



Published in final edited form as:

J Adolesc Health. 2016 January ; 58(1): 33–39. doi:10.1016/j.jadohealth.2015.09.016.

Search engine ranking, quality, and content of webpages that are critical vs noncritical of HPV vaccine

Linda Y. Fu, MD, MS^{a,b,c}, Kathleen Zook, RN, MPH^b, Zachary Spoehr-Labutta^c, Pamela Hu^c, and Jill G. Joseph, MD, PhD^d

^aCenter for Translational Science, Children's National Health System, Washington, DC, USA

^bGoldberg Center for Community Pediatric Health, Children's National Health System, Washington, DC, USA

^cThe George Washington University School of Medicine, Washington, DC, USA

^dBetty Irene Moore School of Nursing, University of California Davis, Sacramento, CA, USA

Abstract

Purpose—Online information can influence attitudes toward vaccination. The aim of the present study is to provide a systematic evaluation of the search engine ranking, quality, and content of webpages that are critical versus noncritical of HPV vaccination.

Methods—We identified HPV vaccine-related webpages with the Google search engine by entering 20 terms. We then assessed each webpage for critical versus noncritical bias as well as for the following quality indicators: authorship disclosure, source disclosure, attribution of at least one reference, currency, exclusion of testimonial accounts, and readability level less than 9th grade. We also determined webpage comprehensiveness in terms of mention of 14 HPV vaccine relevant topics.

Results—Twenty searches yielded 116 unique webpages. HPV vaccine-critical webpages comprised roughly a third of the top, top 5 and top 10-ranking webpages. The prevalence of HPV vaccine-critical webpages was higher for queries that included term modifiers in addition to root terms. Compared with noncritical webpages, webpages critical of HPV vaccine overall had a lower quality score than those with a noncritical bias ($p < .01$) and covered fewer important HPV-related topics ($p < .001$). Critical webpages required viewers to have higher reading skills, were less likely to include an author byline, and were more likely to include testimonial accounts. They also were more likely to raise unsubstantiated concerns about vaccination.

Corresponding author: Linda Fu, MD, MS, Goldberg Center for Community Pediatric Health, Children's National Health System, 111 Michigan Ave, NW, Washington, DC, 20010, USA, lfu@childrensnational.org, 1-202-476-3931.

Conflict of Interest Statement: None of the authors have any potential, perceived or real conflict of interests to disclose. Linda Y. Fu wrote the first draft of the manuscript. No honorarium, grant or other form of payment was given to anyone to produce the manuscript.

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.

IMPLICATIONS AND CONTRIBUTIONS: Studies support the influence of exposure to online content on personal vaccination attitudes. This study finds that webpages critical of HPV vaccine may be frequently returned and highly ranked by search engine queries despite being of lower quality and less comprehensive than noncritical webpages.

Conclusion—Webpages critical of HPV vaccine may be frequently returned and highly ranked by search engine queries despite being of lower quality and less comprehensive than noncritical webpages.

Keywords

consumer health information; HPV vaccines; internet; medical informatics; evaluation studies; health services research; quality control

Human papillomavirus (HPV) infection is the leading cause of cervical cancer which causes more deaths than any other cancer among American women.(1) Additionally, HPV infection is implicated in other anogenital and oropharyngeal cancers as well as genitals warts in males and females.(1) Despite overwhelming evidence supporting the safety and efficacy of HPV vaccine (HPV2 (Cervarix, GlaxoSmithKline, London), HPV4/HPV9 (Gardasil, Merck, Whitehouse Station, NJ)),(1) overall coverage rates in the United States with the three recommended doses of HPV vaccine remain low—37.6% for girls and 13.9% for boys.(2)

