Misinformation and other elements in HPV vaccine tweets: An experimental comparison.

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Abstract

Our study examined how misinformation and other elements of social media messages affect antecedents to human papillomavirus (HPV) vaccination of adolescents. In 2017–2018, we randomly assigned a national sample of 1,206 U.S. parents of adolescents to view one tweet using a 2×2×2×2 between-subjects factorial experiment. The 16 experimental tweets varied four messaging elements: misinformation (misinformation or not), source (person or organization), narrative style (storytelling or scientific data), and topic (effectiveness or safety). Parents reported their motivation to vaccinate (primary outcome), trust in social media content, and perceived risk about HPV-related diseases. Tweets without misinformation elicited higher HPV vaccine motivation than tweets with misinformation (25% vs. 5%, OR=6.60, 95% CI:4.05, 10.75). Motivation was higher for tweets from organizations versus persons (20% vs. 10%, OR=2.47, 95% CI:1.52, 4.03) and about effectiveness versus safety (20% vs. 10%, OR=2.03, 95% CI:1.24, 3.30). Tweets with misinformation produced lower trust and higher perceived risk (both $p<.01$), with impact varying depending on source and topic. In conclusion, misinformation was the most potent social media messaging element. It may undermine progress in HPV vaccination.

Keywords

INTRODUCTION

The human papillomavirus (HPV) vaccine prevents persistent HPV infections that cause six cancers and genital warts (Senkomago et al., 2019). U.S. recommendations are for routine HPV vaccination starting at age 11 or 12 (Meites et al., 2016). However, by 2019, only 54% of 13- to 17-year old boys and girls were up to date on the multi-dose series (Elam-Evans et al., 2020). This coverage is far lower than that of two other vaccines recommended for adolescents (Elam-Evans et al., 2020) and the national Healthy People goal of 80% (Healthy People 2020). In addition to low-quality provider recommendations (Gilkey et al., 2017; Newman et al., 2018) parents' vaccine hesitancy is a barrier to timely vaccination (Salmon et al., 2015). Recent studies have highlighted the role of social media in the spread of vaccine misinformation, which may fuel vaccine hesitancy (Getman et al., 2018; Teoh, 2019).

Public health leaders are increasingly concerned about the potential for misinformation on social media to adversely affect HPV vaccination coverage. In the US, 72% of adults use one or more social media platforms (e.g., Facebook or Twitter) (Pew Research Center, 2019) and for many users, social media is an important source for information about health topics including HPV vaccination (Faasse et al., 2016). While most parents rely on medical information found through their own internet searches to make vaccination decisions for their children, they use social media to exchange information and discuss their perspectives including on HPV vaccination (Getman et al., 2018). Most studies of social media content show some type of misinformation (Teoh, 2019) (defined as "false or inaccurate information regardless of intentional authorship" (Southwell et al., 2019)) such as unverified reports of serious adverse events supposedly caused by HPV vaccine. The potential impact of exposure to such misinformation is concerning. An ecological study mapping information exposure on Twitter to state-level HPV vaccination data found that vaccination coverage was lower in U.S. states where safety concerns, misinformation, and conspiracies made up a higher proportion of tweets (Dunn et al., 2017). Our recent study of U.S. parents of adolescents also found that exposure to stories about vaccination harms may be more strongly associated with HPV vaccination non-adherence (e.g., decreased initiation, increased delay, and increased refusal) than positive stories about HPV vaccine preventable diseases (Margolis et al., 2019).

