RESEARCH PAPER

Insights on HPV vaccination in the United States from mothers' comments on Facebook posts in a randomized trial

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ABSTRACT

In the United States, parents' health beliefs affect HPV vaccination decisions for children. Our team acquired insights into mothers' health beliefs from their reactions and comments to posts on HPV vaccination in a social media adolescent health campaign in a randomized trial ($n = 881$ mothers; 63.1% reported daughters had 1+ doses of the HPV vaccine) evaluating communication intended to reduce daughters' indoor tanning. A total of 10 HPV vaccination messages in didactic ($n = 7$) and narrative ($n = 3$) formats were posted on vaccination need, uptake, and effectiveness and stories of young women who died from cervical cancer and a mother's decision to vaccinate her daughters. These posts received 28 reactions (like, love, and sad buttons; mean = 2.8 per post) and 80 comments (mean = 8.0 per post). More comments were favorable ($n = 43$) than unfavorable ($n = 34$). Data was not collected on views for posts. The most common favorable comment reported that daughters were vaccinated ($n = 31$). Unfavorable comments cited safety concerns, lack of physician support, distrust of pro-vaccine sources, and increased sexual activity of daughters. Mothers posting unfavorable (18.2%) as opposed to favorable (78.6%) comments or not commenting (64.0%) were less likely to have had their daughters vaccinated (chi-square = 22.27, $p < 0.001$). Favorable comments often did not state reasons for vaccinating. Concerns about lack of vaccine safety remain a barrier. Mothers may express distrust in pro-vaccine sources to reduce discomfort with not vaccinating daughters to reduce their risk for HPV infection. Many mothers who remained silent had vaccinated daughters, which suggests they did not revisit HPV vaccination.

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Introduction

Despite the Advisory Committee on Immunization Practices recommending HPV vaccination,¹ only 48.6% of all adolescents aged 13–17 in the United States were up-to-date for the Human Papillomavirus (HPV) vaccination in 2017 (females 53.1%; males: 44.3%). This uptake is far below the Healthy People 2020 target of 80%, diminishing protection against cervical, vaginal, and vulvar cancers in women, oropharyngeal and anal cancers in men and women, and penile cancers in men.^{2–5}

U.S. parents experience several barriers that reduce uptake of HPV vaccination.^{6–10} The most common are safety concerns^{7,11–17} (expressed even by mothers who decide to vaccinate their daughters⁷) and beliefs that HPV vaccines are unneeded because of children's young age,^{7,18} lack of sexual activity,^{12,13,15,18–21} or belief that safe sexual practices can protect them.²¹ Receipt of basic vaccination information does not appear to prompt complete vaccination coverage.^{22–24} Instead, vaccine initiation is influenced by health beliefs (e.g., accurate vaccine knowledge; support for preventive vaccinations; concerns about side effects), whereas vaccine completion, by logistical barriers (e.g., forgetting; scheduling difficulties; child care; travel time; physician hesitancy).^{25–28}

Social media offer a unique channel through which parents can share and receive stories about adolescent health, including on HPV vaccines,¹³ and are essential channels for engaging the public. More than three-quarters of adult Internet users are on social media. Social media usage fluctuates across platforms but *Facebook* remains popular among adults (68%)²⁹ and teens (51%).³⁰ Most Americans (80% of those online) search online for health information⁹ and parents, in particular,^{31–33} use the Internet for information on child health.^{34–36} Social media also have transformed audiences into active participants in public communication who regularly create content, interact with others, and share links, information, and culturally-relevant stories about health. Information shared on social media from (perceived) knowledgeable peers can have a powerful impact^{37,38} and personal networks³⁹ are a common source of information on HPV vaccines.³⁹ An alarming trend is the circulation of inaccurate, misleading, unsupported, and harmful health information on social media,^{40,41} including about vaccines,^{42–44} that can depress their uptake. Vaccine-critical content is often posted on blogs, forums, YouTube and Twitter,^{45–50} with two recent studies finding that 19%–36% of tweets on HPV vaccines were unfavorable toward the vaccine.^{47, 48} In another study, parents reported receiving stories about harms of HPV vaccines more in social media (and traditional news media), while stories on prevention of HPV

