HPV vaccine misinformation on social media: A multi-method qualitative analysis of comments across three platforms

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ABSTRACT

Objective

The purpose of this study was to characterize similarities and differences in HPV vaccine misinformation narratives present in the comment sections of top-performing initial creator posts across three social media platforms.

Methods

A qualitative multi-method design was used to analyze comments collected from social media posts. A sample of 2996 comments were used for thematic analysis (identifying similar themes) and content analysis (identifying differences in comment type, opinion, and misinformation status).

Results

Misinformation was pervasive in comment sections. Cross-cutting misinformation themes included adverse reactions, unnecessary vaccine, conspiracy theories, and mistrust of authority. The proportion of comments related to these themes varied by platform. Initial creator posts crafted to be perceived as educational or with an anti-vaccine opinion had a higher proportion of misinformation in the comment sections. Facebook had the highest proportion of misinformation comments.

Conclusion

Differences in the proportion of cross-cutting themes in the comment sections across platforms suggests the need for targeted communication strategies to counter misinformation narratives and support vaccine uptake.

Innovation

This study is innovative due to its characterization of misinformation themes across three social media platforms using multiple qualitative methods to assess similarities and differences and focusing on conversations occurring within the comment sections.

1. Introduction

The human papillomavirus (HPV) is one of the most common sexually transmitted infections and is linked to six different cancers, including vulvar, vaginal, anal, penile, oropharyngeal, and cervical. [1] Of the four globally licensed HPV vaccines, one is currently used in the United States (US), which targets the HPV types that account for 70–90% of HPV-associated malignancies. As a result, the HPV vaccine is viewed as a critical tool for upstream cancer prevention. [2] The Centers

for Disease Control and Prevention (CDC) recommends HPV vaccination for everyone between the ages of 9 and 26 years. [3] It is typically included with routine school vaccines administered between the ages of 11 and 12 years. [3] In October 2018, recommendations were expanded to include a shared decision-making process between doctors and patients between the ages of 27 to 45 years. [3] Despite CDC recommendations, uptake of the HPV vaccine is still relatively low in the US. [4] Although there have been modest improvements in vaccination rates in recent years, they are still well below the 80% Healthy People 2030 US

target. [5] Barriers to HPV vaccination are diverse and are often framed by religious objections and medical mistrust. [6] Factors influencing vaccination decisions include pain, fear, risk, parental and social influence. [7] Low HPV vaccination rates have been identified as a critical public health challenge, and experts recommend enhanced communication strategies that collectively promote HPV vaccine awareness in conjunction with its safety and additional benefits to increase uptake. [8]

1.1. Social media and health misinformation

Social media platforms, such as TikTok, Facebook, and Instagram, facilitate the creation of online communities, offering users opportunities to interact with one another. [9] Around 7 in 10 Americans use at least one social media platform in their daily lives. [10] While individuals aged 18–29 years (84%) and 30–49 years (81%) use social media at the highest rates, older age groups are also increasingly interacting with these platforms, including 73% of adults aged 50–64 years and 45% of those over the age of 65 years. [10] Individuals use social media to find and share information and build social support networks. [11] These virtual interactions have contributed to a change in the patterns of how individuals seek, use, and evaluate health information and evidence. [11] Previous studies have shown that health decisions are influenced by the social norms and influences found on social media, highlighting the increasing need for accurate health information within these online ecosystems. [9]

Health misinformation can be defined as health-related claims that are based on evidence that is false, misleading due to lack of scientific understanding, or anecdotal. [12,13] This is a general characterization and does not delineate between the deliberate creation and spread of information to cause harm (e.g., disinformation) and information that is created or spreads without malicious intent but considers both as a form of misinformation. [13] The COVID-19 infodemic illustrated the pervasive nature of misinformation on social media [14] and there have been relatively few studies that have characterized this social phenomenon, contributing to a lack of direction in addressing this complex issue. [13] Misinformation on social media has been found to contribute to vaccine hesitancy, potentially impacting HPV vaccination rates. [15-18] A systematic review found that HPV vaccination was associated with the highest volume of health misinformation on social media, [13] highlighting the importance of understanding the false narratives which may impact vaccine confidence.