Vaccine-hesitant parents are usually more active in seeking vaccination information online than vaccine-motivated parents (Jones et al., 2012). The former may also be more susceptible to misinformation because people seek out information that reinforces their pre-existing beliefs (Getman et al., 2018). Many studies have analyzed social media content by sentiment, whether information was pro-vaccine or anti-vaccine (Faase et al., 2016; Ekram et al., 2019; Massey et al., 2016), but characterizing social media only by sentiment oversimplifies the structure of social media communication. Content analyses of the text in

Twitter posts (Dunn et al., 2017; Massey et al., 2016; Keim-Malpass et al., 2017) have shown varying representation of *misinformation* (communication of misinformation or not), *sources* (organizations or individuals), *narrative styles* (stories or scientific facts), and *topics* (safety or effectiveness). Of note, pro-vaccine tweets have tended to include more research-backed information and statistics, and focused on the efficacy of the vaccine to prevent HPV-related diseases (Massey et al., 2016; Kang et al., 2017). Pro-vaccine tweets have also been more likely to originate from organizations like professional associations and health institutions (Keim-Malpass et al., 2017). On the other hand, anti-vaccine tweets have tended to focus on safety concerns and misinformation and used anecdotes as evidence of HPV vaccine causing harms to individuals (Massey et al., 2016; Kang et al., 2017; Broniatowski., 2018).

HPV vaccination content posted on social media, especially Twitter, has the potential to affect vaccine uptake by influencing parents' perceptions and attitudes (Dunn et al., 2017). However, studies have not yet examined the effect of multiple critical messaging elements of social media, especially exposure to HPV vaccine misinformation. To fill this gap in the literature, we conducted an experimental comparison of four tweet messaging elements with a national sample of parents of adolescents who had not yet fully completed the HPV vaccine series. The aim of our study was to assess the impact of exposure to messaging elements (i.e., misinformation, source, narrative style, topic). The outcomes of interest were parents' motivation to get HPV vaccine (primary) as well as trust in tweet's content and perceived risk of HPV-related diseases (secondary). We also assessed the respective interaction of messaging elements in influencing these three antecedents to vaccination (i.e., motivation, trust, and risk).

METHODS

Participants.

Study participants were members of an existing, national panel of non-institutionalized U.S. adults maintained by a survey research company. The panel comprises 55,000 members who were recruited through address-based sampling. The panel's recruitment approach also incorporated geographic stratification to oversample minority groups (e.g., Hispanics). The broad set of geodemographic characteristics accounted in the development and maintenance of the panel makes it to properly represent the U.S. adult population. For our survey, eligible participants were parents of at least one 9- to 17-year-old child who either had not initiated the HPV vaccine series or had received only the first dose. Parents with more than one eligible child responded to survey items about the child with the most recent birthday. From November 2017 to January 2018, the survey company invited a random sample of 2,857 parents from the panel via email. Among those panel members, 1,834 responded by visiting the survey website and accessing the screener to confirm the age and HPV vaccination status of their child. Of these respondents, 1,313 met eligibility criteria, provided informed consent, and completed some portion of the survey. After excluding 50 respondents who did not complete at least two-thirds of the survey, our surveyed sample consisted of 1,263 parents. The survey response rate was 61%, calculated using the American Association for Public Research Response Rate Four (AAPOR, 2015). For the present study, we excluded 57

parents who did not provide responses on the outcome variables. Our final analytic sample had 1,206 parents. Survey non-responders and excluded parents did not differ from this study's sample on any demographic characteristics presented in Table 1 (χ^2 and t-tests all $p>.05$). Eighty-five percent of the study sample (n=1,026) used social media (e.g., Twitter, Facebook, Instagram, Reddit, YouTube); social media use was not a requirement for participation.

Procedures.

We randomly assigned parents to view one tweet about HPV vaccine (Table 2) as part of a 2×2×2×2 between-subjects factorial experiment. The first factor was *misinformation*, whether the tweet communicated misinformation or not. The second factor, *source*, manipulated whether the tweet originated from a person or an organization. The third factor was *narrative style*, whether the tweet communicated information through storytelling (e.g., personal stories, anecdotes) or scientific data (e.g., statistics). The fourth factor, *topic*, manipulated whether the tweet communicated information about the effectiveness of HPV vaccine in preventing diseases or the safety profile of HPV vaccine.