disease occurred more in conversations with others.⁵¹ Some of the vaccine-critical information on HPV vaccines has been circulated by malicious content polluters linked with advertising and malware and bots associated with Russian troll farms on Twitter⁴¹ and social media sites that represent anti-vaccination perspectives.⁵² Parents' comments and reactions to information on social media can provide insights into their beliefs that affect vaccination decisions and also offer practitioners the opportunity to identify misinformation and possibly to correct it.⁴⁰ Past analyses of HPV vaccine-critical social media posts found that they express concerns about mistrust of HPV vaccines, threats to civil liberties, low severity of or susceptibility to HPV disease, vaccine safety, lack of efficacy and benefit, resistance from others, logistical barriers and cost, and cultural/emotional/religious resistance.^{47, 48}

Our team communicated about HPV vaccination with a sample of mothers of 14–17 year- old girls in a program on teen health conducted through *Facebook* private groups. Designed as a social media campaign in which to evaluate the effects of messages to prevent indoor tanning, it included posts on mother-daughter communication and health topics relevant to adolescent girls, including HPV vaccination. In this paper, we describe the posts on HPV vaccination and explore how reactions and comments to them reflected mothers' valence and content of beliefs about HPV vaccinations and predictors of favorability of comments.

Results

Profile of the sample

The sample was comprised of 881 mothers (see [Table 1](#)). They averaged 43.1 years of age. Most were non-Hispanic

Table 1. Profile of the sample of mothers (n = 881).

Age (mean [standard deviation])	43.13 (6.63)
Race	
White	86.6%
Non-White	12.9%
Prefer not to answer	0.5%
Ethnicity	
Not Hispanic/Latino	92.8%
Hispanic/Latino	6.5%
Prefer not to answer	0.7%
Political Leaning	
Conservative	24.0%
Middle of the road	49.8%
Liberal	23.4%
Prefer not to answer	2.8%
General health status: good, very good, excellent	88.3%
Daily servings of fruit (mean [standard deviation])	2.27 (1.54)
Daily servings of vegetables (mean [standard deviation])	2.60 (1.55)
Sugar-sweetened soda/pop intake (drinks) during past 30 days (mean [standard deviation])	8.48 (17.06)
Light or moderate physical activity during past week (mean [standard deviation])	4.18 (3.54)
Vigorous physical activity during past week (mean [standard deviation])	2.73 (2.55)
Body Mass Index (BMI)	
Underweight (<18.5)	2.0%
Normal weight (18.5–25)	30.1%
Overweight (25.1–29.9)	28.0%
Obese (≥30)	39.9%
Binge drank at least once during past two weeks	33.0%
Currently smoke (some days or every day)	19.1%

white (81.6%). The majority of mothers (63.1%) reported that their daughters have had at least one HPV vaccination (20.2% 1 dose, 28.4% 2 doses, and 49.8% 3 doses [1.6% did not report doses]). Most mothers reported that their health status was good, very good, or excellent. However, they averaged nearly nine sugar-sweetened drinks during the past 30 days; 40% were obese based on body mass index; a third binge drank in the last two weeks; and one-fifth currently smoked.

Reactions and comments to HPV vaccine social media posts

The 10 social media posts on HPV vaccination garnered 28 “reactions” (i.e., like [n = 23], love [n = 4], and sad [n = 1] buttons) (range = 0–13 per post; M = 2.8; SD = 4.1) and 80 comments (range = 0–46 per post; M = 8.0; SD = 14.7) from 51 mothers ([Table 2](#)). Two didactic posts, on how 6 out of 10 parents choose to vaccinate their children against HPV and on how much HPV infections among adolescent girls had declined, received the most reactions (n = 6 and n = 13, respectively) and comments (n = 20 and 46, respectively). The remaining posts received far fewer or no reactions or comments. Facebook did not provide a measure of whether participants viewed posts in groups with more 250 members⁵³ as in this study. Thus, we were uncertain whether no reaction or comment occurred when mothers read a post and chose not to react or comment or they failed to read the post. In n=15 cases participants posted a reaction but not a comment so at least a few mothers chose not to comment when reading a post.