1.2. Study overview

Previous research on HPV vaccine misinformation has focused on characterizing a single social media platform and the content contained within initial creator posts. [15,16,18-21] To expand on this existing body of work, this study was developed to consistently examine narratives across three social media platforms – Facebook, X (formerly called Twitter), and TikTok – to gain a comprehensive understanding of HPV vaccine misinformation narratives on social media. While health misinformation is contained within initial creator posts, the spread of false information can often be compounded by majority one-sided dialogue found in the comment sections. [9] Thus, health-related misinformation exists beyond traditional hashtags and is frequently found in the comments below initial creator posts, presenting a challenge to reducing the spread of false information. [19] To fill this gap in the literature, analysis from this study focused on misinformation contained in the comment section of top-performing HPV vaccine initial creator posts to better understand these conversations within the broader context of social media. The Information Manipulation Theory – including the domains of concealment, ambivalence, distortion, and falsification – served as the theoretical framework [19,22] to provide contextualization of this study within the broader field of misinformation. Therefore, the purpose of this study was to characterize HPV vaccine misinformation content found in the comment sections of top-performing initial creator posts across three popular social media platforms. The aims of the study were to:

1. Describe cross-cutting HPV vaccine misinformation themes identified in the comment sections of three social media platforms (*thematic analysis*), and
2. Identify differences in HPV vaccine misinformation content identified in the comment sections of three social media platforms (*content analysis*)

2. Methods

2.1. Ethics

This study was exempted by the West Virginia University Institutional Review Board (protocol #301702262).

2.2. Research design

A qualitative multi-method research design [23] was selected for this study. This intra-paradigm mixed qualitative approach was used as different, yet complementary qualitative research methods were needed to answer the study research questions. [23] First, thematic analysis was used to identify repeated patterns in misinformation comments across all three social media platforms included in the study (Aim 1). Domains from the Information Manipulation Theory were aligned with these cross-cutting themes to provide greater context surrounding the types of misinformation identified. Second, content analysis was used to quantify qualitative datapoints, providing insights into the differences in misinformation content across the platforms (Aim 2). This was a retrospective study, relying on comments that were previously posted on social media for data collection and analysis.

Data was collected from the comment sections underneath top-performing HPV vaccine initial creator posts across three popular social media platforms. Top-performing initial creator posts were identified through a manual search using previously identified hashtags associated with the HPV vaccine. [21] The primary hashtag used to identify posts was #HPVVaccine. A manual search was used to mimic the experience of someone searching for information regarding the vaccine. To be included in the study sample, the initial creator post and comment had to be written in English. Comments had to reference HPV or the HPV vaccine to be included. This reference could occur in the text of the post or through graphics/video.

All comments were collected between July 2023 – January 2024. X/ Twitter comments were collected between July – August 2023, Facebook comments were collected between September – November 2023, and TikTok comments were collected between December 2023 – January 2024. One study team member led data collection and received routine guidance from the principal investigator. Comments were stored in a data collection spreadsheet divided by social media platform. The spreadsheet was reviewed by the research team throughout the data collection period for completeness. Following data collection and cleaning, each comment underwent two forms of analysis to address study aims: thematic analysis (Aim 1 focused on platform similarities) and content analysis (Aim 2 focused on platform differences). Both thematic analysis and content analysis are methods previously used to examine social media health-related content. [24] After thematic analysis and content analysis were completed separately, both sets of findings were merged to provide a comprehensive characterization of HPV vaccine misinformation comments across the three social media platforms. For instance, misinformation themes identified through the thematic analysis process were integrated into content analysis to quantify the qualitative findings across social media platforms.

