impact of HPV vaccine coverage in various regions in the United States.

MATERIALS AND METHODS

Data Source

The Google Trends software offers data relative to the peak popularity of a specific search term for a given time frame. Search terms must surpass a frequency threshold in order to appear in search term results. Data values for specific terms does not represent an absolute number of search volume but is normalized and presented on a scale from 0 to 100. Changes in interest over time, as well as variations in interest across regions, are indicated by values between 0 and 100, with a value of 50 indicating that a search was half as popular and 100 denoting peak popularity. The values for the same search term may vary depending on the selected time period of interest. Google Trends also generates related terms that are frequently searched for, assigning these related terms values for a specific time period.

Study Population

We evaluated public inquiry in genital warts by reviewing online searches publicly available on the Google Trends program. We completed a query search on April 29, 2024, for searches in the United States for terms related to the words “genital warts,” including: “symptoms of genital warts” and “signs of genital warts” from 2004 to 2023. After searching for our terms, Google Trends graphed the popularity of search terms from 2004 through 2023 by US state. Published Centers for Disease Control reported NIS-Teen from 2022, the most recently available year of surveillance data, were compared to

the graph for each search term. The results from the NIS are noted both as those who completed at least one vaccination as well as those who were completely up to date (UTD - completed the entire HPV vaccination series of two to three shots, depending upon precise age at vaccination).

RESULTS

Twenty Year Annual Average Google Trend Search Queries, US, 2004-2023

The national trend data on Google trend searches is provided as a normalized value between 0 and 100 where 100 is peak popularity of a search term and a value of 50 equivalent to half the popularity. The annual average search (**Table 1**) for genital warts showed a steady decline from 2004 at 86.3 reaching a nadir in 2023 at 22.7. Overall, from 2004 to 2023 the average annual percent change showed a decline by 73.70%. The annual percent change saw the largest drop from 2019 (35) to 2020 (26.9) by -23.14%, while the largest increase in search terms was from 2010 (63.2) to 2011 (68.4) at 8.23%.

Top Ten States for Highest Google Trend Searches

Analysis of the Google trends search data revealed the top ten states in the US with the highest twenty-year average for genital warts related search terms as West Virginia (94), Mississippi (92.7), Kentucky (80), Louisiana (75.2), Arkansas (73.5), Indiana (70.8), Alabama (70.1), North Dakota (70.1), South Carolina (69.6) and Oklahoma (76.5) (**Table 2**). Conversely the states with the lowest searches for genital warts related terms on Google trends were Arizona (52.6), Virginia (51.5), Colorado (50.9), Minnesota (50.9), Idaho (50.2), Oregon (49.7), Massachusetts

(49.4), Washington (48.6), California (48.4) and Utah (44.2) (**Table 3**). Minnesota (86.9%), Massachusetts (85.6%), and Washington (85.4%) (**Table 3**) were the only three states to rank in the top ten for both the highest CDC-reported NIS HPV vaccination coverage of at least one dose (≥ 1 HPV) and the lowest 20-year search activity for genital warts. There were seven states— Rhode Island, Philadelphia, Vermont, Iowa, the District of Columbia, Hawaii, and New Hampshire— that ranked highest in ≥ 1 HPV dose on the NIS survey that were not found among top ten highest or lowest Google Trends search inquiries.

Top Ten States for Lowest Google Trend Searches

The six states that were found among the top ten states with highest searches for genital warts (**Table 2**) and also found among the top ten states with the lowest HPV vaccination completion on the NIS are Arkansas (55.7%), Kentucky (55%), South Carolina (54.4%), West Virginia (55.1%), Oklahoma (46.2%), and Mississippi (38.5%). Low HPV vaccination coverage states that were not found on either top ten highest or lowest google trend searches included: Georgia, Texas and Wyoming.

California (72.2%) and Utah (73%) were the only two states to rank in the top ten for both the lowest HPV vaccination coverage (≥ 1 dose) and the lowest Google Trends search activity for genital warts (**Table 3**). Utah was the only state to rank lowest in percent adolescents with at least one HPV vaccination dose (73% ≥ 1 dose) and adolescents completing the vaccine series (55% UTD), while also appearing among states with the lowest Google Trends search activity.