In recent systematic reviews, lower likelihood of HPV vaccine uptake was associated with lower vaccine-related knowledge and less positive vaccine attitudes.(3, 4) A growing body of research points to an association between exposure to online information critical of vaccination and personal anti-vaccine beliefs.(5-7) This relationship is noteworthy because many Americans report consulting the internet for HPV vaccine information.(8, 9) In a 2010 study of 8 vaccine-critical websites, all expressed concerns about vaccine safety and linked vaccination to severe, long-term side effects or death.(10) There have been three recent studies of HPV vaccine information online, all of which found content to be suboptimal. (11-13) Tozzi, et al. compared Italian and English language HPV vaccine-related webpages and found English webpages to be of higher quality.(13) This study identified webpages using only neutral-toned search engine queries and did not evaluate webpages for their bias (i.e. whether they were critical of HPV vaccine or not). Two studies that did assess webpage bias found that a minority (7.9%(11) and 14.4%(12)) were critical of HPV vaccine, but both of these also conducted only neutral-toned queries thereby potentially overlooking vaccine-critical pages. Evidence from Google Trends,(14) which identifies the most commonly-searched related terms as a percentage of all searches, suggests that critical toned queries may be common; for instance, one of the most popular search terms related to “HPV vaccine” is “HPV side effects.”(15) To gain further appreciation of the internet’s potential influence on attitudes, especially among parents who are uncertain about HPV vaccine, it would be helpful to know how often vaccine-critical webpages appear among the top results in HPV vaccine-related search engine queries, as well as how webpages that are critical of HPV vaccine differ from those that are not. The aim of the present study is to provide a systematic evaluation of the search engine ranking, quality, and content of webpages that are critical vs noncritical of HPV vaccination.

Methods

This study did not use human subjects and was exempt from institutional board review.

Search engine queries

Because eight in ten Americans begin health-related internet inquiries using a search engine, (16) and because there is a high degree of overlap in results returned by the most commonly used search engines,(17) we chose to identify webpages for study inclusion with a set of queries entered into a single search engine. We identified webpages using Google based on this particular search engine's popularity (preferred by 83% of users (18) and used in 41% of all searches (19)).

Previous studies of online HPV content have used 6-7 neutral-toned search terms for search engine queries.(11-13) We began with a set of similar neutral-toned root terms: HPV vaccine, cervical cancer vaccine, Human papillomavirus vaccine, Gardasil and *Cervarix*. To identify additional webpages that could be more commonly encountered by users with concerns about HPV vaccine, we also sought term modifiers that could convey vaccination hesitancy. For potential modifiers, we performed an *ad hoc* canvassing of three online parenting forums for user suggestions and searched Google Trends for popular relevant terms.(15) We selected the following modifiers: *risks* (e.g., *HPV vaccine risks*), *pros and cons*, *dangers*, *safety* and *side effects*. In total, we conducted twenty search queries (Table 1).

To ensure prior internet browsing history did not influence search results, all web browser windows were closed and a new Google Chrome incognito window opened for each new query. All queries were conducted and the content of returned webpages saved on August 8 and 9, 2013.

Webpage inclusion and ranking

A recent survey found that 97% of participants only view the first ten webpages returned by search engines, and very few view webpages listed after the first page.(20) Therefore, for each of the twenty queries, we included only the first ten webpages returned or webpages listed on the first page—whichever was fewer. Sponsored webpages, pharmaceutical manufacturer webpages, paid advertisements, news feed articles, and non-English language webpages were excluded, as were webpages only accessible via sponsored links, restricted access, video-only or suspicious according to anti-virus software.

Since webpages closer to the top of search results are more likely to be viewed than those further down,(18) we recorded webpage rank (the order in which a page was returned by a search). If a webpage was returned by more than one search, all rankings were recorded.

Webpage data extraction

Double-data extraction of all webpage information was independently performed by two members of the research team. Advertisements, sidebar content and open comments sections that appeared on webpages were excluded from extraction. Data were entered into a REDCap (Research Electronic Data Capture) form created for this project.(21) In instances of discrepancies between the two independent extractors, a third blinded extraction was conducted to arrive at a majority decision. Overall inter-rater reliability between the first two

independent extractors over all fields was very good with a kappa score = 0.81 (95% confidence interval=0.79-0.84).

Webpage Bias

We categorized bias for all webpages as critical or noncritical of HPV vaccine. Webpages that included content with a bias against vaccination were categorized as overall noncritical if they allotted roughly equal space or more to viewpoints supportive of vaccination.

Webpages that presented only evidence-based content without editorial comment regardless of the focus (e.g., vaccine side effects) were also categorized as noncritical.

Webpage Quality Score

Although there is no universally accepted standard for assessing the quality of online consumer health information,(22) the JAMA (Journal of the American Medical Association) benchmarks are often cited and were the basis for the present study's assessment of HPV webpage quality.(23) The JAMA benchmarks include assessment for disclosures of: *authorship*, *attribution* (references), *source* (website ownership), and *currency* (date of upload or last update). We supplemented the JAMA criteria with two additional metrics that we believed to be relevant from other quality rating scales.(24-26) The additional metrics were: *presentation format* (inclusion of testimonial accounts or not) and *readability*. To assess readability level, we used the Flesch-Kincaid Grade Level Score whose calculation is based on sentence length and number of syllables per word.(27) We calculated a cumulative quality score for each webpage by assigning one point for the presence of each of the following factors for a total possible score of 6: authorship disclosure, source disclosure (including contact information for the responsible person(s) or entity), attribution of 1 reference (with credit given for links to government webpages), currency within 12 months of the extraction date, exclusion of testimonial accounts, and readability level <9th grade. When source disclosure was not found on the saved webpage, the entire source website was searched at a later date.