Comments from mothers were generally more favorable (n = 43) toward HPV vaccination than unfavorable (n = 34) ([Table 3](#)). Looking at themes expressed, some mothers disclosed in comments (n = 31) that their daughters had been vaccinated and also stated the need for boys to be vaccinated (n = 12). A few mentioned a family history of cancer influencing decisions to vaccinate the daughter (n = 3). Unfavorable comments most often cited safety concerns (n = 16), such as possible risks would outweigh benefits to their daughter's health. A few comments (n = 5) mentioned that their physicians did not support the daughter being vaccinated and that the mother did not trust pro-vaccination sources (n = 5). The fear of unknown long-term effects of the vaccination (n = 5) and concerns about increased sexual activity by their daughters (n = 5) were mentioned, too. Examples of these themes are provided in [Table 3](#).

In some cases, posts that received multiple comments created a “conversation” among the posting mothers. It appears that in several cases, the valence of the first comment set the tone for subsequent posts, i.e., an initial positive comment, coded as favorable, received several positive comments in response while an initial negative comment, coded as unfavorable received many additional negative comments. For example, the first response to the post about the decline in HPV rates due to vaccination was “*All of my children completed their HPV vaccines without any side effects and this study increases my peace of mind. I'm glad we decided to immunize.*” Five favorable comments immediately followed

Table 2. HPV vaccination posts in social media campaign.

Post	Type	Total Reactions* (n = 28)	Total Comments (n = 80)
Did you know there are certain diseases (for example, HPV, meningococcal, and whooping cough) that teenagers are more likely to contract? Experts explain why vaccines are the best defense. #link to video	Didactic	1	5
While 6 out of 10 parents are now choosing to vaccinate their children against HPV, many aren't completing the 3-shot series. Do you know if your daughter is up to date on her vaccines?	Didactic	6	20
About 14 million people, including teens, become infected with HPV each year! You can help protect your daughter from the most serious, cancer-causing strains by getting her vaccinated.	Didactic	1	2
HPV vaccines are working! A 2016 study found that the number of girls ages 14–19 with the virus has decreased by 64%. Has your daughter been immunized? If not, talk to her doctor. #link to article	Didactic	13	46
Today would have been Kelly Pozzoli's 36th birthday. She died from cervical cancer at age 33. While fighting for her own life, she shared her story in a documentary about HPV, in the hopes that she would save other lives, too. Watch this documentary with your daughter: #link to video	Narrative	2	0
Amazing! Australian schools started offering free HPV vaccines in 2007 and their rates of infection have dropped dramatically (only 1.1% of women ages 18–24 had HPV in 2015!). How would you feel if your daughter's school started doing the same? #link to article	Didactic	4	5
As of September 2015, less than 20% of Tennessee teens had been fully vaccinated for HPV. Have you talked about the HPV vaccine with your daughter's doctor?	Didactic	1	0
January is National Cervical Health Awareness Month. What do you know about HPV and cervical cancer? Get the facts from the National Cancer Institute: #link to infographic	Didactic	0	2
There wasn't anything Kirk could do after his 22-year-old daughter was diagnosed with cervical cancer. But he'd do a lot differently if he'd known there was a way to prevent it. Since Kristen's death, Kirk has made it his mission to educate other parents and encourage them to talk with their teens about the HPV vaccine. What have you said to your daughter about the vaccine? #link to photo	Narrative	0	0
Who knows better than a doctor? A doctor who's also a mom. Check out this mommy doc explaining why HPV vaccine is so important. #link to video	Narrative	0	0

* Reactions are defined as a sum of the interaction of the like, love, and sad buttons on Facebook.

this one, with other mothers also disclosing that they vaccinated their children. The sixth response was *"I'm going to be that mom but I'm absolutely against this shot. When did we stop teaching our children the consequences of having unprotected sex? That's what is wrong with the younger generation they are led to believe a pill or shot can stop everything."* followed by one favorable rebuttal to the comment and one more unfavorable comment. The tone of this dialogue was generally favorable. By contrast, the responses to the post about completing the entire series took on a more unfavorable tone following the first comment of, *"My children are vaccinated, but they won't be getting this one,"* with four more unfavorable follow-up responses about declining this vaccination for their daughters. In the fifth comment, a mother disclosed that her daughter was vaccinated which was followed by two more mothers disclosing that their daughters had been vaccinated. No additional unfavorable comments followed.