Table 1. Twenty Year Annual Average Google Trend Search Queries, US, 2004-2023

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Annual Average Search for Genital Warts	86.3	81.3	75.5	67.8	72.6	68.9	63.2	68.4	72.8	64.8
Annual Percent Change	-	-5.79%	-7.12%	-10.20%	7.14%	-5.10%	-8.26%	8.23%	6.43%	-10.99%
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Annual Average Search for Genital Warts	55.3	50.6	43.8	41.6	38.8	35	26.9	22.8	23.3	22.7
Annual Percent Change	-14.58%	-8.49%	-13.39%	-5.02%	-6.73%	-9.79%	-23.14%	-15.24%	2.19%	-2.58%

Table 2. Top Ten States for Highest Google Trend Searches

Top 10 States Highest Searches on Google Trends	20 yr Average Searches on Google Trends	NIS Vaccination Coverage % ≥ 1 HPV	NIS Vaccination Coverage % UTD HPV
West Virginia ^a	94	69.9	51.5
Mississippi ^a	92.7	61	38.5
Kentucky ^a	80	66.4	55
Louisiana	75.2	79.8	67.3
Arkansas ^a	73.5	74.7	55.7
Indiana	70.8	75.5	59.6
Alabama	70.1	76.9	59.2
North Dakota ^b	70.1	82.9	74.4
South Carolina ^a	69.6	69.9	54.4
Oklahoma ^a	76.5	46.2	46.2

Top ten states with the highest Google Trend Searches Ten-year average searches are reports as normalized values from 0 to 100.

^a States ranked among the top ten lowest in CDC-reported NIS HPV vaccination coverage.

^b States ranked among the top ten highest in CDC-reported NIS HPV vaccination coverage.

^c States with the lowest CDC-reported NIS HPV vaccination coverage of at least one HPV dose (≥ 1 HPV) and the lowest search activity on Google Trends.

DISCUSSION

In the United States approximately 1% of sexually active adults are estimated to have genital warts.⁶ An estimated 90% of those genital warts cases can be associated with

HPV types 6 and 11.^{3,4} Initially introduced in 2006 with recommendations for 11- to 12-year-old girls, both the HPV quadrivalent and nine-valent forms have been demonstrated to offer significant protection against targeted HPV types, and has since expanded in

coverage to males as of 2015.^{16,17} Several studies have demonstrated decreased prevalence of HPV types among younger women between the pre-vaccine and early vaccine era, with HPV vaccinated young women found to have lower prevalence of vaccine-targeted HPV compared to those unvaccinated in the US.^{18,19} Recognizing that genital warts appears between two to three months after incident infection with HPV, this

outcome could serve as a first clinical indicator in monitoring the impact of the HPV vaccine.²¹ Our findings demonstrate correlations between anogenital symptom search inquiries on Google Trends and states specific percent HPV vaccination coverage, suggesting a potential relationship between public information seeking behavior and HPV vaccination status.

Table 3. Top Ten States for Lowest Google Trend Searches

Top 10 States Lowest Searches on Google Trends	20 yr Average Searches on Google Trends	NIS Vaccination Coverage Percent ≥ 1 HPV	NIS Vaccination Coverage Percent UTD HPV
Arizona	52.6	76.5	62.1
Virginia	51.5	77.5	62.7
Colorado	50.9	79.7	65.7
Minnesota ^b	50.9	86.9	68.6
Idaho	50.2	80.8	66.9
Oregon	49.7	80.7	65.6
Massachusetts ^b	49.4	85.6	77.1
Washington ^b	48.6	85.4	71.1
California ^c	48.4	72.7	60.6
Utah ^c	44.2	73	55.2

Top ten states with the highest Google Trend Searches Ten-year average searches are reports as normalized values from 0 to 100.

^a States ranked among the top ten lowest in CDC-reported NIS HPV vaccination coverage.

^b States ranked among the top ten highest in CDC-reported NIS HPV vaccination coverage.

^c States with the lowest CDC-reported NIS HPV vaccination coverage of at least one HPV dose (≥ 1 HPV) and the lowest search activity on Google Trends.

Our analysis of Google Trends revealed insights into public awareness and interest in anogenital warts over the past two decades and across different US regions. There was a steady decline in annual average searches for genital warts from 2004 to 2023, with an overall reduction by 73.7% in annual average searches during this period. This decline in public interest in anogenital warts coincides with the introduction of the HPV vaccines, suggesting that targeted public health efforts and increased vaccine availability have

effectively raised public awareness and reduced HPV-related diseases. Studies have consistently shown a reduction in anogenital warts following the licensure of the HPV quadrivalent vaccine in 2006.^{22,23} It has also been demonstrated by several studies that receiving at least one dose of the HPV vaccine was effective at reducing the risk of anogenital warts, although receiving the full three doses provided the greatest protection.^{20,22,19} A study by Kasting et al. in 2017 estimated that the prevalence of

receiving any HPV vaccination among young adults aged 19-26 years and 27- 45 years was 36.3% and 9.7% respectively.²⁴ In 2022 it was estimated that 62.6% of adolescents aged 13 to 17 years old in the US were up to date with HPV vaccination with 76% having received at least one vaccine dose compared to 58.6% and 75.1% respectively in 2020.¹⁵ In general, the decline in internet searches for genital warts supports previous studies suggesting that increased population vaccination percentage coincides with decreased prevalence of HPV-related diseases.^{20,22}