2.3. Thematic analysis methods

Comment text was used to conduct a thematic analysis. Comments identified as misinformation through the initial coding process were uploaded to NVivo 14 for theming. An iterative thematic analysis coding process facilitated by three study team members was used to identify themes and subthemes. [25] Routine meetings were used to arrive at consensus for the four cross-cutting misinformation themes and the associated Information Manipulation Theory domains for each. Themes were identified when data saturation, defined as no new themes or codes, was achieved throughout the coding process. [26] To be identified as a theme there had to be at least 10 comments coded to a topic across each of the three social media platforms. These themes were clustered with similar themes and the overarching themes of these clusters were identified by the research team, resulting in cross-cutting themes and associated subthemes.

2.4. Content analysis methods

Each comment was coded for content analysis using a previously established protocol by the study team. [21] The coding categories included *comment type*, including the categories of personal experience, opinion, educational, question, and other which was based on previous studies of social media health content, [27] *comment opinion* including the categories of pro-vaccine, anti-vaccine, none given, and unsure, and *misinformation*, including the categories of yes, no, and unsure using previously established definitions of health misinformation as the basis for identification. [12,13] The variables of type, opinion, and misinformation were also coded for each initial creator post from which the comments were collected. Opinion, type, and misinformation status, along with *social media platform* (Facebook, X/Twitter, TikTok) were the variables used for statistical analysis. Content analysis coding was completed by two research team members. Comments were only coded to one category for each of the study variables. Most text collected for this study was brief, so determining the main focus for the study variables did not result in significant disagreements between the study team members. Coding consensus was reached between the research team members throughout the content analysis coding process at regular weekly intervals. Any disagreements for specific comments were discussed at these weekly meetings until consensus was achieved. Fifty coded comments were randomly selected by the study principal investigator to assess interrater reliability using Cohen's kappa. Kappa results were found to be 0.91, suggesting a high level of interrater reliability. [28] Content analysis data was entered into SPSS v28 for statistical analysis, including between-group differences using chi-square tests of homogeneity.

3. Results

One thousand social media comments ($n = 1000$) were collected for each of the three social media platforms included in the study ($n = 3000$). After reviewing all collected comments, four comments were removed from final analysis because there was debate amongst the research team as to the linkage with the HPV vaccine. The final sample included 2996 comments collected across the three social media platforms included in this study, Facebook ($n = 999$), X/Twitter ($n = 998$), and TikTok ($n = 999$). Sample sizes were consistent with similar studies in the field. [13] Instagram, another popular social media platform, was excluded from the study as a policy implemented during the COVID-19 pandemic removed comments from vaccine-related posts as a means to control misinformation. [29] Comments were identified from an average of 38 top-performing initial creator posts from each of the three social media platforms ($n = 115$).

3.1. Thematic analysis results

Through an iterative thematic analysis coding process, four cross-cutting themes were identified in misinformation comments: adverse reactions, unnecessary vaccine, conspiracy theories, and mistrust of authority. Fig. 1 outlines these cross-cutting themes, associated domains from the Information Manipulation Theory, and provides illustrative quotes from the analyzed comments. Providing quotes from the raw data is aligned with the best practices in presenting qualitative research. [26] Two to three subthemes were identified for each cross-cutting theme. Misinformation about adverse reactions included overall safety of all vaccinations, the HPV vaccine leading to death, and the HPV vaccine causing other health problems. Unnecessary vaccine misinformation included natural cures and remedies and poor lifestyle choices. The conspiracy theory theme included the HPV vaccine having fewer safety regulations, hidden evidence proving vaccine danger, and viewing the HPV vaccine as a population experiment. Finally, mistrust of authority included references to government and governmental bodies (e.g., CDC), pharmaceutical companies, and the healthcare industry overall. Elements from all domains of the Information Manipulation Theory were identified within the misinformation comment text.