We developed the content of our sixteen experimental tweets from real tweets posted in June and July 2017. We modified the content of tweets to match the four experimental factors while attending popular themes present at the time. We also revised the wording of tweets to have readability scores appropriate for the general public. Readability was calculated by averaging five widely-used measures for assessing reading grade level in written communication. The median reading level of tweets was grade 7, and ranged from grade 5–9. For the purpose of our experiment, we developed fictional characters for both persons and organizations (source), except for the American Cancer Society (ACS) and the Centers for Diseases Prevention and Control (CDC). Tweets from persons displayed a common female name (Sarah Wilson) and headshot showing a neutral facial expression (stock image purchased online). Experimental tweets from ACS and CDC displayed the name and logo of both organizations as showed in their official Twitter accounts. Tweets from other organizations displayed a fictional name (Voices Against Vaccines or Vaccine Freedom Alliance) and a stock image of the prohibition sign (red circle with a red diagonal line through it) enclosing a syringe, commonly used in the anti-vaccine movement. Consistent with the definition of health misinformation (Southwell et al., 2019), tweets showing misinformation comprised a range of content, including false claims that contradict evidence (Table 2; tweets 6, 7, 8, 15, 16), inaccurate content like exaggerations (tweet 5), and misleading content that omitted information to fully appraise the claim (tweets 13, 14). Finally, as over three-fourths of real tweets regarding HPV vaccination include one or more hashtags, we incorporated two of the most used in Twitter, #HPV and #vaccine (Massey et al., 2016), in all experimental tweets.

The survey introduced tweets to parents with the prompt, "People and organizations use Twitter to share information about HPV vaccine. We'd like to understand how tweets about the vaccine might affect parents. Here is an example of a recent tweet." After reading this prompt, parents were presented with one out of 16 randomly assigned tweets. The sample size of each tweet ranged from 72 to 78 parents.

Measures.

We used perceived message effectiveness measures to assess the impact of the tweets as this construct is reactive to messaging over a brief exposure (Noar et al., 2018). After viewing the tweet, the survey assessed parents' *motivation* to get HPV vaccine with the item "Does this tweet make you…" with response options dichotomized as motivated ("somewhat more willing to get the HPV vaccine for your child" and "much more") versus not motivated ("much less," "somewhat less," and "neither more or less"). The survey also assessed parents' *trust* in the tweet with the question "How much do you trust this tweet?" The 5-point response scale was dichotomized as trust ("completely," "quite a lot," "moderate amount," and "a little") versus no trust ("not at all"). The survey also assessed parent's *perceived risk* about HPV-related diseases with the item "Does this tweet make you…" with responses dichotomized as high perceived risk ("much more concerned about diseases prevented by the HPV vaccine" and "somewhat more") versus low perceived risk ("much less," "somewhat less," and "neither more or less"). The survey company provided parents' demographic characteristics including sex, age, race and ethnicity, and education. For demographic and health characteristics for the parent's index child (reported by the parent), the survey assessed sex, age, and HPV vaccination status ("0 doses" or "1 dose").

We cognitively tested the survey instrument with a convenience sample of 16 parents of adolescents ages 9 to 17 to ensure participants understood the items as we intended. We pre-tested the instrument with 31 parents from the national panel to ensure proper survey functionality. The full survey instrument, including experimental tweets, is available online at http://noelbrewer.web.unc.edu/hpv/

Data analysis plan.

To check whether randomization created demographically equivalent groups for each of the four experimental factors, we used chi-square tests and *t*-tests. Random assignment successfully created groups that did not differ on those demographic characteristics summarized in Table 1 (all $p > .05$). We evaluated the bivariate relationships between the 4 messaging elements (misinformation, source, narrative style, and topic) and the 3 outcome variables (motivation to vaccinate, trust, and perceived risk) to report their proportions. Separately for each outcome, full logistic regression models assessed the impact of the four factors, and their respective interactions, on motivation to vaccinate, trust and perceived risk. Analyses that treated the outcomes as dichotomous and trichotomous variables showed the same pattern of statistical significance and direction in almost all full model results, with the exception of an interaction for trust (misinformation × source × topic) and perceived risk (source × topic × narrative style) and a main effect for motivation (topic) that no longer met the significance criterion when these outcomes were treated as trichotomous (Supplemental Table 1). All analyses were conducted using SAS version 9.4 and tests were 2-sided. Given the large sample and multiple tests, we adopted a critical alpha of 0.01.