Our study also demonstrated significant regional differences in public interest for genital warts across the US. A comparison between states with the highest Google search inquires for genital warts on Google Trend and the NIS Vaccination Coverage highlighted potential regional variations in public interest and awareness of genital warts. States such as West Virginia, Mississippi, Kentucky, Arkansas, South Carolina, and Oklahoma ranked highest on Google trend genital warts searches and lowest on NIS HPV vaccination coverage suggesting an inverse correlation between vaccine status and genital warts interest (**Table 2**). It would seem apparent that, for the aforementioned states, additional targeted public health efforts should be entertained. Various factors have been implicated in influencing HPV vaccine status in the US, including religiosity, state sex education policy and region and state enforced HPV mandate.^{13,25} Highly religious and/or conservative states have been found to have lower population-based HPV vaccine coverage.^{13,25} Conversely, states like Minnesota, Massachusetts and Washington ranked in the highest on NIS HPV vaccination coverage and the lowest in genital warts Google trend search inquires (**Table 3**). This also implies a potential inverse correlation

between higher vaccination coverage and reduced public information seeking behavior. States like Massachusetts and Washington have implemented comprehensive state-specific public health initiatives to promote complete HPV protection through encouraging public and provider HPV-related education and awareness along with launching school based and statewide HPV vaccination campaigns.²⁶ This suggest that targeted public health related strategies achieve higher state vaccination coverage resulting in lower incidences of HPV-related diseases and, therefore, reduced internet inquiries on genital warts. Other factors that have been associated with increased HPV vaccine uptake are HPV literacy, provider recommendation, sex education policies, and HPV vaccine mandate.^{13,27,22}

A notable finding in our study was that California and Utah ranked in both lowest google trend search inquiries for genital warts and lowest NIS HPV vaccination status (**Table 3**). This finding may be attributed to various factors including decreased awareness, decreased or delayed health care seeking behavior and lower concern about disease risk and susceptibility.^{17,22,26} Previous studies have characterized Utah as highly religious and conservative, with the predominant religion advocating for abstinence.^{13,25} States with higher percentages of religious adults were found to have an 11- fold decrease in HPV vaccine completion rates.^{13,25} Redd et al. found that parents/guardians of high-religious households in Utah were more likely to not vaccinate their children due to their belief that their children were less likely to contract a sexually transmitted disease.²⁹ Concerning California, it is possible that both high migrant and homeless populations might contribute to both low rates of vaccination and low rates of internet inquiry. Considering the disparate factors enumerated above, states like Utah

and California could well benefit from additional and ongoing targeted state specific public education campaigns and outreach efforts tailored to cultural and religious contexts in effort to improve HPV vaccination rates.

Challenges in addressing uptake of the HPV vaccine include the need to overcome the initial perception of the vaccine as primarily for females, misinformation about its purpose to not solely prevent STDs, and public concerns about its safety. However, countries like Denmark and Australia have already seen the benefits of high national HPV coverage and robust national immunization delivery systems. Both countries have observed significant decreases in genital warts following the introduction of the HPV vaccine types. Australia for example has been able to demonstrate the effect of herd immunity, with a 92.6% reduction in genital warts in females and an 81% reduction in males younger than the age of 21 years old.^{20,30} Utilizing google trends as a surveillance tool for public interest can help identify at-risk regions in the US with public information seeking behavior on HPV-related diseases and low HPV vaccination uptake. This information can be used to initiate targeted public health interventions and state specific campaigns to increase public awareness and knowledge regarding the HPV vaccine. Overall, these efforts are crucial in achieving higher vaccination rates and reducing the burden of HPV-associated diseases.

Limitations

Limitations of this study include the inability for Google Trends analysis to provide absolute search values and limited transparency in its algorithm. Other limitations also include that this study relied on data collected on internet users and

therefore could potentially exclude individuals without internet access. Google Trends data is not available stratified by age, while the vast majority of HPV vaccinations are given, as recommended, during pre-adolescence and adolescence.

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