3.2. Content analysis results

Of the initial creator posts used to identify comments for study inclusion ($n = 115$), most were identified as being crafted with the intention of being perceived as educational (59.5%), framed with anti-vaccine opinions (54.2%), and did not specifically contain misinformation (63.2%). Chi-square tests of association were conducted for the initial creator post type, initial creator post opinion, initial creator post containing misinformation, and comments containing misinformation. There was a statistically significant association between initial creator post opinion and comment misinformation, $\chi2(3) = 91.246, p < .001$, and initial creator post type and comment misinformation, $\chi2(4) = 76.079, p < .001$. Initial creator posts identified as being crafted in order to be perceived as educational had the highest proportion of misinformation comments (69.3%) compared to other post types. Initial creator posts that shared an anti-vaccine opinion had a higher proportion of misinformation comments (68.4%) compared to other post opinions. There was not a statistically significant association between the initial creator posts containing misinformation and comments containing misinformation, $\chi2(1) = -0.015, p = .398$.

Observed frequencies and percentages to characterize comments by type, opinion, and misinformation status are presented in Table 1. Chi-square tests of homogeneity were run to assess the proportion of comment type, comment opinion, and comment misinformation across all three platforms. The distributions were not equal across the platforms for comment type, $\chi2(8) = 662.850, p < .001$, comment opinion, $\chi2(6) = 426.876, p < .001$, and comment misinformation $\chi2(2) = 257.997, p < .001$. Approximately 27% of all comments collected from top-performing initial creator posts contained misinformation and Facebook had the highest proportion of misinformation comments (41.1%).

Observed frequencies and percentages to characterize differences in comment type and comment opinion by misinformation status are presented in Table 2. Chi-square tests of homogeneity were run to assess the proportion of comment type and comment opinion by misinformation status across all three platforms. There was a statistically significant difference in distributions across the platforms for comment type and comment opinion by misinformation status, $p < .001$. Misinformation comment types were primarily identified as opinion (78.6%) compared to comments that were not identified as misinformation which were split between opinion (42.1%) and personal experience (33.0%). Misinformation comment opinions were primarily identified as anti-vaccine (97.3%) compared to comments that were not identified as misinformation which were split between anti-vaccine (40.0%) and pro-vaccine (42.3%).

Facebook	X/Twitter	TikTok
Adverse Reactions		
Safety Concerns with All Vaccines (Domains Identified: Falsification, Distortion, Ambivalence, Concealment)		
"Side effects of most medicines is worse than the ailment."	"No such thing as a completely safe and effective vax!"	"Not a safe vaccine but okay"
Causes Death (Domains Identified: Falsification, Distortion, Ambivalence, Concealment)		
"The HPV vaccine is a very dangerous vaccine, which has killed and crippled numerous people."	"HPV vaccines the one killing girls. Stop the vaccines!! Stop the killing!!"	"Gardasil kills. No thank you."
Causes/Exacerbates Other Health Problems (Domains Identified: Falsification, Distortion, Ambivalence, Concealment)		
"HPV vaccine causes abnormal paps, seizures, POTS, and death. Much better to risk a few warts than a lethal injection."	"It caused ovarian failure in some girls so not worth it in my book!"	"… I read research papers that said it's linked to endometriosis, mental health and other long-term effects."
Unnecessary Vaccine		
Clears Up Naturally/Natural Cures or Remedies (Domains Identified: Distortion, Ambivalence)		
"Most HPV clears the body without ANY intervention! These cancers are extremely rare .0012%! Side effects from this vaccine NOT rare!"	"Leave the kids alone, I'm beginning to think the kids would be better off having no vaccines, a healthy lifestyle, natural food clean water."	"Y'all don't need HPV vaccine… your chances of getting cervical cancer are low… and 95% of women have/had HPV your body clears it out by itself."
Abstinence/Poor Lifestyle Choices (Domains Identified: Distortion, Ambivalence)		
"How do you get HPV? Is it airborne, in the water or food. Medicine should not be treating bad behavior."	"Also, don't have sex until you're married and you'll be fine without an unnecessary vaccine."	"Keep your pants zipped before marriage and you don't have to worry about this. I did my husband did no HPV."
Conspiracy Theories		
Fewer Safety Regulations (Domains Identified: Falsification, Distortion, Ambivalence)		
"Rush to market too soon, now we have a bunch of young women who are paying the price."	"HPV Gardasil was NEVER placebo tested. The placebo group was a FAKE placebo - full of aluminum."	"My dad worked in pharmaceuticals and he never let me get that vaccine. They bypassed a lot of safety standards to get it on the market."
Hidden Evidence Disproving Efficacy/Proving Danger (Domains Identified: Falsification, Concealment)		
"Safe and effective: the more you repeat it, the more people might believe it. This is not science, this is assumption upon assumption."	"I look forward to CDC making a PUBLIC effort to regain the nation's trust instead of just pretending the lies you fed us were inconsequential."	"Didn't they say that it was falsified that it protects against cancer"
Population Experiment (Domain Identified: Concealment)		
"We are all a "pool" of Guinea pigs for these big pharmaceutical companies...no thanks!"	"No, no, and no, this is a sterilization program."	"What more does it take to realize that vaccines are actually a bioweapon."
Mistrust of Authority		
Government/Health Organizations (Domain Identified: Concealment)		
"Gardasil is a bad vax do not give it to your child it's not girls they target but the boys as well. The FDA knows it dangerous side effects it will do."	"The political CDC has gotten nearly everything wrong. Does ANYONE have any faith in this? Yup. Gotta keep selling them shots, no matter what!!"	"Anything "they" say is good for you, do the opposite!!!"
Pharmaceutical Companies/Healthcare Industry (Domain Identified: Concealment)		
"Doctors and pHARMa companies should be charged with child abuse to the fullest extent of the law.... along with any other charges."	"Stories like yours are destructive to the money-making agenda of big Pharma. That's why they won't listen to you, and it goes to show, they don't care about anyone's health."	"Can we really trust doctors these days, when they're all being controlled and paid by the big pharma companies?"