RESULTS

Motivation to vaccinate.

Tweets without misinformation elicited higher parent motivation to get HPV vaccine for their children compared to tweets conveying misinformation (25% vs. 5%, OR=6.60; 95% CI: 4.05, 10.75; Table 3). Similarly, tweets from an organization elicited higher HPV vaccine motivation than those from a person (20% vs. 10%, OR=2.47; 95% CI: 1.52, 4.03). Finally, tweets about effectiveness elicited higher HPV vaccine motivation than those about safety (20% vs. 10%, OR=2.03; 95% CI: 1.24, 3.30). Narrative style did not affect HPV vaccine motivation. No interactions were statistically significant for this outcome (Table 4).

Trust in the tweet content.

Tweets without misinformation elicited more trust in the message content than tweets conveying misinformation (p<.01; Supplemental Table 2). Misinformation showed complex interactions with source and topic (Table 4). The reason for the interactions was that tweets from individuals about safety led to lower trust if they were without misinformation compared to tweets containing misinformation (59% vs. 40%, OR=0.45; 95% CI: 0.28, 0.72; Table 5). Under all other combinations of source and topic, misinformation undermined trust. In addition, source, narrative style, and topic all interacted such that reported trust in the message was higher when an organization shared vaccine effectiveness data compared when a person did so (60% vs. 36%; OR=2.70, 95%: 1.68, 4.33). Other combinations yielded middling levels of trust.

Perceived risk about HPV diseases.

Tweets without misinformation led to lower perceived risk of harm from HPV diseases than tweets conveying misinformation (26% vs. 20%, p<.01; Supplemental Table 2). Due to interactions with source and topic (Table 4), tweets without misinformation were especially ineffective at yielding higher perceived risk when they came from people and were about vaccine safety (Table 5). Tweets with a story elicited higher perceived risk than those with data (29% vs 18%, p<.01; Supplemental Table 2), and tweets about effectiveness elicited higher perceived risk of HPV diseases than those about safety (27% vs 19%, p<.01). Source, narrative style, and topic all interacted as they did for trust, but the pattern of findings was less clear cut. Vaccine safety stories elicited higher perceived risk when from an organization than from a person (26% vs 16%; OR=3.09, 95% CI: 1.34, 7.11, Table 5), and the same was true for vaccine effectiveness data tweets (24% vs 13%; OR=2.18, 95% CI: 1.18, 4.02).

DISCUSSION

Social media spreads misinformation on vaccination, but little is known about how the elements of social media messages affect parents' motivation to get HPV vaccine. In an experiment with a national sample of US parents of adolescents due for HPV vaccination, misinformation was the most potent social media messaging element. Tweets without misinformation elicited higher motivation to vaccinate than tweets with misinformation. Motivation was also higher for tweets from organizations versus persons and about

effectiveness versus safety. Misinformation also affected parents' trust and perceived risk but its impact varied depending on the presence of other messaging elements.

Our main finding was that misinformation led to lower vaccine motivation. The finding is especially important as recent research has shown that bots and Russian trolls have spread correct and incorrect information about vaccines on Twitter to create social polarization (Broniatowski et al., 2018). This finding echoes those from another study with 341 young men and women who were randomized to a negative blog post about HPV vaccine, a positive one comparable in length and visual aspects, or control (Nan & Madden, 2012). Compared to the control group, reading the positive blog did not alter HPV vaccine intentions but those who read the negative blog expressed reduced intentions to get HPV vaccine. Thus, vaccine misinformation may be uniquely damaging. In that study, the positive blog focused on statistical summaries of vaccine effectiveness and safety while the negative blog discussed the same two topics using personal stories, confounding misinformation and narrative style. Our factorial design took into account the narrative style of tweets, and we found that misinformation but not narrative style affected motivation.