Webpage Content Score

We selected topics to include in our webpage content score based on their prominence of mention in the HPV recommendations of the Advisory Committee on Immunization Practices.(1) One point was given for mention of each of the following topics for a total possible score of 14: HPV epidemiology, HPV transmission; non-vaccination-related HPV disease prevention; cervical cancer; other lower genital and anal cancer; head and neck cancer; genital warts; HPV vaccine uptake; recommended HPV vaccine recipients; recommended HPV vaccine dosing; how to get vaccinated; HPV vaccine costs; contraindications to HPV vaccine; and *mild or common side effects from HPV vaccine*. In addition, we separately assessed for mention of the following unsubstantiated concerns based on their relevance according to prior studies (3, 11): insufficient HPV vaccine safety research, HPV vaccine regulation corruption or civil liberty violations, alleged HPV vaccine-associated severe side effects or deaths, and HPV vaccination encouraging adolescent sexual activity.

Statistical Analysis

All analyses were performed using Stata, v11.2 (College Station, TX). Chi-square and Fisher exact tests were used to compare independent categorical variables and one-way ANOVA tests were used to compare independent continuous variables.

Results

Rank

The twenty search engine queries returned 175 webpages meeting inclusion criteria, 116 (66.3%) of which were unique. Ranking, tone, quality and content scores of the 116 unique webpages are included in an appendix. Of the 116 unique webpages returned, 39 (33.6%) were critical of HPV vaccine (Table 2). Only 11 unique webpages were returned in the top-ranking slot. Of these, 3 (27.3%) were critical of HPV vaccine. When considering all webpages listed at least once among the top five results, there were 65 unique webpages. Among webpages appearing in the top five results, almost a third were critical of HPV vaccine ($n=20$ [30.8%]).

Adding any of the modifiers to the root term, *HPV vaccine* increased the overall percentage of unique vaccine-critical webpages to 24.4% (11 of 45). Querying the root term, *Gardasil* yielded 2 (25.0%) vaccine-critical webpages whereas querying *Cervarix* and *HPV vaccine* yielded 0 and 1 (11.1%), respectively. In general, queries that included the root term *Gardasil* resulted in the highest ratio of vaccine-critical webpages (27 of 54 [50.0%]). Over half of the resultant webpages from the queries *Cervarix dangers* (5 of 7 [71.4%]), *Gardasil dangers* (5 of 8 [62.5%]), *Gardasil pros and cons* (6 of 10 [60.0%]), and *Gardasil risks* (6 of 10 [60.0%]) were critical of HPV vaccine.

Quality

The overall quality score for the 116 webpages ranged from 1 to 6 with an average of 2.9 ± 1.1 (mean (m) \pm standard deviation (sd)) (Table 3). Vaccine-critical webpages were of lower quality than noncritical webpages (2.5 ± 1.0 vs. 3.1 ± 1.1 , $p < .01$).

In terms of readability, webpages required viewers to have advanced reading skills—nearly at the 12th grade level (11.9 ± 3.0). Vaccine-critical webpages required reading levels above the 13th grade (13.3 ± 2.9), which was two grades higher than that required by noncritical webpages (11.2 ± 2.8 , $p < .01$).

While 14 of the 116 webpages cited five or more references, the majority (78 [67.2%]) cited none (overall $m \pm sd = 2.5 \pm 7.5$, median=0, interquartile range=0,1). The difference in mean number of references cited between vaccine-critical and noncritical webpages (0.9 ± 2.6 vs 3.4 ± 8.9) was not significant ($p = .09$). Over half of the webpages (67 [57.8%]) discussed supposed research findings related to HPV vaccine; however, only 28 (41.8%) of these included references. Of the webpages mentioning research findings but lacking references, we could find no difference in the percentages of webpages that were critical versus noncritical of HPV vaccine (48.7% vs 51.3%, $p = .10$).