Predictors of comments on HPV vaccine social media posts

Analyses were conducted to see whether overall health status, daughter's HPV vaccination status, age, race, and ethnicity of mothers assessed in the baseline survey prior to the social media campaign were associated with whether mothers commented on the HPV posts. Political leaning was associated with daughter's HPV vaccination status (any dose: conservative = 49.3%; middle-of-the-road = 65.8%; liberal = 72.3%, chi-square [$N = 855$, $df = 2$] = 26.19, $p < 0.001$; number of doses: conservative = 1.05, middle-of-the-road = 1.53, liberal = 1.72, $F(df = 2, 844) = 16.22$, $p < 0.001$) so it was also examined. None of these variables

demonstrated univariate associations with whether mothers posted any comment (commented or not) in response to the HPV vaccine posts at an alpha criterion of $p = 0.05$ (2-tailed). However, daughter's HPV vaccination status was related to the valence of comments. Very few mothers posting negative comments had vaccinated their daughters (18.2%) compared to those posting favorable comments (78.6%) or not commenting on the HPV posts (64.0%; chi-square [$N = 878$, $df = 2$] = 22.27, $p < 0.001$). A similar pattern in valence of comments was seen in number of doses of the HPV vaccine (unfavorable comment mean = 0.45 doses; no comment mean = 1.45; favorable comment mean = 2.07; $F(2, 866) = 10.23$, $p < 0.001$).

Discussion

Mothers' comments were divided between showing support for the HPV vaccine and showing opposition to the HPV vaccination. Support for vaccination was primarily in the form of the mother announcing that her daughter was vaccinated. Some mothers may have been motivated to have children vaccinated by a perceived risk of cancer based on family history. However, most positive commenters did not give extensive reasons for vaccinating their children. Thus, at best, these favorable comments might create a higher descriptive norm^{54,55} for HPV vaccination among other mothers (i.e., belief that a larger number of mothers have had their daughters vaccinated). The lack of reasons for vaccinating may mean that this user-generated content may not provide information that counters the inaccurate, misleading, unsupported, and harmful information on vaccines that circulates on social media.^{40–44}

Table 3. Themes expressed in mother comments on HPV vaccination posts from content analysis.