Tweets about effectiveness led to higher motivation than tweets about safety. Many studies that have looked at HPV vaccine acceptance indicate that perceived vaccine effectiveness and safety are important considerations for parents (Gidengil et al., 2019). Consistent with that, national data show that the proportion of parents reporting safety concerns as their main reason for not getting HPV vaccination have decreased over the years to a low 11%, while the proportion of parents who intend to get the vaccine for their children has increased (Hanson et al., 2018). Although effectiveness and safety are common topics in Twitter regarding HPV vaccination (Massey et al., 2016; Keim-Malpass et al., 2017), other topics are also prevalent in social media. On Reddit, for example, the most frequently discussed HPV vaccination topic was political (e.g., parental vaccine rights, governments' powers to mandate vaccination, sexual education policy, politicians' views on vaccines) (Lama et al., 2019). Future studies should assess the impact of being exposed to HPV vaccination topics beyond effectiveness and safety, including contemporary sociopolitical issues.

Tweets from organizations led to higher motivation that persons. This finding is not surprising as familiarity and recognition are important factors in the credibility of spokespersons and organizations (Cartmell et al., 2019). Our findings may be due to several experimental tweets being from two nationally recognized organizations supporting HPV vaccination (ACS and CDC), while other tweets presented fictional characters for both persons and organizations. Importantly, the tweets showing individual persons were strangers to the survey respondent, so we do not know whether a tweet from a known person (e.g., friend, relative, influencer) influences differently compared to our experimental tweets. Although anti-vaccination websites and social media accounts are often operated by individual activists, including a handful of celebrities, a growing number of well-organized and well-funded groups are now leading that movement (The New York Times, 2019). With recent polls showing that many Americans are skeptical about scientists (Pew Research Center, 2019) and only 36% said they have "a great deal" or "quite a lot" of confidence in medical institutions (Gallup, 2019), it is important to ensure public confidence in scientific and medical organizations, especially around vaccination issues. Information about HPV

vaccination needs to come from reputable and trustworthy sources to be most effective (Cartmell et al., 2019).

Our findings suggest asymmetries, with personal stories about harm carrying special weight in undermining trust and altering perceived risk. As noted in prior research, anti-vaccine content online typically present stories or narratives, mostly about adverse events, to evoke people's emotions (Guidry et al., 2015). In contrast, pro-vaccine information is often unemotional statistical summaries or scientific facts. Importantly, people with low numeracy find stories to be more informative than statistical information (Bruine de Bruin et al., 2017). HPV vaccination campaigns may need to integrate more personal stories to enhance vaccine communication effectiveness (Faasse et al., 2016), particularly to reach those individuals who may be more vulnerable to misinformation tactics. Several national organizations including the CDC, the National HPV Vaccination Roundtable, and cancer patient advocacy groups like Cervivor have all started doing more of this to promote HPV vaccination.

Tweets with misinformation also produced lower trust, with impact varying depending on source and topic. In this context, health care providers' role in HPV vaccine communication is more important than ever. Parents who lack a strong provider recommendation for HPV vaccination or do not get their questions answered during clinic visits, may turn to online resources for advice, which may be filled with misinformation. Browsing websites with vaccine misinformation, even for a short time (10 minutes), increase viewers' perceptions of the risk of vaccinating and decrease their intentions to vaccinate (Betsch et al., 2010). When communicating with parents, healthcare providers should use presumptive announcements to clearly recommend HPV vaccination and research-tested messages to address common concerns (Shah et al., 2019). Additionally, providers, through their professional associations, can advocate for system strategies to stop the dangerous spread of vaccine misinformation online. Recently, the American Academy of Pediatrics urged major technology companies to combat vaccine misinformation; many social media platforms have been working diligently on that direction. For example, Twitter now shows the following banner when users search for vaccine-related posts or accounts: "Know the facts. To make sure you get the best information on vaccinations, resources are available from the U.S. Department of Health & Human Services" (the banner also includes a link to the agency's website and Twitter account). Other platforms are no longer allowing anti-vaccine advertising (e.g., YouTube) or have reduced the rankings of groups and pages conveying vaccine misinformation (e.g., Facebook). Equally important, healthcare providers, public health practitioners, and scientists should be involved in the development and implementation of interventions aimed at enhancing people's e-health literacy skills to correctly identify and deal with vaccine misinformation online (Chou et al., 2018).