Almost half of the webpages were missing an author byline (48, [41.4%]). This deficit was more commonplace among vaccine-critical webpages—only 9 (23.1%) critical webpages disclosed authorship which was less than half the percentage (39 [50.6%]) of noncritical webpages ($p<.01$). Amongst webpages that did include bylines, only 28 of 48 (57.4%) were written by authors with stated healthcare credentials such as a medical, nursing or pharmaceutical degree. This did not vary significantly by webpage bias ($p=0.19$).

Most pages listed the website source with contact information for the person or entity responsible for the content (90 [77.6%]). The proportion with adequate source disclosure did not differ between vaccine-critical and noncritical webpages ($p=0.12$). However, actual webpage source type did ($p<.01$). The most common source type for noncritical webpages was the press (20 of 77 [26.0%]). Although the press accounted for a nearly equal ratio of critical webpages (10 of 39 [25.6%]), the most common source type for critical webpages was blogs/forums (17 [43.6%]). Blogs and forums were overwhelmingly critical of HPV vaccine—nearly three quarters (17 of 23 [73.9%]) were against vaccination. Roughly a third of press webpages (10 of 30 [30.0%]) were also critical of HPV vaccine; whereas, this was the case for none of the academic, medical association, crowd-sourced or government agency webpages. Together, the press, for-profit health reference websites and blogs/forums accounted for nearly three quarters (79 [68.1%]) of all webpages returned and 87.2% of all vaccine-critical webpages.

In terms of currency, the majority of webpages listed the date on which they were created or updated (97 [83.6%]). The number of webpages that disclosed their date of creation or last update was not significantly different between vaccine-critical and noncritical webpages ($p=1$). Currency, when disclosed, ranged from May 5, 2008 to August 7, 2013—all subsequent to 2006, the year HPV vaccine was licensed in the United States. Some 68.1% (79 of 116) were created or updated after 2009, the year the vaccine was first recommended for males. Of the 95 sites with a posted date, half were not updated within 12 months of study data collection (49.5%)—this did not differ significantly between vaccine-critical and noncritical webpages ($p=0.8$).

Over a third of the webpages included testimonial accounts (45 [38.8%]). Testimonials were much more common among websites that were critical of HPV vaccine (28 of 39 [71.8%]) vs 17 of 77 [22.1%], $p<.001$). Testimonial accounts focused on: alleged severe side effects, doctors' rationale for recommending the vaccine, or expert commentary on vaccine-related study findings. Most webpages that included testimonials also presented expository messages although three (2.6%) were written exclusively as testimonial accounts, and all of these described unsubstantiated claims of severe HPV vaccination side effects.

Content

On average, webpages discussed slightly fewer than 6 of 14 important HPV vaccine-related topics (5.7 ± 3.4) (Table 3). Nearly 90% (104 of 116) of the webpages mentioned cervical cancer, but fewer than half discussed each of the other HPV-related diseases (Figure). Although roughly half discussed recommended HPV vaccine recipients (63 [54.3%]) and dosing intervals (53 [45.7%]), many fewer included other practical considerations such as how to get vaccinated (25 [21.6%]) or how much it costs (25 [21.6%]). Vaccine-critical

webpages covered fewer important HPV-related topics than noncritical pages on average (4.1 ± 2.8 vs 6.5 ± 3.4 , $p < .001$). Noncritical webpages were more likely than critical webpages to address: HPV transmission, head and neck cancer, non-cervical lower genital and anal cancer, genital warts, recommended vaccine recipients, dosing, mild side effects, and how to get HPV vaccination ($p < .05$). HPV vaccine-critical webpages were more likely to raise unfounded concerns about the insufficiency of HPV vaccine research, HPV vaccine regulation corruption or civil liberty violations, and alleged HPV vaccine-associated severe side effects or deaths ($p < .05$).

Discussion

HPV vaccine-critical webpages comprised roughly a third of the top, top 5 and top 10-ranking webpages in this study. The prevalence of HPV vaccine-critical webpages was higher for queries that used term modifiers and those that included the root term *Gardasil*. Overall, the quality of webpages was mediocre with HPV-vaccine critical webpages scoring lower than noncritical webpages. Webpages overall were not comprehensive in content coverage with over half mentioning six or fewer of fourteen important topic areas. Compared with noncritical webpages, HPV vaccine-critical webpages required viewers to have better reading skills, were less likely to include an author byline, and were more likely to include testimonial accounts. They also covered fewer important topics and were more likely to raise unsubstantiated concerns about vaccination.