Themes*	N (%)	Example Statement
Favorable toward vaccination (n = 43 comments)		
Disclosed daughter being vaccinated	31 (38.8%)	"Absolutely! My daughter was immunized at age 10 and my 12 year old twin boys have one shot left to go before their series of 3 is complete."
Stated need for boys to be vaccinated	12 (15.0%)	"Don't forget your sons either. My 14 year old son's pediatrician looked startled when I asked him to vaccinate C. He said I was one of only a handful of parents who had asked for it for their son. So many girls have parents who refuse this vac thinking it's permission to have sex. I don't want my son to give HPV to one of those girls."
Vaccine reduced mother's anxiety	2 (2.5%)	"All of my children completed their HPV vaccines without any side effects and this study increases my peace of mind. I'm glad we decided to immunize."
Reduced risk of related disease cited	2 (2.5%)	"Yes, she got the series of shots. Our pediatrician recommended it. I also wrote a paper about the pros and cons when Gardasil first came out so I knew the benefits outweighed the risks. I work for a hospital system that specializes in cancer treatment so I've seen how horrible the disease and treatment side effects can be. Anything I can do to minimize my kids' chances of getting cancer is better than nothing."
Mentioned physician support	2 (2.5%)	"My daughter got this when her doctor recommended it. They gave us a magnet that lit up when she was due for the subsequent injections. Very convenient"
Reduced HPV infection rates cited	1 (1.3%)	"Significant reduction in infection with HPV. The most sig for me is the connection between HPV infection and head and neck cancer in young people which is devastating."
Mentioned family history of cancer increasing desire for vaccination	3 (3.7%)	"My daughter has been vaccinated and I plan on doing it for my son's. I had hpv, and had precancerous cells on my cervix and had to have part of my cervix frozen and removed. If I hadn't been going for my annual gynecologist appointments, I would have gotten cancer. This is something I never want my children to go through. My mother had a very rare form of ovarian cancer and had a reoccurrence a couple years ago. I believe strongly in vaccines."
Unfavorable toward vaccination (n = 34 comments)		
Cited safety concerns	16 (20.0%)	"I leave this one for my kids to decide for themselves. My son didn't get it that I know of and so far my daughter hasn't either. My 1 step daughter has and didn't have any problems but her mom found stuff out about it after her first shot and left it up to her also, and she's usually one to give any and every type of medicine she can. Our doctor mentioned fertility concerns about this and I heard about kids not being themselves and unable to do things they previously could. I don't trust it but at the same time cancer runs in our family so we talk about benefits and possible risks and then I leave it up to them since so far they have all been mature enough to make that type of decision. One thing with that article that bothers me is that they state the amount of aluminum in the vaccine is a safe amount because everyone comes in contact with more than that amount every day. Wouldn't that mean that you should limit the amount you intentionally come in contact with? Just like bleach, a small amount might not hurt you but if you get too much of it then it can kill you. Or you might have been exposed to second hand smoke for 1 day and it probably wouldn't hurt you but if you are exposed to it every day, there is definitely more of a chance you will get lung cancer than if you weren't."
Mentioned lack of physician support	5 (6.3%)	"When I asked my OBGYN what she thought about it, she admitted she wouldn't be getting it for her kids"
Stated lack of trust in vaccination sources/ organizations	5 (6.3%)	"I respect the CDC but the chance of getting cervical cancer from HPV given the number of strains of HPV is very low and most cases of HPV are undetected and cure themselves. This vaccine works like the flu vaccine which this year was only 33% effective. It's based on predictive stats and some years they get it right and others they don't. All other vaccines prevent communicable childhood diseases like polio, measles, chicken pox, etc. HPV pathology is not similar to these communicable diseases. While the Europeans have embraced this vaccine, the research in the US isn't convincing and unlike other vaccines, the side effect chances appear to be more than "a sore arm" or a "fever". If my children disagree, they can decide to get this vaccine after they turn 18 and make their own decisions. And like all prevention of STDs they should be using condoms as well."
Stated daughter has been vaccinated, but not the complete series	5 (6.3%)	"My daughter got two shots close together – didn't know there was a third? Can someone explain?"
Cited concerns about unknown long-term effects of vaccination	4 (5.0%)	"I am pro-vaccine also, but like several have stated, there simply isn't enough data (to include long-term) to make me comfortable with it. I pray that my children remain healthy in the absence of receiving the HPV vaccine. But I don't have a good feeling about this one, so I'm not going to do it."
Shared concerns that vaccination will increase sexual activity	4 (5.0%)	"Yes they both have opinions about it! Lol. I personally wish we had not given my oldest the vaccine and let her have the opportunity to decide for herself. She tends to stay sick a lot and I truly believe that any immunization taxes the immune system. Yes, I have debates with many doctors about this. Lol. But we waited with our youngest. She knows that before she can become sexually active that she must allow for 6 months for this vaccine. She is 15 and said she will probably get it before she starts college. Here is the bigger issue...I old my girls to INSIST that their boyfriends have the same vaccine. And if he is not willing, then he is not the one. We may communicate too much in our family, but I feel that knowledge is so important in making informed decisions."
Cited concerns about lack of efficacy	3 (3.7%)	"I had one daughter vaccinated and the other I did not. If a booster is required and they didn't cover all strains, what was the point. They recommend this at 12...a bit young in our household."
Shared apprehension from other mothers	1 (1.3%)	"My two oldest have had it, but there's growing concern among some mom's of my youngest daughter that they shouldn't get the vaccine."