Fig. 1. Cross-cutting misinformation themes and subthemes, illustrative quotes, and Information Manipulation theory domains by social media platform.

Descriptive statistics were used to characterize misinformation themes identified through the thematic analysis process quantitatively across the three platforms and cumulatively (Fig. 2). Approximately 46% of all misinformation comments collected from top performing initial creator posts about HPV vaccination involved conspiracy theories, followed by adverse reactions (25.5%), mistrust of authority (18.9%), and unnecessary vaccine (9.5%). Both Facebook (48.2%) and X/Twitter (48.3%) had conspiracy theories as the top misinformation theme. This differed for TikTok, which had the top misinformation theme as adverse reactions (37.5%).

4. Discussion

Our findings suggest that there are HPV vaccine misinformation narrative similarities and differences across three major social media platforms. In Aim 1 of this study, the research team sought to identify the similarities across social media platforms through a thematic analysis which was used to identify four cross-cutting misinformation themes: adverse reactions, unnecessary vaccine, conspiracy theories, and mistrust of authority. In Aim 2 of this study, the research team sought to identify differences in HPV vaccine misinformation narratives between the social media platforms. These differences were identified

Table 1

Characterization of social media platform comments by type, opinion, and misinformation status.

| | Social Media Platforms | | | |
| | n (%) of comments per platform and comment categories | | | |
	Facebook	X/Twitter	TikTok	Total
Comment Categories				
*Type**				
Educational	40 (4.0)	162 (16.2)	63 (6.3)	265 (8.8)
Opinion	697(69.8)	567 (56.8)	289 (28.9)	1553 (51.8)
Personal Experience	153 (15.3)	128(12.8)	491 (49.1)	772 (25.8)
Question	54 (5.4)	85 (8.5)	146 (14.6)	285 (9.5)
Other	54 (5.4)	57 (5.7)	10 (1.0)	121 (4.0)
*Opinion**				
Anti-Vaccine	786 (78.8)	471 (47.1)	397 (39.7)	1654 (55.2)
Pro-Vaccine	87 (8.7)	407 (40.7)	446 (44.6)	940 (31.4)
No Opinion Given	57 (5.7)	80 (8.0)	109 (10.9)	246 (8.2)
Unsure	68 (6.8)	41(4.1)	47 (4.7)	156 (5.2)
*Misinformation Identified**				
Yes	410 (41.1)	286 (28.6)	96 (9.6)	792 (26.4)
No/Unsure	588 (58.9)	713 (71.4)	903 (90.4)	2204 (73.6)

* Statistically significant ($p < .001$) differences in distributions across platforms.