Our results build on the previous research of Wolfe and Sharp who found that querying *vaccination* yielded a higher percentage of anti-vaccination webpages than *immunization*. (28) We found that in general, queries that included the brand name *Gardasil* were more often anti-vaccine than those that included the name *Cervarix*. Gardasil has an indication for males and therefore much greater uptake in the U.S. which may account for the higher prevalence of anti-vaccine sentiment for searches using this term. In our study, queries that included term modifiers resulted in a greater proportion of HPV vaccine-critical webpages than queries of root terms alone. As might be expected, we found that adding the modifiers *dangers*, *risks* or *side effects* to root terms increased the proportion of vaccine critical webpages. Perhaps less predictably, we also found that adding the more neutral-toned modifiers *pros and cons*, and *safety* did as well. Since longer queries are becoming more common (29) and 40.4% of all queries include three or more terms, (19) our inclusion of longer queries to identify webpages in this study may more accurately replicate typical user search patterns compared to studies that limit their queries to root terms.

One practical application of the finding that longer queries resulted in a greater percentage of low-quality webpages with a critical bias against vaccination is that parents can be alerted to this possibility. Simply warning people of the potential for bias has been shown to reduce the detrimental effect of anti-vaccine claims on online viewers' vaccine risk perceptions. (7) Better yet, given that a third of all webpages returned by our search strategy were critical of HPV vaccine and many of these were of low quality, parents seeking online information about HPV vaccine should be advised to navigate directly to a reputable webpage as recommended by the National Institutes of Health rather than begin with a search engine. (30) High quality, noncritical webpages that can be recommended to parents include pages

maintained by the Centers for Disease Control and Prevention (www.cdc.gov) and the Immunization Action Coalition (www.immunize.org). The appendix lists all webpages reviewed, their tone and quality score.

This is the first study of which we are aware to compare the quality of webpages with and without a critical bias against HPV vaccine. The finding that vaccine-critical webpages were of lower quality is concerning because other studies have suggested that exposure to anti-vaccine content online can have negative effects on vaccination beliefs without users being aware of content credibility.(31) A recent survey of low-income parents of children with special health care needs found that only half felt comfortable determining the quality of health websites.(32) According to the National Assessment of Adult Readability, only 12% of American adults are proficient in health literacy and 36% are at basic or below basic levels.(33) Thus, one cannot discount the potentially persuasive influence on public opinion of popular, low quality anti-vaccine webpages that promote compelling, but unsubstantiated messages.

Similar to previous studies, we found content coverage of HPV vaccine-related webpages to be deficient.(11-13) A recent content analysis of HPV vaccine information online by Madden, et al. found that 25.8% of webpages did not mention cervical cancer and 49.4% did not provide information on ways to obtain the vaccine.(11) In the present study, we found that only roughly half of the webpages described HPV epidemiology and transmission, and most did not describe non-vaccine-related disease prevention such as Pap testing. We also found that a third raised unsubstantiated concerns about the insufficiency of HPV vaccine research, HPV vaccine regulation corruption or civil liberty violations, and alleged HPV vaccine-associated severe side effects or deaths. The abundance of HPV vaccine concerns we found was greater than that found in the study by Madden, et al. in which only 12.4% of the webpages mentioned high risks of HPV vaccination, 2% conspiracy theories and 9% alleged civil liberties violations.(11) The dissimilarity in our findings may be due to differences in our search strategies. We intentionally selected a larger set of terms (20 vs 7), including ones connoting HPV vaccination uncertainty since parents who are undecided about vaccination may be most influenced by what they read online. Thus, our findings may be particularly relevant to information seekers with baseline hesitancy about HPV vaccine.

Our study is limited in that there are currently no data to inform us of the search terms used most often by health consumers seeking information about HPV vaccination online. While we attempted to ascertain this information through non-systematic methods, future research could survey parents stratifying them by their baseline level of vaccine hesitancy. Those who are more versus less hesitant may prefer different search terms, may differ in which resultant webpages they choose to view, and in how they react to the content. Additionally, we identified webpages exclusively using Google and cannot draw conclusions about webpages returned by other search engines. Nonetheless, since more Americans use Google than any other search engine (18, 19) and there is a high degree of overlap among search engine results for medical queries,(17) our results are likely applicable to most search engine users. Finally, as new vaccination recommendations, information or rumors emerge, an updated analyses of HPV vaccine webpage ranking, tone, quality, and content will be necessary.