*Each comment could have statements that expressed more than one theme. In those cases, the comment was counted twice.

There were a number of unfavorable opinions expressed in comments to the HPV vaccination posts. Consistent with other studies, safety concerns appeared to be the most prevalent,^{7,11–17} despite evidence of its ongoing safety.^{56,57} Further, some health care professionals may not strongly

advocate for the vaccination, which could present a barrier to uptake for health care providers are a common source of HPV vaccine information.^{39,58–60} Whether physicians actively discourage vaccination or simply do not strongly advise it when parents express reservations cannot be

discerned here. Some mothers appeared to disparage the organizations recommending HPV vaccination, saying they are untrustworthy, as has been seen previously.^{7,11,14,21} This is a common reaction to risk messages (i.e., fear appeals) when recipients do not feel they are capable of performing recommended behaviors to reduce the risk, or in this case, believe that the advocated risk-reducing action (i.e., HPV vaccination) carries too much alternative risk.^{61,62} One challenge is that such disparagement could be easily transferred to any health expert or agency who tries to correct parents' misperceptions about HPV vaccine and render counter-arguments ineffective. Like in past research, concerns related to sexual activity, especially lack of need or ability to use other prevention methods,^{12,13,15,18–21} were expressed but relatively infrequently (prior research has suggested this objection is waning¹²). However, contrary to past analyses of social media,⁴⁷ mothers in this sample did not mention logistical barriers, cost, or cultural or religious objections. Strategies are needed to correct these vaccine-critical perceptions.

Some mothers appeared aware of the relatively recent recommendations in the United States that adolescent boys be vaccinated for HPV. Currently, U.S. vaccination rates for boys lag behind girls but with awareness of the recommendation, more mothers may vaccinate sons. However, knowledge alone may not be enough to motivate large numbers to parents to vaccinate boys^{22–24} and may require advice from health care professionals or public information campaigns on the risks and benefits to boys.

A strength of these analyses is that mothers were identified and assessed prior to posting the HPV message in social media, rather than identifying their comments and inferring their pre-existing characteristics. Only HPV vaccination status predicted commenting behavior, with unfavorable comments posted almost entirely by mothers who had not vaccinated their daughters. It is notable that most mothers did not post comments and at baseline, many of these non-commenting mother had already vaccinated their daughters, at a rate nearly as high as mothers posting favorable comments. Many of them may have been supportive of the HPV vaccine and had their daughters vaccinated already; thus, they were unaffected by the unfavorable comments. The high rate of vaccination among mothers who commented favorably is not surprising as many of these comments were simply reports that the daughter had been vaccinated.

A weakness in this analysis was that the sample of mothers may have limited generalizability because a) those recruited from Qualtrics were recruited for high social media use, b) mothers lived in states without bans on indoor tanning which might mean that they were in populations less progressive regarding public health issues, and c) daughters were slightly older than the ages at which HPV vaccination is first recommended.

HPV vaccination continues to be somewhat controversial in the United States at least among a small minority of mothers. The fact that mothers supporting vaccination do not always come to its defense on social media may

perpetuate a perception that opposition is larger than it actually is. To overcome the unfavorable opinions some mothers are willing to share on social media, U.S. public health agencies and practitioners need to develop ways to convincingly counter the vaccine-critical information by actively providing information describing the benefits of vaccination, stories about the risks of HPV-related disease, and correcting misinformation, conveying information on vaccine safety, and correcting norms by showing that many mothers choose to vaccinate daughters against HPV. These efforts might be most effective with the large number of mothers who are either not actively resistant to the vaccine or express favorable attitudes but still have not vaccinated their daughters to help reach the 80% national vaccine coverage target. The small number of highly resistant mothers who contributed unfavorable comments may be more difficult to convince, but helping mothers who are uninformed or uncertain about the vaccine to make vaccine decisions informed by accurate information and avoid being influenced by vocal opposition in social media may go a long way toward increasing in HPV vaccine rates.