Strengths and Limitations

Strengths of the experiment include a relatively large, national sample and good response rate. Another strength was the use of tweets content that is likely to be common in Twitter as they were developed from real tweets. The experiment was strengthened by showing participants tweets that were comparable in length, reading grade level, and visual aspects (e.g., text only, similar hashtags); however, matching content (message wording) was not

feasible or practical for every combination of experimental tweets. The experiment also had other limitations. Our experiment focused on tweets, and so the generalizability of our results remains to be established for other social media platforms. Content analyses of HPV vaccine-related posts in Pinterest, Reddit, and YouTube suggest varying patterns of messaging elements that may reflect distinctive communication preferences and vaccine attitudes of their users (Ekram et al., 2019; Lama et al., 2019; Guidry et al., 2015). Similarly, social media vary in the way posts appear. In our study, we showed text-only tweets but accompanying text with videos or pictures is common in Twitter. The use of such imagery may have even larger effects than our experimental tweets. Our experiment measured messaging elements' effects immediately after exposure. The long-term impact of exposure to our experimental tweets, especially subsequent HPV vaccine uptake, was not assessed in the study. In addition, we did not collect baseline data regarding the outcomes of interests; future studies could expand this work by assessing changes pre-/post-message exposure on messaging elements and key psychosocial factors associated with HPV vaccination communication. Also, our findings resulted from a single exposure to one tweet, which may differ greatly from the cumulative effect of HPV vaccine information posted online from multiple people in one's social network, including the effect of being exposed to conflicting information. Our sample was also limited to parents of children who had not yet completed the HPV vaccine series, a priority population for HPV vaccination efforts; however, the generalizability of the findings to parents of fully vaccinated children remains to be established. Future research may seek to expand our study by manipulating other messaging elements in "live" experiments; for example, comparing text only versus visual communication and assessing the impact of varying the number of likes and shares on source credibility. Additionally, research is needed to understand the effects of varying forms of misinformation (e.g., false stories, exaggerations, omissions) and misinformation correction on HPV vaccination.

Conclusions

Our findings provides critical insight about the effects of four common elements of social media messages on parents' motivation to get HPV vaccine for their children. We found that motivation was higher for tweets showing no misinformation versus misinformation, from organizations versus persons, and about effectiveness versus safety. These findings highlight the need for implementing multipronged strategies for disseminating accurate vaccine information to the public in order to encourage positive HPV vaccine behaviors. Effective communication from healthcare providers is necessary as they interact with parents who may have been exposed to misinformation from social media. It is important for social media platforms to continue to implement mechanisms for assessing the accuracy of vaccine content posted online and prevent the spread of misinformation. Finally, interventions to improve people's e-health literacy and efforts to increase confidence in the scientific and medical communities are also urgently needed. Professional associations and public health agencies play an important role in these efforts by fostering public trust in HPV vaccination and evidence, and disseminating straightforward information in social media.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding

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Table 1.

Participant characteristics (N=1,206): United States, 2017–2018

	N	(%)
Parent		
Sex		
Female	647	(54)
Male	559	(46)
Age, y, mean (SD)	42.8	(8.1)
Race/ethnicity		
Non-Hispanic white	850	(71)
Non-Hispanic black	113	(9)
Non-Hispanic multiracial/other	77	(6)
Hispanic	166	(14)
Education		
High school or less	327	(27)
Some college or more	879	(73)
Child		
Sex		
Female	578	(48)
Male	628	(52)
Age, y, mean (SD)	12.5	(2.7)
HPV vaccination status		
No doses [1]	865	(72)
Initiated (1 dose only)	341	(28)

Note.

[1] Include parents who didn't know vaccination status.

Table 2.