Conclusion

For better or worse, the internet is a trusted and frequently consulted source of medical information with nearly 60% of American adults having looked for health information online in the past year.(16) Our study adds to the growing evidence that online consumer health information is often unreliable.(22) We have found that webpages critical of HPV vaccine may be frequently returned and highly ranked by search engine queries despite being of lower quality and less comprehensive than noncritical webpages. Given the prevalence of HPV infection and associated risk for cancer, promoting HPV vaccine uptake by increasing the amount of pro-vaccine content online as well as improving parental online health literacy are worthwhile endeavors for public health. Our results might be interpreted as a call-to-action for physicians and other vaccination champions to improve the quality of vaccine content online by contributing their expertise to press stories, forums and blogs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding source: This work was funded in part by the Eunice Kennedy Shriver National Institute of Child Health and Human Development grant #1K23HD068394-01A1 (L.Y.F. and L.B.). The funding agency had no role in the study design, collection, analysis or interpretation of data, writing of the article or decision to submit the manuscript for publication.

Abbreviations

HPV	Human papillomavirus
M ± SD	mean ± standard deviation

References

1. Markowitz LE, Dunne EF, Saraiya M, et al. Quadrivalent Human Papillomavirus Vaccine: Recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep. 2007; 56:1–24. [PubMed: 17380109]
2. Stokley S, Jeyarajah J, Yankey D, et al. Human papillomavirus vaccination coverage among adolescents, 2007–2013, and postlicensure vaccine safety monitoring, 2006–2014--United States. MMWR Morb Mortal Wkly Rep. 2014; 63:620–624. [PubMed: 25055185]
3. Kessels SJ, Marshall HS, Watson M, et al. Factors associated with HPV vaccine uptake in teenage girls: a systematic review. Vaccine. 2012; 30:3546–3556. [PubMed: 22480928]
4. Sheinfeld Gorin SN, Glenn BA, Perkins RB. The human papillomavirus (HPV) vaccine and cervical cancer: uptake and next steps. Adv Ther. 2011; 28:615–39. [PubMed: 21818672]
5. Nan X, Madden K. HPV vaccine information in the blogosphere: how positive and negative blogs influence vaccine-related risk perceptions, attitudes, and behavioral intentions. Health Commun. 27:829–36. [PubMed: 22452582]
6. Betsch C, Renkewitz F, Betsch T, Ulshofer C. The influence of vaccine-critical websites on perceiving vaccination risks. J Health Psychol. 2010; 15:446–55. [PubMed: 20348365]
7. Betsch C, Renkewitz F, Haase N. Effect of narrative reports about vaccine adverse events and bias-awareness disclaimers on vaccine decisions: a simulation of an online patient social network. Med Decis Making. 2013; 33:14–25. [PubMed: 22875721]