Table 2

Comparing comment type and comment opinion by misinformation status.

| | | Social Media Platforms | | | |
| | | n (%) per platform and misinformation status | | | |
Comment Misinformation*	Comment Categories	Facebook	X/Twitter	TikTok	Total
	Type				
Misinformation Identified	Educational	25 (6.0)	62 (21.6)	2 (2.0)	89 (11.2)
	Opinion	356 (86.8)	193 (67.4)	74 (77.0)	623 (78.6)
	Personal Experience	17 (4.1)	12 (4.1)	14 (14.5)	43 (5.4)
	Question	6 (1.4)	11 (3.8)	3 (3.1)	20 (2.5)
	Other	6 (1.4)	8 (2.7)	3 (3.1)	17 (2.1)
No Misinformation Identified	Educational	15 (2.5)	100 (14.0)	61 (6.7)	176 (7.9)
	Opinion	341 (57.9)	374 (52.4)	215 (23.8)	930 (42.1)
	Personal Experience	136 (23.1)	116 (16.2)	477 (52.8)	729 (33.0)
	Question	48 (8.1)	49 (6.8)	143 (15.8)	265 (12.0)
	Other	48 (8.1)	74 (10.3)	7 (0.7)	104 (4.7)
	Opinion				
Misinformation Identified	Anti-Vaccine	405 (98.7)	279 (97.5)	87 (90.6)	771 (97.3)
	Pro-Vaccine	0 (0)	1 (0.3)	5 (5.2)	6 (0.7)
	No Opinion Given	1 (0.2)	2 (0.6)	0 (0)	3 (0.3)
	Unsure	4 (0.9)	4 (1.3)	4 (4.1)	12 (1.5)
No Misinformation Identified	Anti-Vaccine	381 (64.7)	192 (26.9)	310 (34.3)	883 (40.0)
	Pro-Vaccine	87 (14.7)	406 (56.9)	441 (48.8)	934 (42.3)
	No Opinion Given	56 (9.5)	78 (10.9)	109 (12.0)	243 (11.0)
	Unsure	64 (10.8)	37 (5.1)	43 (4.7)	144 (6.5)

* statistically significant ($p < .001$) differences in distributions across platforms.

through a content analysis which identified a greater proportion of misinformation on Facebook, a greater proportion of misinformation identified on posts framed as educational or anti-vaccine, and differences in predominate misinformation themes. Taken collectively, this study presents a comprehensive understanding of the dialogue surrounding the HPV vaccine occurring within the comment sections of popular social media platforms.

Previous research on HPV vaccine misinformation on social media has focused on initial creator post content and individual platforms. For instance, a study on X/Twitter found that misinformation posts were often related to adverse health effects, mandatory vaccination, and the inefficacy of the vaccine. [18] Similar themes were identified on Instagram, and also included personal narratives clustered around misinformation domains such as concealment, injury, and conspiracy theories. [19] Another study found that misinformation was the most impactful social media element on X/Twitter related to HPV vaccine messaging. [16] Our study results support these previous findings [13] and expand the literature to include three platforms analyzed similarly. In our study sample of approximately 3000 comments found below top-performing initial creator posts, over one-quarter were characterized as containing misinformation, highlighting the pervasiveness of false health information across social media. Of those comments with misinformation, most were framed as opinion, however, educational framing was also significant (11.2%). This supports previous research suggesting that anti-vaccine misinformation frequently uses scientific wording to lend legitimacy to claims. [13] Interestingly, comments without misinformation were more evenly split between being framed as opinion (42.1%) or personal experience (33.0%), highlighting the need for health professionals to participate in interactive dialogue within the comments section so they can counter educationally framed misinformation with facts.