Wording and characteristics of experimental tweets

Tweet	Wording	Characteristics					
		M	**S**	**N**	**T**	**C**	**R**
1	My daughter Isabella, 11, got the #HPV #vaccine yesterday. Nothing happened, the vaccine is very safe. Happy mom!	N	I	S	S	113	6
2	Mom of 2 boys: I got the #HPV #vaccine for my kids. It's the safest choice against HPV infections and cancer.	N	O	S	S	109	5
3	My spouse Robert died from a cancer that could have been prevented. Protect your children, get them the #HPV #vaccine.	N	I	S	E	118	6
4	Cancer survivor: I wish the #HPV #vaccine had been available when I was younger. It could have prevented the cancer that's killing me.	N	O	S	E	134	8
5	My daughter Isabella, 11, got the #HPV #vaccine yesterday. She's having horrible side effects. I feel so guilty.	Y	I	S	S	112	7
6	Mom of paralyzed boy: Tim was left in wheelchair after #HPV #vaccine. Vaccines were nothing but poison for my family.	Y	O	S	S	117	7
7	I developed cervical cancer after getting the #HPV #vaccine. I suffer the adverse reactions of this vaccine every day.	Y	I	S	E	118	9
8	Sad that it takes losing a loved one to see the dangers & lies of #HPV #vaccine. The only effective vaccine is the one not given.	Y	O	S	E	129	5
9	More than 80 million doses of the #HPV #vaccine have been given in the US. The vaccine is very safe.	N	I	F	S	100	5
10	Studies show #HPV #vaccine is not linked to autoimmune problems.	N	O	F	S	64	9
11	Studies show #HPV #vaccine reduces oral HPV that cause head & neck cancers.	N	I	F	E	75	6
12	#HPV #vaccine could prevent over 30,000 HPV–related cancers every year in the US.	N	O	F	E	81	8
13	Physicians in the US have reported more than 31,000 adverse events after giving the #HPV #vaccine. Very unsafe vaccine.	Y	I	F	S	119	7
14	National Vaccine Injury Compensation Program awarded $5,877,710 to 49 victims in claims against the #HPV #vaccine.	Y	O	F	S	114	10
15	#HPV #vaccine is not approved to protect against head & neck cancers. No clinical data exist.	Y	I	F	E	93	6
16	#HPV #vaccine scientist: There is no data showing the vaccine remains effective beyond 5 years.	Y	O	F	E	95	9

M, misinformation (N, no or Y, yes); S, source (O, organization or I, individual); N, narrative style (S, stories or F, scientific facts); T, topic (S, safety or E, effectiveness); C, character count with spaces; R, reading level.

Reading level was computed using a score for the five most used readability indicators (Flesch Kincaid, Gunning Fog, Coleman Liau, ARI and SMOG).

Table 3.

Main effects of tweet elements on motivation to get HPV vaccine: United States, 2017–2018

Tweet element	Parents who were more willing to get HPV vaccine after viewing tweet[1]/total in condition	(%)	OR (95% CI)
Misinformation			
Yes	33/605	(5)	Ref
No	151/601	(25)	6.60 (4.05, 10.75)[*]
Source			
Person	61/598	(10)	Ref
Organization	123/608	(20)	2.47 (1.52, 4.03)[*]
Narrative style			
Data	85/604	(14)	Ref
Story	99/602	(16)	0.93 (0.57, 1.52)
Topic			
Safety	60/600	(10)	Ref
Effectiveness	124/606	(20)	2.03 (1.24, 3.30)[*]

Note. Findings are from a full factorial model that included all main effects and interactions (see Table 4). OR = Odds ratio; CI = confidence interval; Ref = Reference group.

[1] Motivation was dichotomized by combining "somewhat more willing to get the HPV vaccine for your child" and "much more" (motivation=1) versus "much less," "somewhat less" and "neither more or less" (motivation=0).

[*] p<.01

Table 4.