8. Hughes J, Cates JR, Liddon N, et al. Disparities in how parents are learning about the human papillomavirus vaccine. *Cancer Epidemiol Biomarkers Prev.* 2009; 18(2):363–372. [PubMed: 19190161]
9. Brunson EK. The impact of social networks on parents' vaccination decisions. *Pediatrics.* 2013; 131:e1397–404. [PubMed: 23589813]
10. Kata A. A postmodern Pandora's box: anti-vaccination misinformation on the Internet. *Vaccine.* 2010; 28(7):1709–16. [PubMed: 20045099]
11. Madden K, Nan X, Briones R, Waks L. Sorting through search results: a content analysis of HPV vaccine information online. *Vaccine.* 2012; 30:3741–3746. [PubMed: 22019758]
12. Habel MA, Liddon N, Stryker JE. The HPV vaccine: a content analysis of online news stories. *J Womens Health.* 2009; 18:401–407.
13. Tozzi AE, Buonomo PS, Ciofi degli Atti ML, et al. Comparison of quality of internet pages on human papillomavirus immunization in Italian and in English. *J Adolesc Health.* 2010; 46:83–9. [PubMed: 20123262]
14. Google Incorporated. [Accessed March 10, 2014] Where the trends data comes from. Available at: <https://support.google.com/trends/answer/4355213?hl=en>
15. Google Incorporated. [Accessed February 12, 2015] HPV vaccine. Available at: www.google.com/trends
16. Fox, S.; Duggan, M. [Accessed March 10, 2014] Health Online 2013. Pew Internet & American Life Project. Available at: www.pewinternet.org/Reports/2013/Health-online.aspx
17. Wang L, Wang J, Wang M, et al. Using Internet search engines to obtain medical information: a comparative study. *J Med Internet Res.* 2012; 14:e74. [PubMed: 22672889]
18. Purcell, K.; Brenner, J.; Rainie, L. [Accessed March 10, 2014] Search engine use 2012. Pew Internet & American Life Project. Available at: www.pewinternet.org/2012/03/09/search-engine-use-2012/
19. KeywordDiscovery.com. [Accessed February 12, 2014] Keyword and Search Engines Statistics. Jan 1. 2015 Available from: www.keyworddiscovery.com/keyword-stats.html
20. Eysenbach G, Köhler C. How do consumers search for and appraise health information on the world wide web? Qualitative study using focus groups, usability tests, and in-depth interviews. *BMJ.* 2002; 324:573–577. [PubMed: 11884321]
21. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)-a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009; 42:377–381. [PubMed: 18929686]
22. Fahy E, Hardikar R, Fox A, Mackay S. Quality of patient health information on the Internet: reviewing a complex and evolving landscape. *Australas Med J.* 2014; 7:24–8. [PubMed: 24567763]
23. Silberg WM, Lundberg GD, Musacchio RA. Assessing, controlling, and assuring the quality of medical information on the Internet: Caveant lector et viewor--Let the reader and viewer beware. *JAMA.* 1997; 277:1244–1245. [PubMed: 9103351]
24. Boyer C, Selby M, Scherrer JR, Appel RD. The Health On the Net Code of Conduct for medical and health Websites. *Comput Biol Med.* 1998; 28:603–610. [PubMed: 9861515]
25. National Institutes of Health. [Accessed March 10, 2014] MedlinePlus Guide to Healthy Web Surfing. Medline Plus. Available at: www.nlm.nih.gov/medlineplus/healthywebsurfing.html Updated April 18, 2012
26. Global Advisory Committee on Vaccine Safety. Good information practices for vaccine safety web sites. World Health Organization; Available at: www.who.int/vaccine_safety/good_vs_sites/en [Accessed March 10, 2014]
27. Flesch R. A new readability yardstick. *J Appl Psychol.* 1948; 32:221–233. [PubMed: 18867058]
28. Wolfe RM, Sharp LK. Vaccination or immunization? The impact of search terms on the internet. *J Health Commun.* 2005; 10:537–551. [PubMed: 16203632]
29. Tatham, M. Google Received 72 Percent of U.S. Searches in January 2009; Yahoo! Search and Ask.com up from December; Search queries are increasing in length. Hitwise An Experian Company; Available at: http://image.exct.net/lib/fe7c1774726706/d/1/SearchEngines_Jan09.pdf [Accessed February 12, 2014]

30. Zerhouni, EA. [Accessed June 3, 2015] Surfing the web for health information: NIH Medline Plus; Spring. 2007. Available at: <http://www.nlm.nih.gov/medlineplus/magazine/issues/spring07/articles/spring07pg2.html>
31. Allam A, Schulz PJ, Nakamoto K. The impact of search engine selection and sorting criteria on vaccination beliefs and attitudes: two experiments manipulating Google output. *J. Med Internet Res.* 2014; 16:e100. [PubMed: 24694866]
32. Knapp C, Madden V, Wang H, et al. Internet use and eHealth literacy of low-income parents whose children have special health care needs. *J Med Internet Res.* 2011; 13:e75. [PubMed: 21960017]
33. Kutner, M.; Greenberg, E.; Jin, Y.; Paulsen, C. The Health Literacy of America's Adults: Results From the 2003 National Assessment of Adult Literacy. U.S. Department of Education, National Center for Education Statistics; Sep 6. 2006 Available at: nces.ed.gov/pubs2006/2006483.pdf [Accessed on March 10, 2014]

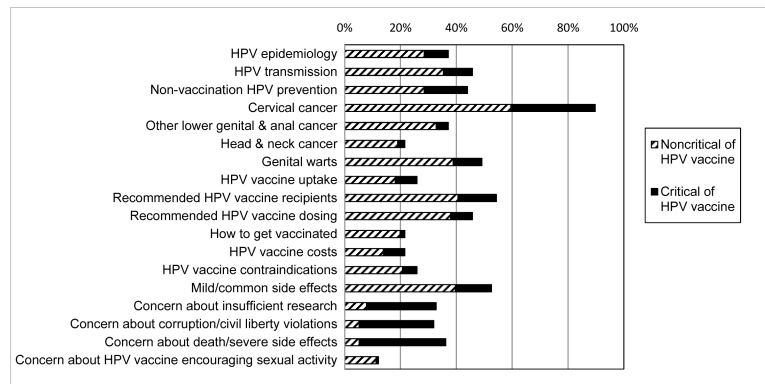


Figure.
Percentage of webpages mentioning various HPV-vaccine related topic areas