Methods

Participants

The trial's purpose was to prevent indoor tanning by adolescent girls using a social media campaign. Thus, to be eligible, mothers had to: 1) live in one of 34 states that did not ban indoor tanning by youth under age 18; 2) have a daughter aged 14 to 17 that lived in the home, 3) consent to participate, 4) read English, 5) complete the baseline survey, and 6) have a Facebook account that she logged into at least once per week. The planned sample size was designed to obtain 80% power to detect intervention/control differences in mother's permissiveness for daughters to indoor tan⁶³ and daughters' indoor tanning,⁶⁴ inflating for a 15% loss to follow-up.

Mothers were recruited in three ways. Initially, community-based strategies (i.e., working with Coordinated School Health Coordinators and community-based organizations [eg. churches, sports leagues, clubs, health clinics, etc.]) and list-based out-calling were used in Tennessee, a state with a parental permission law for minors' access to indoor tanning. These efforts did not enroll enough mothers ($n = 104$). Hence, the sampling frame was expanded to the 34 U.S. states without a complete ban on indoor tanning by youth under age 18 and mothers were recruited from a survey panel maintained by Qualtrics, Inc. ($n = 777$). Mothers enrolled in the trial at a study website where they completed an eligibility screener and provided contact information. Mothers gave permission for daughters to be invited to the study, although daughter participation was not required. The protocols were approved by Western Institutional Review Board (IRB) and IRBs at the University of Connecticut and East Tennessee University.

Experimental design

The experimental design was a randomized controlled design, with three assessments: baseline, 12-months post-randomization, and 18-months post-randomization. Mothers completed the consent form and baseline survey and were compensated with Amazon gift cards for survey completion. Mothers were randomly assigned to one of two Facebook “secret” (i.e., private) groups, using a table created by the project’s biostatistician. The social media moderator added mothers to the assigned groups after the mothers sent her a “friend request;” randomization occurred in the order that friend requests were received. In both groups, mothers received a social media campaign containing posts on adolescent health topics (i.e., mental health, substance use, healthy lifestyle, and HPV vaccination) and mother-daughter communication to blind them to the experimental condition. In the experimental group, 25% of posts addressed preventing indoor tanning and in the control group, 25% discussed preventing prescription drug abuse. The campaign was delivered over 12 months.

Intervention

Content for the social media campaign, named *Health Chat*, was designed using an integrated conceptual framework based on principles of social cognitive theory (SCT),^{65,66} diffusion of innovation theory (DIT),⁶⁷ and transportation theory (TT)^{68,69} (i.e., increasing perceived social norms, behavioral capability, outcome expectations, observational learning, self-efficacy, and interest in alternatives to risky behavior). *Health Chat* posts covered health topics identified as of high interest by mothers in preliminary focus groups: healthy lifestyle behaviors, mental health, mother-daughter communication, vaccination, and substance use. An advisory board of experts provided evidence-based information that the research team translated into Facebook posts. Also, 80% of posts were developed in advance while 20% of posts covered emerging research and current events from news reports, academic publications, and government advisories. All mothers received the posts on topics listed above which constituted 75% of the Facebook feed. For the experimental manipulation, half of the mothers ($n = 443$) received 25% of total posts on indoor tanning prevention (intervention group) and the other half of the mothers ($n = 438$; control group) received 25% on prescription drug abuse prevention. Content posted in each group is not deleted and remains for the duration of the campaign.

Between September 2017 and October 2018, a total of 10 HPV vaccination posts were distributed in the Facebook private groups (Table 2), seven in didactic form and three in narrative form. Didactic messages covered the need for adolescent vaccines, number of people infected by HPV annually, proportion of parents choosing to vaccinate children against HPV, how well HPV vaccines are working to decrease infection rates (two posts), and the National Cervical Health Awareness Month. Two narrative posts told stories of two young women who died from cervical cancer (one from the father’s point of view) and a third

presented a physician telling the story about why she decided to vaccinate her own children against HPV. Narrative posts provided a link to a video or photo of the persons in the story. Some didactic articles also had links to a video ($n=1$), articles ($n=2$), or an infographic on the topic of the post.