Full model results for motivation, trust, and perceived risk: United States, 2017–2018

Tweet element	Motivation to get HPV vaccine[1]	Trust in tweet content[2]	Perceived risk of HPV-related diseases[3]
	p	*p*	*p*
Misinformation	<0.01	<0.01	<0.01
Source	<0.01	0.03	<0.01
Narrative style	0.77	0.05	<0.01
Topic	<0.01	0.61	<0.01
Misinformation × Source	0.91	<0.01	<0.01
Misinformation × Narrative style	0.15	0.19	0.88
Misinformation × Topic	0.27	<0.01	<0.01
Source × Narrative style	0.69	0.03	0.20
Source × Topic	0.15	0.20	0.77
Narrative style × Topic	0.73	0.30	0.02
Misinformation × Source × Narrative style	0.35	0.29	0.40
Misinformation × Source × Topic	0.08	<0.01	0.15
Misinformation × Narrative style × Topic	0.87	0.25	0.78
Source × Narrative style × Topic	0.54	<0.01	<0.01
Misinformation × Source × Narrative style × Topic	0.21	0.70	0.92

Note.

[1] Motivation was dichotomized by combining "somewhat more willing" and "much more" (motivation=1) versus "much less," "somewhat less" and "neither more or less" (motivation=0).

[2] Trust was dichotomized by combining "a little," "moderate amount," "quite a lot," and "completely" (trust=1) versus "not at all" (trust=0).

[3] Perceived risk was dichotomized by combining "much more concerned about diseases prevented by vaccine" and "somewhat more" (risk=1) versus "much less," "somewhat less," and "neither more or less" (risk=0).

Table 5.

Post-hoc examination of interactions: United States, 2017–2018

Tweet elements	Trust		Perceived risk	
	Proportion with trust	OR (95% CI)	Proportion with high perceived risk	OR (95% CI)
Misinformation × Source				
Misinformation, from a person				
Yes	50%		27%	Ref
No	47%	n/a	14%	0.30 (0.17, 0.51) [**]
Misinformation, from an organization				
Yes	46%		25%	Ref
No	63%	n/a	27%	0.91 (0.61, 1.36)
Misinformation × Topic				
Misinformation, about vaccine safety				
Yes	52%		30%	
No	50%	n/a	9%	0.18 (0.10, 0.32) [**]
Misinformation, about vaccine effectiveness				
Yes	44%		23%	Ref
No	61%	n/a	32%	1.49 (1.01, 2.20)
Misinformation × Source × Topic				
Misinformation, from a person about vaccine safety				
Yes	59%	Ref		
No	40%	0.45 (0.28, 0.72) [**]		n/a
Misinformation, from a person about vaccine effectiveness				
Yes	40%	Ref		
No	55%	1.84 (1.15, 2.94) [*]		n/a
Misinformation, from an organization about vaccine safety				
Yes	44%	Ref		
No	60%	1.91 (1.21, 3.04) [**]		n/a
Misinformation, from an organization about vaccine effectiveness				
Yes	48%	Ref		
No	66%	2.18 (1.38, 3.47) [**]		n/a
Source × Narrative style × Topic				
Source, of story about vaccine safety				
Person	50%	Ref	16%	Ref
Organization	54%	1.18 (0.75, 1.88)	26%	3.09 (1.34, 7.11) [**]
Source, of story about vaccine effectiveness				
Person	59%	Ref	32%	Ref
Organization	55%	0.84 (0.53, 1.33)	40%	1.39 (0.86, 2.24)

Tweet elements	Trust		Perceived risk	
	Proportion with trust	OR (95% CI)	Proportion with high perceived risk	OR (95% CI)
Source, of data about vaccine safety				
Person	49%	Ref	21%	Ref
Organization	50%	1.04 (0.65, 1.65)	14%	0.80 (0.38, 1.70)
Source, of data about vaccine effectiveness				
Person	36%	Ref	13%	Ref
Organization	60%	2.70 (1.68, 4.33)[**]	24%	2.18 (1.18, 4.02)[*]

Note. Findings are from a post-hoc tests of statistically significant interactions ($p<.01$) present for both trust and perceived risk (see Table 4). OR = Odds ratio; CI = confidence interval; Ref = Reference group; n/a = Not applicable, interaction was not statistically significant for perceived risk and 2-way interactions (misinformation × source and misinformation × topic) were part of 3-way interaction for trust.

[*] p=.01;

[**] p<.01