Using a qualitative multi-method approach allowed for a deeper understanding of the kind of misinformation occurring within each platform ecosystem. Four cross-cutting themes that echoed previous findings were identified within the comment sections [18,19] and included elements from all of the Information Manipulation Theory domains. [13,22] Comments in the conspiracy theories cross-cutting theme relied heavily on the domains of concealment (e.g., shedding light on a lie) and falsification (e.g., creating false information) while comments in the unnecessary vaccine cross-cutting theme focused on the domains of distortion (e.g., misrepresenting information) and ambivalence (e.g., prompting questions). While similar themes of misinformation were found across the platforms, the proportions of these themes varied. For instance, the theme of conspiracy theories featured prominently in misinformation comments on Facebook and X/Twitter whereas adverse reactions were more popular on TikTok. TikTok has a higher volume of younger users and our findings suggest that to counter misinformation narratives within this age group that is critical to HPV vaccine uptake, health professionals should consider addressing side effects through their content creation, supporting previous research on the platform. [21] While the comment ban on vaccine posts on Instagram limits the spread of misinformation on the platform, it also presents a challenge in engaging younger users in conversation and addressing questions and false information.

These findings warrant further exploration within the context of post-pandemic health communication. COVID-19 misinformation spread rapidly and widely on social media creating an infodemic that had profound effects on health. [14] The impact of health misinformation was particularly visible within disadvantaged populations. [17] Individuals with less educational attainment and less self-efficacy preferred online sources of health information compared to interpersonal sources, such as healthcare providers. [17] The climate surrounding the COVID-19 infodemic has not remained confined within the pandemic. The politicization of the COVID-19 vaccination has expanded to include all vaccinations, including the HPV vaccine. [30] This suggests that the damage to public health and healthcare entities from
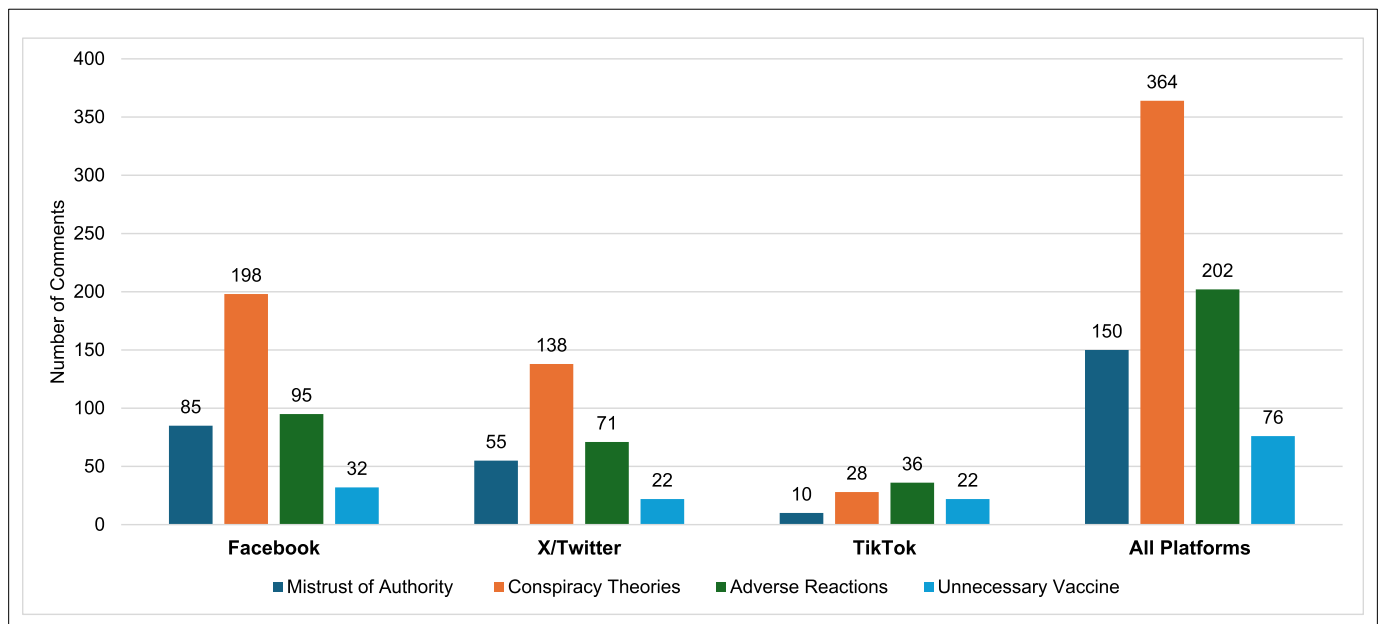
Fig. 2. Misinformation comments by cross-cutting themes collected on Facebook, X/Twitter, TikTok, and cumulatively across all platforms.