Table 1

Terms entered into search engine to identify HPV vaccine-related webpages

Search term
HPV vaccine
HPV vaccine dangers
HPV vaccine pros and cons
HPV vaccine risks
HPV vaccine safety
HPV vaccine side effects
Cervarix
Cervarix dangers
Cervarix pros and cons
Cervarix risks
Cervarix safety
Cervarix side effects
Gardasil
Gardasil dangers
Gardasil pros and cons
Gardasil risks
Gardasil safety
Gardasil side effects
Cervical cancer vaccine
Human papillomavirus vaccine

Table 2

Ratio of unique HPV vaccine-critical webpages to all webpages returned by each search query

Search query	Critical webpage was top ranked result	Critical webpages among top 5 results ^a n/N, %	Critical webpages among top 10 results ^b n/N, %
HPV vaccine	no	0/5, 0%	1/9, 11.1%
HPV vaccine dangers	yes	2/5, 40%	3/9, 33.3%
HPV vaccine pros and cons	no	0/5, 0%	0/6, 0%
HPV vaccine risks	yes	2/5, 40%	3/10, 30%
HPV vaccine safety	no	1/5, 20%	2/10, 20%
HPV vaccine side effects	no	2/5, 40%	3/10, 30%
Cervarix	no	0/5, 0%	0/7, 0%
Cervarix dangers	no	3/4, 75%	5/7, 71.4%
Cervarix pros and cons	no	0/5, 0%	1/7, 14.3
Cervarix risks	no	1/5, 20%	2/8, 22.2
Cervarix safety	no	0/5, 0%	1/8, 12.5%
Cervarix side effects	no	2/5, 40%	3/7, 42.9%
Gardasil	no	2/5, 40%	2/8, 25.0%
Gardasil dangers	yes	2/5, 40%	5/8, 62.5%
Gardasil pros and cons	no	3/5, 60%	6/10, 60%
Gardasil risks	no	2/5, 40%	6/10, 60%
Gardasil safety	no	1/5, 20%	4/9, 44.4%
Gardasil side effects	no	1/5, 20%	4/9, 44.4%
Cervical cancer vaccine	no	0/5, 0%	1/9, 11.1%
Human papillomavirus vaccine	no	0/5, 0%	1/9, 11.1%
All queries	3/11 ^c, 27.3%	20/65 ^c, 30.8%	39/116 ^c, 33.6%

^a Total N for each query is less than 5 if the same webpage was returned more than once among the top 5 results.

^b Total N for each query is less than 10 if the same webpage was returned more than once among the top 10 results or if fewer than 10 webpages appeared on the first page of results.

^c Counts include webpages only once even when they are returned by multiple search queries.

Table 3

Webpage characteristics and quality

	Overall (N=116)	Critical biased webpages (N=39)	Noncritical biased webpages (N=77)	p value
Overall quality score (m±sd) ^a	2.9±1.1	2.5±1.0	3.1±1.1	<0.01
Readability level (m±sd)	11.9 ±3.0	13.3±2.9	11.2±2.8	<0.01
Number of references (m±sd)	2.5 ±7.5	0.9±2.6	3.4±8.9	0.09
Author disclosed, n (%)	68 (58.6)	9 (23.1)	39 (50.6)	0.01
Contact information included, n (%)	90 (77.6)	27 (69.2)	63 (81.8)	0.12
Source disclosed n (%)	90 (77.6)	27 (69.2)	63 (81.8)	0.12
Source type				0.01
Press	30 (25.9)	10 (25.6)	20 (26.0)	
For-profit health reference	26 (22.4)	7 (17.9)	19 (24.7)	
Blog/forum	23 (19.8)	17 (43.6)	6 (7.8)	
Government	16 (13.8)	0	16 (20.8)	
Non-profit	4 (3.4)	1 (2.6)	3 (3.9)	
Crowd-sourced	3 (2.6)	0	3 (3.9)	
Academic	3 (2.6)	0	3 (3.9)	
Medical association	2 (1.7)	0	2 (2.6)	
Other	9 (7.8)	4 (10.3)	5 (6.5)	
Current within 12 mos, n (%)	47 (40.5)	15 (38.5)	32 (41.6)	0.8
Testimonials excluded, n (%)	71 (61.2)	11 (28.2)	60 (77.9)	<0.001
Content score (m±sd) ^a	5.7±3.4	4.1±2.8	6.5±3.4	<0.001

^aMaximum score of 6 possible^bMaximum score of 14 possible