All mothers received the posts in the private Facebook groups in which members and content of the group are not viewable to the public, including other Facebook users. While *Health Chat* was intended for mothers and only mothers were in the Facebook groups, mothers were encouraged to share content with their daughters. The groups were hosted by the moderator who managed the posting schedule, stimulated engagement, corrected inaccurate posts and comments by mothers, and monitored the broader media for trending topics and new research findings to post. Posts occurred once or twice a day, over 12 months ($n = 720$ posts) and were formatted to generate user engagement. A key format for message development was narrative, operationalized by linking to stories from mothers and daughters. TT holds that story formats are effective⁷⁰ recipients identify with characters in a story^{71,72} and narratives shift normative beliefs about risks.^{73–80} Likewise, in DIT⁶⁷ comments and likes from users should increase dissemination and social influence and hopefully help opinion leaders emerge in each group and stimulate collective action through a social comparison process that^{67,81–83} generates conformance with peers⁸⁴ and collective identity,^{81,82} especially on health issues that carry risk and produce uncertainty.^{85–87}

Measures

The relevant measures for this analysis were a series of questions assessing health behaviors addressed in the social media posts other than indoor tanning and prescription drug abuse. Specifically, HPV vaccination of the teen daughters was assessed by asking if the daughter had been vaccinated for HPV and if so, how many shots she had received. In addition, participants rated their overall health status and described their diet (daily servings of fruits and of vegetables and times they drank regular soda or pop that contained sugar or sugar sweetened drinks in the past 30 days), body mass index, regular physical activity, alcoholic beverage intake (number of days in the past 30 days and number of times four or more alcoholic drinks were consumed in a row (binging) in the past two weeks), smoking behavior (smoked at least 100 cigarettes in their lifetime and currently smoke every day, some days, or not at all), mental health (number of days in the past 30 days was their mental health not good), and disability.

Demographics

Mother demographics were collected at baseline. These included the state in which the mother currently lives, age, race, and ethnicity.

Engagement

In each group, 10 unique posts on HPV vaccination were included in the feed. Mothers’ engagement with the HPV

vaccination posts were measured by counting the number reactions (i.e., like, love, and sad buttons) and comments to each post, extracted by a trained research assistant in October 2018.

A total of 80 comments by mothers were extracted (comments by the moderator [$n = 12$] were excluded) and a content analysis was conducted to assess their valence and content. Coding of all the comments was conducted by a trained research assistant and a secondary coding for 20% ($n = 19$) of comments was completed by an additional trained research staff member (agreement = 78.9%; disagreements resolved by discussion between the two coders). The comments were coded as favorable, unfavorable, or irrelevant (i.e., part of general group dialogue but not related to HPV vaccination specifically). Comments were categorized as favorable when HPV vaccines were discussed positively or a participant stated that her daughter was vaccinated. Comments were coded as unfavorable when participants were critical of the HPV vaccine or expressed regret, hesitancy or refusal in getting their daughter the vaccination. Additionally, emergent themes were identified based on the content of the comments.

Themes of favorable comments included: disclosure of daughter being vaccinated; vaccine reducing mother's anxiety; reduced HPV infection rates cited; reduced risk of related disease cited; physician support mentioned; need for boys to be vaccinated; and family history of cancer increasing desire for vaccination. Themes of unfavorable comments included: lack of physician support mentioned; safety concerns; concerns about lack of efficacy; concerns about unknown long-term effects of vaccination; shared apprehension from other mothers; concerns that vaccination increase sexual activity; lack of trust in vaccination sources/organizations; and report of incomplete vaccine series, but not the complete series.

Statistical analysis

Descriptive statistics, such as means and percentages, were generated to summarize the baseline characteristics of the 881 mothers. Statistical tests were conducted to investigate the association between mother baseline characteristics and whether mothers commented on the HPV social media posts. Chi-square tests were performed for categorical characteristics and two-sample t tests were used for continuous baseline characteristics. All tests were performed in SAS 9.3. Alpha criterion levels were set at 0.05 (two-tailed).

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