pandemic misinformation was not restricted to COVID-19 alone. Targeted approaches to health communication can counter public health mistrust and provide an important strategy to prevent the widening of health inequities. [31] The COVID-19 infodemic provides an important inflection point for health professionals to reassess messaging for a variety of topics, like HPV vaccination.

4.1. Innovation

This study is innovative for multiple reasons. The first reason is focused on inclusion of multiple social media platforms. Most studies in the field select a single platform to evaluate, limiting the generalizability to other social media outlets. The research team sought to examine misinformation comprehensively across three leading social media platforms. This presents an opportunity to compare findings to develop targeted communication strategies. For instance, while there were similar themes across all platforms, there were differences in proportion, suggesting the need to target messaging differently. Without this novel approach, the depth and breadth of findings would be limited.

The second innovation in this study is based on research design. In most studies in this field, there is a focus on content analysis or thematic analysis alone. By merging both into a qualitative multi-method approach, the research team was able to characterize content similarities thematically and assess for differences in content proportions by platform and cumulatively. This provides a greater understanding of each unique social media ecosystem.

The third innovation of this study is in data collection. Most studies in the field focus on assessing social media misinformation through initial creator posts alone. This study focused on the comments section, shedding light in an area driven more by dialogue instead of hashtags. This provides a more holistic picture of the ongoing conversations on each platform and can inform intervention and message development.

4.2. Limitations

This study does have limitations. First, data was collected from each platform over a two-month period. This approach did not address any longitudinal changes in narratives across the platforms. Second, data was collected through manual searches. Using social media data scraping software would have systematically identified more data

associated with the HPV vaccine. That said, a manual approach was selected as the research team wanted to use the same data collection method for all platforms and, to date, data aggregators are not available within TikTok. In addition, the research team wanted to mimic a general search if someone was interested in the topic. That said, this is not as comprehensive of a search without the use of social media data scraping software. Finally, qualitative coding and analysis is subjective. The research team integrated routine checking and consensus to achieve high interrater reliability, but it must be considered as a potential study limitation.

4.3. Future directions

Despite the spread of misinformation online, social media offers opportunities to intervene, including real-time corrections, algorithm tagging, and crowdsourced fact-checking. [20] Understanding HPV vaccine misinformation on social media through this study is an important first step in developing interventions for this complex social phenomenon. Based on our study, more effective messaging to counter false information on each social media platform may be created. Our findings suggest that a blanket approach to addressing HPV vaccine misinformation on social media may not be as effective as there are different drivers to conversation on different platforms. Messages targeted to these narratives are needed to test innovative interventions to counter online misinformation like using social listening platforms and trained infodemiologists. [32] Social media is a critical component of daily life for most individuals in the US so learning how to leverage it to counter HPV vaccine misinformation to reduce vaccine hesitancy is essential. Adolescents and young people are the predominant users of social media, making it a critical access point to this age group. As young people continue to gain involvement with their personal health decisions, [7,33] the importance of harnessing social media to reach this group with fact-based messages to encourage positive health behaviors is critical.

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CRediT authorship contribution statement

Dannell Boatman: Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Zachary Jarrett:** Writing – review & editing, Investigation. **Abby Starkey:** Writing – review & editing, Investigation. **Mary Ellen Conn:** Writing – review & editing. **Stephenie Kennedy-Rea:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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